



## Review

## Evolution of co-management: Role of knowledge generation, bridging organizations and social learning

Fikret Berkes\*

Natural Resources Institute, University of Manitoba, 70 Dysart Road, Winnipeg, Manitoba R3T 2N2, Canada

## ARTICLE INFO

## Article history:

Received 15 August 2008

Received in revised form

30 November 2008

Accepted 3 December 2008

Available online 24 December 2008

## Keywords:

Co-management

Knowledge

Bridging organizations

Social learning

Institutions

Governance

Trust

Adaptive co-management

## ABSTRACT

Over a period of some 20 years, different aspects of co-management (the sharing of power and responsibility between the government and local resource users) have come to the forefront. The paper focuses on a selection of these: knowledge generation, bridging organizations, social learning, and the emergence of adaptive co-management. Co-management can be considered a knowledge partnership. Different levels of organization, from local to international, have comparative advantages in the generation and mobilization of knowledge acquired at different scales. Bridging organizations provide a forum for the interaction of these different kinds of knowledge, and the coordination of other tasks that enable co-operation: accessing resources, bringing together different actors, building trust, resolving conflict, and networking. Social learning is one of these tasks, essential both for the co-operation of partners and an *outcome* of the co-operation of partners. It occurs most efficiently through joint problem solving and reflection within learning networks. Through successive rounds of learning and problem solving, learning networks can incorporate new knowledge to deal with problems at increasingly larger scales, with the result that maturing co-management arrangements become adaptive co-management in time.

© 2008 Elsevier Ltd. All rights reserved.

### 1. Introduction

Many resources are too complex to be governed effectively by a single agency. Governance of many kinds of fisheries, forests, grazing lands, watersheds, wildlife, protected areas and other resources, requires the joint action of multiple parties. The concept of governance suggests that we look beyond government, toward public–private–civil society partnerships, as a way of dealing with the shortcomings of single agency, top-down management (Pierre and Peters, 2000; Kooiman, 2003). Co-management, or the sharing of power and responsibility between the government and local resource users, is an arrangement whereby such partnerships can come about. Increasingly, co-management is being combined with learning-based approaches. Adaptive management, or learning-by-doing, was originally formulated as a way to deal with uncertainty and complexity, in place of set management prescriptions (Holling, 1978). It has become collaborative in practice, and time-tested co-management increasingly relies on learning-by-doing. Thus, co-management and adaptive management have been evolving toward a common ground: adaptive co-management. Knowledge

generation and learning have become central issues in such adaptive co-management (Olsson et al., 2004a,b; Armitage et al., 2007).

Kooiman (2003) recognizes three models of governance: hierarchical governance characterized by state intervention, self-governance, and co-governance consisting of collaboration and interplay among different actors. The market/private sector dimension can be added to co-governance, as there is a growing emphasis on incentives and entrepreneurship to achieve conservation objectives. Co-governance is particularly appropriate when user involvement leads to more legitimate management measures and to increasing compliance (Kooiman, 2003). In addition to legitimacy and compliance, justice, equity, and empowerment are also relevant because the basic idea behind co-management is that people whose livelihoods are affected by management decisions should have a say in how those decisions are made. Hence, co-management is not merely about resources; it is about managing relationships (Natcher et al., 2005).

Many researchers have warned against seeing co-management as a panacea for legitimacy (Jentoft, 2000; Mikalsen et al., 2007). As well, Béné and Neiland (2004) argue that the track record of co-management is weak in poverty reduction and empowerment of the marginalized. Co-management, and decentralization in general, often lead to reinforcement of local elite power or to strengthening of state control. Regarding the former, the exclusion of marginal

\* Tel.: +1 204 474 6731; fax: +1 204 261 0038.

E-mail address: [berkes@cc.umanitoba.ca](mailto:berkes@cc.umanitoba.ca)

stakeholders who are poor and politically weak may have negative impacts on equity and community welfare, as seen in fishery cases in Bangladesh, Cambodia, Indonesia, and Philippines (Wilson et al., 2006) and in India's Joint Forest Management (Agarwal, 2001; Nayak and Berkes, 2008). Regarding the latter, co-management can lead to regulatory capture, as seen in a range of cases (Castro and Nielsen, 2001; Nadasdy, 2003). It can be used as a pretext to co-opt community-based management and extend the power of the state (Lele, 2000; Gelcich et al., 2006; Nayak and Berkes, 2008).

There is no single universally accepted definition of co-management but many (Armitage et al., 2007). The term refers to a range of arrangements, with different degrees of power sharing, for joint decision-making by the state and communities (or user groups) about a set of resources or an area. Co-management shares many features with other kinds of partnerships and co-operative environmental governance arrangements involving multiple actors (Berkes, 2002; Plummer and FitzGibbon, 2004).

A close relative, multi-stakeholder arrangements, are characterized by strong horizontal linkages among user groups at the same level of organization, as well as vertical linkages across levels of organization, between stakeholders and government. Many multi-stakeholder bodies are advisory and show a low degree of power sharing. There are other forms of arrangements with horizontal and vertical linkages: policy networks, polycentric governance systems and epistemic communities (Berkes, 2002). These tend to consist of policy makers and technical experts, and may not formally include community representation. By contrast, the hallmark of co-management is to have at least one strong vertical linkage involving the government and a user group, and some formalized arrangement for sharing power and responsibility (Pinkerton, 1989; Berkes, 2002; Borrini-Feyerabend et al., 2004). Most authors do not regard mere consultation or *ad hoc* public participation as co-management. Most definitions of co-management require some institutionalized arrangement for intensive user participation in decision-making.

The term co-management is relatively recent. Pinkerton (2003) traces the earliest use of the term to the late 1970s, in the management of salmon under the Boldt Decision by the US Treaty Tribes in Washington State. However, the practice of formalized power sharing in resource management goes back to earlier times. In the area of fisheries, the earliest documented legal arrangement seems to be the Lofoten Islands cod fishery in Norway in the 1890s (Jentoft and McCay, 1995), and Japanese inshore fisheries under Japan's 1901 *Fisheries Act* and its subsequent revisions (Lim et al., 1995). In the area of forest management, government–community partnerships existed in the community forests of the Kumaon Himalayas, India, from the 1920s and the 1930s (Agrawal, 2005), and in the council forests of Kirinyaga, Kenya, from the 1930s and the 1940s (Castro and Nielsen, 2001). India's Joint Forest Management started in 1972 in West Bengal State as a revenue sharing arrangement to replant degraded forest areas (Agarwal, 2001). The earliest wildlife co-management started in the 1980s in northern Canada and Alaska (Kendrick, 2003) and in Africa for revenue sharing from safari hunting (Getz et al., 1999; Frost and Bond, 2008). Watershed co-management is probably most advanced in the United States (Brunner et al., 2005) and river basin co-management in Europe (Pahl-Wostl and Hare, 2004; Pahl-Wostl et al., 2007). There are early examples of co-management of protected areas, such as the Kakadu National Park in Australia, but protected area co-management did not become widespread until the 1990s (Borrini-Feyerabend et al., 2004).

The early literature depicted co-management as a class of relatively simple partnership arrangements, for example, in the implementation of indigenous land and resource claims (e.g. Berkes et al., 1991). However, the wide range of international experience accumulating since the 1980s indicates that co-management has

become more complex and dynamic than might be concluded from this earlier literature and evolved in diverse directions (Plummer and Armitage, 2007a,b). This paper provides a critical review of some of the ways in which the theory and practice of co-management have evolved, and different aspects have come to the forefront. In particular, the paper analyzes the role of knowledge generation, bridging organizations, social learning and adaptation, and the emergence of adaptive co-management.

## 2. Many faces of co-management

Different aspects (or “faces”) of co-management have emerged in the literature with the unpacking of the concept over the last two decades. The earlier interest in the legal aspects of collaborative arrangements has been replaced by a greater emphasis on process and learning (Carlsson and Berkes, 2005), and on a number of areas that characterize complex adaptive systems: issues of scale, multiple perspectives and epistemologies, path dependence, and uncertainty (Berkes, 2007a). The different aspects or faces of co-management that have been coming to the forefront in the literature can be summarized under a number of headings.

### 2.1. Co-management as power sharing

In most countries, resource management falls under the jurisdiction of the central or state government, but there may be arrangements for sharing power and responsibility with users. Measures of power sharing may be used as criteria in assessing co-management success (Kruse et al., 1998). But it is the nature of power sharing that often makes partnerships problematic. Typically, the less powerful partners are at a disadvantage for a variety of reasons (Nadasdy, 2003), but power sharing can be made more equitable through state legitimization and formalized arrangements, as in land claims agreements in Canada, Australia, New Zealand and elsewhere. It can be further strengthened by institution and capacity building and knowledge sharing. The literature deals with power imbalances, and the barriers embedded in broader social relationships. “In a nutshell, ‘participatory management needs participatory roots’, i.e., some measure of effective dialogue, discussion of issues and participatory democracy *internal* to all relevant social actors” (Borrini-Feyerabend et al., 2004: 175).

### 2.2. Co-management as institution building

Local institutions rarely have a background of working with the government, and government agencies are rarely ready for partnerships (Jentoft and McCay, 1995). Can co-management develop in the absence of deliberate institution building? Some authors advance the notion that co-management can evolve spontaneously through feedback learning over time from simple systems of management. Others have concentrated on identifying appropriate local institutions and building on their strengths, or crafting new institutions where the existing ones do not work or are not appropriate (Ostrom, 2005). Creating a favorable policy environment assists the emergence of functional co-management arrangements. The general lesson from the international literature is that the interplay, or two-way feedback, between government policy and local institutions is necessary for the evolution of co-management (Armitage et al., 2007) and networking has a major role to play (Mahanty, 2002).

### 2.3. Co-management as trust and social capital

Constructing an effective co-management arrangement is not only a matter of building institutions; it is also a matter of building

trust between the parties (Singleton, 1998; Eamer, 2006) and social capital in general (Pretty and Ward, 2001; Plummer and FitzGibbon, 2007). Trust appears to be a determinant of success in many cases of co-management, as a prelude to building a working relationship. Kruse et al. (1998) studied the relationship between user involvement and caribou management effectiveness in Alaska and northern Canada. Contrary to expectations, they found that direct user involvement in joint management boards did not increase the likelihood of co-operation. Rather, the key factor was the frequent presence of government biologists in native communities. Social capital is important, not only in indigenous co-management but also in all cases, because it is a prerequisite for collective action and social learning.

#### 2.4. Co-management as process

Co-management presupposes that parties have, in a formal or semi-formal way, agreed on a process for sharing management rights and responsibilities. But getting to co-management involves institution building, the development of trust and social capital, and generally a long voyage on a bumpy road. Co-management emerges out of extensive deliberation and negotiation, and the actual arrangement itself evolves over time. Co-management is path-dependent. That is, the outcome is strongly influenced by the history of the case (Chuenpagdee and Jentoft, 2007). Long-term studies characterize co-management not as an end-point but as a process in which relationships among the parties are constantly changing (Pinkerton, 1992). The length of time needed for this evolution or development process may be quite substantial, perhaps as long as a decade, as in the case of salmon of the Pacific Northwest (Singleton, 1998) and various examples from the Canadian North (Kendrick, 2003; Eamer, 2006).

#### 2.5. Co-management as problem solving

Management decision-making implies choices between different alternatives, while problem solving has to do with the process of generating these alternatives. Co-management evolves adaptively as a result of deliberate problem solving. But adaptive management requires collaborative processes to establish consensus among the parties before feedback-based problem solving can proceed. Hence co-management and adaptive management complement one another. Cases from Canada and Sweden, traced over time spans of 2–3 decades, indicate that co-management as problem solving enables parties to transfer learning from one situation to another, and tackle increasingly more complex problems (Olsson et al., 2004b). Seen as collaborative problem solving, co-management is task-oriented, concentrating on the *function*, rather than the formal structure, of the arrangement (Carlsson and Berkes, 2005).

#### 2.6. Co-management as governance

The basic idea of co-management fits with the evolving notions of people-centered governance approaches in which the management responsibility is shared among partners. The normative position of many in the co-management literature is that the direct involvement of people in resource management decisions that affect their livelihoods is good governance. It involves effective user participation and problem solving at the lowest feasible level of organization, sometimes called the subsidiarity principle (Kooiman, 2003). Co-management as governance often involves a diversity of players including public and private actors. The polycentric approach recognizes that effective governance often requires multiple links across levels and domains, and seeks overlapping

centers of authority. Such a decision-making structure contributes to the creation of an institutional dynamic appropriate for adaptive co-management and more broadly, for adaptive governance (Folke et al., 2005).

These five faces of co-management can be increased in number, for example, co-management as innovation (Kofinas et al., 2007) and co-management as conflict resolution (McCay, 2002). In particular, two additional faces (co-management as knowledge generation and co-management as social learning) are becoming increasingly important. They are chosen for more detailed treatment here because knowledge and learning issues have been receiving much scholarly and practical attention in moving co-management forward. These two themes are treated here as two major (and related) headings, along with bridging organizations that seem to have a key role in knowledge production and learning.

### 3. Expanding the range of knowledge for co-management

Managing ecosystem services and human well-being is an information intensive endeavor (MA, 2005). It requires knowledge of social–ecological systems in their full complexity in order to monitor resource availability, make decisions about allocation, and respond to feedback from the ecosystem at multiple scales (Berkes et al., 2003). Because of this complexity, it is difficult for any one group or agency to possess the full range of knowledge needed to manage resources. Rather, knowledge for dealing with ecosystem dynamics, resource abundance at various scales, trends and uncertainties, is dispersed among local, regional, and national agencies and groups.

Well documented Millennium Ecosystem Assessment cases show that managing social–ecological systems often requires social networks that span multiple levels of organization to mobilize and integrate dispersed information from various sources (Hahn et al., 2006). Because ecosystems are constantly changing and the human groups who depend on them are also in constant flux (population increase, migrations, changing livelihood needs, new economic opportunities), managers can hardly rely on a static information base and set management prescriptions (Ostrom, 2007).

One of the strengths of co-management is that different partners have the potential to bring to the discussion table knowledge that is acquired at different scales, as seen for example in the long-standing case of Arctic Borderlands Ecological Knowledge Co-op where local observations are often followed up by government monitoring (Eamer, 2006). Cash and Moser (2000) have referred to this phenomenon as scale-specific comparative advantages. Local institutions are best informed about the local level (e.g., state of the local forests; livelihood needs of villagers), whereas the state has a regional and national vantage point and a repertoire of tools and techniques (e.g., scientific databases; remote sensing) not normally available to local institutions. When Reid et al. (2006) explored how science and local knowledge could be best brought together, the most robust bridges were those constructed by combining such complementary kinds of knowledge and capabilities at different levels.

A number of Millennium Ecosystem Assessment cases do in fact provide good examples of such bridging (Capistrano et al., 2005; Fabricius et al., 2007). But in general bringing together science and local knowledge is not easy. First, many scientists and government managers do not trust local knowledge. Second, tacit, unwritten knowledge is often difficult to articulate, or at least difficult to make comprehensible to government managers and scientists (Reid et al., 2006). Third, especially when indigenous groups are involved, local knowledge often arises from a different worldview than does Western science and has different starting points, assumptions and rules (Berkes, 2008).

Caribou co-management in the Canadian North provides an illustration. The earliest case, the Beverly-Qamanirjuaq Caribou Management Board, started in 1982 as a response to a perceived caribou overhunting crisis. The Board members included Canadian federal, provincial, and territorial governments, and representatives of three major indigenous groups (the Inuit, Cree, and Dene) living within the range of this particular herd. The use of both government science and indigenous knowledge became established in the Board only after serious conflicts in the early years. Both governments and indigenous parties seem to have developed a respect for one another's knowledge; Kendrick (2003) characterizes this relationship largely as a process of learning to respect differences. Government scientists still operate under a paradigm of "managing" wildlife, whereas the indigenous groups reject the notion that caribou can be managed, and dislike intrusive management tools such as the use of radio collars on caribou.

In many cases, the different actors need to work and think together, and deliberate to generate new knowledge or make sense of knowledge from different sources. Such "co-production of knowledge" is described by Davidson-Hunt and O'Flaherty (2007: 293): "Working from the premise that knowledge is a dynamic process – that knowledge is contingent upon being formed, validated and adapted to changing circumstances – opens up the possibility for researchers to establish relationships with indigenous peoples as co-producers of locally relevant knowledge." Participatory research builds social capital, and power sharing relationships between researchers and communities can help develop locally appropriate resource management strategies (Arnold and Fernandez-Gimenez, 2007).

#### 4. Bridging organizations and leadership

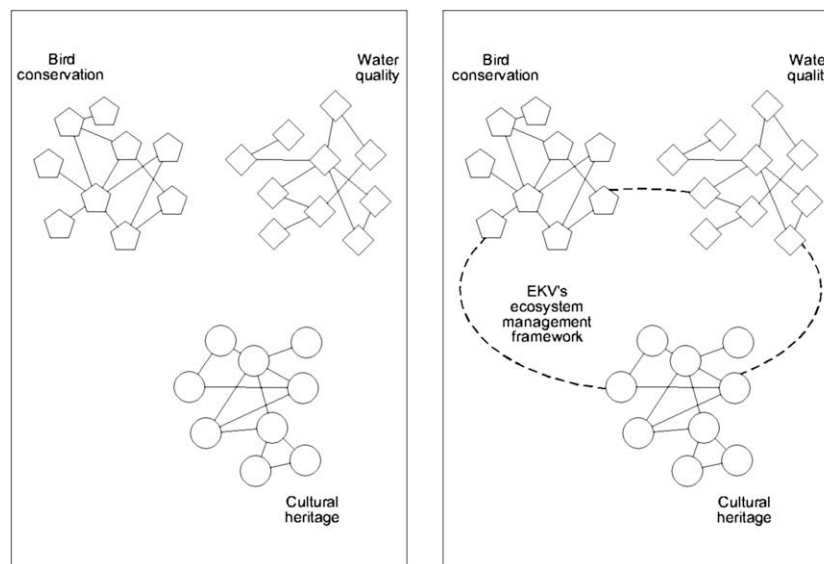
Bringing together science and local knowledge can be facilitated by bridging organizations that provide an arena for knowledge co-production, trust building, sense making, learning, vertical and horizontal collaboration, and conflict resolution. Bridging organizations can respond to opportunities, serve as catalysts and facilitators between different levels of governance, and across resource and knowledge systems (Folke et al., 2005). They are similar to boundary organizations, as originally described for the two-way

translation between science and policy spheres (Cash and Moser, 2000), but are considered to have a broader scope than boundary organizations (Hahn et al., 2006).

In many of the indigenous co-management cases in northern Canada, the formally constituted co-management agency that brings together government and indigenous representatives is the arena in which knowledge translation and a range of other co-management tasks are handled (Berkes et al., 2005; Ayles et al., 2007). For example, in the Beverly-Qamanirjuaq caribou co-management example, it is the Board itself that functions as the bridging organization by providing a forum for knowledge exchange and trust building. However, in the Arctic Borderlands Ecological Knowledge Co-op case, the bridging organization was the forum that came together at the annual meetings (Eamer, 2006). In the Tohono O'odham case, knowledge sharing functions were facilitated by scientists (Arnold and Fernandez-Gimenez, 2007).

The bridging organization in the Swedish Millennium Ecosystem Assessment case of Kristianstads Vattenrike Biosphere Reserve was a municipal organization, the Ecomuseum Kristianstads Vattenrike (EKV), later becoming the biosphere office. The EKV provided the forum for trust building, conflict resolution, and accessing knowledge. For example, when the wetland area in Vattenrike was set aside for conservation purposes, it became overgrown after the halting of grazing. The EKV coordinated the deliberation over this unintended impact of conservation, leading to the co-production of new knowledge. A consensus was reached to the effect that grazing was indeed essential to maintain the wetland system. Based on this understanding, a management decision was taken to provide incentives to make grazing economically viable (Olsson et al., 2004a). By linking networks concerned with different objectives (bird conservation, water quality, cultural heritage), the EKV provided leadership to produce a comprehensive vision and goals (Fig. 1).

The network configuration in Fig. 1 is indicative of a common structural feature of many co-management arrangements. According to Wilson et al. (2006: 526) "Co-management programs in Asia are increasingly characterized by multi-faceted networks." One successful co-management case in the Philippines began with a small aquaculture project but expanded into other activities through alliances with local government agencies and NGOs, one of



**Fig. 1.** The role of the bridging organization, the Ecomuseum (EKV), in the Kristianstads Vattenrike Biosphere Reserve case, Sweden. EKV provided leadership in the form of vision and goals, pulling the different user groups in the Biosphere Reserve into a comprehensive ecosystem management framework and establishing relationships among them. Source: adapted from Olsson et al. (2007).

which had access to international donor funding. Reviewing an extensive, multi-country collaborative fisheries co-management project, Wilson et al. (2006) found that many cases showed partnerships with NGOs and government units at different levels of organization, forming cross-scale networks. The support and participation of government agencies at local and national levels, and NGOs at local, national, and international levels, were found to be critical for the success of these cases. Another significant finding was that co-management programs, once successful, tended to become involved in broader environment and development issues, such as ecotourism and livelihood enhancement (Wilson et al., 2006).

These results are consistent with the findings of a set of community-based conservation projects from the United Nations Development Programme (UNDP) Equator Initiative. A sample of nine of the cases from developing countries of the tropical belt showed that partnerships typically spanned four levels of organization (local, regional, national, international) and involved 10–15 partnerships each (Berkes, 2007b). Lacking formal arrangements for power sharing, these projects were not, strictly speaking, co-management cases, but they showed the pervasiveness of network-like linkages that communities and user groups seem to require to develop the ability to engage with the outside world. Other scholars are coming up with similar findings. For example, Nagendra et al. (2005: 87) found that successful leasehold forests in Nepal were the ones that tended to have networks, and commented on “the extent of technical assistance provided by this almost bewildering array of supportive agencies.” The general finding is that linking different levels of organization and knowledge systems requires networks involving many coordinators and facilitators (Mahanty, 2002; Olsson et al., 2007). These often include outside groups such as NGOs, and their partnership functions in time extend beyond co-management and into broader environment and development issues.

In this regard, leadership is an important and related factor. Olsson et al. (2007) point out the dual importance of bridging organizations and leadership; in the EKV case, the main leader was the director of the Ecomuseum. One can similarly identify key individuals and leaders in the northern Canadian or other co-management cases. The success of co-management in the lobster fishery of Maine was attributed to two factors: the existence of the Maine Fishermen’s Forum, a neutral area for discussion, and the effective leadership of the Marine Resources Commissioner. The Commissioner was also the founder and editor of the *Commercial Fisheries News*, and a well-networked person in the fishing community (Acheson, 2003). Beem (2007) analyzed why co-management developed successfully in the Maine lobster fishery but not in the Chesapeake Bay blue crab fishery, given that the two cases had many similarities. The latter case had a formally constituted bridging organization, the Bi-State Crab Advisory Committee, and many other ingredients necessary for co-management. But the failure of the Chesapeake Bay case may have been due to the top-down nature of the proposed co-management arrangement, and the poor networking of leadership (“policy entrepreneurs” in Beem’s terminology) with the fishing community (Beem, 2007).

Bridging and knowledge co-production seem to be two important characteristics found in successful co-management systems. Bridging organizations and leadership are key factors that enable a co-management system to deal with knowledge issues, especially if local knowledge is based on a different epistemology and worldview than government science. However, these bridging organizations often end up building social capital and dealing with a range of issues other than knowledge. Networking enabled by bridging organizations also helps address conflicts, builds trust, accesses needed resources, builds a common vision and shared goals, and performs other tasks. These many roles of bridging organizations are summarized in Fig. 2.



Fig. 2. The many possible roles of bridging organizations in co-management. No single bridging organization is likely to supply all of these functions. In some cases, a number of organizations may share the various roles of a bridging organization.

Bridging organizations are crucially important because they provide a package of services and facilitate other linkages. Where bridging organizations do not exist, co-management or similar arrangements may end up separately engaging a number of NGOs, government agencies, research organizations, and other partners to satisfy a diversity of needs as, for example, seen in the case of UNDP Equator Initiative projects (Berkes, 2007b). In doing so, these arrangements end up looking like multi-faceted networks (Wilson et al., 2006). Various scholars have pointed out that these networks have another role crucial for co-management, that of facilitating social learning.

## 5. Social learning and adaptation

Social learning is of interest to a number of disciplines, including education and business management. In environmental management, learning-based approaches, in place of set prescriptions, were originally proposed as a way to deal with environmental uncertainty. With its focus on learning-by-doing through iterative practice, evaluation and action modification, social learning came to be considered a defining feature of adaptive management (Holling, 1978; Lee, 1993). But how does learning work? In the education literature, the classic model refers to the process of individual learning based on observation and imitation. With iterative feedback between the learner and the environment, the learner changes the environment and these changes in turn affect the learner.

According to conventional theories, learning occurs at the level of the individual. Yet to focus only on individual learning is too narrow to embrace the various learning processes that seem to operate in environmental management. It is becoming accepted that organizations as well as individuals learn, but learning in larger social systems remains controversial. Clark (2001: 382) argues that it is important “to identify the social groupings of individuals within which learning occurs, and the institutional forms that stabilize and transmit the resulting lessons.” Group-centered and multi-level social learning is increasingly seen as central to decision-making in environmental management. As Pahl-Wostl and Hare (2004: 193) put it, “Management is not a search for the optimal solution to one problem but an ongoing learning and negotiation process where a high priority is given to questions of communication, perspective sharing, and the development of adaptive group strategies for problem solving”.

Armitage et al. (2008) considered three learning theories as relevant to an ongoing social learning process. First, experiential learning is a process of creating knowledge through the transformation of experience, and learning-by-doing (Keen and Mahanty, 2006). Second, transformative learning is a reflective

process that enables an individual's perceptions and consciousness to be altered (Mezirow, 1996); it includes communicative as well as instrumental learning (Sinclair and Diduck, 2001). Third, social learning is a process of iterative reflection that occurs when experiences and ideas are shared with others (Keen et al., 2005). All three theories are related to self-organized learning processes that have emerged as a major theme for collaboration, joint decision-making, and co-management in the social-ecological systems literature (Folke et al., 2005).

In the Kristianstads Vattenrike case, self-organized learning seemed to emerge through networks facilitated by the bridging organization (Fig. 1). But different tasks undertaken by the group did not necessarily engage the entire network. Rather, solving specific problems involved self-organization and engaged only parts of the network, or "nodes". For example, a particular node may tackle the problem of minimizing damage to farmers from migratory cranes. Such a node might involve local farmers, bird conservationists, and some government people. Typically, nodes cut across two or more levels of organization, involve knowledge generation (or co-production), and sometimes experimentation (Olsson et al., 2007). In other instances, new policies provide learning occasions, as in the example of banning grazing that led to wetland becoming overgrown (Olsson et al., 2004a).

These networks and nodes may be said to constitute "learning communities" or "communities of practice". The former refers to groups of people, with a shared interest learning through partnerships; the latter, groups of people or community who have common concerns (domain area) and pursue knowledge through regular interactions based in practice (shared frameworks) (Armitage et al., 2008). The communities of practice concept, emphasizing learning-as-participation and the importance of shared practices and their concept (Wenger, 1998) is particularly apt for describing what really goes on in evolving co-operation. Co-management cases that have a time depth show that effective co-operation indeed develops through time and relies on learning-as-participation (Napier et al., 2005). Each round of problem solving leads to another.

For example, Pinkerton (2003) showed how co-management under the Boldt decision of 1974 evolved through a series of stages. By 1984, protocols for salmon harvesting, the original task, had been accomplished. This was followed by the emergence of the next set of problems, and these went beyond harvest regulation and included issues of habitat, regional planning, and international allocation. Thus the initial co-management agreement, which was about harvests, sets the stage for a complex multi-stakeholder exercise and multi-jurisdictional integrated resource management (Pinkerton, 1992; Pinkerton, 2003).

The Lake Racken case, Sweden, shows a similar progression. Experience in dealing with lake acidification led to knowledge building and learning regarding a range of issues. Participants tackled one problem after another over a period of years. Increased learning resulted in a widening of scope in the problems tackled, and increased capacity to experiment (Olsson and Folke, 2001). A comparative study of Lake Racken and James Bay, Canada, showed that learning-as-participation led to broadening the scope of collaborative problem solving (1) from a particular issue or local resource to a broad set of issues related to ecosystem processes across scales, and (2) from individual actors, to groups of actors, and eventually to multiple actor processes across levels of organization (Olsson et al., 2004b).

Participatory approaches seem to be central to learning by groups because they create the mechanism by which individual learning can be shared by other members of the group and reinforced (Diduck, 2004; Sims and Sinclair, 2008). In the process, social learning may proceed from simple, single-loop learning to

learning-to-learn and double-loop learning that can result in fundamental changes in behavior. Important feedbacks seem to be occurring among the use of participatory approaches, social learning, and the enhancement of social capital, which in turn may facilitate further collaboration (Plummer and FitzGibbon, 2007). Examples considered above indicate that such learning occurs in loops.

Successive loops of learning-as-participation combine elements of adaptive management with elements of co-management, and can be shown as expanding circles over time (Fig. 3). Each cycle starts with observation and problem identification (Downs, 1998). A problem-solving network organizes itself, facilitated by the bridging organization or other supporting group(s) of the co-management arrangement. The identification of problems and opportunities leads to planning for the formulation of solution(s). Participants need to monitor the outcomes of the plan to evaluate the effectiveness of action, followed by reflection that leads to the next cycle (Colfer, 2005; Fisher et al., 2007).

Such a process provides new information at each iteration, information that can be incorporated into the next round of solutions, the basis of adaptive management. But at the same time, each observation-planning-action-outcome cycle is also a learning step, leading to co-management at successively larger scales over time (Pinkerton, 2003; Olsson et al., 2004b). A case that actually shows successive cycles as in Fig. 3, whereby the success with one issue leads to tackling the next, indicates an arrangement that has matured in terms of its internal structure and external linkages (Pretty and Ward, 2001; Berkes et al., 2007). But such a depiction also gives the impression of an idealized unity and harmony among co-management partners. In reality, even the facilitation of co-operation among the actors can be a challenge in itself (Wollenberg et al., 2007). Furthermore, each actor or user group is far from homogeneous. Within a given user group, newly devolved power seems to go disproportionately to the elites. Hence, the fair distribution of power internally, and the empowerment of marginalized groups within the community become problematic (Béné and Neiland, 2004, 2006).

The distribution of power and responsibility on the government side is also far from uniform. Co-management skeptics have questioned whether government agencies would ever willingly give up power (Lele, 2000). But governments are not monolithic; different agencies have different roles and approaches, and the impact of individuals within an organization can be significant (Pinkerton,

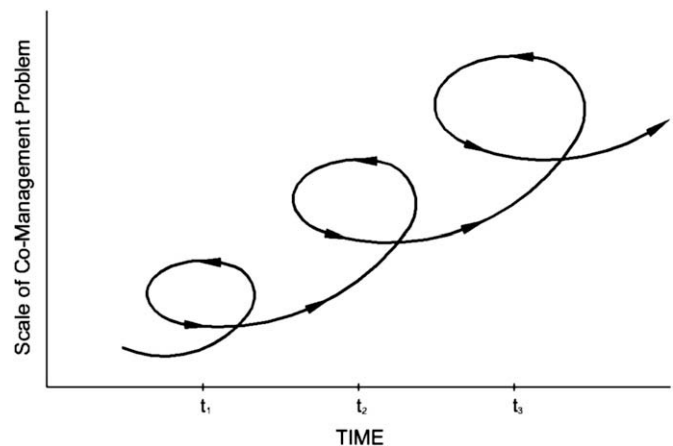


Fig. 3. Learning-as-participation in co-management, resulting in increasing levels of trust and the ability to tackle more complicated problems. Each loop in the figure goes through observation-planning-action-outcome phases, followed by a period of reflection.

**Table 1**  
Similarities and differences between co-management, adaptive management, and adaptive co-management (adapted from Berkes et al., 2007).

|                         | Co-management                                  | Adaptive management  | Adaptive co-management                                       |
|-------------------------|--|--|--|
| Linkages                | Primary focus: vertical institutional linkages | Linking science and management for learning-by-doing       | Horizontal and vertical linkages for joint learning-by-doing |
| Temporal scope          | Short to medium: tend to produce snapshots     | Medium to long: multiple cycles of learning and adaptation | Medium to long: multiple cycles of learning and adaptation   |
| Organizational level    | Bridging between local and government levels   | Focus on managers' needs and relationships                 | Multi-level, with self-organized networks                    |
| Capacity building focus | Resource users and communities                 | Resource managers and decision-makers                      | Needs and relationships of all partners                      |

2007). The dynamics of adaptive co-management create many possibilities. “Not only do the co-managers learn from the ongoing co-management experience, but the very act of engagement in adaptive co-management has the potential to change the way that the dominant management agencies have always conducted their business” (Berkes et al., 2007: 317).

## 6. Adaptive co-management

Social learning is at the heart of iterated rounds of problem solving, along the lines of Fig. 3, which characterizes many long-standing co-management cases. The unfolding of co-management experience since the 1980s suggests the evolution of co-management into what might be called adaptive co-management. As noted by an anonymous referee, “Quite a few scholars and practitioners of adaptive management now practice what is called here adaptive co-management without calling it that.” Adaptive co-management is defined by Folke et al. (2002: 20) as “a process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, ongoing, self-organized process of learning-by-doing,” a definition adopted also by Armitage et al. (2007: 328). In 2001, CIFOR defined a similar concept, adaptive collaborative management, as “a value-adding approach whereby people who have interests in a forest agree to act together to plan, observe and learn from the implementation of their plans (CIFOR, 2008: 2). In practice, adaptive collaborative management has three themes: horizontal interaction among stakeholders, vertical interaction of communities with actors at other levels, and iterative learning (CIFOR, 2008).

Adaptive management and co-management do not have a shared history. Adaptive management emerges from the literature of applied ecology, whereas co-management is most closely associated with the commons literature. Adaptive management and co-management have been evolving toward a common ground because adaptive management without collaboration lacks legitimacy, and co-management without learning-by-doing does not develop the ability to address emerging problems. Examining a set of international cases in a diversity of resource management areas, Armitage et al. (2007) found that time-tested co-management tends to become adaptive co-management. Combining the perspectives of co-management with those of adaptive management produces a synthesis that is different from either (Table 1). By recognizing the importance of both vertical linkages and the consideration of science and management together, adaptive co-management brings local knowledge directly into decision-making. As well, it shows an expanded view of the temporal scope, organizational level, and capacity building. Adaptive co-management is more closely attuned to the needs of resource users than is adaptive management, and more cognizant of learning and adapting than is co-management.

Making a living or managing resources in a rapidly changing, globalized world requires continual learning and adapting, aided by collaborative problem solving. These adaptive processes include slow processes such as muddling through, as well as rapid change that occurs as radical innovation and transformation. Interactive

governance theory suggests the use of institutional experimentation to stimulate learning and to serve as a prelude to finding the right mix of self-governance, co-governance, and hierarchical governance specific to a situation (Kooiman et al., 2005). Learning processes should be structured in such a way that the actors learn from each other and reflect on what they have learned. Learning-by-doing should be interactive because effective learning requires working together (Jentoft, 2007).

One caution is that adaptive co-management, like co-management, is no guarantee of fairness or equity in resource sharing, as in Joint Forest Management in India (Agarwal, 2001). Another caution is that learning does not necessarily lead to adaptation (although each may reinforce the other) and in some situations co-management may not make a difference. In some cases, participatory processes may be reduced to a bureaucratic mechanism in which some groups are able to pursue their private interests at the expense of other, less powerful stakeholders. Mikalsen et al. (2007) provide a concrete example from Norway.

The Norwegian Fishers' Association, which has long been a privileged partner in co-management, has gradually come to be dominated by large-scale operators and offshore trawler interests. The association changed from being an inclusive organization and a defender of social responsibility, to an organization defending the narrow economic interests of a select group. In analyzing this shifting arrangement, the authors do not advocate the exclusion of the Association, but rather the inclusion of other stakeholders. Ironically, “the transformation of the Association from something akin to a public interest group to a trade union may well be seen as an unintended consequence of government action...” (Mikalsen et al., 2007: 207). The government policy in question was the institution of a rights-based fishery around 1990 with individual harvest quotas that emphasized private rights over public interest.

## 7. Conclusions

In most kinds of co-management, there are multiple government agencies and multiple local interests at play, rather than a unitary state and a homogeneous “community”. Instead of focusing on the formal structure of co-management and its power sharing arrangements, one can regard power sharing as the *result*, rather than the starting point of co-management (Carlsson and Berkes, 2005). To do so, co-management can be examined as a problem solving *process* (rather than a static arrangement) involving negotiation, deliberation, knowledge generation and joint learning.

The accumulation of experience since the 1980s has led to theory development (Plummer and Fennell, 2007; Plummer and Armitage, 2007a), and to an unpacking of co-management as power sharing, institution building, and trust building. In the more recent literature, there has been an increased emphasis on co-management as a process involving social learning and problem solving, leading to co-management-as-governance. The consideration of interactive and adaptive aspects of co-management, scale issues in governance levels and in knowledge, multiple epistemologies and

perspectives, uncertainty (through adaptive management), and self-organization (through networks) takes co-management into the realm of complex adaptive systems (Berkes, 2007a; Plummer and Armitage, 2007b).

Two areas highlighted in the present review, knowledge generation and social learning, are key to the examination of the dynamics of co-management. Different maturity stages of co-management can be identified in terms of the degree of power sharing, shifts in worldview, rules and norms, the building of trust and respect, and the elaboration of network arrangements (Berkes et al., 2007). Maturing co-management arrangements become adaptive co-management in time, through successive rounds of learning-by-doing. To put this in another way, co-management that does not learn often becomes a failed experiment. Hence, one important consideration for successful and long-lasting co-management arrangements is the generation and use of knowledge.

Successful co-management is a knowledge partnership. Different levels of organization have comparative advantages in the mobilization and generation of different kinds of knowledge. Bridging knowledge and bridging different levels of organizations are closely related processes. Success in one can lead to success in the other. But combining different kinds of knowledge (science and local knowledge) is a difficult process and a skill that is still emerging (Reid et al., 2006). The task is particularly difficult in co-management involving indigenous people whose knowledge may be based on different worldviews (Moller et al., 2004; Berkes, 2008). Using science together with indigenous knowledge requires, not a synthesis of the two kinds of knowledge, but an ability to develop mutual respect and trust, a task that can easily take a decade (Singleton, 1998; Eamer, 2006) and does not always succeed (Spak, 2005). The role of bridging organizations (Olsson et al., 2007) is critically important in this regard in facilitating knowledge “translation”, but their role goes far beyond knowledge issues and into the coordination of a number of other tasks that enable co-operation.

Social learning is one of these tasks, essential both for the co-operation of partners and an *outcome* of the co-operation of partners. Social learning occurs most efficiently through joint problem solving and reflection, with the sharing of experiences and ideas. Based on the Swedish experience in particular, networks or “nodes” within the larger network of co-managers seem to be the main vehicle by which learning-by-doing occurs (Folke et al., 2005). Whether this finding can be generalized or not, is a potential research area. Learning styles may differ by area and by culture. A number of factors, such as the structure of the co-management arrangement and the style and quality of leadership, may play important roles as well. What we do know is that co-management involves vertical linkages across levels of organization and horizontal linkages among actors at the same level of organization. However, when we map functional relationships and linkages, we do not often see straight vertical and horizontal lines. What we do see instead are networks (Wilson et al., 2006; Olsson et al., 2007).

In the case of developing countries, these networks can include a surprisingly large number of support organizations, not only NGOs but also local and regional government agencies. When the roles of these partners are teased apart, a diversity of functions become apparent: fund raising, institution building, business networking, marketing, technology transfer, knowledge co-production, legal support, infrastructure, and community health and social services (Berkes, 2007b).

The presence of as many as 20 support organizations in some of the cases may be explainable in part by the specializations of these support organizations, in part by the maturity stage of the case (older cases have more partners), and in part by the apparent need

for redundancy of partners by function (Berkes, 2007b). The issue of redundancy is a potential research area. Olsson and Folke (2001) observed that a co-management arrangement that relies on a single support organization or a single key leader is very vulnerable. As inefficient as it may seem, redundancy in partners and their support functions (i.e., having a “Plan B”) confers resilience.

Building such resilience may be particularly important in the case of developing countries in which co-management evolves in an environment of weak institutions. Just to facilitate co-operation may be a challenge in itself. The Center for International Forestry Research (CIFOR) has been facilitating adaptive collaborative management in Indonesia and elsewhere since the 1990s. It has developed a series of tactics to deal with weak and uncertain institutional settings, tactics designed to make adaptive co-managers more receptive to surprise, disorder and serendipity (Wollenberg et al., 2007; CIFOR, 2008).

Along with CIFOR's co-operation recipes, Table 2 lists a number of strategies that have been used to facilitate or improve co-management. These include bridging and co-producing knowledge, participatory research, collaborate monitoring, participatory scenario building, and measures for the fair distribution of co-management power and for accountability. Table 2 is not meant to be a comprehensive list; several studies address conditions of success (Armitage et al., 2007). Given the general understanding that no one set of variables could produce *the* answer in a common management situation (Ostrom, 2007), a more useful approach may be to produce “diagnostic” questions that may be adapted to the context of a given case (Berkes et al., 2007, Box 16.1).

Diagnostics is one promising area for co-management research and practice, and requires carefully conducted case studies across different resource types and geographic areas. Longitudinal studies help understand processes of knowledge creation and learning, reveal capacity-building requirements, and the ways in which networks are elaborated. More investigations are needed on how networks help, what makes bridging organizations work, and why redundancy is important. Learning communities, learning networks, nodes and other groupings within which learning occurs (Clark, 2001) require more work in the context of co-management. How such learning is codified, shared and transmitted, and the diversity of ways of communicating it to the different actors, invite more experimentation (Bonny and Berkes, 2008). Where co-management might be going next includes more detailed analyses of the use of market mechanisms, such as payment for environmental services (Frost and Bond, 2008), and the use of entrepreneurship approaches in general to create incentives for communities to engage in co-management.

A better understanding is needed of the conditions under which learning networks are able to transform their experience from one case to another. How do they proceed from simple, instrumental learning, to learning-to-learn and double-loop learning that requires a shift in perspective (Armitage et al., 2008)? Some co-management arrangements can proceed by widening the scope of the problem from relatively small issues to larger and more complex ones. There is a practical and testable implication of this finding: a new co-management arrangement should start off by tackling small problems, and proceed through successive cycles (Fig. 3) by elaborating the knowledge base while building trust and learning.

A second implication has to do with the design of institutions. Effective co-management requires flexible, multi-level governance systems designed to enhance institutional interaction and experimentation to generate learning (Folke et al., 2002; Kooiman et al., 2005), but there is little experience on how to accomplish this. Experimentation is important as there is no single blueprint or panacea (Ostrom, 2007) for co-management design, but only the

**Table 2**  
Strategies that have been used to facilitate or improve co-management.

| Strategies  | Reference  |
|---|--|
| <i>Bridging knowledge.</i> Incorporating multiple knowledge systems and multiple scales enhances environmental decision-making. The potential in partnerships can be captured by combining complementary knowledge, skills and capacities of different actors at different levels of organization.  | Eamer, 2006; Reid et al., 2006; Berkes, 2008     |
| <i>Co-production of knowledge.</i> The process of knowing is dynamic, and relies on observation, validation and adaptation to changing circumstances. Researchers/scientists working with place-based learning communities can co-produce locally relevant knowledge that neither party can produce alone.  | Davidson-Hunt and O'Flaherty, 2007; Berkes, 2008 |
| <i>Cooperation building tactics,</i> especially in weak institutional settings, can include (1) continuous physical presence, (2) regular contact with people close to decision-makers, (3) maintenance of multiple programs for different groups, and (4) hyperflexibility in resource allocation and schedules.                                 | Wollenberg et al., 2007; CIFOR, 2008             |
| <i>Participatory research.</i> Research that includes rural and indigenous communities as equal partners has the potential to build social capital and enhance local capacity for problem solving. The inclusion of local perspectives fosters the ability to design locally appropriate resource management strategies.                          | Arnold and Fernandez-Gimenez, 2007               |
| <i>Collaborative monitoring.</i> It is difficult to know <i>a priori</i> what to monitor, and local partners can help decide what is to be monitored and how. Monitoring that includes, where possible, local ways of reading environmental signs and signals have the potential to widen the range of information available.                     | Kofinas, 2002; Mutimukuru et al., 2006           |
| <i>Participatory scenario building.</i> Scenarios will be more informative and useful if they can incorporate multiple perspectives. Scenario building that includes joint deliberation about what is known and what is not known provides an ideal space about questioning assumptions made by different disciplines and different perspectives. | Bennett and Zurek, 2006; Kok et al., 2007        |
| <i>Fair/democratic distribution of power.</i> Newly devolved power as a result of co-management arrangements, and decentralization in general, tends to be captured by the local elite. Hence the policy challenge is not decentralization <i>per se</i> but to make it work through various measures to foster fair distribution of power.       | Béné and Neiland, 2004, 2006                     |
| <i>Downward accountability.</i> Co-management is often successful in setting up upward accountability mechanisms (e.g., co-management agency's responsibility to the Minister). However, setting of effective downward accountability mechanisms is also important: agency's responsibility to the user groups.                                   | Béné and Neiland, 2004, 2006                     |

known need to enhance the ability to address problems, learn from experience, reflect, self-organize as necessary, and address the problem again or to move on to the next.

### Acknowledgements

Many of the ideas in this paper were developed jointly with Lars Carlsson, Per Olsson, Carl Folke, Derek Armitage, and Nancy Doubleday. For helpful comments and suggestions on the paper, I thank Ryan Plummer, Derek Armitage, Carol Colfer and two anonymous referees. I thank Christian Orozco Quintero for drawing the figures. My work has been supported by the Social Sciences and Humanities

Research Council (SSHRC) and the Canada Research Chairs program (<http://www.chairs.gc.ca>).

### References

- Acheson, J.M., 2003. Capturing the Commons. Devising Institutions to Manage the Maine Lobster Industry. University Press of New England, Lebanon, NH.
- Agarwal, B., 2001. Participatory exclusions, community forestry, and gender: an analysis for South Asia and a conceptual framework. *World Development* 29, 1623–1648.
- Agrawal, A., 2005. Environmentalism. Technologies of Government and the Making of Subjects. Duke University Press, Durham and London.
- Armitage, D., Berkes, F., Doubleday, N. (Eds.), 2007. *Adaptive Co-Management: Collaboration, Learning, and Multi-level Governance*. University of British Columbia Press, Vancouver.
- Armitage, D., Marschke, M., Plummer, R., 2008. Adaptive co-management and the paradox of learning. *Global Environmental Change* 18, 86–98.
- Arnold, J.S., Fernandez-Gimenez, M., 2007. Building social capital through participatory research: an analysis of collaboration on Tohono O'odham tribal rangelands in Arizona. *Society and Natural Resources* 20, 481–495.
- Ayles, B.G., Bell, R., Hoyt, A., 2007. Adaptive fisheries co-management in the western Canadian Arctic. In: Armitage, D., Berkes, F., Doubleday, N. (Eds.), *Adaptive Co-Management*. University of British Columbia Press, Vancouver, pp. 125–150.
- Beem, B., 2007. Co-management from the top? The roles of policy entrepreneurs and distributive conflict in developing co-management arrangements. *Marine Policy* 31, 540–549.
- Béné, C., Neiland, A.E., 2004. Empowerment reform, yes... but empowerment of whom? Fisheries decentralization reforms in developing countries: a critical assessment with specific reference to poverty reduction. *Aquatic Resources, Culture and Development* 1, 35–49.
- Béné, C., Neiland, A.E., 2006. From Participation to Governance. WorldFish Center, Penang, and CGIAR Challenge Program on Water and Food, Colombo.
- Bennett, E., Zurek, M., 2006. Integrating epistemologies through scenarios. In: Reid, W.V., Berkes, F., Wilbanks, T., Capistrano, D. (Eds.), *Bridging Scales and Knowledge Systems*. Millennium Ecosystem Assessment and Island Press, Washington DC, pp. 275–293.
- Berkes, F., George, P., Preston, R., 1991. Co-management. *Alternatives* 18 (2), 12–18.
- Berkes, F., 2002. Cross-scale institutional linkages: perspectives from the bottom up. In: Ostrom, E., Dietz, T., Dolsak, N., Stern, P.C., Stonich, S., Weber, E.U. (Eds.), *The Drama of the Commons*. National Academy Press, Washington DC, pp. 293–321.
- Berkes, F., 2007a. Adaptive co-management and complexity: exploring the many faces of co-management. In: Armitage, D., Berkes, F., Doubleday, N. (Eds.), *Adaptive Co-Management*. University of British Columbia Press, Vancouver, pp. 19–37.
- Berkes, F., 2007b. Community-based conservation in a globalized world. *Proceedings of the National Academy of Sciences of the United States of America* 104, 15188–15193.
- Berkes, F., 2008. *Sacred Ecology*, second ed. Routledge, New York.
- Berkes, F., Armitage, D., Doubleday, N., 2007. Synthesis: adapting, innovating, evolving. In: Armitage, D., Berkes, F., Doubleday, N. (Eds.), *Adaptive Co-Management*. University of British Columbia Press, Vancouver, pp. 308–327.
- Berkes, F., Bankes, N., Marschke, M., Armitage, D., Clark, D., 2005. Cross-scale institutions and building resilience in the Canadian North. In: Berkes, F., Huebert, R., Fast, H., Manseau, M., Diduck, A. (Eds.), *Breaking Ice: Renewable Resource and Ocean Management in the Canadian North*. University of Calgary Press, Calgary, pp. 225–247.
- Berkes, F., Colding, J., Folke, F. (Eds.), 2003. *Navigating Social-ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press, Cambridge, UK.
- Bonny, E., Berkes, F., 2008. Communicating traditional environmental knowledge: addressing the diversity of knowledge, audiences and media types. *Polar Record* 44, 243–253.
- Borrini-Feyerabend, G., Pimbert, M., Farvar, M.T., Kothari, A., Renard, Y., 2004. In: *Sharing Power. Learning-by-doing in Co-management of Natural Resources throughout the World*. IIED and IUCN/CEESP, and Cenesta, Tehran.
- Brunner, R., Steelman, T., Coe-Juell, L., Cromley, C., Edwards, C., Tucker, D., 2005. *Adaptive Governance: Integrating Science, Policy and Decision Making*. Columbia University Press, New York.
- CIFOR, 2008. *Adaptive Collaborative Management Can Help us Cope with Climate Change*. Infobrief No. 13. Center for International Forestry Research. 4pp.
- Capistrano, D., Samper, K.C., Lee, M.J., Raudsepp-Hearne, C. (Eds.), 2005. *Ecosystems and Human Well-being: Multiscale Assessments*, vol. 4. Millennium Ecosystem Assessment and Island Press, Washington DC Available from: <http://www.millenniumassessment.org/en/Multiscale.aspx>.
- Carlsson, L., Berkes, F., 2005. Co-management: concepts and methodological implications. *Journal of Environmental Management* 75, 65–76.
- Cash, D.W., Moser, S.C., 2000. Linking global and local scales: designing dynamic assessment and management processes. *Global Environmental Change* 10, 109–120.
- Castro, A.P., Nielsen, E., 2001. Indigenous people and co-management: implications for conflict management. *Environmental Science and Policy* 4, 229–239.
- Chuenpagdee, R., Jentoft, S., 2007. Step zero for fisheries co-management: what precedes implementation. *Marine Policy* 31, 657–668.

- Clark, W.C., 2001. Social learning. In: Goudie, A.S., Cuff, D.J. (Eds.), *Encyclopedia of Global Change*. Oxford University Press, Oxford, pp. 382–384.
- Colfer, C.J.P., 2005. The Complex Forest: Communities, Uncertainty, and Adaptive Collaborative Management. Resources for the Future/CIFOR, Washington DC.
- Davidson-Hunt, I.J., O'Flaherty, R.M., 2007. Researchers, indigenous peoples and place-based learning communities. *Society and Natural Resources* 20, 291–305.
- Diduck, A., 2004. Incorporating participatory approaches and social learning. In: Mitchell, B. (Ed.), *Resource and Environmental Management in Canada*, third ed. Oxford University Press, Don Mills, Ontario, pp. 497–527.
- Downs, A., 1998. *Political Theory and Public Choice: The Selected Essays of Anthony Downs*, vol. 1. Edward Elgar, Northampton MA.
- Eamer, J., 2006. Keep it simple and be relevant: the first ten years of the Arctic Borderlands Ecological Knowledge Co-op. In: Reid, W.V., Berkes, F., Wilbanks, T., Capistrano, D. (Eds.), *Bridging Scales and Knowledge Systems. Millennium Ecosystem Assessment and Island Press*, Washington DC, pp. 185–206.
- Fabricius, C., Folke, C., Cundill, G., Schultz, L., 2007. Powerless spectators, coping actors, and adaptive co-managers: a synthesis of the role of communities in ecosystem management. *Ecology and Society* 12 (1), 29. Available from: <http://www.ecologyandsociety.org/vol12/iss1/art29/>.
- Fisher, R., Prabhu, R., McDougall, C. (Eds.), 2007. *Adaptive Collaborative Management of Community Forests in Asia*. Center for International Forestry Research, Bogor, Indonesia.
- Folke, C., Carpenter, S., Elmqvist, T., et al., 2002. Resilience for sustainable development: building adaptive capacity in a world of transformations. In: *Rainbow Series 3. International Council for Scientific Unions (ICSU)*, Paris.
- Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources* 30, 441–473.
- Frost, P.G.H., Bond, I., 2008. The CAMPFIRE program in Zimbabwe: payments for wildlife services. *Ecological Economics* 65, 776–787.
- Gelcich, S., Edward-Jones, G., Kaiser, M.J., Castilla, J.C., 2006. Co-management policy can reduce resilience in traditionally managed marine ecosystems. *Ecosystems* 9, 951–966.
- Getz, W.M., Fortmann, L., Cumming, D., et al., 1999. Sustaining natural and human capital: villagers and scientists. *Science* 283, 1855–1856.
- Hahn, T., Olsson, P., Folke, C., Johansson, K., 2006. Trust building, knowledge generation and organizational innovations: the role of a bridging organization for adaptive co-management of a wetland landscape around Kristianstad, Sweden. *Human Ecology* 34, 573–592.
- Holling, C.S. (Ed.), 1978. *Adaptive Environmental Assessment and Management*. Wiley, London.
- Jentoft, S., 2000. Legitimacy and disappointment in fisheries management – prospects of user participation. *Marine Policy* 24, 141–148.
- Jentoft, S., 2007. Limits to governability: institutional implications for fisheries and coastal governance. *Marine Policy* 31, 360–370.
- Jentoft, S., McCay, B.J., 1995. User participation in fisheries management. Lessons drawn from international experiences. *Marine Policy* 19, 227–246.
- Keen, M., Mahanty, S., 2006. Learning in sustainable natural resource management: challenges and opportunities in the Pacific. *Society and Natural Resources* 19, 497–513.
- Keen, M., Brown, V., Dyal, R., 2005. *Social Learning in Environmental Management*. Earthscan, London.
- Kendrick, A., 2003. Caribou co-management in northern Canada: fostering multiple ways of knowing. In: Berkes, F., Colding, J., Folke, C. (Eds.), *Navigating Social-ecological Systems*. Cambridge University Press, Cambridge, pp. 241–267.
- Kofinas, G., 2002. Community contributions to ecological monitoring: knowledge co-production in the U.S.–Canada Arctic Borderlands. In: Krupnik, I., Jolly, D. (Eds.), *The Earth is Faster Now*. Arctic Research Consortium of the United States, pp. 54–91. Fairbanks.
- Kofinas, G.P., Herman, S.J., Meek, C., 2007. Novel problems require novel solutions: innovation as an outcome of adaptive co-management. In: Armitage, D., Berkes, F., Doubleday, N. (Eds.), *Adaptive Co-Management*. University of British Columbia Press, Vancouver, pp. 249–267.
- Kok, K., Biggs, R., Zurek, M., 2007. Methods for developing multiscale participatory scenarios: insights from southern Africa and Europe. *Ecology and Society* 13 (1), 8. Available from: <http://www.ecologyandsociety.org/vol12/iss1/art8/>.
- Kooiman, J., 2003. *Governing as Governance*. Sage, London.
- Kooiman, J., Bavinck, M., Jentoft, S., Pulin, R. (Eds.), 2005. *Fish for Life: Interactive Governance for Fisheries*. Amsterdam University Press, Amsterdam.
- Kruse, J., Klein, D., Braund, S., Moorehead, L., Simeone, B., 1998. Co-management of natural resources: a comparison of two caribou management systems. *Human Organization* 57, 447–458.
- Lee, K.N., 1993. *Compass and Gyroscope*. Island Press, Washington, DC.
- Lele, S., 2000. *Godsend, Sleight of Hand, or Just Muddling Through: Joint Water and Forest Management in India*. Overseas Development Institute. *Natural Resource Perspectives* No. 53.
- Lim, C.P., Matsuda, Y., Shigemitsu, Y., 1995. Co-management in marine fisheries: the Japanese experience. *Coastal Management* 23, 195–221.
- MA, 2005. *Ecosystems and Human Well-Being. General Synthesis. Millennium Ecosystem Assessment*. Island Press, Chicago. Available from: <http://www.millenniumassessment.org/en/Synthesis.aspx>.
- Mahanty, S., 2002. Conservation and development interventions as networks: the case of the India ecodevelopment project. *World Development* 30, 1369–1386.
- McCay, B.J., 2002. Emergence of institutions for the commons: contexts, situations and events. In: Ostrom, E., Dietz, T., Dolsak, N., Stern, P.C., Stonich, S., Weber, E.U. (Eds.), *The Drama of the Commons*. National Academy Press, Washington DC, pp. 361–402.
- Mezirow, J., 1996. Contemporary paradigms of learning. *Adult Education Quarterly* 46, 158–173.
- Mikalsen, K.H., Hernes, H.K., Jentoft, S., 2007. Leaning on user-groups: the role of civil society in fisheries governance. *Marine Policy* 31, 201–209.
- Moller, H., Berkes, F., Lyver, P.O., Kislalioglu, M., 2004. Combining science and traditional ecological knowledge: monitoring populations for co-management. *Ecology and Society* 9 (3), 2. Available from: <http://www.ecologyandsociety.org/vol9/iss3/art2>.
- Mutumukuru, T., Kozanyi, W., Nyrenda, R., 2006. Catalyzing collaborative monitoring process in joint forest management situations: the Mafungautsi forest case, Zimbabwe. *Society and Natural Resources* 19, 209–224.
- Nadasdy, P., 2003. Reevaluating the co-management success story. *Arctic* 56, 367–380.
- Nagendra, H., Karna, B., Karmacharya, M., 2005. Examining institutional change: social conflict in Nepal's leasehold forestry programme. *Conservation and Society* 3, 72–91.
- Napier, V.R., Branch, G.M., Harris, J.M., 2005. Evaluating conditions for successful co-management of subsistence fisheries in KwaZulu-Natal, South Africa. *Environmental Conservation* 32, 165–177.
- Natcher, D.C., Davis, S., Hickey, C.G., 2005. Co-management: managing relationships, not resources. *Human Organization* 64, 240–250.
- Nayak, P., Berkes, F., 2008. Politics of co-optation: community forest management vs. joint forest management in Orissa, India. *Environmental Management* 41, 707–718.
- Olsson, P., Folke, C., 2001. Local ecological knowledge and institutional dynamics for ecosystem management: a study of Lake Racken watershed, Sweden. *Ecosystems* 4, 85–104.
- Olsson, P., Folke, C., Hahn, T., 2004a. Social-ecological transformation for ecosystem management: the development of adaptive co-management of a wetland landscape in southern Sweden. *Ecology and Society* 9 (4), 2. Available from: <http://www.ecologyandsociety.org/vol9/iss4/art2/>.
- Olsson, O., Folke, C., Berkes, F., 2004b. Adaptive co-management for building resilience in social-ecological systems. *Environmental Management* 34, 75–90.
- Olsson, P., Folke, C., Galaz, V., Hahn, T., Schultz, L., 2007. Enhancing the fit through adaptive co-management: creating and maintaining bridging functions for matching scales in the Kristianstads Vattenrike Biosphere Reserve Sweden. *Ecology and Society* 12 (1), 28. Available from: <http://www.ecologyandsociety.org/vol12/iss1/art28/>.
- Ostrom, E., 2005. *Understanding Institutional Diversity*. Princeton University Press, Princeton.
- Ostrom, E., 2007. A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Sciences* 104, 15181–15187.
- Pahl-Wostl, C., Hare, M., 2004. Processes of social learning in integrated resources management. *Journal of Community and Applied Social Psychology* 14, 193–206.
- Pahl-Wostl, C., Craps, M., Dewulf, A., Mostert, E., Tabara, D., Taillieu, T., 2007. Social learning and water resources management. *Ecology and Society* 12 (2), 5. Available from: <http://www.ecologyandsociety.org/vol12/iss2/art5/>.
- Pierre, J.B., Peters, G. (Eds.), 2000. *Governance, Politics and the State*. Macmillan, Basingstoke.
- Pinkerton, E. (Ed.), 1989. *Co-operative Management of Local Fisheries*. University of British Columbia Press, Vancouver.
- Pinkerton, E., 1992. Translating legal rights into management practice: overcoming barriers to the exercise of co-management. *Human Organization* 51, 330–341.
- Pinkerton, E., 2003. Toward specificity in complexity: understanding co-management from a social science perspective. In: Wilson, D.C., Nielson, J.R., Degenbol, P. (Eds.), *The Fisheries Co-management Experience*. Kluwer, Dordrecht, pp. 61–77.
- Pinkerton, E., 2007. Integrating holism and segmentalism: overcoming barriers to adaptive co-management between management agencies and multi-sector bodies. In: Armitage, D., Berkes, F., Doubleday, N. (Eds.), *Adaptive Co-Management*. University of British Columbia Press, Vancouver, pp. 151–171.
- Plummer, R., Armitage, D., 2007a. Crossing boundaries, crossing scales: the evolution of environment and resource co-management. *Geography Compass* 1 (4), 834–849.
- Plummer, R., Armitage, D., 2007b. A resilience based framework for evaluating adaptive co-management: linking ecology, economics and society in a complex world. *Ecological Economics* 61, 62–74.
- Plummer, R., Fennell, D., 2007. Exploring co-management theory: prospects for socio-biology and reciprocal altruism. *Journal of Environmental Management* 85, 944–955.
- Plummer, R., FitzGibbon, J., 2004. Some observations on the terminology in co-operative environmental management. *Journal of Environmental Management* 70, 63–72.
- Plummer, R., FitzGibbon, J., 2007. Connecting adaptive co-management, social learning, and social capital through theory and practice. In: Armitage, D., Berkes, F., Doubleday, N. (Eds.), *Adaptive Co-Management*. University of British Columbia Press, Vancouver, pp. 38–61.
- Pretty, J., Ward, H., 2001. Social capital and the environment. *World Development* 29, 209–227.
- Reid, W.V., Berkes, F., Wilbanks, T., Capistrano, D. (Eds.), 2006. *Bridging Scales and Knowledge Systems: Linking Global Science and Local Knowledge in Assessments*. Millennium Ecosystem Assessment and Island Press, Washington DC.

- Sims, L., Sinclair, A.J., 2008. Learning through participatory resource management programs: case studies from Costa Rica. *Adult Education Quarterly* 58, 151–168.
- Sinclair, A.J., Diduck, A.P., 2001. Public involvement in EA in Canada: a transformative learning perspective. *Environmental Impact Assessment Review* 21, 113–136.
- Singleton, S., 1998. *Constructing Cooperation: the Evolution of Institutions of Comanagement*. University of Michigan Press, Ann Arbor.
- Spak, S., 2005. The position of indigenous knowledge in Canadian co-management organizations. *Anthropologica* 47, 233–246.
- Wenger, E., 1998. *Communities of Practice: Learning, Meaning and Identity*. Cambridge University Press, Cambridge, UK.
- Wilson, D.C., Ahmed, M., Siar, S.V., Kanagaratnam, U., 2006. Cross-scale linkages and adaptive management: fisheries co-management in Asia. *Marine Policy* 30, 523–533.
- Wollenberg, E., Iwan, R., Limberg, G., Moeliono, M., Rhee, S., Sudana, M., 2007. Facilitating cooperation during times of chaos: spontaneous orders and muddling through in Malinau District, Indonesia. *Ecology and Society* 12 (1), 3. Available from: <http://www.ecologyandsociety.org/vol12/iss1/art3/>.