A social–ecological approach to conservation planning: Embedding social considerations

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Natalie Corinna Ban
University of Victoria

Jordan Tam
University of British Columbia - Vancouver

Sarah C. Klain
Oregon State University

Natalie Stoeckl
James Cook University

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A social–ecological approach to conservation planning: embedding social considerations

Natalie C Ban[1*], Morena Mills[1,2], Jordan Tam[3], Christina C Hicks[1,4], Sarah Klain[3], Natalie Stoeckl[4], Madeleine C Bottrill[5,6], Jordan Levine[3], Robert L Pressey[1], Terre Satterfield[3], and Kai MA Chan[3]

Many conservation plans remain unimplemented, in part because of insufficient consideration of the social processes that influence conservation decisions. Complementing social considerations with an integrated understanding of the ecology of a region can result in a more complete conservation approach. We suggest that linking conservation planning to a social–ecological systems (SES) framework can lead to a more thorough understanding of human–environment interactions and more effective integration of social considerations. By characterizing SES as a set of subsystems, and their interactions with each other and with external factors, the SES framework can improve our understanding of the linkages between social and ecological influences on the environment. Using this framework can help to identify socially and ecologically focused conservation actions that will benefit ecosystems and human communities, and assist in the development of more consistent evidence for evaluating conservation actions by comparing conservation case studies.

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Despite use of the best available biophysical information and the investment of considerable time and effort, many conservation initiatives have been ineffective in motivating and guiding communities to implement the desired actions. As a result, these efforts fail to achieve their objectives (Wilson *et al*. 2007; Knight *et al*. 2008). Conservation planning is the development of spatial plans and the implementation and continued application of conservation actions (eg protection of sensitive or biodiverse areas, management of invasive species, restoration of degraded landscapes) in specific areas, usually at a regional scale (eg encompassing a network of sites where conservation actions are undertaken, within or among ecoregions; Margules and Pressey 2000). Such planning is intended to reduce biodiversity declines in a transparent and socially responsible manner by explicitly stating overall goals and specific objectives, and then providing options for achieving them, despite limited financial resources (Margules and Pressey 2000; Pressey and Bottrill 2009). However, when such planning fails to characterize the inevitable hard choices and trade-offs involved in applying conservation actions, failures in implementation often result. Insufficient consideration of social processes (the dynamic interactions between individuals, institutions, social organizations, and cultural norms) in the social–ecological systems (SESs) in which the planning has occurred contributes substantially to this failure. Examples of contributing factors that lead to failures to implement conservation include poor understanding of the socioeconomic constraints and opportunities that shape implementation (Cowling and Wilhelm-Rechman 2007; Knight and Cowling 2007); outside agendas that conflict with local needs (Chan *et al*. 2007; Smith *et al*. 2009); and insufficient training and incentives for researchers to turn regional conservation designs into actions on the ground (Knight *et al*. 2008; Arlettaz *et al*. 2010).

In a nutshell:

- Effective conservation planning must include both social and ecological considerations
- The social–ecological systems (SES) framework described here provides a basis for comparing conservation case studies
- A SES approach helps to explicitly consider trade-offs between ecological and social components of a system, allowing compromises to be identified
- A suite of methods and tools borrowed from the social sciences can help conservation planners understand and navigate the social complexities that underlie conservation decisions

Conservation biologists have been reluctant to engage in the messy and complex social and political aspects of implementation (Sayer *et al*. 2008), perhaps because conservation planning emerged from the natural sciences and remains predominantly rooted therein (Knight *et al*. 2006). Yet such planning – which explicitly values biodiversity – is part of a social process. It is also negatively affected by differences in power between those who make decisions about biodiversity management and those who are affected by its outcomes (Knight *et al*. 2008). Furthermore, conservation planning is extremely compli-

[1]*Australian Research Council Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia* [*]*(natalie.ban@jcu.edu.au)* ; [2]*Global Change Institute, University of Queensland, St Lucia, Australia;* [3]*Institute for Resources, Environment and Sustainability, University of British Columbia, Vancouver, Canada;* [4]*The Cairns Institute and School of Business, James Cook University, Townsville, Australia;* [5]*Australian Research Council Centre of Excellence for Environmental Decisions, University of Queensland, St Lucia, Australia;* [6]*Conservation International, Arlington, VA*

cated because it presents many problems for which the "solutions" generally lead to the emergence of additional issues (Rittel and Webber 1973). Accordingly, while conservation plans cannot be expected to routinely produce win–win solutions, they could yield outcomes that are acceptable to the various sectors involved (White *et al.* 2012), and which are better able to guide day-to-day conservation decisions. Thinking about trade-offs in terms of both the social and ecological implications of conservation actions can allow thoughtful and constructive compromises to emerge.

In this review, we discuss various ways in which social considerations have been included in conservation planning to date and offer some improvements. We suggest that linking conservation planning with an interdisciplinary SES framework (Ostrom 2009, 2010; hereafter referred to as "Ostrom's SES framework") is a way to effectively embed social considerations therein by broadening the predominantly ecological context to a social–ecological one.

Rationale for including social considerations in conservation planning

The rationale for integrating social considerations into conservation planning – from the perspective of planners – is that the actions that emerge are more likely to achieve their goals and to be more sustainable. Tailoring plans to the attitudes, preferences, and behaviors of stakeholders, how these change, and the process of engaging stakeholders transparently (eg engaging them throughout the planning process and providing them with all available information so that they can make informed decisions) should improve the plans overall and increase compliance with any associated recommendations (Ban *et al.* 2009). Explicitly including social considerations also creates the opportunity for planning processes to become more realistic and inclusive, clarifying the hard choices and complex trade-offs between and within conservation and other objectives (eg livelihoods and equity; Hirsch *et al.* 2010; McShane *et al.* 2011). Although an ethical imperative to include social considerations may not always be evident, because conservation is motivated by biodiversity values, conservation planners have an ethical responsibility to respect the right of local communities to be an integral part of the planning process.

Social considerations in conservation planning to date

A number of approaches have been suggested for expanding the inclusion of social considerations in conservation planning. Knight *et al.* (2006) outlined an operational model for this that emphasized the need for implementation strategies and the importance of including stakeholders throughout the process, to reflect local knowledge when gathering information about the region under consideration. Similarly, the stages involved in systematic conservation planning have been increased from the initial ecology-centric approach articulated by Margules and Pressey (2000) to include five new stages (Pressey and Bottrill 2009), most of which concern the social, economic, and political context in which the conservation initiative will take place (WebFigure 1). While current conservation planning frameworks (Knight *et al.* 2006; Pressey and Bottrill 2009) include some social considerations, they do not yet provide a truly integrative approach that recognizes substantial social processes and social–ecological linkages.

Practical developments that have occurred as a result of calls to improve the integration of social considerations into conservation planning fall into two categories, both of which are linked to the assessment part of conservation planning: (1) use of spatial data pertaining to existing resource use, and (2) the addition of social assessments, including identification of areas where conservation is more likely to succeed (ie "conservation opportunities").

Spatial data on human uses

Spatial data on how people use resources are increasingly incorporated into conservation assessments and are usually represented as threats to biodiversity or as costs associated with conservation actions. For instance, when human activities represent a threat to biodiversity (eg land clearing), planners either avoid highly threatened areas (eg areas slated for land clearing) to minimize conflict (when other, less sensitive areas exist that have the same biodiversity values) or give priority to areas of high biodiversity value that are highly threatened to protect them before land clearing occurs (where there are no viable alternatives) (Pressey and Taffs 2001). Planners deal with costs in similar ways, where the "costs" relate to acquisition (eg land value; Ando *et al.* 1998; Carwardine *et al.* 2010), management, damage to economic activities arising from conservation programs, and loss of extractive opportunities (for a review of terrestrial and marine systems respectively, see Naidoo *et al.* 2006; Ban and Klein 2009). The term "costs" is also used more generically, to refer to liabilities related to past or present human uses. Although there is scope for improving the representation of costs in conservation planning, once the costs of a planning process are defined, planners commonly use decision support tools (such as Marxan) to minimize costs while achieving conservation objectives. For example, the rezoning of the Great Barrier Reef in Australia aimed to incorporate at least 20% of the total area of each bioregion while reducing human impacts (Fernandes *et al.* 2005).

Social assessments

Social assessments (also termed situation analyses, social analyses, or stakeholder assessments) are a common component of conservation planning. These assessments contextualize aspects of the social systems that exist in the planning region, describing the social, cultural, economic, and political conditions in the area (Knight *et al.* 2006; Conservation Measures Partnership 2007; Cowling and Wilhelm-Rechman 2007; Figure 2, stages 1–3, 5). Some social assessments focus on the local opportunities for conservation that emerge where social factors align to create a willingness among community stakeholders to implement conservation actions; these may be community-led initiatives or may be linked to regional planning (Cowling and Wilhelm-Rechman 2007). Game *et al.* (2011) provide an example of the latter approach, working with communities in the Solomon Islands to identify protected areas through several rounds of meetings between community members and conservation planners, thereby combining the priorities of the communities with a systematic assessment of areas characterized by a high level of biodiversity.

Limitations of current approaches

To date, the inclusion of social considerations in conservation planning has been limited in several ways. First, although social data (eg opportunity costs) have increasingly been included in conservation assessments, the approaches used have not been consistent (Timko and Satterfield 2008). Gaining an understanding of what kinds of social factors matter, why they matter, and how this information should be collected, integrated, and interpreted has proved challenging. Second, incorporating social data into conservation assessments requires these data to be simplified and mapped, when in fact some social or cultural priorities may be distinctly aspatial and/or that information was not articulated in spatial terms initially. For example, many ethnographic insights into the underlying tensions that influence compliance (Fabinyi 2010) were not intended to be mapped and so lack spatial representation, making it difficult to include them in conservation assessments. Third, the process and products of systematic conservation planning tend to be static, prescriptive, and often technical, which limits the scope for including dynamics, values, and trade-offs among different objectives when these considerations are not articulated in prescriptive and technical (usually "measurable") terms. Fourth, limited guidance exists on how to move from recognition of the need to address social aspects of resource use in conservation planning to actually incorporating these into planning. Despite these limitations, the advantage of the systematic conservation planning framework (Margules and Pressey 2000) is that it is transparent and has been widely used. It can serve as a starting point to infuse a more comprehensive view of social considerations and trade-offs into conservation (see also Satterfield *et al.* in press).

Insights from the social sciences

Critical perspectives

Given that critical analysis is central to many of the social sciences, these disciplines offer fertile territory for a detailed scrutiny of conservation practices. For example, there have been in-depth criticisms of various aspects of conservation (eg exclusion or eviction of local peoples) and community-level conflicts (Agrawal and Gibson 1999; Brosius 1999; Brechin *et al.* 2003). Such criticisms should persuade conservation planners to take into account alternative viewpoints (eg whether biodiversity matters in its own right, or whether meeting basic human needs should be a priority) and to bear in mind how a wide spectrum of different values can influence choices; such considerations help to clarify some of the motives underlying human behavior. However, there is understandable wariness among conservation planners of such critical perspectives. The exhaustive analysis of social systems, such as in anthropological studies, could in principle greatly enhance the appropriateness, and effectiveness, and subsequent implementation of conservation plans (Harper 2002). The challenge remains: to increase engagement and communication between natural and social scientists so as to improve conservation in practice (Igoe 2011; Redford 2011), in part by providing a common language and framework for various fields to contribute to a fuller understanding of the drivers and impacts of conservation initiatives (Ostrom 2009).

Interactions between people and the environment

Insights and techniques borrowed from the social sciences have the potential to create more realistic expectations regarding the outcomes of conservation initiatives and to enhance the effectiveness, efficiency, and sustainability of these initiatives, by providing a better understanding of the complex linkages between people and the environment at multiple scales (Figure 1). These linkages have been investigated by several communities of scholars, including political and human ecologists, ecological anthropologists, and economists. The study of SESs draws insights from all of these fields, and others as well (Berkes *et al.* 2003). A deeper understanding of SES dynamics can highlight multiple issues that are relevant to conservation. For example, SES studies can help explain the benefits and drawbacks of multiple knowledge systems (eg different ways of viewing the world), informal institutions (eg the rules that people abide by, including social norms), and cross-scale networks. Most importantly, a SES view emphasizes the unpredictable, dynamic, and evolved nature of linked social and ecological systems (Berkes *et al.* 2003).

Ostrom's SES framework was developed to provide an understanding of the governance processes that lead to improvements in or deterioration of renewable natural resources (Ostrom 2009). The framework grew out of a large body of interdisciplinary research about coordinated resource management successes and failures. It divides SESs into subsystems, based on the resource (eg forests, coastal areas, etc), resource units (eg trees, fish), governance systems (eg management of a forest or a coastal

Figure 1. *Cultural linkages between people and the environment highlight the importance of considering both ecological and social aspects in conservation planning. (a) The creation stories of many different cultures link people and animals, such as the Haida First Nation's legend of the raven and first humans as depicted in this sculpture by Bill Reid, making it inappropriate to ignore that linkage. Understanding food and harvesting traditions, such as (b) smoking salmon in Alaska and (c) catching nearshore reef fish in Palau, helps conservation planning meet subsistence needs.*

area), and actors (ie stakeholders, such as hikers, loggers, and fishers). These four subsystems interact with each other and with the overarching social, economic, and political settings and related ecosystems (ie interactions and outcomes, with variables like harvesting levels, deliberative processes, activities carried out by communities, and social and ecological performance measures), leading to resource management outcomes (Ostrom 2009). While the framework emerged mainly from studies at local scales, it is just as applicable at regional and even global scales. Other frameworks (principally ones that are not connected with conservation) that have similarly linked social and ecological components include the following: "pressure–state–impacts–response" (Turner 2000), "sustainable rural livelihoods" (Scoones 1998), "disaster resilience of place" (Cutter *et al.* 2008), and "pressure and release" (Blaikie *et al.* 1994). However, we contend that the SES framework, as presented by Ostrom (2009), is the most appropriate for use in conservation planning because it encompasses a comprehensive group of social and ecological factors, all of which are applicable to conservation.

Linking the process of conservation planning with the SES framework

Integrating SES frameworks into conservation generally, and Ostrom's SES framework (Ostrom 2009) specifically, can serve to include nuanced local and regional social considerations into conservation planning. This integration can be achieved by providing practitioners and academics from different disciplines with a common vocabulary and a logical structure for classifying factors deemed as important influences in developing and implementing a conservation plan. In particular, linking the stages of systematic conservation planning (Pressey and Bottrill 2009) to Ostrom's SES framework (Ostrom 2009) (Figure 2; see WebFigures 1 and 2 for more detail) allows planners to think beyond the usual concerns. For example, at present, conservation planners do not routinely consider existing or potential governance systems, even though this might aid conservation. By understanding governance variables (ie the attributes that constitute a governance system, such as rule-making organizations, social norms that determine informal procedures for management, collaborations between different agencies or sectors, legal systems, current rules, and policy tools), planners can expand their approach and/or conservation actions to consider some or all of these factors. Thinking about such variables will also highlight the importance of multiple scales (eg the dynamics of government agencies and non-governmental groups at levels above and below the scale at which planning is occurring). Furthermore, one area where alternative theories, perspectives, and values can be integrated into conservation plans is within the "action situation" in Ostrom's SES framework (Ostrom 2010). The action situation is a step in the planning process whereby proposed conservation actions and their likely outcomes can be evaluated in light of the stakeholders' opinions and beliefs. In this way, Ostrom's SES framework can provide a first

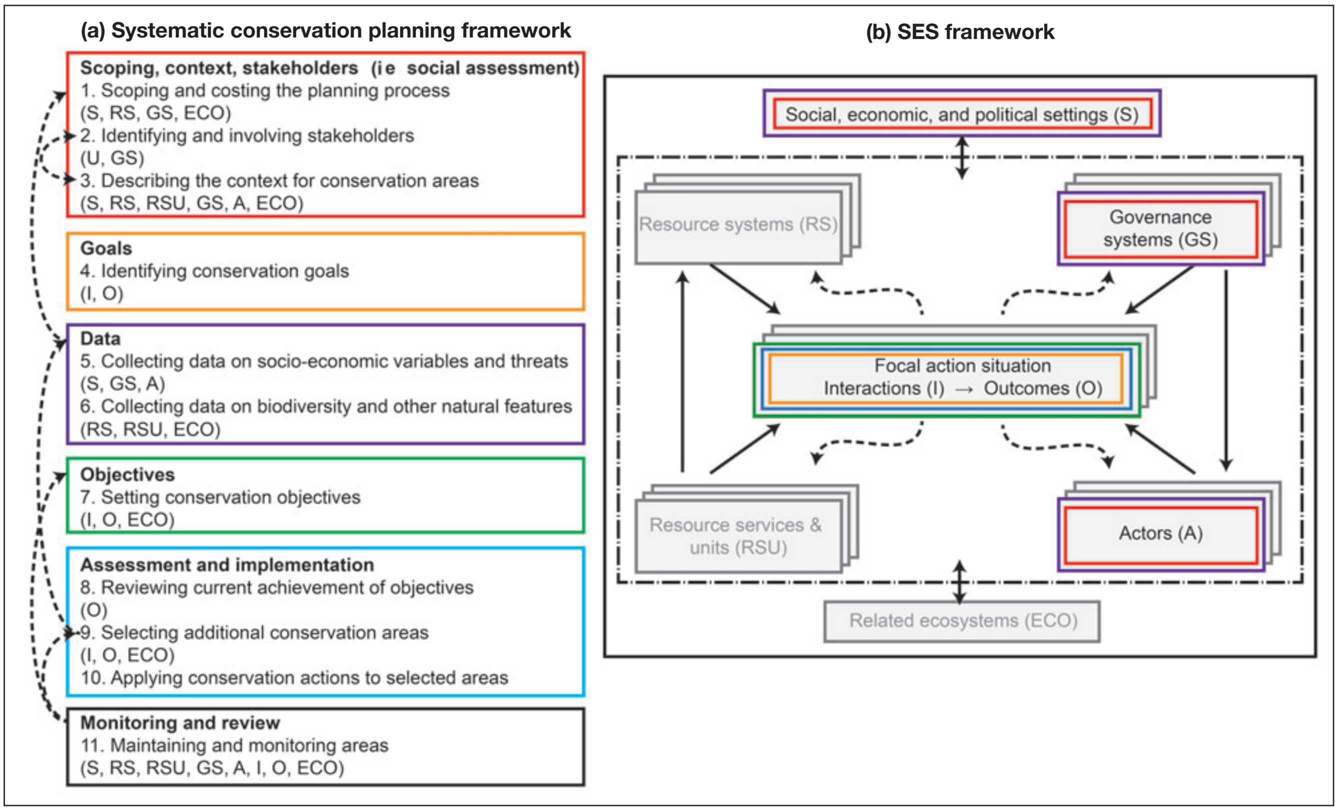

Figure 2. *Linkages between frameworks for (a) systematic conservation planning (Pressey and Bottrill 2009) and (b) social–ecological systems (SES) (Ostrom 2007, 2009, 2010). In (a), the colors depict categories of stages: dashed arrows represent feedback loops between categories of stages, or, where arrows enter boxes, feedback loops between specific stages. The colors in (b) link the most directly relevant social–ecological subsystems to planning stages in (a). In (b), grey text relates primarily to ecological considerations, which we do not discuss; solid arrows indicate direct links, and dashed arrows indicate feedbacks; the dashed box denotes the action situation embedded in a broader SES; the multiple versions of boxes symbolize that there can be multiple subsystems for each action situation. Abbreviations after stages in (a) refer to those components of the SES, defined in (b), which are relevant to specific stages of systematic conservation planning. See WebFigures 1 and 2 for more detail.*

step toward bringing together social considerations and conservation practices.

In practice, designing a conservation plan that incorporates SES thinking might entail some or all of the following: (1) careful consideration of both the social and ecological elements of the target region and their interactions; (2) inclusion of social scientists familiar with SES ideas in the planning process; (3) building capacity within existing complementary local or regional institutions; (4) discussion among planners about which methods, tools, and data are appropriate to the planning context (WebTable 1); and (5) prioritizing data collection and analysis. Furthermore, mainstreaming key social concepts and methods into existing planning frameworks through policies and day-to-day activities can promote acceptance and long-term commitment of social considerations. Admittedly, linking the frameworks will take time, experimentation, and a commitment by planners. We therefore highlight two specific ways in which conservation planning and SES thinking can be linked: (1) Ostrom's SES framework can be used to guide comparative analyses of conservation case studies, thereby creating an evidence-base for conservation actions; and (2) social objectives and stakeholders' goals can be incorporated into conservation planning.

Comparative analysis of conservation case studies

The conservation community currently lacks a general understanding of which conservation actions work in different contexts (Sutherland *et al.* 2004). Assessment of conservation cases under a common framework could help to develop an understanding of the relationships between social contexts and effective conservation actions. This in turn would help identify context-appropriate conservation actions, thereby improving the chances of successful conservation outcomes. A relatively modest allocation of funding to monitor progress could help to assess the social and ecological effectiveness of particular strategies (Neugarten *et al.* 2011). Although conservation planners could carry out such an assessment as part of the planning process (ie assess which conservation actions are more likely to be effective, based on past experiences), academics could also play a role here.

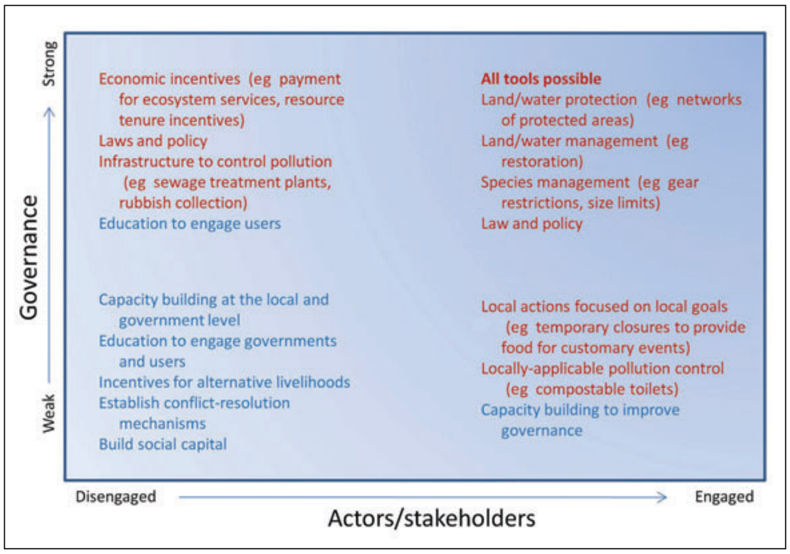

Figure 3. *Theoretical model relating conservation and supporting actions to variation in engagement of stakeholders and strength of governance. Planners face two options: select direct conservation actions based on the existing context (red text), and/or select supporting actions to change the context (blue text; ie to better engage users and/or to strengthen governance). The actions shown here are illustrative; appropriate specific actions will vary according to the context. The actions are not intended to be mutually exclusive and multiple actions might be necessary in one place. Schematic based on a similar concept by McClanahan* et al. *(2008); actions are loosely based on Salafsky* et al. *(2008).*

In a SES, conservation actions are immediately embedded in a complex web of social and ecological processes and interactions. Ostrom's SES framework could cue planners to potentially relevant variables, which would help determine how the various actors should be involved and what constitutes an appropriate conservation action. For instance, a particular form of protected area might require the involvement of stakeholders who have strong leadership roles, traditional knowledge, and social capital, as well as a need for a relatively well-developed governance system (Figure 3). Where governance is limited, conservation actions might need to be altered, or may need to be coupled with or preceded by supporting actions that bolster local institutions and governance. These arrangements could then be incorporated into the planning process (eg in this example, stages 3 and 10 of Figure 2a).

In work that led up to the SES framework, Ostrom (1990) identified eight principles (more recently reformulated to 11; Cox *et al.* 2010) that, in different combinations, are commonly found in institutions that successfully manage resources (see WebTable 2). These principles can be used as a starting point to investigate systems of conservation interest and identify appropriate and feasible conservation actions, potentially including sustainable use. Planners should seek conservation opportunities in situations where these principles are already in operation, if conservation actions in these areas are not yet sufficient. Furthermore, Ostrom's SES framework can be used as a diagnostic tool to identify additional design principles that relate to both social and ecological variables.

Social goals, objectives, and ecosystem services

Conservation planners are actively pursuing practical ways to integrate social considerations into conservation initiatives, including through social goals, objectives, and ecosystem services, potentially implemented through zoning. Social goals are general statements regarding desirable outcomes that might support conservation (eg "reduce local poverty"; Holland *et al.* 2009), but are not direct conservation goals (a direct conservation goal, in contrast, might be to protect biodiversity in perpetuity). Social objectives are specific and quantitative articulations of goals (eg "expand available schooling to 85% of the population under the age of 16"). Some social goals and objectives could serve to increase compliance with the rules governing conservation areas (eg a goal might be: "to ensure viable fisheries livelihoods"; the objective would be: "fishing-designated areas provide at least 90% of previous catch for each fishery"). SES thinking can help planners identify social objectives that may not be immediately obvious, such as building trust and forging links within the social network structure. Multiple objectives can be pursued through zoning – that is, geographically defining areas where different types of activities are allowed (eg marine spatial planning in the oceans; Ehler 2008; Klein *et al.* 2010). Similarly, planners are starting to prioritize management actions to provide ecosystem services that benefit people and biodiversity (Chan *et al.* 2006; Cowling *et al.* 2008), thereby linking conservation goals and social concerns. Incorporating multiple objectives is extremely difficult, however, and although decision support tools can be helpful, they are merely tools and cannot provide satisfying outcomes in and of themselves. Rather, they may provide options or potential scenarios that can be discussed during the planning phase.

Benefits of linking conservation planning and SES thinking

Linking SES thinking and conservation planning could highlight trade-offs among different objectives inherent in conservation decisions. Planners will always be faced with hard choices, but clearer trade-offs may compel them to modify biodiversity priorities or justify the inequalities they create. We therefore expect the emergence of a deeper understanding about how trade-offs are perceived and experienced from multiple perspectives (McShane *et al.* 2011). In the long run, this honesty and clarity may

Figure 4. *Involving people in planning. (a) Provincial leader annotating a map to identify areas for potential future marine conservation in Fiji. (b) Village leaders deciding on their vision for future resource management practices in Ovalau, Fiji. (c) Social scientist carrying out interviews with resource users in Kenya. (d) Map with notes from an interview about marine values in British Columbia, Canada.*

yield more effective conservation initiatives. Furthermore, an additional benefit of integrating SES thinking into conservation planning is based on the former's emphasis on dynamics, interactions, and processes at multiple scales, whereas planning is all too often viewed as occurring in a static context.

■ Methods and tools

Linking SES thinking and conservation planning requires analytical techniques that can provide insight into the social components and interactions of SES. Connecting the two frameworks also requires integration of different methods and tools into a coherent process. The social sciences offer many methods and tools for incorporating social considerations into conservation planning (eg Figure 4), but most are rarely applied. We outline examples of some tools here, and touch on some key examples in WebPanel 1 and WebTable 1. We broadly categorize methods and tools by their value to three interlinked facets of the planning process: (1) describing and analyzing the SES in which planning is taking place; (2) eliciting input into the planning process; and (3) analyzing and selecting appropriate conservation actions.

First, many methods from the social sciences can assist with describing and analyzing the SES in which planning is taking place. A starting point might be to investigate aspects of the social–ecological system that have been repeatedly found to be linked to successful resource management (ie design principles; WebTable 2). One example is the existence of clearly defined spatial and social boundaries. Another is the congruence between rules about extracting resources (appropriation rules), rules about labor, materials, and money for management (provision rules), and the local conditions (Ostrom 1990; Cox *et al*. 2010). Questionnaires can be designed to establish levels of agreement and clarity regarding spatial and social boundaries. "The institutional analysis and development" framework (Ostrom 1990) helps in understanding existing institutional arrangements within a region; this in turn helps to avoid problems with coordination and conflict between existing and future rules governing resource use (Imperial 1999).

Second, methods from the social sciences can help to elicit input into the planning process, and finally, their methods and tools can help to select and analyze appropriate conservation actions. The design principles can again serve as a starting point; Ostrom (1990) identified critical aspects in resource governance (participation of stakeholders in rule-making, monitoring and sanctioning, and recognition of local autonomy). One example of this approach is through participation in the planning process, which can be garnered through collaborative mapping (Ban *et al.* 2008). This design principle could also be used to select appropriate actions. Questionnaires can be designed to establish current and historic levels of participation in resource management, which can assist in predicting the likelihood of stakeholder compliance. Participatory approaches (eg through structured decision making) can be used to elicit values of stakeholders toward conservation, and thus can help to identify appropriate conservation options (Gregory *et al.* 2001; see also WebTable 1).

Limitations of local and regional conservation planning

Our review has focused on regional conservation planning, but global forces – such as international policies, the national economy, fluctuations in commodity prices, and water and food insecurity – strongly influence conservation endeavors at all scales. While these forces might be acknowledged, addressing them has been beyond the remit of conservation planning, and so they have remained a core challenge for conservation (not just conservation planning). Ostrom's SES framework can be a starting point for exploring these forces because in theory it can be used to investigate SES at all scales. Understanding these types of pressures also allows planners to avoid inadvertently reinforcing them or simply displacing their impacts to other areas of conservation importance. The future task of conservation planners might not only be to build resilient, adaptive, and culturally sensitive institutions for regional biodiversity protection, but also to broaden views and strategies so as to understand and start to address global pressures.

Conclusion

A major shift in the planning community will be needed to integrate social–ecological thinking into conservation planning – one that places the same importance on social considerations as on ecological ones, and that seeks to integrate the two. We hope that this shift will begin with the integration of concepts that have emerged from the SES framework into conservation planning.

Ultimately, lessons from SES thinking and research and other insights from the social sciences can enhance conservation planning efforts, and potentially help secure a more certain future for conservation – and hence biodiversity – in a world of growing human needs and impacts.

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WebPanel 1. Some methods and tools to integrate social considerations into a linked conservation planning, social–ecological systems approach

Here we outline some social science methods and tools that can be used to link conservation planning and social–ecological systems (SES) approaches; these are broadly categorized according to their value with respect to three interlinked facets of the planning process: (1) describing and analyzing the SES in which planning is taking place; (2) eliciting input into the planning process; and (3) analyzing and selecting appropriate conservation and supporting actions for the planning context (see WebTable 1 for a brief description of the social science methods and tools mentioned). We also link the design principles (WebTable 2) that characterize robust institutions for managing pooled resources (Cox *et al*. 2010) to the categories.

(1) Describing and analyzing the SES in which planning is taking place

Describing and analyzing the SES in which planning is undertaken is relevant to several stages of the conservation planning process: setting the scope of the planning exercise, context, and identification of stakeholders (stages 1, 2, and 3 in WebFigure 1) as well as data collection (stages 5 and 6 in WebFigure 1) are points at which social analyses can most directly inform the planning process. These stages also link to several design principles (WebTable 2). In particular, the design principles indicate that clearly defined spatial and social boundaries, and congruence between local conditions and rules about extracting and managing resources, are more likely to lead to successful management (Cox *et al*. 2010). Several social science methods and tools are useful in assessing the situation. For example, when outlining the context for planning, the institutional analysis and development framework helps planners and academics to understand the existing institutional arrangements in the region, thereby avoiding problems with coordination and conflict between existing and future rules governing resource use (GS in WebFigure 2; Imperial 1999). Similarly, while identifying stakeholders, social network analysis promotes understanding of interactions between agencies and actors responsible for resource management decisions (A, I, and O in WebFigure 2). Based on such analyses, processes can be established to facilitate exchanges between actors and/or agencies to achieve effective management (Vance-Borland and Holley 2011). Input–output models, social accounting matrices, and (computable) general equilibrium models are also useful for analyzing the financial interactions between key user groups (A in WebFigure 2). Input–output models can trace the influence of changes to one part of the SES (eg reduced agricultural production) on other parts of the system (Miyazawa 1976; Liew 2000). Moreover, these models can be extended to investigate socioeconomic interactions (I in WebFigure 2; Huang *et al*. 1994; Eder and Narodoslawsky 1999; O'Doherty and Tol 2007).

(2) Eliciting input into the planning process

Designing an appropriate process for including stakeholder input in the planning process is important in facilitating ownership and buy-in of the resulting plan; this in turn can improve implementation. All the components of the SES should feed into process design (WebFigure 1), and several design principles provide insight into the conditions more likely to lead to sustainable management (see WebTable 2). In particular, stakeholder participation in rule-making, monitoring, and graduated sanctions (eg fines imposed on an individual that become progressively higher with additional offences) are important, as is the presence of conflict-resolution mechanisms and recognition of rights (Cox *et al*. 2010). Several tools are pertinent here. Some, such as collaborative mapping tools, are increasingly common in planning (eg to assist with stakeholder participation in rule-making and monitoring; Elwood 2006; Ban *et al*. 2008; Raymond *et al*. 2009), while others have rarely been applied. For example, a process for describing and sharing mental models – the frameworks that people use to interpret and understand the world – can strengthen the success of conservation planning and draw out linkages that may not have been obvious to planners (S, A, and I in WebFigure 2; Fischer and Young 2007). In turn, sharing mental models can facilitate clear and open communication among stakeholders, aid in overcoming obstacles to incorporating multiple sources of knowledge into planning, enable shared ownership of a conservation plan (ie rule-making), and improve social assessments (Biggs *et al*. 2011). A range of techniques can be used to illustrate and elicit mental models from stakeholders, including content analysis, procedural mapping, task analysis, cognitive mapping, and consensus analysis (Carley and Palmquist 1992; Biggs *et al*. 2008).

There are also numerous methods for eliciting stakeholder values and preferences when constructing goals and objectives as a basis for joint rule-making and conflict-resolution (eg A, I, and O in WebFigure 2). For example, deliberative democratic methods allow groups of people (eg through citizens' juries) to discuss their values (Niemeyer and Spash 2001). In these types of methods, rather than treating values as static, they are conceptualized as multi-dimensional and dynamic; people's values can change when they learn from and consider the views of others (Gregory and Slovic 1997; Niemeyer and Spash 2001). By allowing multiple preferences to be expressed, such an approach is arguably more democratic (Rowe and Frewer 2000), equitable (Rippe and Schaber 1999), inclusive of stakeholders, and more able to take collective values and ethical concerns into account than when one only considers economic or biodiversity values (Niemeyer and Spash 2001).

Multi-criteria decision making (MCDM) methods (eg Kiker *et al*. 2005; Ananda and Herath 2009) and structured decision making can be based on one of two processes to obtain the values that will be required as inputs: active deliberation (in the same vein as the deliberative democratic traditions mentioned above) and the development of metrics of value (Renn 1999; Gregory *et al*. 2001), which are then used to systematically and transparently analyze options for achieving objectives. Metrics can include dollar values, but alternatives are possible (eg grade point average) if an accepted or naturally intuitive metric is not available (Keeney and Gregory 2005). MCDM can also employ relative weighting, transforming participant preferences so they can be used in formal decision-making processes that involve explicit trade-offs (eg analytic hierarchy process, a structured technique for organizing and analyzing complex decisions). While MCDM techniques have been applied to conservation efforts in the past (Moffett and Sarkar 2006; Sarkar *et al*. 2006), there is still plenty of room to include social and social–ecological considerations (eg through the selection of stakeholder participants).

(3) Analysis, selection, and design of appropriate conservation and supporting actions for the planning context

The SES framework allows conservation planners to evaluate the relative merits of goals, objectives, or conservation actions in terms of probability of success. This evaluation would focus on

continued

WebPanel 1. – *continued*

the action situation (ie interactions leading to outcomes; I and O in WebFigure 2), thereby allowing planners to learn about which combinations of aspects of the SES framework are more likely to lead to successful implementation. The analysis, selection, and design of appropriate conservation initiatives and supporting actions should therefore be incorporated into the conservation planning process (ie all options that could lead to desired outcomes; O in WebFigure 2 should be considered). For example, in a broader context, McClanahan *et al*. (2008) focused on implications of climate change as it relates to community resilience. They developed a framework to consider site-specific susceptibility to climate change and the capacity of societies to cope with and adapt to such change. Supporting actions in this context could include transforming and adapting characteristics of SES to those that support sustainable management (eg through education or leadership programs), building capacity within communities to cope with change, and providing government assistance to increase alternative income streams that are less reliant on resource extraction.

Conservation actions are commonly thought to equate directly with the creation of protected areas, but many other possible actions are relevant, including land/water management, species management, and law and policy changes (Figure 3; Ferraro and Kiss 2002; Salafsky *et al*. 2008). Decisions about which conservation actions are most appropriate can be made in the planning stages of describing the context (stage 3, WebFigure 1), identifying goals and objectives (stages 4 and 7, WebFigure 1), and assessment and implementation (stages 8–10, WebFigure 1). Identifying relevant conservation actions is one option for explicitly considering trade-offs in benefits and costs to biodiversity and people (eg by comparing conservation options that fully protect areas to those where some uses are allowed; I and O in WebFigure 2). Indeed, cost–benefit analyses are an increasingly popular approach in conservation planning, implemented through a return-on-investment system (Wilson *et al*. 2006, 2007; Grantham *et al*. 2008; Klein *et al*. 2010). However, cost–benefit analyses are insufficient for considering equity of distribution of costs and benefits across stakeholder groups. Other decision frameworks that have been less commonly applied, such as MCDM and the deliberative democratic methods highlighted above, can be used to complement cost–benefit analyses. Furthermore, as discussed in the previous section, incorporating social objectives that support conservation could be another means of engaging users and selecting appropriate conservation plans and related actions.

To be truly effective, cost–benefit analysis requires, as input, dollar estimates of the changes in "value" that are likely to occur across all parts of a system affected by conservation actions (Adamowicz 2004), although dollar-free methods are starting to emerge. There are many non-market valuation techniques that are, at least in theory, capable of generating such estimates (Garrod and Willis 1999; Bateman *et al*. 2002; Getzner *et al*. 2005; NRC 2004; US EPA 2009), but most of these techniques are in essence weighted voting systems, with the weights being determined by dollars. As such, users of these tools implicitly accept the underlying distribution of income as appropriate, which may be highly undesirable. Some social accounting models and general equilibrium models avoid this problem by reporting physical and financial impacts separately, but there are also dollar-free techniques for assessing relative values for the various trade-offs (Larson 2010). Research in this area is relatively new but may have much to offer, particularly when comparing the values of stakeholders with vastly different incomes.

An important advance, particularly in a social–ecological context, is multi-dimensional trade-off analysis of ecosystem services (I and O in WebFigure 2; Gatto and de Leo 2000; Chan and Ruckelshaus 2010; Nelson and Daily 2010). As Gatto and De Leo (2000) pointed out, choices can be made between alternatives, even if those alternatives have non-comparable metrics. Following this logic, resource economists have introduced the concept of efficiency frontiers into conservation, for example demonstrating how alternative land-use configurations can be represented in terms of expected impacts on biodiversity (represented on one axis, in units of expected number of surviving species) and market values associated with agriculture, managed forestry, and rural-residential use (represented on a second axis, in units of dollars; Polasky *et al*. 2008). More recent advances include the representation of multiple ecosystem service values, including carbon sequestration, storm peak management, soil conservation, and water quality, modeled on land-use and biophysical habitat data (Nelson *et al*. 2009) or, in a coastal context, with wave attenuation for coastal protection, habitat for fishes, shrimp farming, and wood products (Barbier *et al*. 2008). Although mechanistic understanding of ecosystem service provision is primitive in many cases, where present it can be used to better understand trade-offs, and offers a promising means for ensuring that social and ecological outcomes are not represented as separate and at odds, but rather as interacting and sometimes complementary.

In addition to methods for assessing trade-offs (eg cost–benefit analysis), the selection and implementation of conservation and supporting actions can be aided by consideration of psychological factors. For example, accounting for stakeholder attitudes, subjective norms, and moral obligations (St John *et al*. 2010), emotion (Kals *et al*. 1999), social capital (Pretty and Smith 2004), incentive structures (Ferraro 2001), and cognitive biases (Johnson and Goldstein 2003) can influence how stakeholders might perceive conservation actions. This social understanding has multiple applications. For instance, knowledge of social norms can be applied to both the design of conservation payment schemes (Chen *et al*. 2009) and environmental communication and messaging (Cialdini 2003). In the parlance of SES, these are critical aspects of actors that can have substantial impacts on outcomes.

WebTable 1. Description of social science methods and tools mentioned in the text as examples relevant in systematic conservation planning

Method or tool	*Description*	*Typical source of data*	*Sample of relevant reference(s)*
Institutional analysis and development framework	Conceptual framework used to examine existing institutional arrangements (in the broad sense of institutions as mechanisms and structures of social order and cooperation governing the behavior of individuals), and how these influence people's collective behavior.	Normally requires surveys and interviews as new primary data.	Imperial (1999); Ostrom (2005)
Social network analysis	Mathematical approach used to investigate the structure of a group based on ties between individual actors. Social networks analysis can provide insight on sharing of knowledge and nformation of natural resource management.	Data collected by surveys or interviews.	Crona and Bodin (2006); Vance-Borland and Holley (2011)
"Green" input–output (IO) models, social accounting matrices, and computable general equilibrium (CGE) models	These models represent the way in which different sectors of the economy interact with each other, and with the environment. They thus allow one to determine how a change to one part of the system impacts other parts of the system, both initially and as a series of "knock-on" effects.	These models are extremely data intensive. Some relevant data are occasionally collected by government agencies, but often such models need to be built over time as data are collected.	Miyazawa (1976); Huang *et al.* (1994); Eder and Narodoslawsky (1999); Liew (2000); O'Doherty and Tol (2007)
Cognitive mapping	A process by which individuals acquire, store, recall, and decode information about the relative locations and attributes of the everyday spatial environment.	Necessary to collect primary data through interviews.	Kitchin (1994); Delisle *et al.* (2009)
Collaborative mapping, participatory geographic information systems (GIS)	Combines a range of geo-spatial information management tools and methods, such as sketch maps and GIS, to represent peoples' spatial knowledge. Maps are used as interactive vehicles for spatial learning, discussion, information exchange, analysis, and decision making.	Necessary to collect primary data, conduct semi-structured interviews, and/or workshops.	Elwood (2006); Ban *et al.* (2008); Raymond *et al.* (2009)
Mental models	Mental models are the cognitive frameworks that people use to interpret and understand the world. A range of techniques can be used to illustrate and elicit mental models, including content analysis, procedural mapping, task analysis, cognitive mapping, and consensus analysis.	Necessary to collect primary data through individual or group interviews.	Carley and Palmquist (1992); Biggs *et al.* (2011)
Deliberative democratic methods	Deliberative democratic methods can take many forms (eg citizens' juries and panels, deliberative polling), but can largely be described as decision-making processes involving inclusive problem-focused dialogue. Each such method creates a forum for the sharing and generation of ideas and opinions.	Data collected through open discussion by stakeholders can be supplemented by primary data describing the problem under consideration.	Smith (2003); Carpini *et al.* (2004); Baber and Bartlett (2005)
Multi-criteria decision making (or analysis)	Multi-criteria decision making encompasses many methods (eg ranking and weighting algorithms) that provide a framework and means to select and facilitate choices among alternatives using stakeholder judgments.	Typically this involves an objective, a set of alternatives, and criteria on which alternatives are to be judged. These can be stakeholder derived or not and involve single or multiple decision makers. Primary data are often needed to evaluate an alternative's fulfillment of specific criteria.	Kiker *et al.* (2005); Giove *et al.* (2009)
Cost–benefit analysis	Technique for ensuring that decision makers consider both the costs and the benefits of change, thus striving to ensure that choices maximize net benefits (benefits minus costs), not just benefits.	Requires data on both costs and benefits of choices. Non-market valuation studies are often used to collect some of the data, but financial data from private businesses or governments about the implementation costs are often required, necessitating primary data collection.	US EPA (1999); Adamowicz (2004); Mishan and Quah (2007); Boardman *et al.* (2009)

continued

WebTable 1. – *continued*

Method or tool	*Description*	*Typical source of data*	*Sample of relevant reference(s)*
Non-market valuation methods – examples include (but are not limited to): (1) Valuation techniques that use market prices of associated goods/services, for example to analyze changes in value, loss of earnings, or replacement cost. (2) Revealed preference techniques. (3) Stated preference techniques, such as contingent valuation or choice experimentation/modeling.	Techniques for estimating the relative financial value or "worth" of goods and services which do not have market prices but are nonetheless of "value". Revealed preferences are those that people can reveal by their habits.	Normally requires surveys and interviews as new primary data.	Garrod and Willis (1999); Bateman *et al*. (2002); Getzner *et al*. (2005); NRC (2004); US EPA (2009); WRI (2011)
Consideration of psychological factors	Knowledge of how affected stakeholders might perceive conservation actions and behave in response might increase the probability of effective implementation. This includes, for example, more nuanced understandings of effective incentives, stakeholder attitudes, and communication and policy framing.	Necessary to collect primary data through individual or group interviews. If possible, field experimentation may also be informative.	Saunders (2003); Clayton and Brook (2005); Saunders *et al*. (2006); St John *et al*. (2010)

WebTable 2. Description of the design principles that characterize robust institutions for managing common pool resources (adapted from Ostrom [1990] and Cox *et al*. 2010)

(1a) Clearly defined boundaries: individuals or households who have rights to withdraw resource units from the common-pool resource (CPR) must be clearly defined.

(1b) Clearly defined boundaries: the boundaries of the CPR must be well defined.

(2a) Congruence between appropriation and provision rules and local conditions: appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions.

(2b) Congruence between appropriation and provision rules and local conditions: the benefits obtained by users from a CPR, as determined by appropriation rules, are proportional to the amount of inputs required in the form of labor, material, or money, as determined by provision rules.

(3) Collective-choice arrangements: most individuals affected by the operational rules can participate in modifying the operational rules.

(4a) Monitoring: monitors are present and actively audit CPR conditions and appropriator behavior.

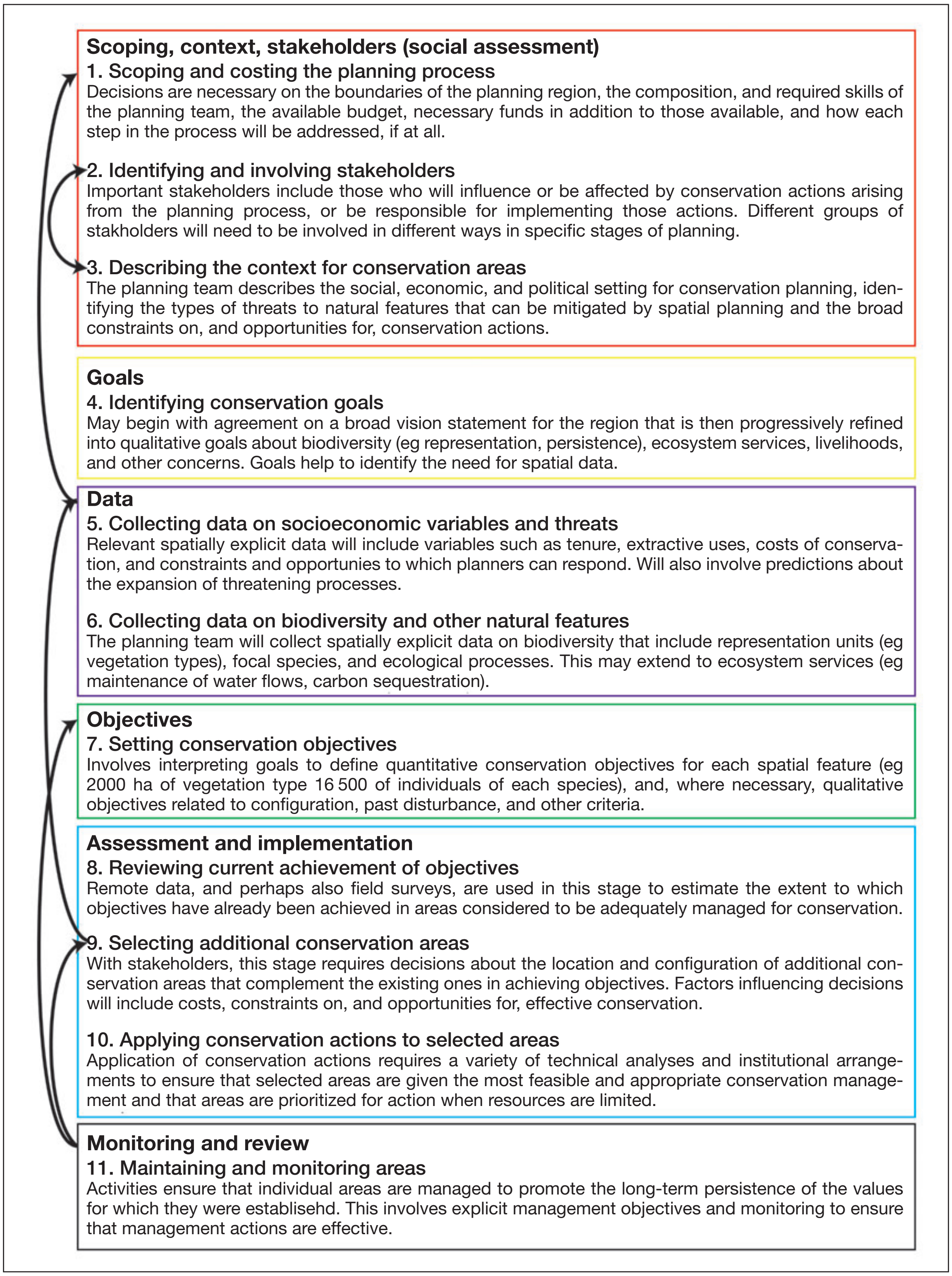
(4b) Monitoring: monitors are accountable to or are the appropriators.

(5) Graduated sanctions: appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and context of the offense) by other appropriators, officials accountable to these appropriators, or both.

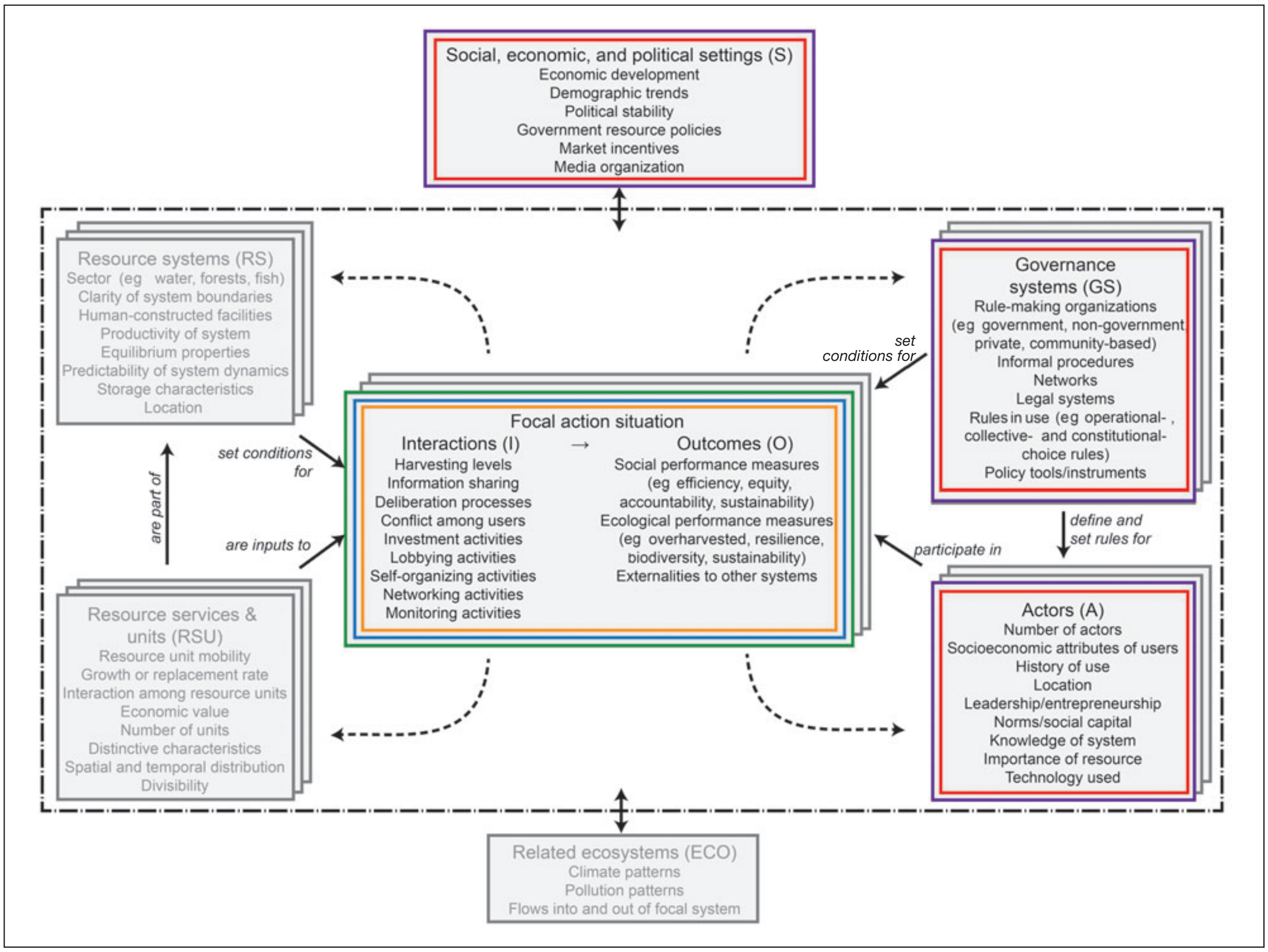
(6) Conflict-resolution mechanisms: appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials.

(7) Minimal recognition of rights to organize: the rights of appropriators to devise their own institutions are not challenged by external governmental authorities.

(8) Nested enterprises: appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.



WebFigure 1. *Details of the systematic conservation planning framework outlined in Figure 2a. Description of the stages is taken from Pressey and Bottrill (2009). The colors depict categories of stages which link to colors in WebFigure 2; arrows represent feedback loops between categories of stages, or, where arrows enter boxes, feedback loops between specific stages.*



WebFigure 2. *Details of the social–ecological system (SES) framework outlined in Figure 2b. The boxes depict second-level variables for each heading, as outlined by Ostrom (2009, 2010) and as currently proposed (E Ostrom pers comm). The colors link the social–ecological subsystems to planning stages in WebFigure 1, in which the corresponding social considerations are particularly likely to be important. Grey text relates primarily to ecological considerations, which we do not discuss here. Solid arrows indicate direct links and dashed arrows are feedbacks. The dashed box denotes the action situation embedded in a broader SES; the multiple versions of boxes symbolize that there can be multiple subsystems for each action situation. The text in italics interprets direct links.*

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