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Conservation priorities: identifying need, taking action and evaluating success

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"What I decided I could not continue doing was making decisions about intervening when I had no idea whether I was doing more harm than good"

Archie Cochrane

Introduction

Conserving biodiversity requires identifying and addressing the myriad of problems generated when humans exploit natural resources. This challenge is ongoing and expensive in terms of time, money and access to the necessary expertise. Needs invariably outweigh resources, and actions require prioritization on multiple fronts. Conservation also needs approaches that enable more effective objective setting, as well as critical evaluation of conservation actions and of the extent to which targeted problems are solved.

Although there might seem to be room for some optimism given the increased investment in protected areas, sustainable forest management, and the management of invasive species, the rate of biodiversity loss does not appear to be slowing (Butchart et al. 2010; Secretariat of the Convention on Biological Diversity 2010). In addition, information on the nature and scale of conservation problems is accumulating faster than our ability to process it and respond effectively. Current rates of biodiversity loss

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exceed estimates of historical rates by several orders of magnitude (Millennium Ecosystem Assessment 2005). Species extinctions are invariably associated with direct drivers, such as habitat loss and overexploitation, though secondary extinctions can readily be triggered by the initial loss of species that provide key ecosystem functions. Interaction effects between land use and climate change also present increasingly complex challenges for global conservation (Iwamura et al. 2010).

Conservation is part of a continuous cyclical process in which management activities are implemented in spite of uncertainties about their effectiveness. This process typically starts with the detection of the decline or degradation of an aspect of nature that we value. Once this change has been identified, conservation goals can be set, such as an area of habitat to be protected, a wetland area to be restored or species decline to be arrested or reversed. When goals are made clear, interventions can be selected and implemented, and their relative success or failure assessed in order to inform future action. In this cycle of doing and learning, conservation decision making ultimately involves some scientific evaluation of the effectiveness of past efforts to guide future actions (Pullin & Knight 2001; Knight et al. 2006).

Priority setting in conservation research and action will always reflect human-oriented values and be forever changing and contested, not least as baselines of human values shift and other societal priorities change. Nevertheless, science can be a potent guiding force in informing decision making and can help improve the cost-effectiveness of conservation practice. Conservation science is just one component of the overall decision-making process. Economic, social and political considerations also play a role and may determine the outcome. For example, decisions concerning which species and habitats are worth saving are strongly influenced by the necessarily subjective values of individual stakeholders, as well as by the political and socio-economic opportunities and constraints of the region of concern. Science can advise on which are likely to be the most cost-effective solutions for conserving the giant panda, for instance, but this information is only one factor in deciding how much money should be spent on its conservation, or the way in which available funds should be spent.

Table 1.1 Example summary of steps and processes that might be included in a decision-making framework

Steps	**Processes**
Objective setting: desired trends, targets, time frame	Social process: priority assessment, stakeholder consultation, ethics approval
Solution scanning: identify potential interventions, actions	Expert process: consultation, workshops
Effectiveness assessment: comparison of previous intervention performance	Evidence-based process: evidence synthesis, predictive models
Cost-effectiveness assessment: value from investment	Evidence-based process: economic assessment, planning models
Outcome evaluation: programme evaluation	Mixed methods process: quantitative and qualitative data analysis

In this opening chapter, we first explore ways in which priorities for both conservation action and research emerge and are evaluated. Recognizing that conservation is ultimately a societal process underpinned by values and beliefs, we describe how decisions about resource allocation for conservation actions can be informed by explicit use of scientific evidence in decision-making frameworks. Decision-making frameworks are composed of a set of transparent principles and criteria that can help evaluate the pros and cons of alternative choices, thereby facilitating the identification of cost-effective actions (Table 1.1).We end by outlining future challenges to the development of decision-making frameworks for conservation that encompass policy, management and research.

Identifying need for action

Effective conservation depends on identifying priorities for specific research and/or action. As described in this section, these are typically verified by one of two routes. The first route is more reactive and involves the detection, through surveillance monitoring, of a change in status of a taxon, species group, habitat or ecosystem. The second route is more proactive and works by identifying potential threats that may cause significant negative changes in the future.

Detection of ecological changes

Surveillance monitoring, whether of changes in habitats, species or even life history attributes of particular species, can sometimes detect unexpected and important changes useful for prioritizing conservation activity (whether for action or research). For example, long-term data on the widespread declines of sea turtles (Crouse et al. 1987) have motivated the discovery, development and implementation of innovative solutions such as turtle exclusion devices on shrimp trawlers. In another example, the UK Common Birds Survey (now, with a change in methodology, the Breeding Birds Survey), which was set up in 1962 partly to identify changes in bird populations from direct organophosphate pesticide poisoning, has played an important role in detecting a range of other issues requiring action. These include bird responses to agricultural change and changes in woodland management, as well as to changing conditions in the African wintering grounds (Newson et al. 2009).

Even when ecological changes are detected, the challenge remains of how to interpret and communicate the significance of monitoring data. Biodiversity indices that combine a range of trend data are increasingly used to represent broader changes in the environment, and are often welcomed by policy makers responsible for setting high-level targets. For example, in 2000 the UK government set a target of reversing the decline of farmland birds by 2020. One of the reasons why this target was selected over others was that a single index was available for tracking whether or not the desired changes were taking place. On a global scale, the Living Planet Index (Loh et al. 2005) and other composite indices are being used to track progress towards reducing the current rate of biodiversity loss (Secretariat of the Convention on Biological Diversity 2010). In the last decade, catalysed by the Millennium Ecosystem Assessment (2005) and its political impact, there has been an increase in emphasis on measuring change in ecosystems and the services they provide to human well-being and the global economy. The Economics of Ecosystems and Biodiversity (TEEB) project, for example, has estimated monetary values for many of the headline metrics used to measure environmental change in an effort to help guide conservation policy (Sukhdev et al. 2010). This guidance includes a detailed consideration of subsidies and incentives, environmental liability, national income accounting, cost-benefit analysis, and methods for implementing instruments such as Payments for Ecosystem Services (PES). Adoption of a more ecosystem-based approach to conservation may ultimately encourage a shift in societal values and political priorities far beyond that achieved by traditional species-based conservation approaches.

Identification of the most endangered species has provided a long-standing focus for conservation research and action since the inception of the IUCN Red Lists in the 1960s (IUCN 2011; Mace et al. 2009). Red Lists of species and their conservation status were initially based on subjective expert-based threat assessments for different species groups. The Red Listing process and assessment of extinction risk have now become much more rigorous, and are based on a combination of factors involving population size, rate of decline, size of the distribution range of the species as well as other empirical measures of threat (Mace et al. 2011). More recently, Rodríguez et al. (2011) have argued the need for analogous ecosystem-level threat assessments, suggesting they may be more efficient and less time consuming than species-by-species evaluations, given that ecosystems better represent biological diversity as a whole and require fewer resources to survey. Despite concerted efforts, by 2010 the status of only 47,978 of the world's 1,740,330 known species had been evaluated for potential inclusion on the IUCN Red List (IUCN 2011).

Proactive decisions based on value and threat

Conservation priorities are commonly based on asset value (e.g. total number of species or the number of endemic species in a defined area) and/or potential threat to those assets. Brooks et al. (2006) reviewed nine major approaches for setting global conservation priorities. Most of these approaches prioritize highly irreplaceable regions, with some being reactive (prioritizing high-vulnerability, threatened areas), and others more proactive (prioritizing low-vulnerability wilderness areas). A lack of data means that it is difficult to compare these approaches in terms of their success in generating conservation funding (Halpern et al. 2006), but hot spots alone have mobilized at least $750 million of funding for conservation in these regions (Brooks et al. 2006). More specifically, conservation funding mechanisms have been established for several of the approaches, such as the $100 million, 10-year Global Conservation Fund focused on high-biodiversity wilderness areas and hot spots, and the $137 million Critical Ecosystem Partnership Fund, aimed exclusively at hot spots. The Global Environment Facility, the largest financial mechanism addressing biodiversity conservation, has since 2006 applied a Resource Allocation Framework (RAF) to prioritize its distribution of funds. The RAF allocates resources to countries based on (among other factors) their potential to generate global environmental benefits, which for biodiversity is assessed in relation to the distributions of species and ecosystems and their threat status (GEF 2005).

Given the uneven global distribution of biodiversity, prioritizing conservation efforts makes sense to ensure the 'biggest bang for our buck' (Brooks et al. 2006; Possingham & Wilson, 2005; Wilson et al. 2006). One major challenge is that different measures of conservation value are not always strongly correlated, and as such need to be given joint consideration in any priority setting exercise. For example, Funk & Fa (2010) used global vertebrate distributions in terrestrial ecoregions to evaluate how continuous and categorical ranking schemes target and accumulate endangered taxa within the IUCN Red List, Alliance for Zero Extinction (AZE) and EDGE of Existence programme. By employing total, endemic and threatened species richness as well as an estimator for richness-adjusted endemism, Funk & Fa (2010) showed that all metrics target endangerment more efficiently than by chance. However, each selects unique sets of top-ranking ecoregions, which overlap only partially, and include different sets of threatened species. From these analyses, Funk & Fa (2010) developed an inclusive map for global vertebrate conservation that incorporates important areas for endemism, richness and threat.

Providing information to support prioritization of conservation action has become something of a cottage industry, with many overlapping initiatives collating data on species and habitats, their distribution and status, and the level of protection they are afforded. Some examples are the GEO-Biodiversity Observation Network (www.earthobservations.org/geobon.shtml), the Global Biodiversity Information Facility (www.gbif.org) and the World Database of Protected Areas (www.wdpa.org). While these different databases undoubtedly provide useful information, this plethora of global information providers, well summarized by Brooks et al. (2006), overlap considerably. Such duplication may risk repeating past efforts and wasting valuable resources (Mace et al. 2000). Moreover, they do little to guide decisions on where precisely to allocate resources within large priority areas, and the types of interventions that should be attempted (Wilson et al. 2006).

Systematic conservation planning (SCP) is increasingly widely used to help solve conservation problems at a particular site. At the simplest level, SCP employs analyses of numerical data related to the distribution of biodiversity to aid decision making and optimize allocation of effort (Margules & Sarkar 2007), but it can also involve the application of decision-making frameworks. At the landscape scale, Wilson et al. (2007) have shown that combining information on the spatial distribution of conservation objectives and the cost-effectiveness of actions can achieve more efficient allocation of resources (see section on 'Taking action' below).

However, there is currently a serious mismatch between the development of these methodologies and their use by conservation implementation bodies (global, governmental and non-governmental). Knight et al. (2008) reviewed 88 published conservation plans and found that two-thirds failed to deliver any conservation action. Much of this shortcoming can be attributed to the researchers themselves, as many studies were academic and did not plan for practical and regionally specific implementation (Knight et al. 2008). However, the converse situation is also true in that numerous conservation plans that are implemented are not supported by any systematic or peer-reviewed study. Part of the reason for this is that incentives for conservation bodies to evaluate the success of their investments are often lacking. Achieving the necessary cultural shift in conservation planning will require critical pressure from donors and funders (including the general public) for conservation agencies to adopt and implement more transparent measures of performance (Keene & Pullin 2011).

Scientists are often aware of conservation issues that may be prominent in the future but have attracted little research or policy consideration (Sutherland et al. 2008). Providing mechanisms for the articulation and publication of such issues can become a useful tool. This process, known as 'horizon scanning', is the systematic search for incipient trends, opportunities and constraints that can affect the probability of achieving present and future management goals and objectives. Horizon scanning seeks to inform policy decisions by anticipating issues and accumulating information about them, and is employed by a number of different types of organizations, ranging from the military to, more recently, conservation scientists. As examples, these exercises identified issues such as a step change in pressure on land for agricultural production (Sutherland et al. 2008), high-latitude volcanism (Sutherland et al. 2010) and fracking to remove natural gas (Sutherland et al. 2011a). In each case these have subsequently become high-profile issues (as exemplified by the eruption of Eyjafjallajökull soon after Icelandic volcanoes were discussed), and identifying the issues provides the opportunity to be better prepared (Sutherland & Woodroof 2009).

Since 2009 there has been an annual horizon-scanning exercise to identify global environmental issues (Sutherland et al. 2010). This has involved specialists in horizon scanning, experts in specific areas (e.g. coral reefs, diseases or invasives) as well as representatives from large organizations that have a wide range of conservation interests. The need for this is illustrated by the fact that conservation scientists apparently did not clearly foresee the major shift to biofuel in 2006 by the USA and European Union, with serious consequences for food security, climate change and biodiversity (Fitzherbert et al. 2008; Koh & Wilcove 2008). As a community, we should have seen this coming and been well prepared to contribute to the debate. Issues that are identified as being potentially important but not well recognized are debated and ranked to form a shortlist (Table 1.2). Conservation organizations have taken these issues and identified their responses using a six-point classification, from not planning to track or respond to this issue to committed to

Table 1.2 Examples of horizon-scanning issues given in Sutherland et al. (2010, 2011a)

Example	Issues
Arctic tundra burning	Increased tundra burning associated with climatic conditions, fuel availability and sea ice retreat may impact upon species and human communities, and alter the role Arctic ecosystems play in the global carbon cycle (Hu et al. 2010)
Microplastics	Plastic waste in the sea disintegrates to form tiny fragments to which chemicals may adhere; impact is poorly understood (Barnes et al. 2009)
Hydraulic fracturing (fracking)	Natural gas can be extracted from organic-rich shale basins by pumping in water at high pressure. The impact on hydrology and pollution is poorly understood (Kerr 2010)
Nanosilver	Nanoscale silver is primarily used as an antimicrobial to safeguard human health. Risk to bacteria in ecosystems and aquatic vertebrates is suggested by increased deformities and mortality of exposed zebrafish embryos (Choi & Hu 2009)
Artificial life	These new forms of life could produce vaccines and chemicals, including fuel derived from carbon dioxide. Risks, if the technology becomes widely accessible, include potential interactions with genes and species in natural communities and the potential for malicious use (Lartigue et al. 2009)
Synthetic meat	Muscle stem cells can be taken from live animals, multiplied in a growth medium and stretched to make muscle fibres, potentially shifting meat production from farmland to the factory with considerable impacts for land use (Madrigal 2008)
Assisted colonization	There is considerable debate as to whether this is creating a new wave of invasive species or whether this is an inevitable and sensible conservation measure (Ricciardi & Simberloff 2009; Vitt et al. 2009)
Promotion of biochar	Pyrolysis lessens decomposition, thus may sequester carbon over a long period. However, little is known about the impact on the soil, nor is there a detailed consideration of the source of the wood (Royal Society 2009)

responding now through practice or policy work; in many cases the sensible response is to wait until further developments occur (Sutherland et al. 2012).

Taking action: what to do with limited resources

The concept of prioritizing conservation action is easy to grasp. There are many alternatives for action (interventions) but only limited resources are available to be deployed so difficult choices have to be made. Deciding on how to spend resources depends not only on values but also on what is achievable with current knowledge (Mace et al. 2009).

In approaching this problem, it is useful to list all possible interventions (or candidate solutions) relating to an identified need or problem. One such exercise has been undertaken by Jacquet et al. (2011) who assembled an international team of marine experts to identify potential interventions for protecting the marine environment. The team listed a total of 181 potential interventions, such as 23 cost-effective ways of reducing accidental by-catch of seabirds in fishing nets. Such methods include using streamer lines or spreading shark liver oil in the water to scare birds, deploying acoustic deterrents or setting lines at the side rather than the stern to avoid birds foraging closer to the fishing vessels. Such an exercise can never be fully comprehensive, but it works as a valuable starting point to identify options for action and needs for evidence of their comparative effectiveness in achieving the desired conservation outcome.

Beyond simple listing exercises, a number of decision-making frameworks have been developed to guide the process of moving from conservation goals and potential interventions through the allocation of resources to implementation and conservation monitoring (Wilson et al. 2007; Pullin et al. 2009; Segan et al. 2010). All these frameworks have some common features including:

- a holistic conservation goal that is derived from societal values and concern about undesirable changes and losses to those values. This broad goal (e.g. conservation of tropical forests) may be translated into a more specific conservation target or objective, e.g. to halt loss of tropical forest cover by 2020
- an assumption of a limited budget being available to achieve the stated objectives, and the need to decide which strategies and objectives are most deserving of priority investment, and in which order
- a consideration of all potential interventions that are available to help achieve an objective, assuming that it is invariably necessary to adopt a complementary set of interventions
- explicit use of systematic review and evaluation of effectiveness to inform prioritization of interventions. What do we know about what works and what does not, and how was this learning achieved?
- explicit consideration of the cost-effectiveness of interventions: is the impact of intervention X worth the money compared with intervention Y or no intervention?
- the need to monitor and evaluate resource allocation decisions based on outcomes in relation to objectives (i.e. what impact did our decisions have and why?). See section on 'Evaluation success' below.

One of the most intractable problems is how to allocate funds among alternative conservation actions to address specific threats. To address this, Wilson et al. (2007) proposed an explicit 'ecoaction-specific' framework that focuses on specific objectives, and accounts for the economic costs of interventions (Figure 1.1). The approach goes beyond the decisions to protect areas or species and considers the optimal allocation of resources to specific management interventions in order to address known threats. Wilson et al. demonstrate the utility of this approach by applying it to the management of Mediterranean ecoregions, addressing threats such as invasive species and fire and comparing the likely performance of different interventions based on their cost and the likely biodiversity gain per dollar invested.

A similar approach seeks to determine appropriate interventions for the realization of high-level policy objectives (e.g. halting loss of tropical forest cover or reduction of illegal wildlife trade). Pullin et al. (2009) compared the UK National Service Framework for reducing premature death due to heart disease (the method is well established in the health services) with a potential framework for resolving biodiversity issues, such as the lessening of the impact of alien invasive species. In the health service example, targets for reducing the problem were used to generate strategic actions (such as primary, secondary and tertiary prevention and treatment). Potential interventions contributing to these strategies were then identified based on evidence of their effectiveness (from systematic reviews). For example, thrombolytic therapy has been identified as effective acute treatment, whereas cardiac rehabilitation programmes are effective tertiary prevention for those already suffering from heart disease. The implementation of the National Service Framework enabled the target of reducing premature death from cardiovascular disease by 40% from baseline (1999) to be met 5 years earlier than expected. This equates to thousands fewer premature deaths per year. Such a generic framework that guides decision making from a general policy goal to a set of specific interventions might be useful in conservation. Pullin et al. (2009) concluded that strategic actions (prevention, control and eradication in the case of invasive species) and

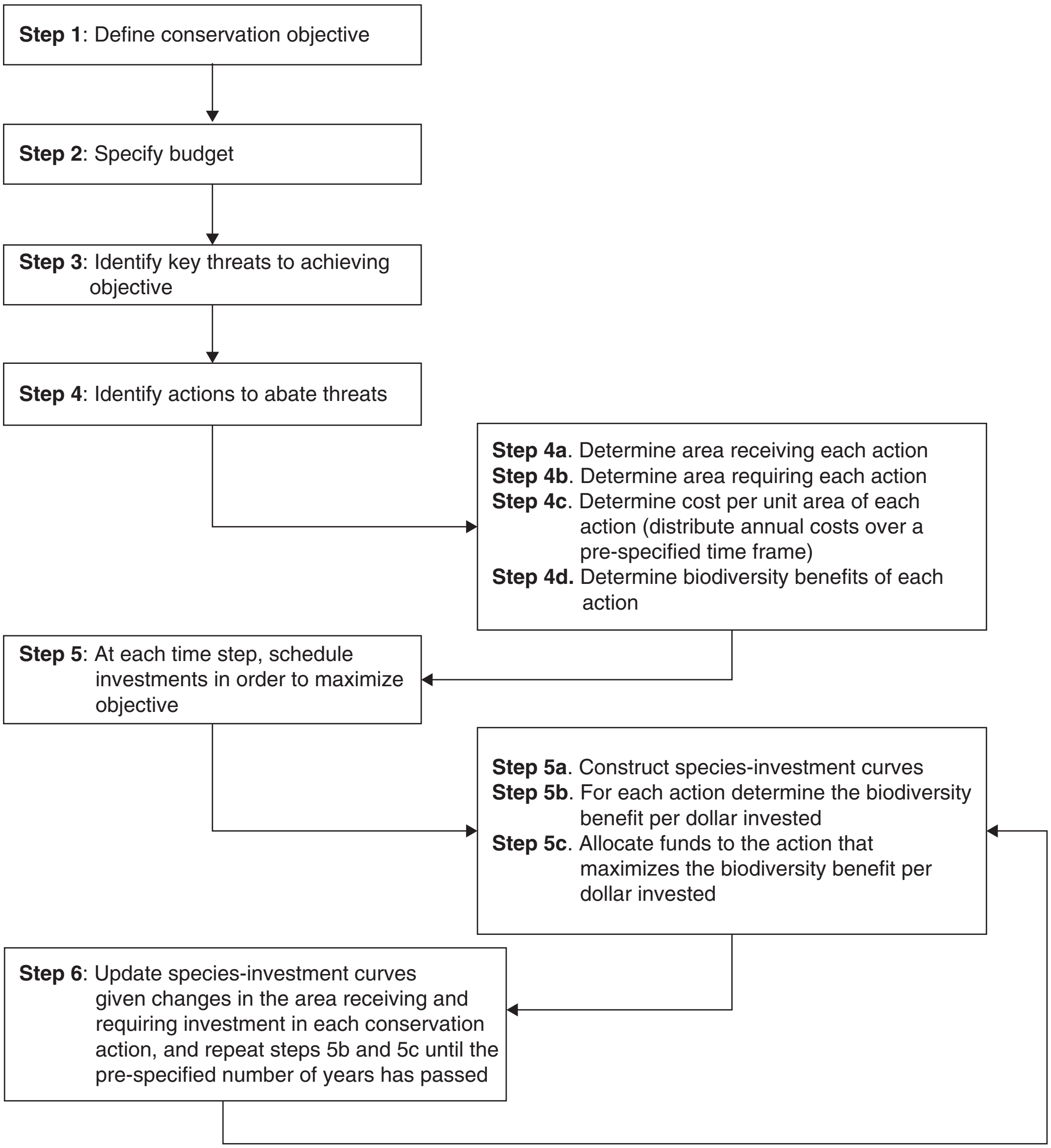

Figure 1.1 Decision steps involved in the conservation investment framework (from Wilson et al. 2007).

potential interventions (e.g. poison baiting for eradication) can readily be identified. Indeed, much of this work has been done by the IUCN Invasive Species Specialist Group. However, evidence for the effectiveness and cost of each intervention is generally lacking. The conservation community has not as yet conducted the necessary research or evidence syntheses (Pullin & Knight 2009). Consequently, it is not possible to make objective, evidence-based decisions among alternative interventions. In a similar way, Segan et al. (2010) considered the methods used by existing government structures, such as the National Institute for Health and Clinical Excellence in England and Wales (NICE), for optimizing resource allocation. In the NICE framework, any intervention is assessed against alternative interventions for achieving a specified goal, in terms of both relative effectiveness of impact and cost. Thus, for example, when protecting fish stocks, the designation of marine protected areas might be assessed against fishing quotas in terms of cost-effectiveness in delivering conservation benefits.

Taken together, the above examples combine: (1) the social process of objective setting, (2) the expert-based process of 'solution scanning', (3) assessing and predicting relative effectiveness of interventions through systematic review and evidence synthesis, and (4) the economic basis of assessing cost effectiveness (see Table 1.1).

A different challenge in planning conservation action is the question of how to measure the comparative value of success among alternative actions, in terms of both the cost of action (cost-effectiveness analysis) and the perceived value of the outcome to society. For example, what might be the comparative value of a successful wetland restoration that requires minimal future management versus the arrested decline of a large mammal that will require considerable continued investment to maintain? In health, there is a standard metric of benefit (the quality-adjusted life-year, QALY) that is recognized as both socially and economically relevant. The QALY is based on the number of years of life added by an action (intervention), and weighted by the quality of life experienced by the patient in each year (i.e. 1.0 for perfect health to 0.0 for death; a debilitating side-effect of treatment might reduce the weight to 0.5). Conservation has no such single simple metric. One useful concept developed by Wilson et al. (2006) is the 'optimal allocation of conservation effort' in which one could use a transferable metric such as the number of species conserved per unit area, but this is both difficult to measure and contestable as a universally valid standard.

Evaluating success

The realities of conservation practice mean that rigorous assessment of the results of projects and programmes is challenging for several reasons.

- *Time frames*: natural systems often take longer than the funding period to undergo detectable change.
- *Scale and context*: conservation actions may have results at different scales from those at which they are implemented and/or from the overall scale of the problem they seek to address.
- *Objective setting*: conservation actions often address multiple objectives, which are sometimes poorly articulated.
- *Attribution*: conservation action (as distinct from research) usually comprises multiple simultaneous interventions, leading to difficulties in attributing outcomes.
- *Resources*: funding agencies and natural resource managers are often reluctant to divert scarce resources from action to monitoring and research, along with uncertainty about what to evaluate and monitor (Gardner 2010).
- *Counterfactual*: rigorously assessing what would have happened without the intervention (a control or counterfactual) can be difficult.

A systematic review of the effectiveness of community forest management programmes in providing global biodiversity and local human welfare benefits found evidence for all of these problems (Bowler et al. 2010), and suggested measures to improve the quality of study designs and provide better evidence of their effectiveness in the future.

In some cases, there is also an insidious disincentive for claiming or demonstrating success in that perceived improvements may reduce the case for public, political and/or financial support for conservation action. Conversely, however, lack of demonstrable success may result in 'donor fatigue'. Furthermore, there are considerable disincentives for assessing and publicizing less successful conservation actions and the problems that explain them (Redford & Taber 2000).

Here we expand on each challenge in turn and identify some possible solutions.

Time frames

Conservation responses usually require time scales much longer than that of the intervention. For example, projects that aim to improve the status of slow-growing trees or large mammals cannot detect population changes during the time frame of the project. Species with long generation times may take decades to respond sufficiently for the effects of an intervention to be measurable above baseline variability.

Scale and context

Scale is important both in geographical terms (where and over how large an area is an intervention expected to be effective, and therefore where should it be monitored and assessed?) and in relation to the scale of the problem. How should practitioners assess the effectiveness of their own actions in relation to the scale of the problem they seek to address? Which is better: a highly effective intervention on a small area or weaker intervention across a wide area?

Objective setting

Despite improvements over recent years in articulating clear objectives for conservation work, it is common that objectives are too poorly formulated to allow rigorous evaluation of success. This is partly due to the reactive 'crisis management' nature of much conservation action. A further contributing factor is that many conservation projects have multiple objectives, some of which may be perceived as less important and/or less attractive to funders and are therefore left unstated or poorly articulated. For example, conservation projects that are supported within development agendas must emphasize their objectives related to human well-being. Similarly, project documents may emphasize the conservation objectives for charismatic species (e.g. large mammals, birds) even when the proposed action is equally or more important for addressing taxa or problems perceived as less attractive to donors (e.g. small brown moths). When there are multiple objectives, the total burden of research and monitoring needed to advance and track progress towards all of them can be very heavy and a major drain on resources. Therefore, evaluation is often limited to a few of the most explicit objectives (or the ones that are easiest to measure). Thus, for example, a project aiming to conserve African birds by improving the livelihoods of local communities and reducing pressures on forest habitats emphasized the livelihoods objectives to obtain its funding from a donor in the development sector. As a result, its monitoring budgets had to be devoted primarily to assessing its livelihoods impacts, and few resources were available for monitoring forest cover or bird populations.

Attribution

Interventions are frequently conducted simultaneously, often by different actors, and it is difficult to attribute changes to particular interventions and actors. Areas and issues that are perceived as of urgent conservation importance, such as the fragmentation of the Atlantic Forest of Brazil or the impacts of ecotourism in the Virunga Volcano region in Central Africa, are the focus of intense conservation effort by many actors and organizations. The Critical Ecosystem Partnership Fund (CEPF) has identified a very large range of funders and organizations working on conservation in the Western Ghats hot spot. These include at least three Indian central government departments, state forest departments, multilateral donors, such as the World Bank and the GEF, and as many as nine bilateral donor agencies (e.g. the UK's DFID), and the CEPF itself. Several international non-governmental organizations (NGOs), including the Ford Foundation, WCS, BirdLife International, and the National Fish and Wildlife Foundation, are also active in the Western Ghats, at least 19 national NGOs have programmes of action and/or research within the hot spot and large numbers of research projects are carried out by academic and technical institutions (CEPF 2007). Of necessity with such a large number of actors, many approaches are employed in parallel, and monitoring is often not unified or strategic across conservation programmes, some of which may differ (financially or physically) by several orders of magnitude. This makes it difficult to link individual changes or outcomes to individual actions or interventions.

Resources

Limited resources and a focus on action mean that practitioners (in conservation and other fields) can be reluctant to divert resources to learning rather than doing (see below), and this is especially true where many objectives are combined and/or many actors involved. In the latter case, collaborative effort may possibly achieve some efficiencies and reduce the total resources needed to assess the achievement of stated objectives.

Counterfactual

However desirable it is to have non-treatment areas for comparison, the realities of conservation practice (limited resources, urgency) mean that most interventions are conducted without an explicit control. Therefore, it is usually impossible to measure or demonstrate success relative to what would happen without (or with a different) intervention. Even where control areas are used, it is often difficult to assess the extent to which the treatment and control samples differ at the beginning of the treatment, potentially confounding the result.

The consequence of failure to cope with these challenges is poor monitoring and evaluation, resulting in future conservation investment decisions that are largely based on belief rather than evidence. In the case of community forest management, this investment amounts to billions of dollars annually (Bowler et al. 2012).

Therefore despite the difficulties, the importance of assessing success has risen higher on the agendas of both practitioners and donors, and researchers have contributed some useful tools. Among the approaches being used to improve the situation are those related to planning and adaptive management, others tied to identifying and assessing outcomes, and new statistical approaches for selecting matched control areas to provide more rigorous assessment of the effectiveness of interventions.

The development of clear frameworks or results chains can help to make objectives explicit, to clarify assumptions about the links between interventions and overarching objectives, and to identify key components of success and their associated monitoring needs. For example, a common intervention in conservation projects is environmental education, frequently targeted at school children, but it is often not clear how these activities relate to project objectives, such as improvement in the status of a population of a particular species. Development of a robust conceptual model of the conservation problem and rigorous application of logical framework or results chain approaches will help to elucidate the conceptual links (or lack of them) between educating school children and the effective conservation of a given target species. These might be that the education programme will build children's awareness and appreciation of the importance of an over-hunted species, and that they will share this with their parents whose choices in the market or the hunt will be affected. By making such logic explicit as a 'theory of change', it will be possible to identify and highlight the constraints and assumptions that apply to each stage in the conceptual chain, such as assumptions about the abilities of the children to understand the main concepts, the degree of influence they have over their parents' actions and the factors influencing whether adults are able to change their behaviour. The use of logical frameworks and related approaches has become standard procedure in other sectors, such as development, and several recent advances have helped to clarify their application in conservation (Salafsky et al. 2001). The Conservation Measures Partnership (www.conservationmeasures.org), in its *Open Standards for the Practice of Conservation*, has provided a consensus among several major conservation organizations (including the Nature Conservancy, African Wildlife Foundation, Wildlife Conservation Society and WWF-US) on the application of these approaches and other aspects of adaptive management in conservation (CMP 2007) and has further provided tools to facilitate their implementation (Miradi software; www.miradi.org).

There has also been considerable recent emphasis on assessing the degree to which the Open Standards and other recognized aspects of good practice are applied, and on using this as an indicator of the likely success of conservation actions. Such 'conservation audits' are described in detail by O'Neil (2007). A similar approach, assessing the degree to which elements of good management are in place, is used in some assessments of management effectiveness in protected areas (Leverington et al. 2008), including the Management Effectiveness Tracking Tool (METT) employed by the WWF and the World Bank to assess management of forest protected areas (Stolton et al. 2007), and the Rapid Assessment and Prioritization of Protected Areas Management – RAPPAM (Ervin 2003).

Another emerging approach builds on results chains to identify *outcomes* (as distinct from *procedures*) that are expected to lead ultimately to conservation success (improved status of target species, ecosystems and sites). A results chain is a tool that clarifies assumptions about how conservation activities contribute to reducing threats and achieving the conservation of biodiversity or thematic targets (O'Connor 2005). It maps out a series of causal statements that link factors in an 'if … then' fashion – for example, if a threat is reduced, then status of a biodiversity target is enhanced or if an opportunity is taken, then a thematic target might be improved. Results are assessed in relation to those intermediate steps, using rigorous quantitative approaches, expert assessment or self-evaluation.

In developing tools for implementing this approach, the Cambridge Conservation Forum drew on the experience of practitioners from many of its member organizations and on existing categorizations of conservation action (Salafsky et al. 2002, 2008) to define seven broad categories of conservation activity and generic results chain models for each of them (Kapos et al. 2008, 2009, 2010). A scorecard-style questionnaire-based tool was developed to help practitioners assess the results of both past and ongoing conservation projects. Assessing the degree to which intermediate outcomes have been achieved can support adaptive management and provide insights on likely long-term effectiveness of interventions, even where resources may be too limited to support appropriate biological monitoring. Thus, for example, assessing behaviour change among local communities or effective implementation of a regulation adopted as a result of advocacy efforts may provide a clear pointer to eventual improvements in the status of an exploited species.

Recently, several groups have applied novel statistical approaches to provide rigour in assessing the longer term effectiveness of specific conservation interventions (e.g. Andam et al. 2008; Linkie et al. 2008). Particularly promising are the matching techniques used for identifying counterfactual values as a basis for assessing conservation outcomes where no controls have been deliberately established (Ferraro & Pattanayak 2006; Ferraro et al. 2007). These have especially been applied in assessing the effectiveness of protected areas in reducing deforestation (e.g. Nelson & Chomitz 2009, 2011; Joppa & Pfaff 2010, 2011). These analyses have effectively accounted for the fact that many protected areas are remote from drivers of deforestation by matching them with similar controls, and have shown that reductions in deforestation in protected areas are much lower than previously thought. This is important information for planning protected areas systems and targeting other conservation interventions.

While these approaches potentially reduce the need for investing field effort in establishing and monitoring control areas, they are most applicable where the response variables affected by conservation action are readily detectable – they have so far only been applied in assessing effectiveness in reducing deforestation. They require a very careful selection of control areas and often rely upon the availability of, and ability to process very large data sets. Nonetheless, they provide an important opportunity to validate empirically the procedural standards and other proxies that may be used more widely for assessing the effectiveness of conservation actions and programmes.

When and for whom is research a priority?

Beyond efforts to understand patterns of natural variability in the abundance and distribution of species and habitats, there are essentially two areas of conservation research: identifying problems and identifying solutions. The first is concerned largely with measuring human-induced environmental change and understanding the drivers responsible for such changes, while the second is concerned largely with assessing the effectiveness of alternative interventions. To date, a lot more research has been conducted on the former than the latter, and there is still a scarcity of evidence on what types of management or policy intervention have been most successful in tackling key problems (Sutherland et al. 2004). Recent developments in evidence synthesis and the application of systematic review methodology are addressing this gap (Pullin & Knight 2009).

Very occasionally, a problem may be so large, and the method of resolving it so clear and simple, that research is not necessary (e.g. closing down of a sewage outflow that drains directly onto a rare salt marsh). However, conservation problems invariably abound with uncertainty, risk and controversy. There is rarely strong consensus amongst different stakeholders as to the importance of a given problem, and where there is general support for action, there is usually a variety of alternative solutions available, the relative effectiveness of which is unclear (see section on 'Taking action' above). Research can provide much needed clarity as to the most pressing problems or rewarding solutions, but the challenge comes in deciding whether further research is really needed or whether enough information is already available to take informed action. There are two important reminders that should be considered when making this decision.

First, it may be the case that there is enough information available to make adequately informed decisions without further research. Instead, what is lacking is sufficient political will and resources, or the opportunity for making a strategic investment. As discussed earlier in this chapter, a surprising amount of information is already available to help guide conservation decision making, both regarding the distribution of biodiversity at global (e.g. the Key Biodiversity Areas assessment of the IUCN) and regional (e.g. the www.natureserve.org portal which compiles information on rare and endangered species and ecosystems in the Americas) scales, and the relative effectiveness of alternative intervention strategies (see evidence syntheses and databases at the Conservation Evidence project – www.conservationevidence.

com – and the Collaboration for Environmental Evidence – www.environmentalevidence.org). It is common to hear the call that more research is needed before any recommendations can be made. Such advice can be problematic because funding for continued research and conservation action often comes from the same pot, and opportunities for successful interventions may be short-lived. Because access to species data is only one of the factors that determines the overall success of a conservation plan (Knight et al. 2006), there comes a point where the collection of ever more field data is redundant. Grantham et al. (2008) provide a convincing example of this by demonstrating that a database of South African protea (the regionally endemic plants for which South African *fynbos* vegetation is so famous) could be reduced in size by a factor of 25 without any marked impact on the effectiveness of spatial conservation prioritizations.

Second, it is important to consider that academic performance is not always correlated with the generation of practical and effective conservation guidance. As such, investment in research, unless carefully managed, may not produce the desired results. In 2001 Tony Whitten and colleagues challenged the conventional views on the value of conservation research, claiming that much of conservation biology is 'a displacement behaviour for academics' and that many scientific priorities are far removed from what is really needed to safeguard the future of biodiversity (Whitten et al. 2001). While this essay was deliberately provocative, there is often an irrefutable gap between the indicators used to measure success in academia (e.g. numbers of publications and impact factors) and those used to measure success in on-the-ground conservation programmes (e.g. reductions in loss of habitat, increased numbers of an endangered species) (Chapron & Arlettaz 2008), and much research is criticized for failing to provide practical management recommendations (e.g. Meijaard & Sheil 2007). One possible solution is to assess research papers by their contribution to the knowledge that is considered a priority by policy makers and practitioners; this approach has been used to evaluate papers testing interventions to enhance bee populations (Sutherland et al. 2011b).

As Arlettaz et al. (2010) illustrate in a project to restore endangered hoopoes in the Swiss alps, ensuring that research is capable of developing useful recommendations requires the involvement of scientists in the actual implementation process. However, there are opportunity costs to investing time and resources in tackling messy on-the-ground conservation problems in a timely fashion. It is unrealistic to expect that individuals can operate effectively as both researchers and managers, but it is vital that scientists are given professional recognition for their practical as well as academic impact.

Identifying priority research questions and knowledge gaps

Identifying the kind of research that is likely to deliver the most useful and cost-effective results is deceptively difficult. Foremost is the need to be explicit and transparent about the choices available in deciding what to study, and about the ultimate purpose of different types of research, given overall conservation objectives and alternative ways of spending our time and resources. Choices of research questions are commonly decided based not on any objective or systematic framework, but rather on some combination of circumstance, personal interest, past experience and personal appeal. To try and get around this, it can be useful to step back and appraise the different kinds of motivation that underpin choices about what to study.

First, what is the likely value of a new piece of research for delivering measurable outcomes for biodiversity conservation? What is the scale of the problem or threat that is being studied, and can results be generalized to other places and species or are they confined to a specific site or taxon? What is the relative importance of the problem being studied, given other threats? For example, many biologists have focused their research efforts on understanding the role of infectious diseases, climate change and acidification on declining amphibian populations. These are justifiable concerns, yet a much bigger problem facing the survival of amphibians worldwide is habitat loss and degradation, which has received disproportionally little attention (Gardner et al. 2007).

As well as thinking about likely impacts, it is important to consider the probability that results will be adopted by relevant decision makers. If you are charged with advising a small island state in the Pacific on how to mitigate population declines of endemic species, it is arguably more useful to focus efforts on threats that fall under their jurisdiction (e.g. habitat loss, eradication of exotic species) than factors almost completely outside their control (e.g. climate change).

Second, and as mentioned previously, it is important to reflect on what information is already available and where evidence is critically lacking. If enough biological data are already collected to identify (if only crudely) areas of high conservation priority, it may be more worthwhile collecting information on the costs of different conservation activities and availability of land to achieve a particular goal (Wilson et al. 2009).

Finally, it is important to contemplate the feasibility of a conservation project, where feasibility includes access to necessary background data, appropriate experimental treatments (whether natural or directly manipulated) and study site conditions, and technical expertise necessary to tackle adequately the posed research question, and sufficient funds to ensure that the research is conducted with necessary rigour. Sometimes a project may be highly desirable but impossible to implement, as the conditions just do not exist in the area of interest.

Evaluation and learning from experience as forms of research

While it is important to recognize and think about trade-offs between research and management, as well as between competing research objectives, it is also important to avoid extended procrastination. When it comes to conservation research, the most valuable learning can often be achieved only once the first measurements are made, and at least a few different interventions have been tried and responses evaluated. As highlighted at the start of this chapter, research should not be conceived as a linear process with clear start and end points but rather a continuous cycle of observation, evaluation and recommendation that feeds back into future changes in management, which in turn require their own evaluation. In this sense, research and management are two sides of the same coin; neither exercise makes proper sense unless accompanied by the other. This notion has its roots in adaptive management (Holling 1978; Stem et al. 2005), but also highlights the importance of many less formal or indirect ways of 'learning by doing', or experiential learning as it is termed by educationalists, including implicit and tacit knowledge, and expert observation (Fazey et al. 2006). Experienced observers and conservation practitioners may, without any formal training, be able to recognize emergent properties and make good predictions of environmental change without being able to explain precisely how they do it. Fazey et al. (2006) present an example of this by eliciting the expert knowledge of on-the-ground managers – including both local government staff and cattle ranchers – of wetland systems in Australia.

Conclusions and recommendations

Whilst past conservation actions may well have saved many species and habitats, biodiversity continues to decline. To date, conservation has fallen short in providing evidence of measurable benefits and value for money. This is true for both science and action. You cannot manage what you do not measure, and without measurement, the effectiveness of conservation research and action is fraught with uncertainty both within and outside the community. That said, measurements cost time and money and need themselves to be justified. To demonstrate value for money, the conservation community needs to put in place a more transparent system for identifying priorities, deciding on appropriate actions and measuring effectiveness. The concept is simple but the actors and actions are so many and complex that a major improvement in information and knowledge sharing is vital if we are to progress and become more effective. Decision makers need to be able to identify knowledge gaps and communicate those to science funders, not just as a wish list but with evidence that the gaps are real, are of the highest priority, and are inhibiting their ability to make decisions. Conservation scientists need to balance their (often healthy) tendency toward challenging current wisdom and emphasizing uncertainty with a need to provide critical evidence syntheses and evaluations of the success of conservation actions and find scientific consensus in a way that is useful to decision makers. These latter roles are undervalued in academic institutions that depend on traditional publication-based reward systems.

It is most likely that decision-making frameworks will be more widely adopted in conservation if they can be first demonstrated on a real-world conservation problem, such as those articulated in the Convention on Biological Diversity Aichi Targets (Convention on Biological Diversity 2011). Whether policy makers and funders will take the risk of investing in such a programme remains to be seen. Nevertheless, many of the components described above are already being used and are arguably increasing in frequency. To date, we are not aware of any conservation programme in which all these pieces have been combined. There may be many reasons for this, but here are a few.

- *Lack of vision and time*: many conservation organizations work on a largely responsive mode and dedicate much of their time to dealing with short-term problems and fundraising. Framing any conservation programme within a broader strategic framework requires an ability to step back and calmly evaluate the costs and benefits of different choices. Ideally this requires dedicated staff members or a department.
- *Lack of data*: decision-making frameworks are only viable if there is sufficient accessible information to inform the steps in the process. Rigorous evidence syntheses in the form of systematic reviews are few and this inhibits the key step of comparing effectiveness of alternative interventions.
- *Perceived cost*: employing the range of skills and conducting the range of tasks implied in the use of decision-making frameworks is expensive. Data mining, evidence synthesis and programme evaluation are all resource-hungry activities.
- *Fear of objective processes outside organizational control*: for smaller conservation organizations, these processes might seem to threaten their very existence by questioning the programmes for which they raise money, such as buying land for protection or for species-based management and recovery programmes. For government departments, the process might suggest the adoption of policies that would be unpopular with the electorate or powerful pressure groups.
- *Lack of incentive*: there is no incentive for organizations in which financial performance does not rely on the effectiveness of conservation action *per se*, despite it being an implicit objective. Many organizations provide little information on their effectiveness (nor is it demanded by any independent body); instead they appeal to their members and donors in terms of ongoing threats to species and habitats and of the ability of the organization to act on their behalf (i.e. they are action oriented, not performance oriented).

There have been many individuals in conservation who have sought to facilitate the increased use of good science in conservation decision making and to provide the tools to inform priority setting and resource allocation. Some reside in academia, whilst others populate conservation organizations, government departments and the business community. Some come from other disciplines such as economics, public health, information science and programme evaluation. A major social challenge is to marshal this diverse group to the benefit of conservation at large. Informal networks and collaborations, such as the Environmental Evaluators Network and the Collaboration for Environmental Evidence, are developing interdisciplinary communities capable of generating information that will inform conservation decision making in a co-ordinated and transparent way. There are also some signs of intergovernmental demand for assessments of changes in biodiversity, but at present there is often no clear structure in which that community should work (and be provided with the resources). The emergence of an Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (ipbes.net) might provide such a structure but its remit is still to be determined. Whatever the major structures and organizations turn out to be, a new culture of effective, rather than simply well-intentioned, conservation practice is essential if tough conservation challenges are to be met with continuingly scarce resources.

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The difficulty lies not so much in developing new ideas as in escaping from old ones

John Maynard Keynes

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