Effective conservation planning requires learning and adaptation

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Conservation decisions often involve uncertainty about the underlying ecological and social systems and, in particular, how these systems will respond to the implementation of conservation actions. Future decision making can be improved by learning more about these systems and their responses to past conservation actions, by evaluating the performance of the actions being undertaken. This is a "passive" adaptive management approach to conservation. However, the purposeful and experimental application of different conservation actions can yield greater knowledge through more rapid and targeted learning. This is an "active" adaptive management approach to conservation. Improving future management decisions through learning should be viewed as essential to all conservation plans. Unfortunately, the incorporation of explicit learning processes within the greater framework of conservation planning processes is rare. Here, we provide an overview of factors to consider when attempting the implementation of an adaptive approach to conservation planning, along with ideas for future research.

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Over the past two decades, an increasingly systematic approach to planning, decision making, and management has become "best practice" in conservation (Margules and Pressey 2000). The field of "systematic conservation planning" is concerned with the creation and implementation of spatially explicit conservation actions, ranging from strict protected areas to temporary off-reserve management activities using clearly specified objectives (Margules and Pressey 2000). A substantial set of theoretical and practical guidelines for maintaining biodiversity and ecosystem function have been developed (Margules and Sarkar 2007), as well as several operational models that use these guidelines to provide direction for practitioners when undertaking systematic conservation (eg Margules and Pressey 2000; Knight *et al.* 2006; Figure 1). However, uncertainty hinders our ability to predict the responses of social and ecological systems to planned conservation actions (Gunderson and Holling 2002).

In a nutshell:

- There has been a general lack of discussion on how to incorporate learning processes into conservation planning, to reduce uncertainty regarding which actions to apply
- Information can be gained by reviewing past actions, but effective learning is more likely to result from experimentation
- Potential advantages include identifying the best conservation instruments on private land and creating temporary protected areas that move to where the greatest benefits can be achieved
- Incorporating learning and adaptation into conservation planning can be challenging and requires a change in the mindset of people and institutions

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Uncertainty can be reduced through learning, as it gives people the opportunity to adapt to changing dimensions and knowledge of social–ecological systems (Fazey *et al.* 2007). Of particular relevance to conservation planning are processes of social learning (Knight *et al.* 2006; Fazey *et al.* 2007). Social learning can be defined as a process of iterative reflection designed to improve knowledge that supports collective action, and which occurs through partnerships where experiences and ideas are shared with others. It is an ongoing process of "learning by doing" (Keen *et al.* 2005). Reflecting on the learning process, so as to encourage new learning, is an especially important activity, but one that is rarely used effectively for conservation planning initiatives. Social learning processes aim to increase the human capacity to solve problems and adapt to changing conditions (Holling *et al.* 1978), and thus are essential components of operational models in establishing a collective capacity for adaptive management (Salafsky *et al.* 2002).

Adapting conservation actions in response to new knowledge, termed "adaptive management" (Holling 1978), is now seen as a critical part of effective conservation practice (Parma 1998). Adaptive management principles have been applied broadly in other fields related to conservation, including protected area management

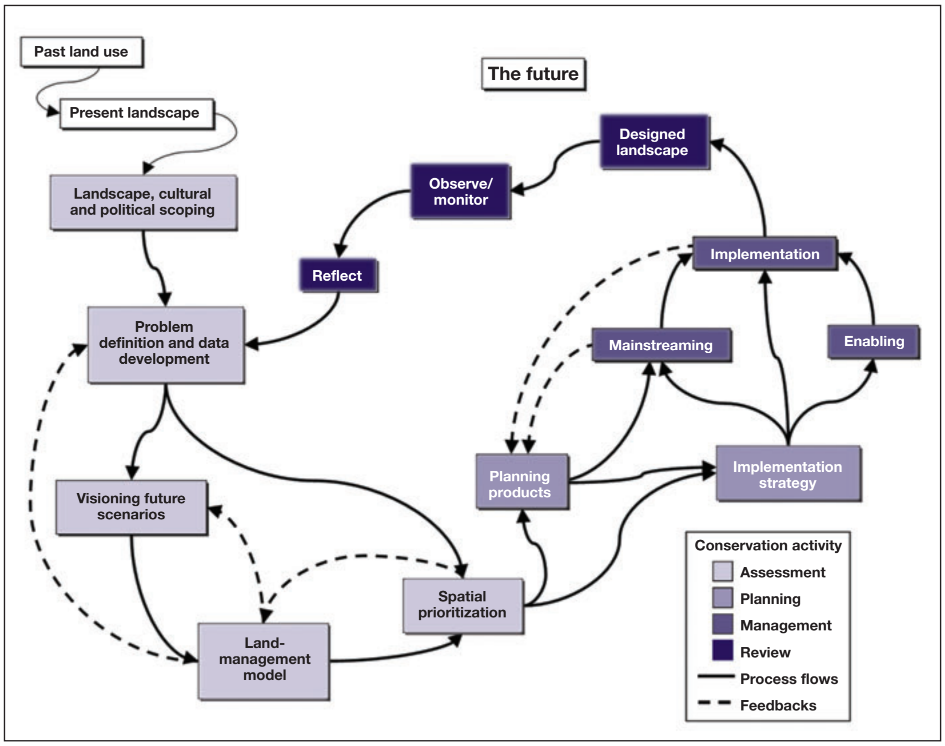

***Figure 1.** An example of an operational model for conservation planning, which explicitly comprises phases of assessment, planning, and management. Adapted from Knight* et al. *(2006).*

(Biggs *et al.* 2003), natural resource management (Savory 2001; McCarthy and Possingham 2007; Lyons *et al.* 2008), and urban design (Felson and Pickett 2005). However, existing operational models for conservation planning offer limited direction on how adaptation should take place. To become adaptive, individuals need to learn in a variety of ways (Fazey *et al.* 2007). Explicit detailing of the techniques, personnel, and institutions required to implement adaptive conservation planning is essential for ensuring that learning is both rapid and effective, and leads to better decision making.

Learning is a process, rather than a single event, in which conservation planners gain knowledge to make better decisions. Our intention here is not to provide a new operational model for conservation planning, but to suggest ways in which existing operational models can explicitly integrate learning processes and thereby promote the flexibility to adjust conservation plans as learning evolves. We also discuss why we believe that more effective conservation decisions are likely to result from active experimentation and evaluation of different conservation actions, and why more research is needed.

■ Adaptive conservation planning

Conservation plans constitute prioritized actions in space and time. Ideally, priorities are complemented with a process for developing an implementation strategy in the context of stakeholder collaboration. In the process of conservation planning, the planning team: (1) defines specific objectives that facilitate the attainment of conservation goals in an efficient and effective manner; (2) applies decision-support tools that help guide where, how, and when conservation actions should occur; and (3) allocates responsibilities for how implementation will occur (Possingham *et al.* 2001; Knight *et al.* 2006). Adaptive conservation planning explicitly acknowledges uncertainties in the conservation planning process, and addresses them through learning.

Decision-making processes can be formulated as a structured decision analysis. This is often done through a comparative analysis of the relative effectiveness of alternative actions. This requires explicitly stated objectives and an understanding of the potential consequences of, and constraints on, conservation actions (Lyons *et al.* 2008). Decision analysis tools, such as computer-based models and algorithms (Possingham *et al.* 2001) or approaches based on expert opinion (eg Mittermeier *et al.* 1995), can help determine which actions are best, while uncertainty can be reduced through monitoring and the evaluation of different actions (Nichols and Williams 2006; Kapos *et al.* 2008). Conservation plans are rarely implemented quickly, and should therefore be able to incorporate adaptations to change as more is learned about the effectiveness of different actions within a region.

■ Adaptive management and learning

Learning and adaptively refining a conservation planning process can occur in two ways – passively or actively (Holling 1978; Parma 1998). If the conservation planning process proceeds only by reviewing the performance of previous and current actions, and then altering future actions in response, then it is termed "passive"; this is the most common form of adaptive management. An emerging discipline in conservation biology is "active" adaptive management, which seeks to balance both short-term management objectives and formal learning processes, so as to achieve optimal long-term management/conservation outcomes. In this way, active adaptive management is a form of management that values learning, because of its ability to optimize management/conservation outcomes in the long term. For example, different conservation instruments, such as the acquisition of land or monetary incentives to landholders, can be trialed, and their costs and benefits compared within a region. There is now a large body of literature on adaptive techniques for natural resource management (Holling 1978; Parma 1998), but surprisingly little discussion of its principles and applications in the field of conservation planning (but see Salafsky and Margoluis 1999; Salafsky *et al.* 2002). The Open Standards, created by The Conservation Measures Partnership, are designed to help guide practitioners when developing learning programs (Figure 2).

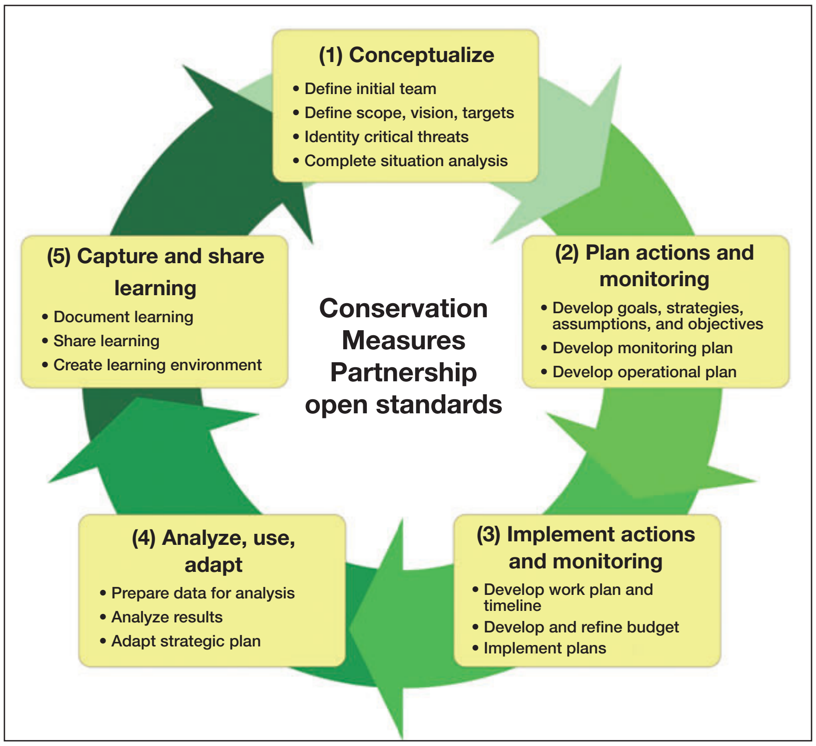

Figure 2. *The Open Standards Project Management Cycle. These are from the Conservation Measures Partnership. The standards are five steps that comprise the project management cycle: (1) conceptualizing the project vision and context; (2) planning actions and monitoring; (3) implementing actions and monitoring; (4) analyzing data, using the results, and adapting the project; and (5) capturing and sharing learning. It is a constantly evolving framework. Information can be found at www.conservationmeasures.org/CMP/.*

An active approach to adaptive conservation planning often requires experimental manipulation. Randomized trials that test particular strategies and approaches are a robust method, but despite their popularity in the medical and social sciences, they have rarely been applied in conservation (Sutherland *et al.* 2004; Ferraro and Pattanayak 2006). This might be due to the perceived permanence of many conservation decisions; for example, it is extremely difficult to reverse decisions about the establishment of protected areas. Similarly, there are limited opportunities to replicate actions in different places under controlled conditions, if each place is different ecologically and socially and in time and space, making it harder to learn general relationships and principles. This might also be due to the general absence of long-term conservation planning programs, inadequate funding, or a lack of appreciation for the importance of adaptive management.

Ferraro and Pattanayak (2006) suggest that an alternative to randomization experiments may be the application of quasi-experiments, where reasonable alternative case studies are compared and eliminated through careful analysis of the outcomes of similar conservation scenarios. Practitioners trained in traditional randomized testing may feel uncomfortable with this approach to learning, as the actions might not have been planned for comparative purposes (see Panel 1, Figure 3). Nevertheless, valuable insights into the effectiveness of different strategies can be gained, and represent a substantial improvement over lack of knowledge or personal preference (Sutherland *et al.* 2004; Pullin and Knight 2005).

Learning and adaptation will be accelerated through the evaluation of conservation actions in different regions (Figure 4). This includes learning through systematic scientific reviews (Sutherland *et al.* 2004; Pullin and Knight 2005), but also through more informal discussion among practitioners. Examples of learning networks include the IUCN's World Conservation Learning Network (www.wcln.org) and The Nature Conservancy's ConserveOnline (http://conserveonline.org).

Future research priorities

Four issues are particularly important for targeting research to improve adaptive conservation planning.

(1) How much investment in learning is required?

Decisions on how and when to invest in learning should take into account the likely costs, in terms of both time and money, and the potential benefits, in terms of improved conservation (Salzer and Salafsky 2006). Too much time and too many resources spent gathering data to inform learning can mean that areas of high conservation value are degraded before agencies feel they have learned enough to make decisions with confidence. Alternatively, if there is inadequate learning, opportunities and efficiencies may be lost (Grantham *et al.* 2009). Ideally, data collection should occur continually and conservation plans refined accordingly. Gerber *et al.* (2007) provide one of the few studies that have applied an adaptive decision-support system that continually updates both a model and a conservation plan through time, in this case specifically for leopard groupers (*Mycteroperca rosacea*) in the Sea of Cortez.

While adaptively monitoring ecological systems is commonly cited as a way to potentially improve conservation plans, human factors are also important when deciding how much to invest in learning (Cowling and Wilhelm-Rechmann 2007). First, human capital (eg education, skills, knowledge, and leadership) can affect the ability of institutions to understand the importance of adaptive management and their ability to implement it effectively

Panel 1. A comparative approach to learning about different conservation strategies

Data on comparing different conservation strategies can lead to important advances in understanding their effectiveness. McClanahan *et al.* (2006) compared the success of three different approaches to monitoring marine protected areas (MPAs) in Indonesia and Papua New Guinea (Figure 3). Effectiveness was compared by measuring the total biomass of commonly targeted reef fish between areas of conservation management and areas without conservation management. Large positive differences indicate a more effective conservation outcome. Surprisingly, they found evidence that community-based management was more effective than the widely proposed traditional approaches to MPAs. This was despite protected reefs being periodically opened to fishing in the community-based protected areas.

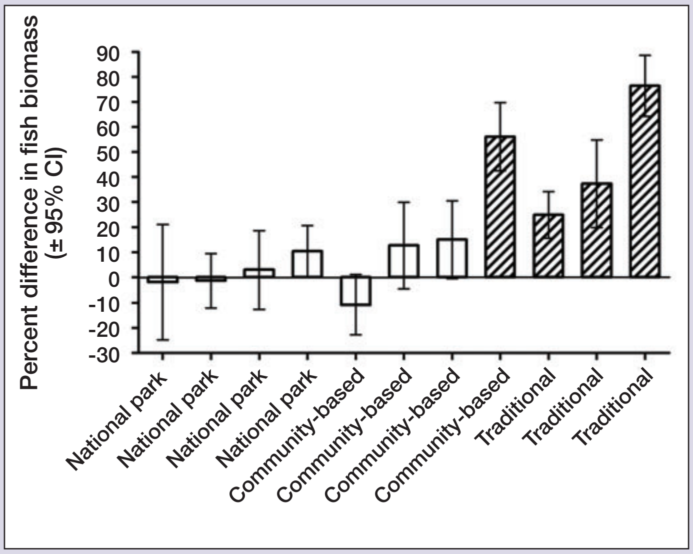

Figure 3. *The total biomass of commonly targeted reef fish between areas of conservation management and areas where there was no conservation management, showing the percentage difference (± 95% CI) between the two. Hatching indicates those with statistically significant differences. Large positive differences indicate a more effective conservation outcome. From McClanahan* et al. *(2006).*

(Brunckhorst 2002). Second, the institutions and organizational structures required to repeatedly gather, analyze, and evaluate the information supporting adaptive management in the long term must be established and managed. This can be complicated, especially in large organizations, such as government agencies, where various sections are often responsible for different aspects of the adaptive management process (eg setting policy, gathering data, implementation and evaluation).

(2) What are the advantages of learning and adapting in conservation planning?

Here we describe situations where adaptive conservation planning might lead to improved decisions.

Opportunities for implementing effective conservation actions can, and typically do, emerge unexpectedly (Knight and Cowling 2007; McDonald-Madden *et al.* 2008). For example, private landowners may be willing to engage in voluntary conservation agreements following changes in their economic circumstances, or when incentives are offered by conservation organizations. Conservation planners need to be able to adapt to conservation opportunities as they arise and, where possible, encourage the emergence of new opportunities (Knight and Cowling 2007). Recognizing opportunities has led to new research on adaptive decision rules, devised to help achieve objectives in a dynamic context (eg Turner and Wilcove 2006). So far, however, these methods have not incorporated the option of waiting for new opportunities or ways of creating opportunities (but see McDonald-Madden *et al.* 2008). Because conservation can involve irreversible losses, there is a complex and poorly understood tradeoff between acting on current opportunities and waiting for, or finding, new ones (Grantham *et al.* 2009).

To increase opportunities, experimental application of different conservation instruments can help conservation planners to learn about the factors that define conservation success under a range of different circumstances, thereby reducing the gap between conservation plans and their implementation. In regions where private land ownership is high, rapid advances in securing conservation goals are more likely to occur through the implementation of temporary or non-binding conservation measures, such as off-reserve conservation actions, along with other, more permanent approaches, such as land acquisition (Murphy and Noon 2007). This is because a major constraint to implementation is the ability to take advantage of opportunities (eg landowners' willingness to sell their land, be involved in specific management instruments, participate in specific programs, or collaborate with specific stakeholders; Moore *et al.* 2001).

A variety of instruments may be available to a conservation agency, including governmental regulation, tax breaks, voluntary agreements, and market-based incentives. An active adaptive approach would be to apply and compare all instruments experimentally, to learn their costs and benefits, since more effective decisions are likely to result from the application of a mix of instruments and no one instrument can be the universal panacea for conservation problems (Knight *et al.* 2006). There are few examples that describe the application of this type of approach.

Conservation agencies are regularly forced to manage inefficient protected area networks because previously implemented protected areas were designated on an ad hoc basis (Pressey 1994). While it is understandable that conservation agencies might be hesitant to remove pro-

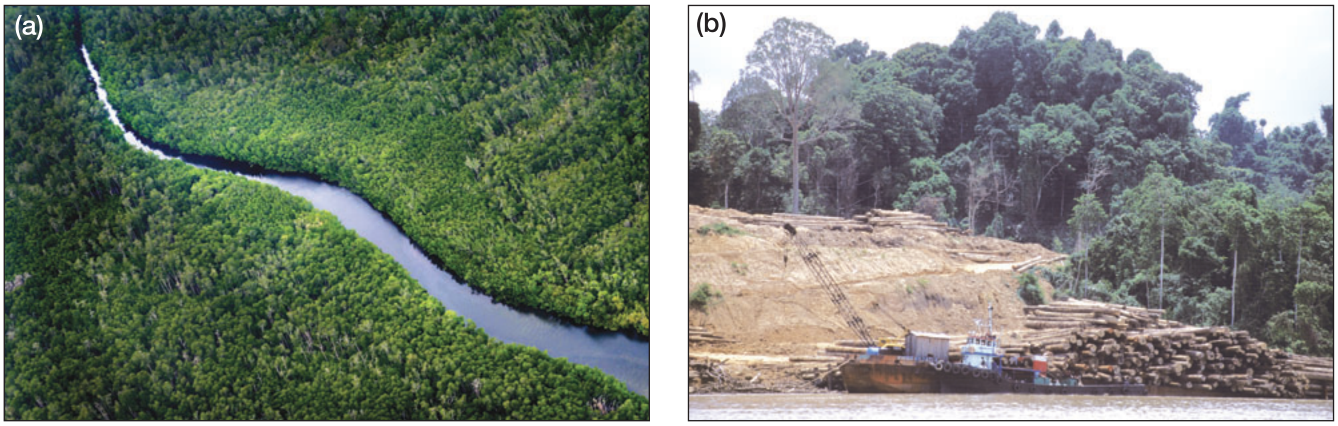

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Figure 4. *(a) Sungai Wain Forest Reserve in East Kalimantan, Borneo, Indonesia, and (b) forest logs loaded on a barge on the Berau River in East Kalimantan. In the East Kalimantan region, The Nature Conservancy is monitoring the success of different forest management practices. The knowledge gained through this monitoring is used to make decisions about the nature of future conservation investments in the region, and to provide lessons for other regions.*

tection from existing protected sites, areas managed for conservation cannot operate optimally if past decisions are not reversible. As more information is gathered, planners should be able to adapt the areas managed for conservation to ensure the best use of scarce conservation resources. Reversal of protection requires careful consideration, as protected areas may fall prey to alternate priorities, or even genuine abuse, by corrupt or misinformed governments and conservation agencies.

For some ecosystems, such as grasslands, biodiversity can recover relatively quickly from disturbance so that the benefits of protection are subject to diminishing returns. Adaptively relocating temporary protected areas to where return on investment is high may lead to the greatest improvement in the overall health of the system. This approach could be made independent of the condition of the ecosystem, through periodic rotations (Cinner *et al.* 2006), or dependent on the condition of the system, through monitoring, to learn where the greatest benefits of protection can be achieved. This adaptive approach has been successfully applied to restoration projects and fisheries management initiatives (Parma 1998).

The ability to shift conservation actions can help secure dynamic ecological processes. This is because such processes may require a dynamic approach in areas managed for conservation (Bengtsson *et al.* 2003). Such areas may be spatially or temporally variable; examples include maintaining a mosaic of succession types (Bengtsson *et al.* 2003) and tracking highly migratory species (Hobday and Hartman 2006; Grantham *et al.* 2008). Dynamic protected areas will require a conservation plan to be continually updated, depending on the state of the system.

(3) What are the challenges facing learning and adaptive conservation planning?

Implementing active adaptive conservation planning may be socially and politically challenging. For example, the need to investigate a suite of possible conservation actions could lead to the temporary application of suboptimal conservation actions and clearly indicates a lack of understanding. This could be hard to justify to funding bodies and the general public. The long time frames needed for evaluating alternative actions for some conservation outcomes might not match the time frame of a conservation project; furthermore, it can be difficult to separate the effect of conservation actions from changes that would have occurred anyway (Saterson *et al.* 2004; Ferraro and Pattanayak 2006).

Although there are benefits to having a diversity of approaches to conservation (Redford *et al.* 2003), it is important to separate current best practice from less effective strategies. For agencies that rely on public funding, we recognize that it can be difficult to develop conservation strategies that are both informed by good science and marketable to funders, who are often uncomfortable with the uncertainty implied by adaptive management approaches.

Stakeholders, particularly those benefitting from, or negatively affected by, the implementation of specific conservation instruments, may be unhappy with changing circumstances. For example, those receiving payments as the result of a temporary protected area might lose income if it is moved elsewhere. Landowners whose production activities are curtailed when a temporary protected area shifts onto their property can be equally unhappy. Specific strategies are required to overcome stakeholders' disappointment or resentment.

Negative outcomes of conservation projects are often underreported, as the stigma of failure may lead to diminished future financial support or professional embarrassment (Redford and Taber 2000), but a bias toward only reporting successful conservation actions will compromise our ability to learn. There is also uncertainty about the proportion of scarce resources that are necessary for the successful application of adaptive conservation, and the opportunity and transaction costs involved in implementing a conservation action which may then be reversed. Other impediments include the challenge of securing a change in the mental models of individuals required for implementing an adaptive approach; for example, the reversal of existing protected areas that are not in the most advantageous places for conservation, an issue that many conservationists consider heretical (Fuller *et al.* 2010).

Implementing learning systems and adaptive management will require refinement of existing institutions and practices within organizations. In some – perhaps many – cases, there will be resistance to these changes, because they might shift a power balance or increase a person's workload, are not generally supported, or simply because people dislike change. Implementing adaptive conservation planning is ultimately a social process, and so managing people is likely to be the greatest challenge.

(4) How can conservation theory and practice be more closely linked?

Our capacity to learn can be improved by linking theory and practice. Participatory action research should be embraced, that is, where research questions are sourced from practitioners and not from academic theory. The learning that is central to adaptive management is gained from post hoc analysis of previous conservation actions. Effective scientists move consciously and routinely between the operational and conceptual perspectives of their discipline, to ensure that application informs theory and vice versa (Knight *et al.* 2006). This will be most accurately and effectively achieved by linking the peer-reviewed literature to practitioners' activities.

■ Conclusion

Conservation planning is a dynamic process, the science of which has generally focused on one-time-only assessments of optimal protected area configuration. We suggest a shift is needed, toward a more adaptive approach to the conservation planning process. By deliberately including learning in the conservation planning process, future conservation decisions are likely to be more effective, as uncertainty may be reduced. Although not comprehensive, we have outlined several areas where we believe more research is needed. This will necessitate a shift by conservation planners toward greater self-reflection, a focus on process as opposed to outputs, and improved collaboration with those implementing adaptive conservation planning.

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