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METHODS

A resilience-based framework for evaluating adaptive co-management: Linking ecology, economics and society in a complex world

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ABSTRACT

Adaptive co-management brings together collaborative and adaptive approaches in pursuit of sustainable resource use and social–ecological resilience. Enthusiasm for this management approach, however, is countered by recent critiques regarding outcomes. A lack of evidence from consistent evaluation of adaptive co-management further exacerbates this situation. This paper revisits the issue of evaluation in natural resource management and recasts it in light of complex adaptive systems thinking. An evaluative framework for adaptive co-management is developed which directs attention toward three broad components: ecosystem conditions, livelihood outcomes and process and institutional conditions. Scale-specific parameters are offered for each component to facilitate systematic learning from experience and encourage cross-site comparisons. Conclusions highlight the importance of systematically incorporating evaluation into the adaptive co-management process and recognize the challenge for resource agencies and researchers to shift from a conventional to a complex adaptive system perspective.

1. Introduction

Co-management has had a profound impact on natural resource management and recent efforts to integrate ecology, economics and society. Central to co-management is the idea that the responsibilities for allocating and using resources are shared among multiple parties (Pinkerton, 1989; Berkes et al., 1991). Early co-management research offered an innovative commentary on the potential of collaboration, especially between Aboriginal peoples and government agencies (see Pinkerton, 1989; Berkes, 1989). Having captured the attention of researchers and managers struggling to advance administration of common resources, the concept of co-management is "…being heralded as an emergent intellectual tradition to guide the stewardship of natural resources" (Natcher et al., 2005). During the past 15 years our understanding of co-management has been enriched as terminology has been refined (e.g., Berkes et al., 1991; Yandle, 2003; Plummer and FitzGibbon, 2004a), case studies of practice have been assembled (e.g., Pomeroy, 1996; Symes, 1997; Silvern, 1999), and conceptualizations (e.g., Pomeroy and Berkes, 1997; Plummer and FitzGibbon, 2004b; Carlsson and Berkes, 2005) as well as theoretical understanding have been explored (Pinkerton, 1989, 1999, 2003; Plummer and Fennell, in press). Why has co-management been so

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enthusiastically pursued? In their synthesis of reasons used to promote co-management Plummer and FitzGibbon (2004b) point to the (potential) outcomes of enhanced equity and efficiency of decision-making, broader based legitimization for actions, and increased capacity at a local scale.

Adaptive co-management is the logical extension of co-management and is receiving an increasing amount of attention (e.g., Ruitenbeek and Cartier, 2001; Marschke and Nong, 2003; Olsson et al., 2004; Armitage et al., in press). Synergies between the concepts of collaboration and adaptive management yield a community-based system which encompasses complex cross-scale linkages and the process of dynamic learning (Olsson et al., 2004). Consequently, adaptive co-management is "a process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, ongoing, self-organized process of trial-and-error" (Folke et al., 2002, p. 8). Adaptive co-management offers considerable appeal in light of the complex systems view. Complex systems theory considers nature as an evolutionary process made distinguishable by adaptive cycles which are nested at scales increasing in size which results in uncertainty, non-linearity, and self-organization (Holling and Gunderson, 2002; Holling et al., 2002; Berkes, 2004). Olsson et al. (2004, p. 87) suggest that "this self-organizing process of adaptive co-management development, facilitated by rules and incentives of higher levels, has the potential to make the social–ecological systems more robust to change".

There is an important counter current to the enthusiasm associated with both co-management and adaptive co-management. Plummer and FitzGibbon (2004b) observe that empirical evidence pertaining to the outcomes of co-management is nascent. Nadasdy (2003, in press) goes further in his critical examination of the broader social and political context of co-management and adaptive co-management. He argues that failure to attend to the political economy in which such practices are embedded reinforces existing inequities (Nadasdy, in press). Natcher et al. (2005) further elaborate upon the 'hidden' conflicts evident in undertaking co-management across cultures. The lack of information on outcomes and critical inquisition is not unique to co-management: Kellert et al. (2000) note that little data exists on the social and ecological goals of community-based natural resource management while Conley and Moote (2003) observe that collaborative approaches to managing natural resources are garnering the attention of vocal critics. Skepticism regarding collaborative approaches is due to: significant problems (e.g., circumventing regulations, no accountability) in decision-making processes devolved by government; power imbalances and co-option, exclusion of the general public, and perpetuation of narrow interests (Conley and Moote, 2003; Bryan, 2004; Frame et al., 2004).

Although benefits and limitations of co-management are increasingly recognized, a dearth of literature and experience exists on how co-management should be evaluated. Carlsson and Berkes (2005, p. 72) recently observe that "…although ecosystems and institutional systems show a large diversity, our tools for conceptualizing and analyzing co-management are strikingly blunt, and more research needs to be done to refine these tools". Even the broader notion of collaborative environmental planning is recognized as being rarely evaluated (Chess, 2000; Bellamy et al., 2001; Frame et al., 2004). The call for evaluation is becoming common due to an interest in appraising the idealized narrative of collaboration, determining means of overcoming associated barriers, and assessing institutional efforts (Conley and Moote, 2003).

In addition to the general void of evaluation in co-management and limited investigations of collaboration, more fundamental problems exist because an evaluative mechanism is ill-positioned to deal with emerging views of reality, such as complex systems theory. Connick and Innes (2003, p. 178) observe that "many evaluations of collaborative policy making miss the mark because they come from the perspective of an older, modernist paradigm of policy making predicated on the assumption that policies can be designed to produce predictable outcomes, even in very complex settings". The value of incorporating evaluation systematically into adaptive co-management is elevated because it is a critical part of the approach. Bellamy et al. (2001, p. 408) explain that "evaluation is fundamental to identifying change, supporting an adaptive approach that is flexible enough to meet the challenge of change, and enabling progressive learning at individual, community, institutional, and policy levels. However, evaluation in natural resource management policy has been neglected and a substantial gap is emerging between theory and practice".

Central to an assessment of adaptive co-management is the ability to document outcomes and respond to critical questions posed by both supporters and opponents. What bearing does adaptive co-management have on the environment or a particular resource? Are sustainable livelihoods enhanced? Is adaptive capacity developed at a local scale? Are adaptive co-management processes a reality or rhetoric? In this paper we develop a framework to evaluate adaptive co-management and foster systematic learning across multiple sites. The paper begins with the subject of evaluation; the purposes of evaluation as it relates to natural resource management are described, methods of application are explored and linkages to complex systems theory are cultivated. An evaluative framework for adaptive co-management is developed from literature on ecological resilience, livelihoods, and consensus building and collaborative processes. In addition to providing a framework to evaluate adaptive co-management, we posit that the framework can provide a basis to facilitate reflexivity, consistent cross-site comparisons and contribute to theory development. The paper concludes with a discussion around the merits of incorporating systematic evaluation into adaptive co-management as an approach that links ecology, economics and society.

2. Evaluation and natural resource management

Evaluation is the process of systematically assessing the merit (s) or worth of an act (Meyers, 1981; Guba and Lincoln, 1989; Chess, 2000). The enterprise is rooted in education and the assessment of school children's performance scores, the profile and importance of which increased significantly in the late 1960s and early 1970s (Meyers, 1981; Guba and Lincoln, 1989). The call for evaluation in natural resource management coincided with this time period and grew considerably during

the 1980s. Mitchell (1989) documented the sharp increase in evaluative studies pertaining to natural resources during this time and explains that the enterprise of evaluation offers practical value to resource analysts because it identifies shortcomings in resource policies, programs, or projects and may justify or query both decisions and actions.

In one of the most comprehensive volumes on evaluation, Guba and Lincoln (1989) document the evolution of evaluation through three generations. Measurement was central to the first generation of evaluation where emphasis was placed on technical application of instruments to gauge variables; second generation evaluation (known as formative evaluation) retained the idea of measurement, but stressed the description of patterns pertaining to stated objectives; and, third generation evaluation extended the role of the evaluator to explicitly pass judgment. In response to the shortcomings of earlier approaches, they propose responsive constructivist evaluation. Their 'fourth generation' evaluation is responsive because it actively engages stakeholders in the process of determining evaluative parameters; it is also methodologically based upon constructivist paradigm which stresses dialectic process and constructed basis of reality (Guba and Lincoln, 1989).

The responsive constructivist approach to evaluation strongly resonates with trends in natural resource management during the past decade. The interest in and trend towards public participation (especially at community or local scales), collaboration, integration, and knowledge pluralism are well established (e.g., Chess, 2000; Kellert et al., 2000; Conley and Moote, 2003; Bryan, 2004; Carlsson and Berkes, 2005). Conley and Moote (2003) have comprehensively examined the issue of evaluating collaborative natural resource management in terms of approaches (why, who, and what), standards for comparisons, evaluative methods and the need to coordinate research efforts. Their work points to the need for evaluation to reflect the intent of the initiative (criteria have tended to coalesce around the criteria of process, environment and socio-economic) as well as be driven from the collaborators. Despite these ongoing efforts, evaluation is a rare occurrence (Chess, 2000; Bellamy et al., 2001; Frame et al., 2004). Bellamy et al. (2001, p. 408) observe that "existing models of evaluation of natural resource management and planning are fragmented in terms of reconciling different domain perspectives in evaluation, do not provide an integrated evaluations, and are not sensitive to the socio-economic, policy/institutional, and environmental context within which performance is assessed".

3. Recasting evaluation in a complex adaptive system worldview

Evaluation hinges on how we understand the world. Current evaluative mechanisms were identified as problematic in the introductory remarks of this paper because of their foundation in the modern paradigm or worldview (Connick and Innes, 2003). Central to the modernist view is the metaphor of the world as machine, with the underlying fundamental assumption that the world is knowable and predictable through reductionism and the scientific method (see Capra, 1982; Tierney, 2001; Williams and Sewpaul, 2004). Substantial challenges confronting the modernist paradigm and the related notion of government include: the ability of the model to resolve contradictions between environmental quality and wealth (Glasbergen, 1998); questioned legitimacy as confidence in government is low (Connick and Innes, 2003); and, doubts about the capability of this largely reactive model to sufficiently support advanced environmental policy problems which are characterized as being complex and uncertain (Galsbergen, 1998; Innes and Booher, 1999a,b). A new mindset is required to understand what collaborative modes of resource planning can accomplish and the conditions under which the results are worthwhile (see Innes and Booher, 1999a; Connick and Innes, 2003). In this section of the paper we consider the tenets required for a 'new mindset' for evaluation that corresponds to a complex adaptive systems view.

Largely as a response to the shortcomings identified above, a significant transformation has occurred from government to governance, which broadens the scope of actors involved and emphasizes the need for co-operative or collaborative nature (Meadowcroft, 1998; Innes and Booher, 1999a; Loughlin, 2004). Underlying governance and collaboration is complexity science, a paradigm emerging from physical sciences that is increasingly being utilized to understand economic and social organization (Innes and Booher, 1999a). Unlike the machine metaphor of the modernist paradigm, complexity science views the world as continuously adapting and changing in response to environmental feedback (Innes and Booher, 1999a; Connick and Innes, 2003). According to complex systems theory reductionism provides limited insight as the world is characterized by surprises and discontinuities (Ruitenbeek and Cartier, 2001). Systems are self-organizing with properties emerging through nested levels via multiple interactions and feedback mechanisms as relationships among entities are non-linear (Levin, 1999; Ruitenbeek and Cartier, 2001; Folke et al., 2002; Gunderson and Holling, 2002). Complexity science has also been identified as a way to bridge natural and social sciences (Ison et al., 1997) and has led to the development of social–ecological systems approaches (Berkes and Folke, 1998; Berkes et al., 2003; Berkes, 2004).

Trends in resource management and co-operative governance underscore the need for evaluation to also be based on complexity thinking (Innes and Booher, 1999a; Bellamy et al., 2001; Campbell et al., 2001; Connick and Innes, 2003; Anderies et al., 2004). This important assertion has largely been developed by Judith Innes, who has produced a series of papers establishing a framework for evaluating collaborative planning using complex adaptive systems thinking (see Innes and Booher, 1999a,b; Connick and Innes, 2003). Despite this connection, Bellamy et al. (2001, p. 2) observe that "significantly, no clear evaluative frameworks have emerged to guide continuous program development in the way natural resource management initiatives contribute to on-going improvements in resource use sustainability and social well-being of the communities concerned". They contend that evaluation of natural resource management policies ought to connect the instrumental rationale of an initiative to actual results, permit assessment of impacts and serve as a process, and be interactive and constructive. In response to these principles and to overcome the many challenging issues they identify in evaluating natural resources management (e.g., breadth of criteria, multi-dimensional impacts, intangible outcomes,

causal ambiguity, multiple perspectives on success), Bellamy et al. (2001) develop a systems-based evaluation framework. Their framework is a dynamic process that consists of characterizing the issue or problem, articulating the intent of the initiative and the evaluations, making transparent its rationale, implementing evaluation (determine criteria, select methods, synthesize results), and ongoing feedback. Campbell et al. (2001) use the components of integrated resource management as a starting point to assess the performance of management systems via sustainable livelihood indicators. Novelty of their approach resides in positioning the four-level hierarchy (principles, criteria, indicators, and verifiers) within the process of social learning, which is central to adaptive management (Campbell et al., 2001). Most recently, Anderies et al. (2004) have articulated a framework to analyze the robustness of social–ecological systems. Combining the three elements of interest (the resource, its governance, and associated infrastructure) offers innovation as it conveys connectivity and highlights potential interactions within such systems. Drawing upon this background, we consider how adaptive co-management may be evaluated.

A number of issues should be kept in mind when considering the framework subsequently proposed. First, our intention is to identify key parameters as identified in the literature upon which to evaluate the performance and outcomes of adaptive co-management, useful for both single and cross-site comparative analysis. Mapping out a suite of specific criteria and indicators is beyond the scope of this paper, and would in any case prove problematic because specific criteria and indicators — particularly those directed at evaluating social processes and livelihood dimensions will have an important contextual basis. Rather, drawing on the logic of Berkes and Seixas (2005) and Carpenter et al. (2005), concerning the development of 'surrogates for resilience', we use the term 'parameters' to denote a focus on higher-order but critical components, processes and structures of social–ecological systems which can be used as a focal point to orient an evaluation of adaptive co-management (see also Wilson et al., 1996). Thus, the parameters suggested here are meant to be: forward looking rather than oriented to measures of the current state or condition of the system; should reinforce one another, address multiple facets of concern and be replicable; be theoretically grounded (i.e., identifiable in the literature); and highlight cross-scale influences (see Berkes and Seixas, 2005). Second, the framework elaborated here is scale-specific and emerges from a 'local' perspective. We do not seek to offer a comprehensive framework for sustainability evaluation, nor a framework to evaluate large-scale regional processes. Rather, the framework starts from the perspective of more specific co-management cases where the focus of concern is typically a relatively well-defined resource (fishery, wildlife, forest), protected area or sub-watershed. Third, we recognize that evaluation from the modernist paradigm ideally requires a baseline against which to assess outcomes. In recasting evaluation in complexity science important caveats emerge. The objective of a baseline may be limited due to shifting stability of a system. It may also be irrelevant if acquired during a turbulent period. Moreover, in most co-management cases comprehensive baselines are not available. Evaluation in such cases may, in effect, act as a baseline. We hope that this framework can encourage co-managers to proactively reflect on the types of information and data required to adequately evaluate co-management efforts.

4. An evaluative framework for adaptive co-management

The instrumental rationale of adaptive co-management is sustainability: it aims to solve resource problems through a collaborative process which fosters ecologically sustainable livelihoods (Berkes, 2004; Carlsson and Berkes, 2005; Folke et al., 2005; Armitage et al., in press). As Cummings et al. (2005) note, deliberate progress towards sustainability necessarily involves an understanding of the dynamics of linked social/economic–ecological systems. As illustrated in Fig. 1, we examine the above rationale through the lens of resilience to identify three focal components for evaluation in adaptive co-management processes: an ecological component, an economic component approached using a sustainable livelihoods framework, and a process component that draws attention to the role of institutions and power.

Resilience thinking has emerged as one conceptual framework with which to understand change and the multiple, cross-scale interactions in social–ecological systems (Gunderson and Holling, 2002; Berkes et al., 2003). Although grounded in the ecological sciences (Holling 1973), resilience has increasingly been tested and applied by natural and social scientists to examine a range of ecological communities (Gunderson, 2003), linked social–ecological systems (Berkes and Folke, 1998; Berkes et al., 2003), and institutional and organizational arrangements (Anderies et al., 2006; Folke, 2006; Walker et al., 2006). Anderies et al. (2004) make the key point that resilience is a framework for systematically thinking through system dynamics (rather than a coherent body of theory) and that the concept helps in our understanding of complex systems behaviour.

Berkes et al. (2003), identify three central features of resilience: (1) the ability of a system to absorb or buffer disturbances and still maintain its core attributes; (2) the ability of the system to self-organize; and (3) the capacity for learning and adaptation in the context of change. Walker et al. (2006) describe resilience as the potential of a system to remain in a particular configuration, and maintain feedbacks, functions, and an ability to reorganize following disturbance-driven change. Consistent with these definitions, resilience thinking leads to several insights about complex system behaviour that provide useful context for evaluating adaptive co-management, and thus an entrée into the identification of focal areas for evaluation where complexity is a starting point for analysis. For example, resilience is dependent on a limited set of slow variables which act to structure the dynamics of the system. Slow moving variables that operate at larger spatio-temporal scales (e.g., connectivity in forested ecosystems, long-standing institutions, or values in social systems) promote stability, maintain the legacies necessary for natural evolutionary or adaptive processes, and enable a 'remember' effect. Fast variables operating at smaller temporal and spatial scales (e.g., insect outbreaks in forest ecosystems, individual preferences in social systems), however, can overwhelm

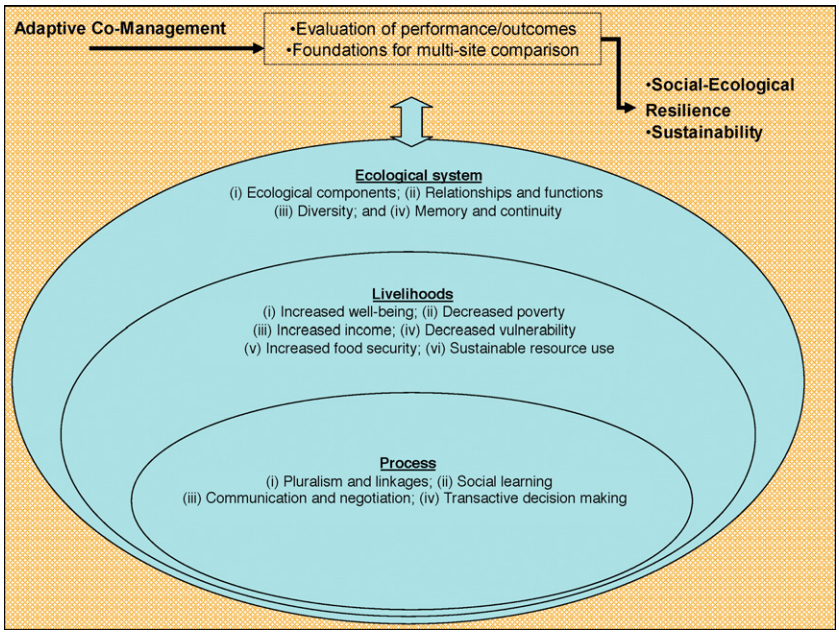

Fig. 1.

slower variables, thus precipitating a period of revolt or creative destruction and eventual reorganization (Holling, 2001; Ruitenbeek and Cartier, 2001; Gunderson and Holling, 2002). Kinzig et al. (2006), for example, draw attention to the existence of multiple thresholds in social–ecological systems, and the potential for regime shifts and possibility of alternative regimes. They point out that this potential is linked to numerous and diverse controlling, slow, variables that operate at different spatial and temporal scales and in different domains. Understanding the social–economic and ecological processes that destabilize these slow variables, and lead potentially, to fundamental system change (i.e., regime shifts) presents an important focus for adaptive co-management evaluation. For co-managers, therefore, a central objective may be to keep social–ecological systems from moving towards or further into system states or conditions that meet neither ecological nor socio-economic sustainability criteria (i.e., avoiding system 'flips' that occur when certain thresholds are reached).

Resilience thinking offers, therefore, a potentially unifying concept when evaluating adaptive co-management in complex systems as it highlights an important feature of ecological and livelihood outcomes, and raises the challenge of goal formation as a key social process. There is a normative dimension to the notion of resilience because the resilience of certain social–ecological system configurations may not be desirable (see Carpenter et al., 2005). Efforts to define resilience must be situated in the context of contested and evolving human interests (Armitage and Johnson, 2006), thus highlighting the critical role of human interaction mediated through adaptive co-management processes. In the following sections, we draw attention to the key parameters that may provide a consistent focus for evaluation of adaptive co-management efforts, and also serve as a basis for systematizing learning across multiple sites to support empirical examination and theory development.

4.1. *Ecological component*

Co-management is a long-term social process, rather than a technical intervention or set of structural arrangements (Plummer and Fitzgibbon, 2004b, in press; Carlsson and Berkes, 2005). Most recent critiques of co-management reflect this awareness (Nadasdy, 2003; Stevenson, 2004; Natcher et al., 2005), but as a result, are silent about the ecological outcomes of the approach even though co-management originally emerged in response to the problematique of ecologically sustainable resource management. Our intention with this framework, in part, is to reinsert ecological outcomes as a key component of adaptive co-management evaluation. The concept of critical natural capital provides a starting point, and is defined as the components and processes in nature (Table 1) considered essential to environmental sustainability.

Table 1 – Components, processes and characteristics of natural capital

Component	Key characteristics and ecosystem function
Air	Atmospheric and climatological properties and processes (e.g., air quality, precipitation, temperature, wind)
Water	Hydrological processes and properties (reservoirs, runoff, river discharge, groundwater, etc.)
Land	Bedrock and geological processes (minerals, tectonics); geomorphological processes and properties (weathering, deposition); soil processes and properties (texture, fertility and biological activity)
Habitats	Vegetation characteristics (structure, biomass, evapotranspiration); flora and fauna (species diversity, dynamics); life-community properties (food chain interactions, decomposition); conservation value/integrative aspects

Adapted from Ekins et al. (2003: 169).

Critical natural capital is categorized in a variety of ways. For example, Pearce and Turner (1989) categorized the key elements and features of natural capital in terms of source, sink and service functions. de Groot et al. (2002) organize natural capital according to regulation, production, habitat and information functions. In considering these categories of natural capital, Ekins et al. (2003: 170) draw attention to the differences between: 1) the 'functions of' natural capital as the processes and cycles within natural systems which are responsible for sustaining and maintaining the stability and resilience of ecosystems; and 2) natural capital 'functions for' humans in terms of the provision of resources, sinks for waste, and so on. While both are of concern, we place the evaluative focus of the ecological component on the former, while the normative dimension addressing the link between the use of natural capital (the function for) and human welfare is encapsulated in the process component.

Directing the focus of adaptive co-management evaluation in regards to ecological outcomes poses a particular challenge given the state of knowledge of most ecosystems. Evaluation effort should be directed, therefore, at identifying those ecological attributes and functions that are of particular importance in a given system in recognition of the time and resources constraints faced by most co-managers. Ekins et al. (2003) suggest that attributes of natural capital of particular concern are environmental functions that: 1) cannot be substituted for by other functions (whether environmental or technological); 2) functions whose loss would be irreversible; and 3) functions whose loss would risk or actually involve losses that are too significant to be acceptable — the loss of certain functions represents a point at which key thresholds would be crossed, leading to the system of concern flipping into a different stability domain. This latter point in particular draws attention to the limits of an ecologically stable state perspective and the need to ensure that adaptive co-management processes maintain or build resilience.

Cummings et al. (2005) use resilience, for example, to examine key dimensions of complexity and change, and suggest that the resilience of a given system is dependent upon four elements:

- Components that make up the system, such as specific ecosystem types/habitats, species (e.g., consumers and producers), and biophysical features (geomorphology, soil structure, topography);
- Relationships between components which include nutrients and biogeochemical cycles, food webs and trophic interactions which link organisms to one another and their biophysical environment;
- Diversity (specifically biological) which is a key source of innovation and renewal in the system, including response diversity (the diversity of responses to environmental change among species contributing to the same ecosystem function; see Elmqvist et al., 2003); and
- Ecological memory and continuity which provides a surrogate of the ability of the system to maintain itself through space and time and continue to self-organize.

These elements can serve as broad parameters of concern and are thus useful in terms of framing the evaluation focus of adaptive co-management. In the context of these parameters of ecological resilience, moreover, Holling (2001) has convincingly argued that the complexity of living systems (of nature and people) is an emergent outcome of a small number of controlling processes, rather than from the random association of a large number of interacting factors. Thus, natural systems are structured by a relatively small set of processes with a strong influence across temporal and spatial scales (Table 2). In reference to this, Holling (2001, p. 391) notes that:

> These processes establish a persistent template upon which a host of other variables exercise their influence. Such 'subsidiary' variables or factors can be interesting, relevant, and important, but they exist at the whim of the critical controlling factors or variables. If sustainability [as the instrumental rationale of adaptive co-management] means anything, it has to do with a small set of critical self-organized variables and the transformations that can occur in them during the evolutionary process.

For co-managers, this suggest that evaluation efforts should seek to identify and attend to the slow, controlling variables that determine system configuration, and a limited number of faster variables operating at small spatial and temporal scales that can overwhelm slower variables and lead potentially to alternative system states. This recognition is starting to be taken up by others developing evaluative frameworks for sustainability more broadly (see Bagheri and Hjorth, 2006). For evaluation purposes, Cummings et al. (2005) also argue that it is necessary to state *a priori* when the resilience of a particular and desirable ecosystem configuration is lost. Doing this in relation to the critical slow and fast moving variables of particular systems is likely warranted. Thus, identifying fixed points (e.g., loss of 40% of the primary consumers in a defined ecosystem) provides the basis upon which to evaluate adaptive co-management outcomes where ecological resilience provides a broader context for considering management goals. From the perspective of adaptive co-

Table 2 – Example system variables and speeds in different types of systems

System type	Variables		
	Fastest	Slower	Slowest
Forest-pest dynamics	Insect	Foliage	Tree
Forest fire dynamics	Intensity	Fuel	Trees
Savanna	Annual grasses	Perennial grasses	Shrubs and grazers
Shallow lakes and seas	Phytoplankton and turbidity	Sea grasses	Grazers
Deep lakes	Phytoplankton	Zooplankton	Fish and habitat; phosphate in mud
Wetlands	Periphyton	Saw grass	Tree island; peat accreation
Human disease	Disease organism	Vector and susceptibles	Human population

Adapted from Holling et al. (2002: 69).

management evaluation, the ecosystem or resource of focus will evolve and change through time, but the essential attributes of that system as understood through the identification of key parameters will be maintained if the system is to be considered resilient (Table 3). If adaptive co-management leads to the maintenance of a desirable ecosystem configuration (as articulated in the context of the process component) over a specific timeframe, and in the context of various stresses (e.g., changes in the prescribed harvest rate, modifications in resource access), then adaptive co-management process can be said to be leading to positive outcomes. If desired social and livelihood outcomes are achieved based on key livelihood or process parameters (see below), but ecologically undesirable outcomes emerge (i.e., outcomes that undermine diversity, memory, key relationships or components), the performance outcomes of adaptive co-management are likely considerably less positive (Table 3).

4.2. *Livelihoods component*

The sustainable livelihoods framework emerged in the 1990s in response to the failure of development interventions to appropriately conceptualize the cross-scale and complex economic, social, ecological and behavioural choices confronting predominately rural, agricultural producers (Chambers and Conway, 1991; Scoones, 1998; Carney, 1998). The sustainable livelihood approach has since been adopted by a range of development actors (e.g., bi-lateral and multi-lateral banks and development agencies), and provides a reasonably coherent framework for evaluating linked economic–social outcomes associated with adaptive co-management.

Table 3 – Example generic ecological parameters for evaluation

	Parameters of concern			
	Ecological components	Relationships and functions	Diversity	Memory and continuity
	Example secondary parameters (focused on key slow and fast variables)[a]			
Source, sink and life-support attributes	• Species (e.g., keystone species) • Stocks (e.g., fish) • Landscape change • Vegetation patterns • Hydrology	• Key ecological processes (fire) • Species interactions • Productivity and biomass • Nutrient cycling, food web disruptions • Concentrations of pollution (e.g., from lagoon aquaculture)	• Species richness and diversity • Response diversity	• Ecosystem protection (e.g., reserves) • Landscape patchiness, landscape mosaics • Corridors, networks for wildlife

[a] Dependent on dominant ecosystem type (forest, fishery, etc.).

A livelihood can be defined as the set of strategies employed by individuals and households to make or gain a living, as determined by capabilities, tangible (e.g., natural resource, human, physical) and intangible (e.g., claims and access relationships) assets (Chambers and Conway, 1991). More recently, the ideas of complexity and resilience, already embedded in the livelihood approach, are being emphasized (Adger et al., 2002; Barrett and Swallow, 2006; Marschke and Berkes, 2006). Resilient livelihoods are those that can: (i) cope with and are able to recover from shocks and stresses; (ii) maintain or enhance existing capabilities and assets despite uncertainty; and (iii) ensure the provision of sustainable livelihood opportunities for future generations (Chambers and Conway, 1991; DFID, 1999; Ellis, 2000). Livelihoods are an emergent outcome of multiple socio-economic, institutional and ecological drivers interacting across scales. Property rights, ethnicity and class, and local resource control are just a few of the factors that shape local livelihoods and create vulnerabilities (from both external and internal forces) for individuals engaged in adaptive co-management.

As outlined by Farington et al. (1999), the sustainable livelihoods framework provides an analytical structure that is useful in reconciling complexity and interconnections among economic–social outcomes and governance interventions such as adaptive co-management. In the context of this framework, the livelihood approach is used to identify parameters to evaluate adaptive co-management outcomes concerning economic benefits and incentives, and 'rationality' in the 'choice' of economic or livelihood strategies. The decision to adopt the sustainable livelihoods approach for the purpose of the evaluative framework is based on the assumption that individuals will pursue (in the context of changing priorities and perceptions) a range of livelihood outcomes, including income generation, vulnerability reduction, health and well-being (Farington et al., 1999). Evaluations of adaptive co-management will need to account for these parameters when determining performance outcomes because they represent some of the primary material and everyday concerns of individuals and communities engaged in adaptive co-management.

There are some criticisms of the livelihood approach (Ashley and Carney, 1999; Ellis, 2000) as currently applied in the field. For example, considerable attention is devoted to an examination of assets and vulnerability issues. Although the so-called 'transformative structures and processes' (e.g., policies, institutions) that influence livelihoods are identified, the complex legacies of history and embedded power relationships that influence those structures and processes are not always explicitly addressed. The approach, moreover, has been critiqued as being too broad and encompassing to be meaningful for understanding key components and processes in specific locations (Farington et al., 1999; Longley and Maxwell, 2003), although this does not pose problems for the identification of higher-order parameters for evaluation. Finally, most livelihood analyses are not explicit in terms of the dynamic ecological and social context in which they are embedded. The conventional livelihood model is premised on a single dynamic equilibrium, and assumes that investments

and interventions directed at building sustainable livelihoods will converge upon a stable, idealized state (de Haan and Zoomers, 2005). A multiple dynamic equilibria construction of livelihoods extends the conventional sustainable livelihoods framework to highlight the difficulty in predicting outcomes (Barrett and Swallow, 2006), and importantly, the limits of scale-specific and techno-bureaucratic policy interventions. Such insights are of value in considering adaptive co-management evaluation.

Despite the limitations, Farington et al. (1999) note that the sustainable livelihood approach can be used not only for project and program design, but for monitoring, review and evaluation purposes as well. In this latter regard, and with reference to evaluation and cross-site comparison, the sustainable livelihood approach directs attention toward the positive and negative livelihood (socio-economic) impacts associated with adaptive co-management efforts, and the identification of specific co-management interventions that limit the potential for significant livelihood disruption. Such outcomes can be measured through an examination of the relationship between adaptive co-management interventions and the implications for various asset or capital stocks held by individuals and households. Measurement can also be achieved by linking qualitative and quantitative analyses of vulnerability of key actors in the process (e.g., local resource resources) with adaptive co-management interventions (see Table 4).

Table 4 thus outlines key parameters and example secondary parameters to consider when examining livelihood outcomes associated with adaptive co-management. This is critical as there is to date limited evidence to link community-based co-management or community driven initiatives lead to materially better socio-economic outcomes (Mansuri and Rao, 2004). As Farington et al. (1999) suggest, moreover, minimizing the costs to livelihoods may often be as important as maximizing benefits. This recognition has significant implications for the evaluation of adaptive co-management. Livelihoods are indeed multi-dimensional and multi-faceted, shaped by both perceptual elements and material reality. Understanding the outcomes of adaptive co-management in either single- or multi-case contexts will require attention to the broad economic insights highlighted in the livelihood approach, allowing for the elaboration of detailed criteria and indicators to suit specific geographies of time and place.

Finally, a fundamental challenge for evaluating the livelihood outcomes of adaptive co-management is to recognize that access to particular livelihoods in particular instances is bound up by property relations and rights, and configurations of power. Thus, the notion of endowments (the right of access to elements of a livelihood) and entitlements (the access actually obtained by an individual) in the livelihood context (Sen, 1992; Leach et al., 1999), draws attention to the need to link adaptive co-management evaluation to social relations, institutions and organizations, each of which have specific meanings and connotations (see North, 1990; Ellis, 2000). Social relations refer to the gender, caste, class, age, ethnicity and religious dimension; institutions include the formal rules, conventions and laws, as well as the informal codes of behaviour in society; and organizations are those places where individuals are bound by the purpose of achieving certain objectives. The process component of adaptive co-management is thus of critical importance. Indeed, key elements of the livelihood approach provide a bridge to the other elements of the evaluative framework, including a concern with natural capital (ecological component), and the social processes, structures and institutions that shape livelihoods (process component).

4.3. *Process component*

An appropriate starting point to assess the process component is to distinguish adaptive co-management from the many other potential forms of management. In an effort to overcome the imprecise labeling of co-operative arrangements, Plummer et al. (in press) develop an assessment framework (see Table 5). Specificity is fundamentally important because if evaluation is to be meaningful it must appraise reality against intended goal (s) and/or outcome(s) (Conley and Moote, 2003). Adaptive co-management, as defined in the initial paragraph of this paper,

Table 4 – Livelihood (economic, social) parameters for evaluation

Overarching parameters					
Increased well-being	Decreased poverty	Increased income	Decreased vulnerability	Increased food security	Sustainable resource use
Example secondary parameters					
Livelihood assets or capital stocks					
• Human capital (skills, knowledge, health, etc.)					
• Social capital (networks, groups, rules, norms, sanctions; relationships of trust, reciprocity, exchange)					
• Natural capital (stocks (fish) and key ecological services (nutrient cycling)					
• Physical capital (infrastructure and producer goods)					
• Financial capital (financial resources — cash, bank deposits, livestock, jewels and regular inflows of money)					
Vulnerability context					
• Trends (e.g., market change)					
• Shocks (economic, biophysical)					
• Seasonality					
Policies, institutions and processes (linked to "Process Component")					
• Institutions, organizations, policies (formal, informal)					
• Decision-making context (social processes, culture, gender, age, class, caste, etc.)					

Adapted from DFID (1999).

Table 5 – Co-operative Natural Resource Management Assessment Framework

Elements	Key considerations
Context	Description of the operating environment (physical resources, social setting, etc.); property rights; management systems (regimes); scale(s)
Conditions	Perceived interdependence (crisis); recognition of mutual benefit; involvement of a broker, leader and/or energy center; pre-existing networks; opportunity for negotiation
Representation	Scope (community or local, private/commercial, government); reflective of organization/agency; diversity; size
Power	Legislation and regulation (authority); policy and guidelines; democratic procedures (e.g., transparency in decision-making, access to information); administrative structures; financial arrangements (accountability); political structures and processes; historical customs and values; costs and benefits (perceived fairness, equitable distribution)
Process	Problem setting (who is involved, articulation of the problem, relative importance within the domain); direction setting (goals and objectives, procedures, etc.); structuring (e.g., formality, roles and responsibilities); outcomes

Adapted from Plummer et al. (in press).

is "a process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, ongoing, self-organized process of trial-and-error" (Folke et. al., 2002, p. 8). The purpose (instrumental rationale) of adaptive co-management, as stated at the start of the evaluation section, is to address resource issues via collaboration while concomitantly encouraging ecologically sustainable livelihoods.

The elements offered in Table 5 also permit methodical consideration of contextual factors (both problem and social) (see Honadle, 1999) derived from the co-operative literature (including partnerships, collaboration and co-management), and in turn a systematic basis of evidence upon which cases of cooperation can be differentiated, as called for by Mandell (1999). The element of power (the ability to exert influence) is illustrative as it details eight considerations (see Table 5) that should be taken into account to understand the nature of the arrangement. While the assessment framework is consistent with commentaries describing co-management as a formal or structural agreement(s) (e.g., Enevoldsen, 1998; Silvern, 1999), it neglects the functional side of co-management (Carlsson and Berkes, 2005).

Recently, Carlsson and Bereks (2005, p. 65) contend that "an alternative approach is to start from the assumption that co-management is a continuous problem-solving process, rather than a fixed state, involving extensive deliberation, negotiation and joint learning within problem-solving networks". A strong movement is clearly evident in the literature to consider both co-management and adaptive co-management as evolving processes (Olsson et al., 2004; Plummer and FitzGibbon, 2004a; Carlsson and Berkes, 2005; Folke et al., 2005; Armitage and Johnson, 2006; Plummer, 2006). To gain insight as to how a process such as adaptive co-management may be evaluated we start with the connection between decentralization (the move towards governance), co-management, and collaborative planning, as established by Plummer (2006). Conventional notions of success (the formation of agreements, achievement of goals, and implementation of projects) are paradoxical in evaluating consensus building because communicative processes are of critical importance while concomitantly being without boundaries of time, space and subject matter (Innes and Booher, 1999a). Communicative rationality, which is based on dialogue among pluralistic actors regarding a particular issue, directs specific attention to qualities of the process as "…the stakeholders must be equally informed, listened to, and respected, and none can be

Table 6 – Characteristics of adaptive co-management and generic process parameters for evaluation

Characteristics			
Collaboration			Social learning
Pluralism and linkages	Communication and negotiation	Transactive decision-making	
Example parameters of concern			
• Multiple types of stakeholders (government, resource users, industry)	• Shared understanding develops	• Decisions are reached through dialogue (tend towards consensus and/or consent)	• Shared actions (experiments) are undertaken
• Diversity of interests represented	• Dialogue builds consideration and appreciation	• Diverse inputs present in decision-making	• Modifications are made from an ongoing process of reflection (reflexivity)
• Multiple perspectives on the problem domain	• Perspectives exchanged and modified via discursive communication	• Equity and efficiency promoted	• Responses are made to routine errors (single loop learning)
• Connections across multiple scale (local, regional, watershed, etc.)		• Multiple types of information accepted via multiple systems of knowledge (e.g., traditional ecological knowledge)	• Responses are made to values and policies from which routines stem (double loop learning)
			• Active questioning of the governing norms and protocol in which values and polices are embedded (triple loop learning)

accorded more power than others to speak or make decisions" (Innes and Booher, 1999a, p. 418). In following this logic, the evaluation of adaptive co-management must also acknowledge and account for the importance of process.

So how can we distinguish adaptive co-management both structurally and functionally from other forms of collaborative undertakings in natural resource management? Table 6 outlines the salient characteristics of adaptive co-management gleaned from the literature (e.g., Plummer and FitzGibbon, in press; Armitage et al., in press). While many of the characteristics outlined are common to various forms of co-operative natural resource management (e.g., pluralism, communication, transactive decision-making), collaboration and social learning are inimitable. The centrality of collaboration to co-management is well established (Pinkerton, 1989; Lane, 2001; Schusler et al., 2003) with an increasing amount of attention being directed at understanding the nuances of this process (e.g., Plummer, 2006) as well as social learning specifically in adaptive co-management (e.g., Olsson et al., 2004; Plummer and FitzGibbon, in press). Table 6 also connects the characteristics of the adaptive co-management process to example evaluative parameters of concern. These example parameters of concern detail functional aspects for which coincidence is positively considered.

A myriad of outcomes are inextricably linked to the process of adaptive co-management. Outcomes here refer to consequences that accrue as a result of the adaptive co-management process. Table 7 presents two overarching evaluative outcome parameters of ecological sustainability (see component one) and livelihoods (see component two). These outcomes are the ultimate aims of adaptive co-management (along with other forms of collaborative natural resource management, see Conley and Moote, 2003) and necessitate purposeful consideration; they also present considerable challenges in terms of attribution, causation and effect time. In light of these challenges, it is helpful to identify other examples of outcomes that contribute to the ultimate parameters of concern. We adapt Innes and Booher's (1999a) three-fold outcome typology in Table 7 to illustrate examples of first, second, and third order parameters for evaluation. First order parameters present examples of tangible and intangible outcomes from the specific adaptive co-management initiative. Innes and Booher (1999a) observe that often process and outcomes blur in reality; intangible outcomes can be as, even more, important than tangible ones in collaborative planning; and, outcomes are not restricted to the boundaries of the specific initiative. Second order parameters extend beyond the scope of the specific initiative and past the boundary of the problem domain. Third order parameters tend to be latent and may become manifest long after the specific initiative is over.

Table 7 – Example generic outcome parameters for evaluation

Ultimate parameters of concern	
Enhanced livelihoods (see component one)	Ecological sustainability (see component three)
Example first order parameters (from the specific initiative)	
Tangible	*Intangible*
• Resource management plans	• Enhanced legitimization for policies and actions
• Resolution of conflict/dispute and/or agreement regarding resource issue	• Greater adaptive capacity (flexibly live with uncertainty and deal with cross-scale dynamics)
• Codified statement of actions	• Social and human capital (see livelihood assets in component one)
• Agreed upon sanctions	• Creative ideas for solving problems
• New or modification of institutional arrangement(s) (formal and/or informal) — policies, strategies, organization, etc.	• Encourages contemplation and questioning of routines, values and governance
Example second order parameters (outside boundaries of the project)	
• New co-operative undertakings beyond the specific issue • Extends engagement and learning across scales • Changes in perceptions (attitudes) and actions (behaviours) • Enhances the efficiency and effectiveness of responding other issues within the problem domain • Outgrowth(s) from the initial arrangement to address additional issues within the problem domain	
Example third order parameters (evident subsequently)	
• Enhanced adaptive capacity at the local level ○ Learn to live with uncertainty and change ○ Create opportunities for self-organization that match scales (ecosystems and governance) and anticipate external drivers • Empowerment of broader 'community' • Ongoing use of co-operative approaches • New institutions codified and/or enshrined in law	

5. Conclusions

Adaptive co-management aims to not only solve resource problems through collaboration, but also aspires to foster ecologically sustainable livelihoods. Adaptive co-management is a relatively new concept around which an idealized narrative has formed with relatively little empirical evidence and even less evaluative experience. While this is akin to the situation Conley and Moote (2003) describe in collaborative natural resource management, we argue that initiating evaluation of adaptive co-management is critical. Responding affirmatively to the questions posed in the introductory section of this paper (among others) will ultimately be the litmus test of adaptive co-management as an approach to link ecology, economics and society. Given the relative newness of the concept considerable opportunity exist to initiate systematic and ongoing evaluations. In an effort to overcome our 'strikingly blunt' tools in this regard, we have positioned evaluation within the complex adaptive system worldview and developed an evaluative framework for adaptive co-management through the lens of resilience. Recognizing the need for criteria and indicators which are contextually specific, we proposed generic parameters for the components of ecological sustainability, livelihoods, and process.

The evaluation framework proposed in this paper enhances understanding of adaptive co-management, assessing integrated performance (as called for by Bellamy et al., 2001), and appreciating when these results are worthwhile (as called for by Innes and Booher, 1999a; Connick and Innes, 2003). Conley and Moote (2003) describe the need to coordinate research efforts and the many challenges (e.g., generalizability, differing units of analysis, multiple perspectives, etc.) associated with conducting evaluations utilizing various methods (e.g., case studies, surveys, meta-analyses). It is our hope that the parameters outlined in this paper provide a basis for consistent comparison across multiple sites, and fruitful dialogue across a myriad of situations and experiences with adaptive co-management. Amassing empirical evidence which is ground in practice not only contributes to the collective understanding of adaptive co-management in theory but it also permits articulation of arguments to policy markers, international development organizations, and resource agencies.

Evaluation within a complex adaptive systems worldview should place a priority on responding (adapting) to feedback. Systematically incorporating the framework proposed in this paper as part of an adaptive co-management initiative is important because it establishes an evaluative mechanism, and in turn insures feedback and reflexivity that are critical to adaptive co-management. Accounting for the range of parameters presented in the proposed evaluative framework draws attention to process as well as outcomes (tangible and intangible).

Recasting evaluation in the complex adaptive worldview presents substantial challenges to international development agencies and professional resource managers. While acknowledging the potential biases of participatory or self-evaluations in collaborative natural resource management, Conley and Moote (2003) stress that there is indeed an important role to be filled by participants. Adaptive co-management takes this role one step further as social learning and reflexivity are inherent in the initiative and are undertaken by all involved. Evaluation in adaptive co-management is a shared endeavor which also acts as a mechanism for direction setting. Although ecological and livelihood sustainability serve as ultimate parameters of concern they are often difficult to specifically attribute to an adaptive co-management initiative and/or may not appear immediately. An emerging imperative for funding organizations, government agencies, and the participants themselves is to acknowledge all outcomes (both tangible and intangible) from such undertakings which may ultimately contribute to social–ecological resilience and sustainability.

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