Improving the Practice of Conservation: a Conceptual Framework and Research Agenda for Conservation Science

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Abstract: *Effective conservation requires addressing three fundamental questions whose answers can only be sought in conservation practice: (1) What should our goals be and how do we measure progress in reaching them? (2) How can we most effectively take action to achieve conservation? and (3) How can we learn to do conservation better? This essay provides a conceptual framework and research agenda for a conservation science that uses the principles of adaptive management to answer these questions. The framework is based on a general model of a conservation project. The conservation target involves defining the specific area or population the project is trying to influence. This target is affected by direct and indirect threats and opportunities; we provide a table of potential direct threats. Conservation actions that are taken to counter these threats can be divided into approaches, strategies, and specific tools; we present a comprehensive table of potential approaches. Finally, the practicioners that take these actions include individuals, organizations, project alliances, and networks; we define the specific functional roles necessary to achieve effective adaptive management. We then use this framework to outline a research agenda for conservation science that involves defining clear and practical measures of conservation success, determining sound guiding principles for using conservation strategies and tools, and developing the knowledge and skills in individuals and organizations for good adaptive management and thus for making conservation more effective.*

Mejoramiento de la Práctica de la Conservación: un Marco Conceptual y un Programa Para la Ciencia de la Conservación

Resumen: *La conservación efectiva requiere trafar tres preguntas fundamentales cuyas respuestas solo pueden encontrarse en la práctica de la conservación: 1) ¿ Cuales deben ser nuestras metas y como medimos el progreso en alcanzarlas? 2) ¿ Cómo podemos realizar acciones más efectivas para lograr la conservación? y 3) ¿ Como podemos contestar a llevar a cabo mejor la conservación? Este ensayo proporciona un marco conceptual y un programa de investigación para una ciencia de la conservación que utiliza los principios del manejo adaptativo para responder estas preguntas. El marco se basa en un modelo general de un proyecto de conservación. El objetivo de conservación involucra la definición del sitio específico o población afectada por el proyecto. Este objetivo es afectado por amenazas directas e indirectas; proporcionamos una tabla de amenazas directas potenciales y otros factores. Las acciones de conservación que se realizan para contrarrestar estas amenazas se pueden dividir en aproximaciones, estrategias y herramientas específicas; presentamos una extensa tabla de aproximaciones potenciales. Finalmente, los actores que pueden participar incluyen individuos, organizaciones, alianzas de proyectos y redes que practican la conservación; definimos los papeles funcionales específicos necesarios para alcanzar un manejo adaptativo eficiente. Luego utilizamos este marco para delinear un programa de investigación para la ciencia de la conservación que involucra la definición de medidas claras y prácticas del éxito de la conservación, determinando principios conduc-*

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tores sólidos para utilizar estrategias y herramientas de conservación, y el desarrollo de conocimiento y habilidades en individuos y organizaciones para realizar un buen manejo adaptativo y por lo tanto aprender lograr se hace una conservación más efectiva.

> In the varied topography of professional practice, there is a high, hard ground where practitioners can make effective use of research-based theory and technique, and there is a swampy lowland where situations are confusing "messes" incapable of technical solution. The difficulty is that the problems of the high ground, however great their technical interest, are often relatively unimportant to clients or to the larger society, while in the swamp are the problems of greatest human concern.
>
> Donald Schön (1983)

Three Fundamental Questions Facing the Practice of Conservation

It is difficult to imagine a problem that merits greater human concern than the conservation of biodiversity. As we humans have become increasingly conscious of the inextricable link between our own survival and that of the many species around us, the field of conservation has taken on a new sense of urgency. Yet despite large investments—decades of work, hundreds of projects, thousands of trained professionals, and millions of dollars—progress in conservation has been slow and erratic. We have yet to fully discover the secrets of effective conservation: forests are still burning, coral reefs continue to be dynamited, wildlife populations are overharvested, urban sprawl worsens, and our global climate is changing with unpredictable consequences. We are mired in Schön's (1983) "swampy lowlands" dealing with confusing "messes," and it seems there is no compass, path, or map to help us find our way.

Scientific research could help us navigate this terrain. Until recently, however, most research has focused on the relatively "high, hard ground" of conservation biology. This work has been effective at answering some basic questions. For example, research on the question of which species and ecosystems are most imperiled has led to a vastly enhanced understanding of species and the complex ways in which they are interrelated as well as to lists of endangered and threatened species and ecosystems (World Conservation Union 1996; Dobson et al. 1997*b*; Association for Biodiversity Information 2001). Likewise, answering the question of where we should take action has catalyzed a whole cottage industry of priority-setting exercises designating areas of conservation importance (e.g., Ricketts et al. 1999; Sullivan Sealey & Bustamante 1999), identifying hotspots and ecoregions where critical species can be protected (e.g., Myers 1988; Dinerstein et al. 1996; Myers et al. 2000), and developing methods for siting reserves (e.g., Pressey et al. 1993; Prendergast et al. 1999).

Much more difficult, however, are three messy but fundamental questions whose answers must be sought in the biological, social, economic, and institutional lowlands of conservation practice: (1) What should our goals be and how do we measure progress in reaching them? (2) How can we most effectively take action to achieve conservation? (3) How can we do conservation better? To date, the professional conservation community has answered these questions inadequately. Collectively, we have not been very successful in defining clear, measurable goals for our work to guide us in our endeavors. We have not been able to systematically develop operational principles that can help us understand which actions work, which do not work, and why (Pullin & Knight 2001). And we have not enabled most individuals and institutions to develop the knowledge and skills needed to make conservation more effective.

In this essay, we suggest that a conservation science based on the compass of adaptive management (Lee 1993) can help answer these fundamental questions. This applied discipline draws on both biological and social sciences to support conservation practitioners in their work. We first present a basic model of a conservation project to provide a framework for understanding the practice of conservation. We then use this model to outline a research agenda for conservation science that involves collaborating with practitioners to answer these questions and improve the practice of conservation.

A Framework for Understanding the Practice of Conservation

Because conservation involves combining both natural ecosystems and human societies, conservation practitioners are dealing with systems that are extremely complex. Furthermore, the urgent nature of the problem demands that they take immediate action despite the risks inherent in our lack of certainty about how best to proceed. Over the past few decades, different fields dealing with complex systems have developed convergent approaches for deciding how to take action in the face of risk and uncertainty (Salafsky et al. 2001). Examples include adaptive management of ecosystems (Lee 1993;

Gunderson et al. 1995), reflective practice (Schön 1983), and the theory of learning organizations (Senge 1994). In this essay, we use the term "adaptive management" to refer to this type of approach within conservation.

Adaptive management combines research and action. Specifically, it is the integration of design, management, and monitoring to systematically test assumptions in order to adapt and learn (Salafsky et al. 2001). If one were to define a spectrum with pure research at one end and pure practice at the other, then adaptive management would be in the center. Pure researchers seek to understand how the world works and are successful if knowledge increases, regardless of what happens to the system they are studying. Pure practitioners seek to change the world but do not invest effort in trying to understand the system in which they are working. Adaptive managers attempt to reconcile these viewpoints: they want to change the world and achieve a defined goal, but they are also willing to invest effort in systematically learning about whether their actions work or do not work and why.

Given the complex nature of the systems in which conservation operates, the urgent need for action, and the current lack of information as to how to best proceed, we take as a given that effective conservation ultimately requires an adaptive management approach. Adaptive management is thus both a learning technique that we urge conservation practitioners adopt and a guide to our own inquiry in this paper.

A key tenet of adaptive management is that when dealing with a complex system, practitioners must first describe it in a relatively simple conceptual model to be able to both understand and efficiently change the system. This model records current understanding and provides a common language through which people with different perspectives can discuss the situation. Following this tenet, Fig. 1 presents a general model of a conservation project. In this context, the term "project" refers to any set of actions undertaken by a group of practitioners to achieve some defined end (Margoluis & Salafsky 1998). The scale of a conservation project can thus range from actions by a local community to conserve a sacred grove over a couple of months to efforts by an international conservation group to conserve biodiversity in all of Africa over decades. We provide details of the various parts of the general model (Fig. 1) as a framework for understanding the practice of conservation.

In laying out our framework, we are defining a set of terms for conservation work. Wherever possible, we have used terms from other similar efforts, including, in particular, the Conservation by Design framework developed by The Nature Conservancy (2000*a*, 2000*b*). In some places, however, we have used different terms where we feel they are clearer. We focus on terminology because it is essential that all people involved in this type of work have a common language with which to describe the systems that they are working with or at least the ability to translate accurately between different sets of terms.

Biodiversity as the Conservation Target

The starting point for any project is to define the specific conservation target that the project ultimately would like to influence (Margoluis & Salafsky 1998). In the general model of a conservation project (Fig. 1), the target is biodiversity. In most projects, this biodiversity is defined as the species and ecosystems in a specific area, the scale of which can range from a small pond to an entire continent. For some projects, however, the targeted biodiversity cannot be tied to specific places, but must be regarded as a stand-alone entity (e.g., populations of migratory birds or pelagic fish). In some cases, defining a specific area or population to manage may be fairly straightforward, such as the biodiversity in a given national park. In most cases, however, such definition is surprisingly difficult (Salafsky et al. 1999).

Integrated conservation and development projects present a difficult challenge in defining a target because, by definition, they have multiple targets related to both conserving biodiversity and improving human welfare. As a rule, in these cases, it is operationally easier to develop separate conceptual models for each target. In doing so, one generally finds that sustainable development concerns appear as factors affecting conservation targets, and vice versa. In other words, conservation is a necessary but not sufficient condition for sustainable development, and sustainable development is a necessary but not sufficient condition for conservation. Here, we restrict ourselves to cases in which biodiversity appears as the target and do not enter into the entire debate over conservation versus sustainable use (World Conservation Union et al. 1991; Robinson 1993; Redford & Richter 1999).

In addition to defining the conservation target, it is also useful to describe its state or condition. Researchers have worked hard to find ways to describe the state of biodiversity in a given site, and there is not much we can add to these efforts. Following Noss (1990) and Redford and Richter (1999), we subdivide biodiversity into components that include genetic diversity, species/population diversity, and ecosystem/community diversity. Each of these components can be discussed in terms of its composition, structure, and function. In our models, we focus on attributes of specific species and ecosystems because they are easiest for practitioners to monitor over time; The Nature Conservatory's Ecological Integrity Assessment is one example of this type of methodology (Parrish et al. 2002).

Human Activities as Threats

The next part of the model identifies the threats and other factors that affect a project's conservation target. Taken together, the target, threats, and other factors com-

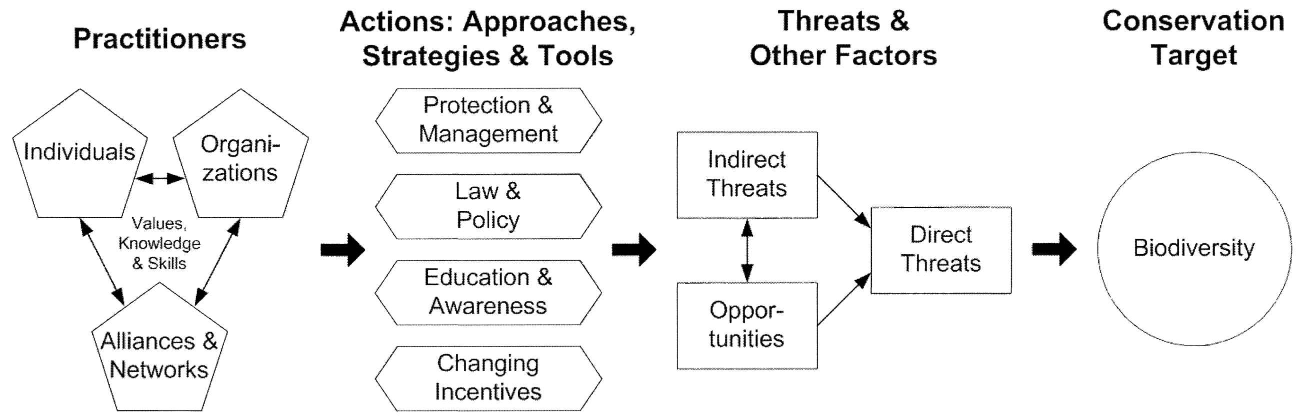

Figure 1. A generalized model of a conservation project.

prise the initial project situation. In this model, we explicitly assume that all threats to biodiversity are linked to human activities, following the compositionalist argument outlined by Callicott et al. (1999), which states that *"Homo sapiens'* acquisition of culture has propelled the species out of nature's ambit" so that "any human modification of nature is unnatural."

In the general model (Fig. 1), direct threats are the factors that negatively affect biodiversity (for example, commercial logging or overfishing by local community members). When it comes time to counter the threats, it will be important to know who or what is causing which threat. Thus, in listing direct threats, it is important to specify who or what is behind them: logging by local people to build their houses is a different threat than logging by large industrial companies, even if it is the same people cutting down the trees in each case. In general, it is convenient to divide direct threats into internal threats caused by people who live on or near the site and external threats caused by people who live some distance away. Behind these direct threats are indirect threats and opportunities that are the drivers that lead to the direct threats (for example, poverty, local people's lack of education and awareness, or resource management institutions).

Table 1 presents a taxonomy of different types of direct threats and is meant to provide a general guide to categories that project managers can review to make sure that they have identified all the threats at their specific site. It is not practical in the context of our general model to provide a table of indirect threats and opportunities, which would contain all factors related to human populations, livelihood activities, and governance mechanisms. Ultimately, however, it may be possible to develop common "chains" of causally linked factors that lead to specific direct threats, as shown in Fig. 2. Part of the art and skill of building a specific model for any given project involves determining which factors are relevant and thus worth explicit inclusion. In Fig. 2, for example, a site-based project designed to address clearcut logging must take into consideration world timber prices as an external variable. Although prices are important, the project cannot affect them because they are determined by world timber prices or demand. Project managers may therefore want to show world prices in their model because this factor may influence their ultimate success and needs to be monitored, but they may choose not to worry about depicting the factors in the chain further to the left. On the other hand, project managers may be able to do something about the factors influencing local community members' knowledge about their legal rights with respect to the forest and would thus want to include these factors in their model.

Conservation Actions: Approaches, Strategies, and Tools

The third part of the model shows the conservation actions that project managers can use to change the project situation. Selecting the right actions to achieve conservation may seem like a simple task, but it can in fact be quite difficult. Traditionally, conservationists employed one broad approach: direct protection through the establishment of parks or by limiting harvest of key species. Over time, they began adding other approaches to their tool kit, including legal and policy reform and environmental education efforts. And still more recently, conservationists have begun trying to find economic and other incentives that would induce stakeholders to act to protect and conserve biodiversity.

As shown in the general model (Fig. 1), conservation actions can be broadly grouped into four categories: direct protection and management, law and policy, education and awareness, and changing incentives. Table 2 contains a taxonomy of specific tools in each of these categories. Determining what to call a "tool" can be difficult. If we think about organizing a carpenter's toolbox, we could first subdivide its contents into broad functional categories such as tools designed to turn fasteners. Within this broad functional category, there are general types of tools such as wrenches or screwdrivers. And these general types of

Table 1. A preliminary taxonomy of direct threats to biodiversity.

General threats[a]	Examples of specific direct threats[b]: forest	savannah, grasslands, deserts	freshwater	marine
Ecosystem elimination[c]				
conversion to agricultural land	swidden plots, farms, plantations, ranches	farms, ranches	farmland reclamation	aquaculture
economic development	roads, dams, urban areas, settlements	roads, dams, urban areas, settlements	dredging, diking, filling, urban areas	dredging, diking, filling, urban areas
harvesting ecosystem elements	clearcut logging, chip and pulp mills	severe overgrazing	extensive water diversion	intensive coral mining, bottom trawling, drift netting
mineral extraction	mining, oil drilling	mining, oil drilling	mining, oil drilling	mining, oil drilling, deep sea mining
climate change	severe fires, drought, hurricanes	severe fires, drought	drought, salizination	temperature fluctuation, sea-level fluctuation
Ecosystem degradation[c]				
partial conversion	selective logging	grazing	water diversion	coral mining
pollution	acid rain, toxic chemicals, litter, radioactive fallout	radioactive fallout	acid rain, sewage, toxic chemicals, flotsam	sewage, sediment, toxic substances, oil spills, radioactive fallout
human presence	tourism, off-road vehicles, war and military activity	tourism, off-road vehicles, war and military activity	commercial and recreational boats, war and military activity	dive tourism, cyanide and bomb fishing, war and military activity
ecosystem disruption	fragmentation, fire, fire suppression, predator removal	fragmentation, fire, fire suppression, predator removal	change of salinity patterns	coral bleaching, predator suppression
exotic species	introduction or escape of plants and animals	introduction or escape of plants and animals	ballast water, introduction or escape of plants and animals	ballast water, introduction or escape of plants and animals
Species decline and elimination				
overexploitation of species	hunting, gathering	hunting, gathering	fishing, hunting	fishing, hunting
physical disturbance	disruption of nesting, disruption of migration	disruption of migration	disruption of migration, power-plant intakes	disruption of migration, disruption of reproduction
pathogens	disease and pollution effects	disease and pollution effects	disease and pollution effects	disease and pollution effects

[a] *Direct threats in a generic sense.*
[b] *Examples of the threat in different types of biomes.*
[c] *Rows are not completely mutually exclusive: for example, there is obviously a gray area between ecosystem elimination and degradation.*

tools can be further subdivided into actual tools such as 10-mm socket wrenches or large flat-head screwdrivers. In a similar fashion, Table 2 contains a taxonomy of broad approaches and more-specific strategies. Beneath each of these strategies, but not shown in the table, are the actual conservation tools that conservation practitioners use. For example, conservation projects do not set up enterprises or even linked enterprises in a generic sense. Instead, they set up specific businesses such as community homestays or forest-guiding services.

Specific strategies and conservation tools under each approach can be defined based on the scale at which the tool is being used and the practitioner using it, among other factors. Under the strategy "reserves and parks," for example, a project could use tools that include large parks administered by a national government, medium-sized reserves managed by a private organization, and small community-run sacred groves. Under the strategy "media campaigns," a project could use tools that include global television advertising campaigns on Cable

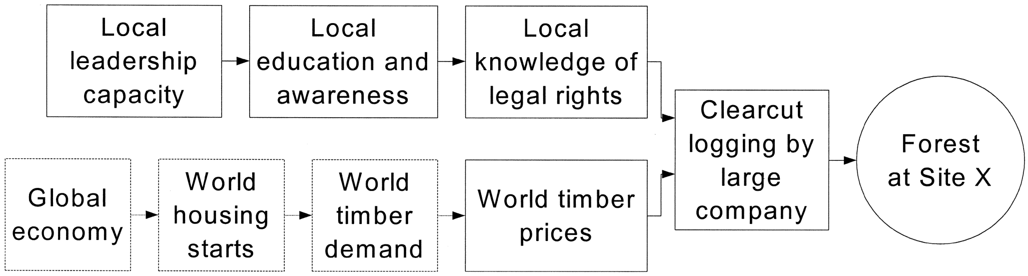

Figure 2. Example of a causal chain of factors affecting a conservation target.

News Network or efforts to write letters to the editor of a small-town newspaper.

In establishing a taxonomy of conservation actions, our goal was to be comprehensive at the level of the approaches, meaning that all conservation tools could fit somewhere in the cells in Table 2 or at least in a modified version of the table. One consequence of our attempt to be comprehensive is that although all the cells in the table are at a similar level, they may not have the same number of tools in them (the problem is analogous to having a biological genus that has only one or two species versus a genus that has hundreds of species). Beneath the level of the approaches, however, the table provides only a couple of examples of strategies and is not comprehensive. Future versions of Table 2 should provide practitioners with a detailed list of tools they have at their disposal to counter threats at their project site. If we have learned one thing, however, it is that there is not one tool that will lead to conservation at all sites, or even at any one site over time. Instead, practitioners need to employ the appropriate mixture of tools to counter the specific threats to biodiversity at the site where they are working. To do so, they need to know the conditions under which each tool works and under which it does not.

Practitioners and Their Values, Knowledge, and Skills

The final part of the model (Fig. 1) shows the practitioners that take conservation action at any given project site. Analogously to the way that Callicott et al. (1999) describe ecosystems, we can think about these practitioners from both compositional and functional perspectives.

From a compositional perspective, at the most basic level, actions are undertaken by individuals who value conservation and have the skills and knowledge to make it happen. Individuals involved in conservation include resource users, field practitioners, program and portfolio managers, researchers, donors, and policymakers. At the next level, individuals are generally affiliated with organizations, which include nonprofit organizations, government agencies, for-profit firms, universities and research centers, and foundations. Within each of these categories, organizations can be further subdivided based on size and primary focus (e.g., local vs. global). Most organizations do not undertake conservation projects on their own. Instead, at the next level they form project alliances with other organizations to implement specific projects. These alliances can take different forms, including informal collaborations, contractual agreements, partnerships, and consortia (Margoluis et al. 2000). Finally, at the highest level, are various networks that enable individuals, organizations, and alliances to work and exchange information with one another. Networks include informal working groups, organizational families, learning portfolios, and academic societies.

Table 3 describes the practitioners that practice conservation from a functionalist perspective, listing the knowledge and skills required for good adaptive management, which we believe is required to achieve effective conservation. There are five fundamental functional roles that a project team (or organization or alliance) needs to fill to undertake effective adaptive management: design, management, monitoring, analysis, and communications. Each role requires people with certain knowledge and aptitudes and specific programmatic and administrative skills.

A Research Agenda for Conservation Science

Any model of a complex system is necessarily a simplification of reality. The test of a model is the extent to which it helps promote understanding of both the current conditions of the system and ways of influencing the system to reach a desired outcome. We used our general model to propose a research agenda for conservation science based on answering the three fundamental questions we posed at the beginning of this paper.

What Should Our Goals Be and How Do We Measure Progress in Reaching Them?

In developing an operational definition of conservation success, it is helpful to consider as an analogy the practice of medicine. Over the past centuries, doctors have developed operational definitions of what it means for an individual to be healthy. With this goal in mind, doctors then use various indicators such as temperature and blood pres-

Table 2. A preliminary taxonomy of biodiversity conservation approaches and strategies[a]

Protection and management	*Law and policy*	*Education and awareness*	*Changing incentives*
*Protected areas** reserves and parks: IUCN categories I & II (Kenya Wildlife Service) private parks (Langholz et al. 2000)	*Legislation and treaties** developing international treaties (Convention on Biological Diversity) lobbying governments (Sierra Club)	*Formal education**[c] developing school curricula (World Wildlife Fund Windows on the Wild) teaching graduate students (Jacobson 1990)	*Conservation enterprises** linked: e.g., ecotourism (Salafsky & Wollenberg 2000) unlinked: e.g., jobs for poachers (Salafsky & Wollenberg 2000)
*Managed landscapes**[b] conservation easements (Gustanski 2000) community marine protected areas (Parks & Salafsky 2001)	*Compliance and watchdog** developing legal standards (Convention on Trade in Endangered Species) monitoring compliance w/standards (TRAFFIC)	*Nonformal education**[c] media traning for scientists (Jacobson 1999) public outreach via museums (Domroese & Sterling 1999)	*Using market pressure** certification: positive incentives (Forest Stewardship Council) boycotts: negative incentives (Rainforest Action Network)
*Protected and managed species** bans on killing specific species (Convention for Regulation of Whaling) management of fur-bearing mammals (Freese 2000)	*Litigation** criminal prosecution (U.S. Fish & Wildlife Service) civil suits (Sierra Club)	*Informal education**[c] media campaigns (Greenpeace) community awareness raising (Public Interest Research Groups)	*Economic alternatives** sustainable agriculture and aquaculture (Margoluis et al. 2001) promoting alternative products (Viagra instead of rhino horn)
*Species and habitat restoration** reintroducing predators (U.S. Fish & Wildlife Service) recreating savannas and prairies (Stevens 1995; Dobson et al., 1997a)	*Enforcement** implementing sanctions (U.S. Fish & Wildlife Service) military actions/nature keeping (Terborgh 1999)	*Moral confrontation** civil disobedience (Greenpeace) monkeywrenching/ ecoterrorism (EarthFirst!)	*Conservation payments** quid-pro-quo performance payments (Ferraro 2001) debt-for-nature swaps (Conservation International)
*Ex-situ protection** captive breeding (zoos, aquaria, and botanical gardens) gene banking (Kew Gardens Millenium Seed Bank)	*Policy development & reform** research on policy options (World Resources Institute) advocating devlution of control (Wyckoff-Baird et al. 2000)	*Communication** environmental publishing (Island Press) web-based networking (forests.org)	*Nonmonetary values** spiritual, cultural, existenced values (Ehrenfeld 1981) links to human health (Meffe 1999)

[a] *Columns contain broad categories of tools. Each column contains five broad approaches (*) and then two examples of more specific strategies under each approach. Implementing each strategy involves using specific conservation tools (not shown). For each strategy, we also provide an example of an organization known for using this strategy and/or a reference describing and defining it. Citing specific organizations using a tool does not imply that this is the only tool this organization uses or that it is the only group using this tool.*

[b] *This category primarily includes conservation actions in lands managed for natural resource production that do not fall into IUCN categories I–V (World Conservation Union 1994).*

[c] *These terms follow those of Fien et al. (1999).*

sure to determine whether a person is healthy or sick. For example, a doctor can take a patient's temperature to see if the patient is above the norm and requires intervention such as administering aspirin. Once the intervention has been applied, the doctor can then retake the patient's temperature to see if the intervention worked as anticipated. If it hasn't, the doctor must try a different intervention. The key to this process is to have indicators that are measurable, precise, consistent, and sensitive to the phenomenon being tracked (Margoluis & Salafsky 1998). It is also equally important to have methods for collecting the indicator that are feasible, cost-effective, and appropriate (Margoluis & Salafsky 1998).

Like doctors, conservation practitioners have their own indicators, but they generally do not meet the above criteria very well. Traditional conservation indicators have focused on the condition of the conservation target (the far right-hand side of Fig. 1). Some projects initially attempt to measure elements of biodiversity directly, such as looking at the change in the number of species in a given area over time. These efforts are theoretically problematic and practically next to impossible to carry out. As a result, most projects now focus on looking at changes in the population levels of key resource or indicator species and in ecosystem area and functioning. Unfortunately, many of these biologically based indicators and methods

Table 3. Critical functional roles for conservation practitioners.*

	Functional role				
Skill type	*design*	*management*	*monitoring*	*analysis*	*communications*
Knowledge and general aptitudes	*Conceptualization* systems thinking model development problem setting	*Strategic thinking* visioning weighing alternatives	*Assumption testing* experimental design cause-and-effect thinking	*Analytical thinking* statistics computer skills	*Strategic communications* strategic thinking writing and design skills conflict resolution skills
Programmatic skills	*Situation analysis* site assessment capacity assessments *Project design* planning scenario evaluation	*Strategic planning* setting targets goals, objectives, activities *Project implementation* developing workplans setting budgets	*Develop monitoring plan* monitoring strategy indicators and methods *Assess methods* effectiveness cost-effectiveness and practicality	*Information management* data processing and storage data cleaning *Data analysis* qualitative data quantitative data	*Product planning* audience and media identification needs assessment *Product development* pilot testing techniques production skills
Administrative skills	*Coordination* facilitation partnership development proposal development	*Organizational management* personnel management financial management organizational development	*Evaluation* performance evaluations financial evaluations process tracking	*Information systems* develop and run systems database management cost-benefit analysis	*Routine communications* internal systems external reporting public relations

**Skills required for an organization to conduct effective adaptive management and therefore achieve successful conservation. Many of the skills could be assigned to different roles, but someone in the organization needs to have these skills.*

are not feasible, cost-effective, or appropriate (Salafsky & Margoluis 1999*b*).

The problems inherent in using only biological indicators, such as the area under forest cover or population levels of select species as measures of conservation success can be understood through the following simple thought experiment. Consider two similar 10,000-ha patches of forest. One is currently being used by a local community that has tenure rights over it and that practices shifting cultivation in 2000 ha and hunting in the remaining 8000 ha. The second is untouched by humans. Which one is more conserved? Obviously, using only biological indicators and methods, we would say the second one. Consider the same problem, however, with the additional knowledge that the second patch of forest is slated to be clearcut by a logging company within a year. In this case, the biological indicators clearly are not sufficient.

To develop better conservation indicators using our model (Fig. 1), it helps to define conservation goals as not only maintaining or attaining a certain biological state but also as reducing both current and future threats and developing practitioners that can use various tools to take effective action to detect and counter these threats. The challenge here is to develop indicators that can be used by practitioners at all points in this model. Practitioners can use current biological knowledge to create operational systems for assessing the health of conservation targets. One example is the measures-of-success scorecard developed by The Nature Conservancy (2000*b*). Practitioners can use the list of direct threats in Table 1 to assess changes in threats over time. An example is the threat-reduction assessment index (Salafsky & Margoluis 1999*b*). Practitioners can use the categorization of tools in Table 2 to generate measures of the process of conservation. And practitioners can use the list of skills in Table 3 to develop measurements of individual and institutional capacity to undertake effective conservation. For example, an organization could potentially develop specific criteria for attaining the status of novice or master practitioner in each of these skills. The organization could then use these criteria to develop specific diagnostic instruments that could be used by project teams to identify their own strengths and weaknesses. Based on this diagnosis, the teams could then either develop their own capacity or form alliances with other people with complementary skills. The teams could also revisit the criteria over time to monitor progress in their capacity-building efforts.

How Can We Most Effectively Take Action to Achieve Conservation?

In developing principles for using the various strategies and tools that conservation practitioners have at their disposal, let us return to our medical analogy. Doctors have a variety of tools with which to address different health problems in patients. They can prescribe various drugs, propose behavioral or dietary changes, or conduct surgery. In choosing the tools to use with a given patient, a good doctor does not make random choices, use the one cure that he or she is known for, or use the cure in fashion that year. Instead, the doctor draws on theory and knowledge about each of the tools in the medical toolbox that have been developed through a long history of clinical research. This research provides the doctor with specific knowledge about each tool: conditions under which it is likely to work, why it works, cases in which it is contraindicated, its interactive effects with other tools, its potential side effects, its cost, and its pros and cons in comparison with other options.

Similarly, effective conservation action depends on practitioners knowing about the costs and benefits of available conservation strategies and tools (Table 2). Unfortunately, conservation lags far behind medicine: we are still back in the dark ages of trial and error in which most conservation practitioners rely largely on anecdotal evidence, fashion, and gut feelings to select which strategies and tools to use (Pullin & Knight 2001). The challenge here is to link practitioners together to conduct clinical research to test and evaluate each strategy and tool, learning the conditions under which each works and does not work. Practitioners can then encapsulate this research in general and yet nontrivial principles that can be passed on to other conservation practitioners. These principles should be not only scientifically accurate but also capable of passing the practitioner's "so-what" test (Salafsky & Margoluis 2001).

This learning can be done on an informal basis within a program or network. Alternatively, in a learning portfolio, project teams can develop a formal learning framework they can use to collect a common set of data across all projects (Salafsky & Margoluis 1999*a*). Practitioners become both the researchers who work together to test assumptions about the tool and the teachers who help each other develop their individual and institutional capacity. A learning portfolio can be used to define success, develop knowledge about tools, and improve the capacity of individuals and institutions in the portfolio. One of the first examples of a learning portfolio is the Biodiversity Conservation Network, which was established to specifically test a linked enterprise–based strategy for conservation (Salafsky et al. 1999, 2001). Other learning portfolios are now being formed to test strategies such as locally managed marine areas, wildlife management, and ecotourism (Foundations of Success 2001).

How Can We Learn to Do Conservation Better?

Our final question concerns developing the capacity of individuals and institutions for adaptive management so they can continue to learn and improve on their own. The field of medicine has pure researchers who conduct basic scientific investigations and, at the other end of the spectrum, those such as physicians and nurses who practice medicine. Between theoreticians and practitioners, medicine has a vast network of applied researchers who take pure research and turn it into effective tools for practical use. These applied researchers also work with clinical partners to study their patients and test the efficacy of different tools under different conditions.

There is a long tradition of applied research in many fields associated with biodiversity conservation, including wildlife management, natural resource management, and development. And there are a number of universities that train students in effective conservation and organizations that work on developing the skills of their staff. But it could be argued that this role is not yet fully developed for biodiversity conservation. Furthermore, we cannot afford to divorce the researchers from the practitioners. The challenge is to develop conservation practitioners with adaptive-management knowledge and skills (Table 3) who can serve as the applied researchers for conservation science (Jacobson & Robinson 1990). This knowledge and these skills can be developed by promoting the use of adaptive management at three levels: the project, the portfolio, and the discipline.

Project-level adaptive management involves ushering a conservation project through the complete adaptive-management cycle (Margoluis & Salafsky 1998; Salafsky et al. 2001). Instead of merely trying different actions, practitioners first think about the conditions and threats at their project site. They then develop a specific set of goals, objectives, and activities that outline the tools they will use to address the threats. Next, they develop a monitoring plan that outlines the assumptions behind the tools they are using and details what data they need to collect to test these assumptions. They then implement their actions, collect and analyze the data they specified, and communicate their findings to the appropriate audiences. This process helps them adapt and improve their project, learn from both their successes and their failures, and develop their capacity. The challenge is to develop and improve systems for project-level adaptive management such as the conservation-by-design approach used by The Nature Conservancy (2000*a*) or the measures-of-success approach described by Margoluis and Salafsky (1998).

Program or portfolio-level adaptive management involves going through a similar cycle with a group of projects in a network or learning portfolio, as described in the previous section. In addition to sharing their experiences and pooling their knowledge about the conservation tools they are using, project managers can also help one another develop their capacity. A key challenge is not only building the capacity of specific individuals and organizations in the network or portfolio (what we might term "first-order" capacity building), but also building the capacity of teachers who can in turn train all the members of the network or portfolio ("second-order" capacity building). Examples of this second-order capacity building are the portfolio- coordination teams being developed in learning portfolios (Foundations of Success 2001).

Finally, discipline-level adaptive management involves linking conservation research practitioners around the world. It also includes developing journals and other mechanisms through which practitioners can exchange information and experiences, such as the articles published in "Conservation in Practice" in *Conservation Biology* and in the magazine *Conservation in Practice.* Ultimately, it involves developing a body of knowledge—the discipline of conservation science—that can be shared, taught in schools, and improved over time. The challenge is to develop this discipline. Following the tenets of adaptive management, we hope that the definitions, assumptions, and proposals inherent in the framework and research agenda we have presented can serve as starting points for an emerging theory of conservation science that will be refined and improved over time.

Conclusions

We have outlined three main challenges for the discipline of conservation science: (1) to define clear and practical measures of conservation success, (2) to determine sound guiding principles for using conservation strategies and tools, and (3) to develop the knowledge and skills in individuals and organizations for practicing adaptive management and thus making conservation more effective. Meeting these challenges are the foundations of success that will ultimately improve the practice of conservation.

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