INVITED FEATURE: PROTECTED AREAS AS SOCIOECOLOGICAL SYSTEMS

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Protected areas and their surrounding territory: socioecological systems in the context of ecological solidarity

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Abstract. The concept of ecological solidarity (ES) is a major feature of the 2006 law reforming national park policy in France. In the context of biodiversity conservation, the objectives of this study are to outline the historical development of ES, provide a working definition, and present a method for its implementation that combines environmental pragmatism and adaptive management. First, we highlight how ES provides a focus on the interdependencies among humans and nonhuman components of the socioecological system. In doing so, we identify ES within a framework that distinguishes ecological, socioecological, and sociopolitical interdependencies. In making such interdependencies apparent to humans who are not aware of their existence, the concept of ES promotes collective action as an alternative or complementary approach to state- or market-based approaches. By focusing on the awareness, feelings, and acknowledgement of interdependencies between actors and between humans and nonhumans, we present and discuss a learning-based approach (participatory modeling) that allows stakeholders to work together to construct cultural landscapes for present and future generations. Using two case studies, we show how an ES analysis goes beyond the ecosystem management approach to take into account how human interactions with the environment embody cultural, social, and economic values and endorse an ethically integrated science of care and responsibility. ES recognizes the diversity of these values as a practical foundation for socially engaged and accountable actions. Finally, we discuss how ES enhances academic support for a socioecological systems approach to biodiversity conservation and promotes collaboration with decision-makers and stakeholders involved in the adaptive management of protected areas and their surrounding landscapes.

Key words: biodiversity conservation; Camargue Regional Natural Park, France; Cevennes National Park, France; ecological solidarity; national park policy; protected areas as socioecological systems; socioecological system

Introduction

Protected areas (PAs) continue to represent a primary response of human societies to the loss of biodiversity around the world (Jenkins and Joppa 2009, Bertsky et al. 2012). Indeed, with the growing human population, urban sprawl, and forest exploitation, the designation of PAs has become a critical issue worldwide (Zube and Busch 1990, Ghimire et al. 1997, Hanna et al. 2008, Fuller et al. 2010), particularly in relation to their role in local development of rural or urban areas (Brandon and Wells 1992, Stolton et al. 2003, Emerton et al. 2006). Different models of PAs coexist, in terms of the roles and relationships among the institutions and stakeholders who participate in their designation and governance, and how biodiversity conservation strategies are adapted to local social and ecological contexts (Mose 2007, Dudley 2008). However, a common theme is the issue of the social legitimacy of PAs; if the management of a protected area is not felt to be legitimate, it can be perceived by communities as a usurpation of local rights (Foucault 2004, Reed 2008). Because acting on nature impacts humans and their activities, and acting on human activities impacts nature, a socioecological approach is necessary.

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Indeed, PAs in which humans live have become more and more numerous, and a PA often represents a particular type of socioecological system (SES; Brandon and Wells 1992, Berkes and Folke 1998, Phillips 2004, Ostrom 2007, Cumming et al. 2015). At the same time, PA management clearly requires consideration of, and action in, the human-made landscapes beyond their administrative boundaries (a form of "extended SES"), if key ecological functions such as complementary wintering areas or hydrological functioning are to be maintained (Grumbine 1994, Mathevet and Mauchamp 2005, Hansen and DeFries 2007, Stolton and Dudley 2010). However, the paradigm transition from "fencing nature" (i.e., spatial segregation of land-use objectives) to creating "networks of nature" beyond PA boundaries is problematic (Hanna et al. 2008). Competition for the control of, and access to, land is increasing worldwide, creating numerous conflicts and raising new questions concerning the relationships between humans and nature (Folke 2006, Lockwood et al. 2006). Such conflicts drive social change and reveal the complexity of the individual and collective (local, regional, and global) interests at stake.

Social representation, value systems, and social innovation play a critical role in biodiversity conservation (Stolton and Dudley 2010). Local stakeholders (including decision-makers) often question the legitimacy of neo-rurals, NGOs, and government agencies to manage their territory, according to a definition of nature that they do not share (Micoud 1993). PA management staff thus face the challenge of forging a new direction for policy and governance of their roles in the SES of which they are a part. In this context, adaptive management has become an important tool providing links between science and conservation practice (Margoluis and Salafsky 1998). In contrast to the traditional "command and control" approach, adaptive management of ecosystems integrates biodiversity conservation policies as experiments in which we can learn to develop new management practice (Holling 1978). Ecosystem-based management is an ongoing adaptive management experiment (Grumbine 1994) that links private and public landowners, businesses corporations, and conservation organizations with scientists to plan and act on larger scale (Primack 2010). What is, however, still needed here is a more solid socioecological foundation for such action in which the long-term preservation of ecosystems and their processes is viewed in an approach that also involves sustaining the current needs and values of society.

The objective of this study is to propose a conceptual framework for collective action on biodiversity conservation (beyond the administrative boundaries of PAs) that is grounded in the identification of social and ecological interdependencies and the actions necessary to maintain them. This framework is based on the concept of ecological solidarity (ES), which, as we describe in the first part of the study, has arisen following a recent law related to national park policy in France. We then present a method to identify and collectively explore (with local stakeholders and scientists) ES that is illustrated by two different case studies. Third, we compare ES with the widespread ecosystem-based management approach to demarcate the added value of ES framework for biodiversity conservation in a context of adaptive management.

Our purpose throughout the study is to describe the strengths and limitations of the ES concept within the setting of PA management. We highlight the value of the ES framework from both an academic perspective, where ES can be used in the analysis of socioecological systems, and a management perspective, where ES can be used to foster collaboration between scientists, decision-makers, and stakeholders, and thus enhance the implementation of sustainable conservation actions.

The Genesis of Ecological Solidarity

The reform of the national park system (Law 2006-436 of 14 April 2006) introduced into French environmental policy the concept of ES. The law specified that a national park (NP) consists of one or more terrestrial or marine core areas, requiring strict regulatory protection, and an area of membership, defined as all or part of the territory of the municipalities which are eligible to become part of the national park as a consequence of their geographical continuity and/or their ecological solidarity with the core area(s). These municipalities can thus voluntarily contribute to the protection of the core area by adhering to the charter of the national park.

Prior to this law, French policy (initiated in 1960), designated national parks with regulatory protection of nature in a core zone surrounded by a peripheral zone where social, economic, and cultural development should be compatible with biodiversity conservation, rural life, and local cultures, and at the same time attract tourists in search of natural and cultural landscapes and local traditions. By coupling economic development and nature conservation, these *parcs à la française* differed from most North American and African parks where human activities often are based on temporary visits and actions (Larrère et al. 2009). However, the peripheral zone was often locally perceived and used as an area where development could occur as long as there were no obvious direct negative impacts on the core zone, almost as if it represented a compensation for the constraints on the activities of former users and land owners in the core zone (Mathevet et al. 2010). This lack of coherence between the different zones was underlined in a parliamentary report submitted to the Prime Minister (Giran 2003). As a result of land-use conflicts and a

balance of power with different state services other than the Ministry of the Environment, the national park services were not able to drive changes in the peripheral zone (Larrère et al. 2009). National parks created under the initial law thus suffered from severe social conflicts, and the decision-making process of top-down management of PAs gave the impression to local communities and elected representatives of a usurpation of their role as decision makers for their territory.

To improve the territorial coherence between the NP core zones and their surrounding landscapes, the reform highlighted the "solidarity" that should be recognized between the two zones, the idea being to develop a territorial project, based on joint interest, awareness, and the active engagement of stakeholders in the conservation objectives of the NP. Indeed, the concept of ES has an ecological science dimension (spatial interactions of species with other species including humans and their abiotic environment), which provides a sort of de facto causality, a social dimension related to the objectives of sustainable development and a moral dimension that integrates the mutual dependence of the two NP zones. However, but not surprisingly, the 2006 law did not define ES. We thus created a multidisciplinary team coordinated by a local environmental consultancy and involving a plant and an animal ecologist, a social scientist, an environmental policy scientist, and a lawyer to define and illustrate the application of the concept of ES.

The Definition of Ecological Solidarity

A review of the biodiversity conservation, ecosystem-based management, and adaptive management literature (e.g., Walters 1986, Grumbine 1994, Margoluis and Salafsky 1998, Salafsky and Margoluis 1999, Poiani et al. 2000, Lockwood et al. 2006, Lindenmayer et al. 2008, Primack 2010), illustrates that ES has its roots in two traditional notions: (1) ecology based on biophysical and functional interactions, and (2) the solidarity among people with a shared goal and a sense of community who are committed to the common good and wellbeing of the community (Mathevet et al. 2010, Thompson et al. 2011). ES can thus be defined as the interdependence of living beings in the context of spatial and temporal variation in their physical environment (Mathevet et al. 2010). ES has three main components (Fig. 1): the dynamics of ecological processes and biodiversity in space and time (i.e., ecological interdependency), the direct and indirect uses of the socioecological system, and the recognition that human beings are an integral part of the function of an ecosystem (i.e., socioecological interdependency), and the sociopolitical and normative framings of the territory (i.e., territorial interdependency).

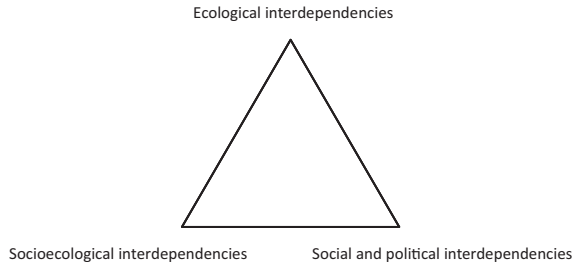

Fig. 1. The three main components of ecological solidarity for biodiversity conservation (adapted from Mathevet et al. 2010, Mathevet and Bousquet 2014).

There are two main dimensions associated with this definition of ES. First, ES contains the idea of a debt; because we are dependent on each other, we are a "debtor," whether we like it or not, when we contribute to the destruction of life. ES thus underlines the "community of fate" between human society and the environment and thus a moral tie between humans (individuals, social groups) and nonhumans (i.e., humans are tied in a web of relationships with other humans and nonhumans, some chosen and some not). Second, ES reflects a contract that fixes the limits of human action on nature in terms of rights and duties (Serres 1995). As such, ES participates in the implementation of a principle of responsibility for nature and for future generations of humans and other species (Jonas 1984).

The concept of ES reflects a classic Leopoldien ecocentric ethic (Leopold 1966) of living together and being a member of a socioecological community in which humans act and decide on actions according to their consequences. Natural systems are dependent on social complexity (Berkes and Folke 1998, Chapin et al. 2009). The major feature of ES is that it mixes both normative and scientific dimensions: what is (nature) and what should be (the purpose). In contrast to a strictly biocentric ethic, ES does not grant moral rights to nature and ecological systems. ES is, however, close to a weak anthropocentric environmental ethic (Norton 2005), in the sense that the interests and the aspirations of humans are not all instrumental or utilitarian. Nature protection also stems from an appreciation of its beauty or its scientific interest, in the absence of any moral or monetary value. Thus, with regard to its epistemic basis and philosophical foundations, ES has its roots in both ecocentric and weak anthropocentric ethics; a sort of a pragmatic compromise based on scientific understanding and also the integration of the value of experiences of natural objects and places in human value formation (Norton 2005, Minteer 2012).

Identifying Ecological Solidarity

ES incorporates issues related to the ecological connectivity and coherence of the components of a

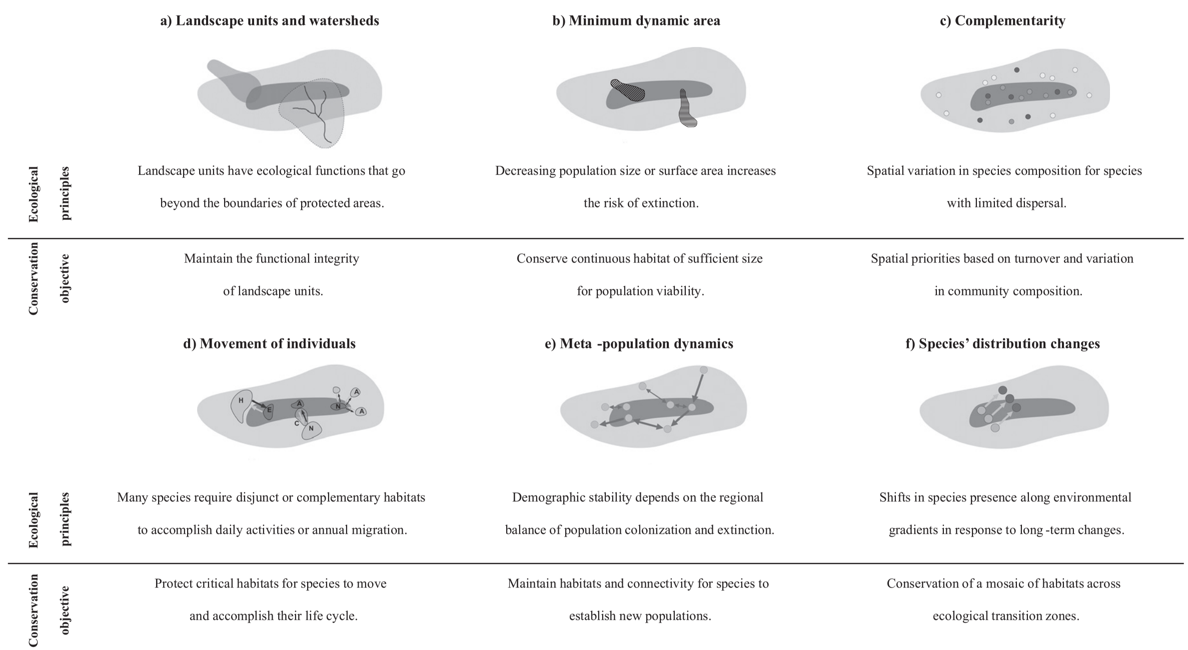

FIG. 2. Six schematic representations of ecological principles and examples of associated conservation objectives that provide a basis for ecological solidarity (adapted from Mathevet et al. 2010, Thompson et al. 2011) between a protected area (dark shading) and its surrounding landscape (light shading): (a) landscape entities and watersheds, (b) continuity of minimum dynamic area (hatched surfaces), (c) complementarity (species turnover; in the example here, each circle with a different degree of shading could represent the occurrence of a different listed species), (d) individual movements for seasonal migration (sites marked with an H and E) or daily feeding activities (A) and nesting sites (N), which may involve corridors (C), (e) meta-population dynamics (arrows are colonization events), and (f) species' distribution change in response to long-term environmental variation (arrows represent the direction of movement with loss of populations in an original range and new populations in a new range).

landscape and the need to adopt socially and ecologically responsible policies for biodiversity conservation (Thompson et al. 2011). The dynamics and function of SESs reflect their history of interactions with human societies in time and space (Berkes and Folke 1998, Walker et al. 2002, Berkes 2008). The primary goals of biodiversity conservation stem from such dynamics and concern the maintenance of ecological dynamics at different spatial scales (Poiani et al. 2000, Lindenmayer et al. 2008), the functions and services of different ecological systems (Costanza et al. 1997, Daily 1997, MEA 2005), and the capacity of species to evolve in the face of future environmental change, i.e., their evolutionary potential (Erwin 1991, Stockwell et al. 2003). These ecological interactions and interdependencies are essential to long-term ecological integrity on a range of spatial scales but may not be obvious at the stakeholder level (Stafford Smith et al. 2009). They also require a spatial consideration of ecological dynamics at the local habitat and wider landscape scales, and previous authors have worked to provide a classification (or a check list) of the processes acting at different scales for their appreciation in a conservation context (Poiani et al. 2000, Lindenmayer et al. 2008). Building on such work, Thompson et al. (2011) detailed six schematic representations of the spatial features of the organization and dynamics of ecological systems to provide a functional ecological foundation to ES and to identify ecological interdependencies between a PA and its surrounding area (Fig. 2). These representations cover the diversity of spatial and temporal scales of heterogeneity and biological levels of organization (individual, population, species). Each representation is based on specific ecological principles that can be reframed in terms of specific conservation objectives (for examples see Thompson et al. [2014]).

The management of interactions among human activities and environmental problems such as biodiversity conservation occurs in institutions created at different governance levels (Ostrom 2009). However, social issues such as the willingness of stakeholders to share the responsibility for biodiversity conservation and choice of management activities or the rising awareness of biophysical interdependencies and physical reconnection with nature (i.e., experiencing nature on the ground) may represent more effective ways to foster solidarity and implement conservation management (Mathevet et al. 2010). In this way, solidarity can be seen as a "loose form of social binding" characterized by latent (but not obligatory) reciprocity or explicit interdependencies (Bots et al. 2008).

To illustrate the diverse social dimensions of ES, we identify eight types of socioecological interdependencies that can be adapted to the context of biodiversity conservation (Table 1). This schematic typology is based on three key principles. The first is the sense of a community of life (ownership or sense of belonging) that leads a stakeholder or social group to wisely use land and natural resources and to support humans or nonhumans in the belief that he/she shares certain values and objectives with all or some of the community members. The second is the voluntary obligation (interest) of a stakeholder or social group to adopt a strategy of land-use and natural resource use which supports humans or nonhumans in the belief that some are better equipped than others to achieve these objectives. The third are obligations (laws and social rules) to sustainably use land and natural resources and to support others in harmony with nature. Socioecological cohesion can be based on the idea that human societies are part of a community of life and share a common identity and self-consciousness (e.g., deep or driven solidarity). Solidarity can also be based on responsibility for others (e.g., radical solidarity) or on complementary interests of wealth production or self-protection (e.g., self-interested or calculated solidarity). These principles of solidarity, based on wise, strategic, and sustainable action, are essential elements in the functioning of SESs at both individual and collective levels.

Implementing a conservation policy based on ES requires local actors. In practice, this involves setting up the effective management of a common good and thus, in terms of conservation, respectful ecosystem use, and limitation of negative impacts. Here, territorial interdependency (TI) brings coherence to sociopolitical interdependencies and provides leverage for public policies that promote sustainable and inclusive territorial development (Fig. 1). Based on case studies in the Cevennes National Park (Appendix S1) and the Camargue Regional Natural Park (Appendix S2) in France, both of which include a UNESCO Biosphere Reserve, we identify three kinds of TI (following Mauss 1950, Gardin 2006). The first is based on peer reciprocity and involves organizations in which professionals such as farmers, livestock breeders, or hunters meet to develop solutions to specific problems (e.g., economic promotion of local meat or rice production, crop damage by wildlife). The second type of TI involves inegalitarian reciprocity and concerns organizations in which environmentalists, conservation scientists, or government agencies construct top-down solutions for the stakeholders who benefit from specific measures. It is based on the model of a gift that is not reciprocal even though there may be an additional cost or a loss of earnings. This generates conflicts because, as Mauss (1950) stressed, a gift that is not reciprocal is a contradiction because it cannot create social bonds. As a result, solidarity is not achieved. Indeed local stakeholders often end up in heated conflict with environmentalists and conservation scientists that want to help them (Alphandery and Fortier 2001), simply because of the weight of the symbolic debt generated by the gift (e.g., subsidies), especially if the

TABLE 1. Sociological principles and possible conservation tools associated with eight types of socioecological interdependence (adapted from Bots et al. 2008, Mathevet 2012).

Type of socioecological interdependence	Principles			Examples of conservation tools or instruments
	Ownership (community of life)	Voluntary obligations (interests)	Obligations (law and social rules)	
Deep solidarity	yes	yes	yes	(1) educational programs and hands-on experiences to teach public environmental issues and values; (2) increasing capacity of audience to engage in conservation; (3) supply information to consumers about biodiversity impacts of purchasing decisions; (4) incentives directly target people likely to donate money to conservation efforts
Opportunistic solidarity	no	yes	yes	(1) efforts to persuade land owners or users to endorse conservation goals, efforts to build conservation capacity; (2) collective engagement of all key stakeholders and willingness to compromise
Calculated solidarity	yes	yes	no	(1) technical assistance; (2) awards (signal community conservation efforts); (3) stewardship awards, certification program of lands and products meeting environmental management standards
Driven solidarity	yes	no	yes	(1) regulatory prohibitions and requirements; educational program
Self-interested solidarity	no	yes	no	(1) direct conservation payments; (2) tax credit, debt absorption, relaxation of regulatory standards; (3) market creation, improvement (mitigation requirements, carbon credit trading, market aesthetic value of biodiversity, i.e. ecotourism)
Imposed solidarity	no	no	yes	(1) government or NGO acquisition of land or resource rights; (2) regulatory prohibitions and requirements
Radical solidarity	yes	no	no	education and culture
Altruistic	no	no	no	education and culture

stakeholder cannot influence the way the gift functions and its specifications. The third type of TI is based on multilateral reciprocity, in which people are invited to collaboratively create solutions to individual and collective problems (Gardin 2006).

Based on this typology, we conclude that the issue at stake is to design charter contracts based on multilateral reciprocity (e.g., regional natural park or biosphere reserve charter, integrated conservation and development project; McShane and Wells 2004) because, at the present time, most existing contracts (e.g., for European agro-environmental policy or EU Natura 2000 policy) generate top-down inegalitarian solidarity.

Exploring the Rising Awareness of Ecological Solidarity

In regard to the sustainable management of SES, it is now critical to contribute to decision-making and the implementation of concrete conservation policy. By focusing on ES, the plurality of values and their contexts may be more clearly identified (Minteer 2012). For example, the transformative value, i.e., the value associated with transforming preferences in relation to a higher ideal (Norton 2005) can be more explicitly recognized. Another advantage of such a pluralistic approach is that it creates the conditions for cooperative action, allowing the formation of strategic alliances for social change. This pluralistic approach is based on a form of environmental pragmatism that is closely associated with the view based on adaptive management. Environmental pragmatism represents a procedural view of ethical decision-making in which moral principles are considered as hypotheses regarding what is valuable according to the management context and the environmental problem, and in which the correct action is identified by discussion based on a variety of knowledge and value systems (Minteer 2012). This is thus a form of social learning through experimental adaptation, and thus bears marked similarity to the notion of adaptive

management (Berkes and Folke 1998, Norton 2005). In this way ES creates a means to navigate in the face of change and promotes a process of learning about the dynamics and function of socioecological systems by using science and social learning as tools to achieve collaborative planning and management (Nowotny et al. 2001).

ES highlights socioecological interdependencies among humans who are not aware of their existence (Mathevet 2012). Used to highlight social, ecological, and territorial interdependencies among the human and nonhuman components of the socioecological system, the ES concept may foster collective action as an alternative or complementary approach to state- or market-based approaches (Pretty 2002, Ostrom 2005). As argued by Leeuwis (2000) and Barnaud and Antona (2014), it is essential for actors with diverse roles, ideas, and values to feel that they are mutually dependent in solving problems and adopting a sustainable development respectful of biodiversity. The enhancement of feelings of interdependence among heterogeneous actors, and the awareness and acknowledgement of interdependencies between actors and between humans and nonhumans may be achieved through learning-based approaches and their engagement in collective actions (Leeuwis and Van Den Ban 2004).

Mutual interdependence in reality is often an independence–dependence nexus. For instance, the upstream user of any watershed or irrigation scheme is able to use water independently of dependent downstream users. Thus interdependence is the degree to which the components of the socioecological community are mutually dependent on the others. The ES framework suggests to analyze and explore these asymmetric interdependencies following a method based on five axes: (1) Recognition of interdependency between ecological functions and components at various spatial and hierarchy scales, as scales issues are always critical in the governance of natural resources and biodiversity; (2) Recognition of interdependency between users of natural resources and landscapes that are often interdependent because they have competing interests and they modify or maintain ecosystems and ecological functions through their practices; (3) Recognition of interdependencies between policies and areas as the structure and composition of the landscape have an impact on biodiversity dynamics. Integrating landscape dynamics beyond the boundaries of any PAs require the coordination of various stakeholders; (4) Valuation of the components of the socioecological systems and of the interdependencies that integrate power relationships among stakeholders; (5) Crafting of rules to sustain natural resource and conserve biodiversity based on collective action (Ostrom 2005). In that way, stakeholders may work together. They may reach some consensus, share values and aspirations, or at least reach some congruency of meaning, and as a result they may engage in collective action supportive of ES.

Thus, ES is not about homogenizing cultural values to enforce universality, but rather a framework for revealing functional interdependencies and identifying the ecological, cultural, social, and economic aspects of their consequences. The diversity of values and the ways of assessing them need to be recognized, and procedures that encourage diverse cooperative actions promoting ES need to be developed. By integrating a plurality of values and ensuring that issues are assessed by extended peer communities (Funtowicz and Ravetz 1994), ES promotes institutional or policy entrepreneurship and encourages concrete socioecological governance changes (Hisschemöller et al. 2001).

To collectively explore ES and encourage such changes, we need to couple the principles of Dewey's pragmatism (Norton 2005) and of adaptive comanagement by combining the systematic, rigorous approach for deliberately and iteratively learning from management actions intending to improve subsequent management, policy, or practice with collaborative management and decision-making (Berkes et al. 2003, Tengö et al. 2014). It should thus provide communities with experience that supports or refutes the claim that processes or objects are valuable.

We present the different stages in the process of ES exploration. These are adapted from the companion modeling approach (ComMod Group 2003; Etienne 2011) and are iterative, with potential feedback at each stage.

(1) Delimitation of the issues and boundaries of the region in consultation with the stakeholders. Specific attention should be paid to clarifying how to shift from political and administrative units to ecologically functional units (Fig. 2). (2) Socioenvironmental assessment to define natural, economic, and sociocultural features of the region and identify stakeholders for the launch of projects and to generate interaction among actors (i.e., to identify who should be included and why). (3) Implementation of a participatory approach that allows the sharing of worldviews, values, and norms during collective meetings and workshops. Reinforcing less powerful actors (due to low income, illiteracy, etc.) should be an objective here in order to improve public participation. The leader of the process should pay attention to collective dynamics as well as individual–group interactions. The issues at stake are to develop a social process to legitimate points of view and forms of knowledge (local, empirical, traditional, and scientific) and to develop a process of participatory modeling that preserves the diverse individual positions within the collective representation of the SES. (4) Assessing the outputs of the participatory modeling approach in full- and sub-group discussions related to ES, functional interdependence, and impacts of human activities. The main objective here is a collective clarification to formulate explicit hypotheses and indicators used during modeling and to adapt the model to suggested changes that are collectively validated. The model represents a

mediation tool to incite stakeholders to think collectively beyond solely developing future ecology scenarios. (5) Identification of biodiversity issues and priorities in consultation with experts and local communities. (6) Identification, discussion, and establishment of conservation and development principles, goals, and targets. (7) Progressive collective planning of initiatives related to both conservation and development. (8) Development of indicators to monitor biodiversity, and social and socioecological systems, together and individually, with specific attention given to social performance, decision-making, and the adaptive co-management process. (9) Symbolic and collective agreement on the territorial project to be implemented. (10) Development of a periodic project-assessment framework based on adaptive management principles.

Throughout this process, participants identify features that should be saved for the benefit of future generations (see Appendices S1 and S2 for examples). In this process, it is crucial to specify the socioecological characteristics and dynamics that are critical for future human wellbeing, and that any decision that impacts these should be assessed.

Comparison with the Ecosystem Management Approach

The relationships between social and ecological systems have become a central issue in biodiversity conservation and sustainability sciences (Folke et al. 2002, Berkes et al. 2003, Ostrom 2009). Several approaches have been developed to analyze SESs, most of which, for example the adaptive management and resilience approaches, have roots in natural sciences and have developed to become transdisciplinary (Walters 1986, Armitage et al. 2008, Keith et al. 2011). Others emerge from a social science background, e.g., the framework for analyzing SESs (Ostrom 2009) and political ecology (Robbins 2012) and mostly focus on political science and economy, environmental justice, and natural resource management. In this section we discuss the ES framework within the context of existing conservation science approaches and in particular compare it to the widespread ecosystem management approach that features in the framework of the Convention on Biological Diversity. Our objective here is not to provide an exhaustive comparison but to focus on specific features of the ES framework to illustrate its added value.

The ecosystem management approach (EM) is an adaptive management strategy that deals with complex SESs. It integrates the management of land and natural resources and aims at balancing biodiversity conservation, sustainable use, and equitable sharing of benefits from natural resource exploitation (Grumbine 1994, 1997). As such, it takes into account cultural dimensions and considers humans as an integral part of ecosystems. The EM and ES frameworks share several features and principles, which include the recognition of objectives as a choice for society, the objective of decentralized management, a consideration of the extended impacts of actions, an understanding of the social-political-economic contexts that help reduce power asymmetry or market distortions, the need for action at different spatial and temporal scales, the acceptance of change and uncertainties, long-term management for future generations, and the critical importance of involving all relevant stakeholders (Lackey 1998, Szaro et al. 1998). However, even in its form of adaptive co-management that combines an iterative learning dimension of adaptive management with collaborative management in which rights and responsibilities are shared (Olsson et al. 2004), EM lacks a clear-cut conceptualization of the way scientists and local stakeholders should work together to integrate various forms of knowledge and stimulate stakeholder engagement (Reed 2008, Barnaud et al. 2011, Daré et al. 2011). There is thus a marked difference between the two concepts.

The ES framework provides added value for analyzing PAs and their surrounding landscape as an integrated SES, with respect to the specification of different frameworks (i.e., value-normative frameworks), situated and local knowledge, and the beliefs and conflicts between stakeholders that concern ecological interdependencies. Ethically relevant qualities such as consciousness, sensitivity to others, and ethical practices of care for both humans and nonhumans are at the heart of ES. Exploring ES may lead to accepting solidarity through cultural diversity beyond PA boundaries. We can thus identify several differences in the underlying frameworks for EM and ES. First, traditional EM implementation tends to build solidarity on an exclusionary form of bonding which defines conservation issues in dualistic opposition to local users' interests. Second, by privileging the legitimacy of natural sciences and rationalism in the exploration of socioecological interactions, EM tends to disqualify emotional features and to rationalize and rank values and norms (Stolton and Dudley 2010). In other words objectivity and universality tend to exclude sense of place, care, compassion, and emotionality. Third, the "fences and fines" doctrine focuses on the PA itself. By insisting on boundaries and ignoring the governance issues of the environment that surrounds a PA, the EM does not consider the PA and its surrounding landscape as a single SES (McShane and Wells 2004). The EM approach is thus markedly different from an approach based on ES, and the latter could perhaps alleviate some difficulties in the implementation of the EM linked to differences in its perception by different actors (see Koontz and Bodine 2008).

It is not, however, enough to agree on the needs to protect biodiversity and to better manage natural resources for an agreement on measures and tools

to be implemented (Lockwood et al. 2006). Biodiversity conservation and integrated development project implementation take place in a context of a triple uncertainty involving scientifically measurable ecological evidence, social dynamics and representations, values, and normative uncertainty. Based on monitoring and experiments, natural sciences help clarify the first class of uncertainty, to improve our understanding of the functioning of a SES and implement adaptive management (Barnaud and Antona 2014). Social and policy sciences identify and map social structures and representations, but also power relationships and institutional arrangements (Ostrom 2005, Reed 2008). All this knowledge may be useful to implement adaptive co-management (Carpenter et al. 2001) with local communities, but to deal with norms and values we need not only political philosophy and environmental ethics (Norton 2005) but also an approach (e.g., companion modeling) that integrates the dynamics of relationships between humans and nonhumans and between members of the involved community, the dynamics of situated knowledge and values, and the dynamics of the SES (Mathevet and Bousquet 2014). The issue at stake here is to promote and collectively explore social and ecological interdependencies.

By prioritizing ecosystem services, EM differs from the ES framework. The latter maintains its focus on a pluralistic evaluation of nonhumans and natural systems, while EM has a more philosophical position based on taking care of ecosystem services, giving high priority to human interests. For this to be complete, a broader perception of ecosystem services that incorporates more pluralistic approaches, deeper non-use values, and cultural dimensions is necessary (e.g., Chapin et al. 2009, von Heland and Folke 2014). Collective exploration of ES goes a step further in that it deals with (1) the moral considerability of a diversity of elements (e.g., landscapes, ecosystems, species), (2) a diversity of technical actions (e.g., restoration, biodiversity conservation, pollution treatment), and (3) various principles and consequences of actions (e.g., deliberating, deciding, acting). By exploring and collectively acknowledging ES, PA policy could move beyond the construction of socioecological interactions to interrogate asymmetric power relations (Barnaud et al. 2010).

Finally, within a SES, maintaining ES requires exploration of its local specificities and its related forms of attachment. Bearing in mind the difficulties intrinsic to power relationships and equity issues in participatory approaches, developing a companion modeling approach could be particularly useful here (ComMod 2003, Etienne 2011). In light of the limitations of a traditional modeling approach with rigid, strict assumptions, a narrow scope, and lack of stakeholder participation in the design and development of the models, a participatory modeling approach can indeed represent means to explore the behavior of a SES and ways of solving problems. This approach thus highlights the sense of place and the multiple interpretations of a given SES by different actors according to their norms and values and contributes to collective learning and cooperative interactions (ComMod Group 2003). Finally, such an approach offers a social experiment that goes beyond the simple respect of different opinions by developing the power to think and hesitate together, to diverge in order to become closer, and to better learn individually and collectively. The use of computer simulators, multi-agent models, and role-playing games help stimulate collective learning about a SES by creating, modifying, and observing a model and its simulations with the actors (Bousquet and Le Page 2004). Based on the sharing of such representations and simulations, mutual understanding of stakeholders (including decision-makers and researchers) is changed (Grimblett 2002, Barnaud et al. 2010). Finally, despite a costly and time-consuming process, the participatory modeling approach enhances the process of decision-making, both in its technical (information, action effects) and sociological (cooperation, place of the actor in the decision-making process) dimensions, and encourages constant feedback between improved knowledge and the process of decision making (Pahl-Wholst and Hare 2004, Grimm and Railsback 2005).

Conclusion

Biodiversity conservation does not necessarily require subjugation of local communities, as claimed by some conservationists (e.g., Miller et al. 2014). In our analysis, a PA is often itself the primary obstacle to conservation because of the disruption of norms and values it imposes on local stakeholders. This raises the question of legitimacy, and the need for mutual recognition of the interest of the PA by its managers, local elected officials, and by all the stakeholders that act within and around the PA. This concerns the identity of the whole territory that encircles the PA. The lack of recognition, lack of identity, and lack of integration of local knowledge and dialogue represent a quadruple deficit that requires careful attention. ES between stakeholders and the area in which they have a stake is important to consider in any integrated development and conservation policy.

ES is a concept that complements the key features of both environmental pragmatism and adaptive co-management, including learning from policies, synthesis of different knowledge systems, and a collaborative approach by inviting the stakeholders to collectively explore and discuss the various ways to value socioecological interdependencies and integrate their social, ecological, and economic consequences. By promoting dialogue and participatory modeling, building trust and social capital, the ES is also an approach that endorses place-specific knowledge, values, and governance.

Currently, the ES concept has only been developed in France, and it is too early to assess its strengths and weaknesses in different contexts. A major contribution of ES to the design and management of PAs is that it can help build links between theory and scientific evidence, between value systems and action, and between political institutions and processes, which together improve land planning and management processes. The ES that one may imagine as synonymous with interdependence actually leads to an alternative way of viewing the plurality of ties and, as a consequence, how we value and choose these ties and our attachment to them. PAs and their surrounding landscapes are a single SES and we thus must build a trajectory of collective life that integrates the variability of ecological dynamics and processes, and focuses on the direct socioecological relationship between the PA and the surrounding sociopolitical landscape.

Beyond the boundaries of PAs, an ES approach means reconnecting facts, values, decisions, and actions, as well as ecological processes, management practices, local knowledge, cultural issues, and public policies. ES could contribute to the development of an ethically integrated science of care and responsibility in a framework of socially engaged and accountable action-research. The collective exploration of ES paves the way to a new social contract for human–nature relationships and ecosystem functions that focuses on what individuals are able to do, and emphasizes the importance of freedom of choice, individual heterogeneity, and the multiple dimensions of welfare (Sen 1999). The awareness and consciousness of ES could move us closer to a fairer society that is more respectful of the integrity of living communities and the resilience of SESs (Folke et al. 2011). It is a concept that provides a compelling invitation to strive towards a major transformation of our moral and political order based on the virtues of common sense, humanity, and respect.

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