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POLICY PERSPECTIVE

Making Tough Choices: Picking the Appropriate Conservation Decision-Making Tool

Shannon D. Bower[1,*], Jacob W. Brownscombe[1,*], Kim Birnie-Gauvin[1], Matthew I. Ford[1], Andrew D. Moraga[2], Ryan J. P. Pusiak[3], Eric D. Turenne[4], Aaron J. Zolderdo[1], Steven J. Cooke[1,5], & Joseph R. Bennett[2,3,5]

[1] Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University, Ottawa, ON K1S 5B6
[2] Geomatics and Landscape Ecology Research Laboratory, Department of Biology, Carleton University, Ottawa, ON K1S 5B6
[3] Department of Biology, Carleton University, Ottawa, ON K1S 5B6
[4] Department of Biology, University of Ottawa, Ottawa, ON, K1N 6N5
[5] Canadian Centre for Evidence-Based Conservation and Environmental Management, Institute of Environmental Science, Carleton University, Ottawa, ON K1S 5B6

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Correspondence
Shannon D. Bower, Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University, Ottawa, Ontario, Canada, K1S 5B6,
Tel: +613-520-2600, ext. 4377.
Email: Shannon.Bower@carleton.ca

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*Authors contributed equally
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Abstract

Conservation practitioners face complex challenges due to resource limitations, biological and socioeconomic trade-offs, involvement of diverse interest groups, and data deficiencies. To help address these challenges, there are a growing number of frameworks for systematic decision making. Three prominent frameworks are structured decision making, systematic conservation prioritization, and systematic reviews. These frameworks have numerous conceptual linkages, and offer rigorous and transparent solutions to conservation problems. However, they differ in their assumptions and applicability. Here, we provide guidance on how to choose among these frameworks for solving conservation problems, and how to identify less rigorous techniques when time or data availability limit options. Each framework emphasizes the need for proper problem consideration and formulation, and includes steps for monitoring and evaluation. We recommend clear and documented problem formulation, adopting structured decision-making processes, and archiving results in a global database to support conservation professionals in making evidence-based decisions in the future.

Introduction

Accelerating biodiversity loss coupled with limited data, time and monetary resources necessitates careful allocation of conservation activities (Margules & Pressey 2000). Several useful tools have been developed for systematic conservation decision making (CDM) and many practitioners currently implement these tools in some form. However, practitioners face dilemmas regarding tool choice and implementation including how to fit systematic decision-making process into complex local realities where conditions may change over time (Pressey *et al.* 2013).

A recent paper by Schwartz *et al.* (2018) offered a thorough analysis of CDM frameworks and their use. Here, we offer a process for selecting among frameworks suited for different purposes (structured decision making [SDM], systematic prioritization, and systematic reviews [SR]) to best address conservation problems (Figure 1). While acknowledging that numerous CDM tools and implementation frameworks exist, it is our view that these three frameworks represent the most common types of CDM processes, and that they are good examples of how structured frameworks can be nested (Case Study 1; Figure 1), or used individually when dictated by logistical constraints. We illustrate systematic CDM processes

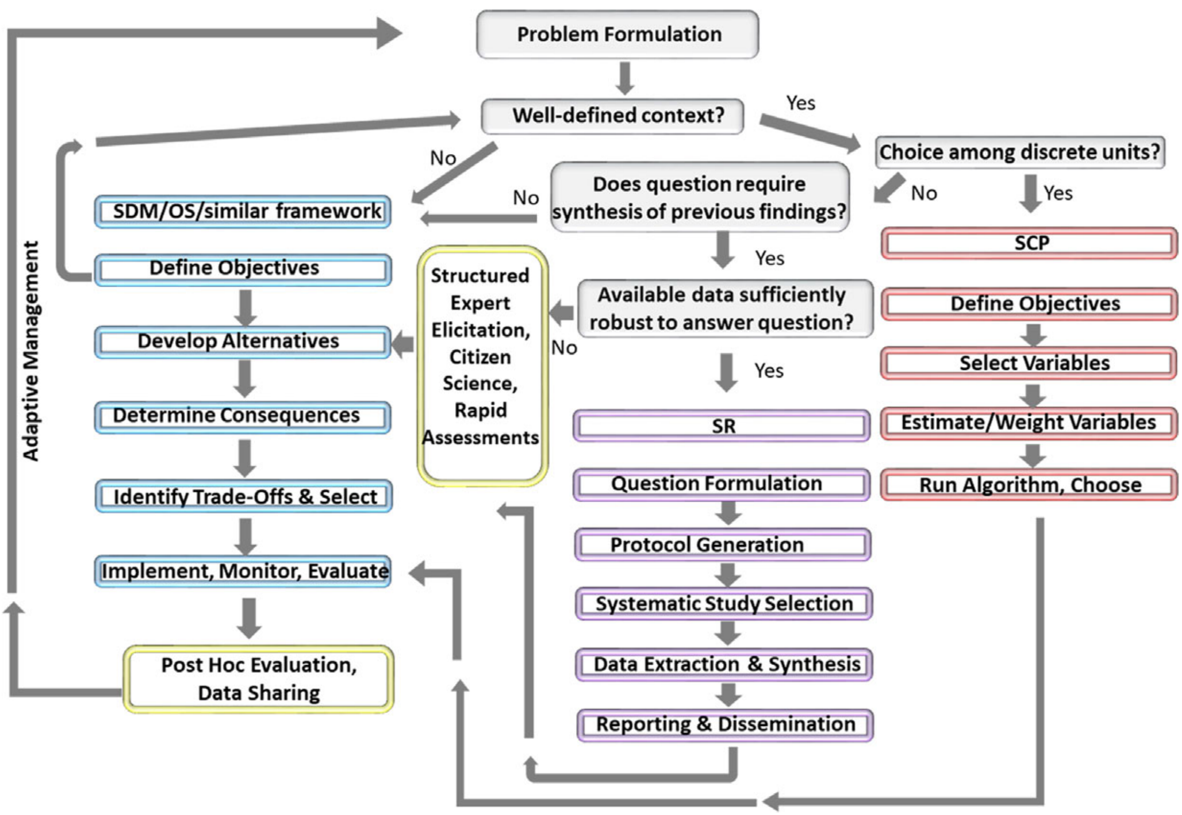

Figure 1 Flow chart outlining the CDM process and connectivity of SDM (SDM/OS/similar framework), SR, and SCP frameworks. Blue, purple, and red boxes represent steps in SDM/OS/similar framework, SR, and SCP, respectively. Orange boxes highlight alternative options for practitioners constrained by funding, time, or data limitations, and recommended post evaluation actions. SDM-type frameworks are used as a backbone for the overall CDM process, such that SR processes cycle back to "develop alternatives" phase of SDM-type frameworks (to operationalize the SR outcomes), and SCP joins SDM-type frameworks at the final step of implementation. Adaptive management is presented as the overarching cyclical pattern of SDM-type frameworks, such that the final stage is to cycle back to earlier points based on the outcome of the previous cycle.

using SDM as a backbone that is akin to numerous similar, stepwise frameworks (including Open Standards; Schwartz *et al.* 2018). We also clarify the choice of specific tools used throughout CDM framework processes (Table 1). Our intention is to describe the general function and connectivity of these processes such that practitioners can more easily find tools adapted to their specific needs. These frameworks and associated tools can be useful in diverse CDM scenarios, including generating appropriate research questions, making decisions when faced with uncertainty, and balancing the interests of stakeholders, ultimately increasing the efficacy of conservation efforts and improving the transparency of the CDM process.

Problem formulation

A crucial first step in any CDM process is the proper formulation of the problem. The importance of this step, and its challenges, are often underestimated (Gregory *et al.* 2012; Groves & Game 2015). Game *et al.* (2013) suggest that problems or questions are often framed too broadly (e.g., to save species X) instead of setting a clear objective of minimizing or maximizing a given state. However, the decision problem must also be constructed in the context of the broader fundamental objectives and values of the decision makers (Gregory *et al.* 2012; Groves & Game 2015). Formulating a clear and tractable problem that is anchored in the fundamental objectives and values can be difficult. However, excellent general guidance can be found in Hammond *et al.* (2015), Gregory *et al.* (2012), and Groves & Game (2015). Several specific techniques can also help clarify conservation problems. These include influence diagrams and decision trees, all of which are useful for characterizing the connectivity among potential outcomes (Table 1). Predictions from these types of models can be enhanced using more advanced techniques, such as Bayesian networks (Marcot *et al.*

Table 1 Examples of commonly applied tools for practitioners to use in framing conservation problems, and throughout the CDM process

Tool	Description	Applications	Examples
Influence diagrams	Graphical representation of the relationships between decisions and outcomes	Characterizing complex systems, causal relationships; helpful for accounting for uncertainty	Marcot (2006)
Value trees	Organizes objectives into a hierarchy	Organizing objectives, related performance measures in complex scenarios	Gregory *et al.* (2012)
Value models	Calculates weighted index of the combined effects or value of a given action	Quantifying action impacts by integrating a weighted value, e.g., habitat quality	Renn *et al.* (1993)
Structural equation modeling	Set of mathematical models to characterize conceptual networks	Using algorithms to characterize statistical influence diagrams	Yoon *et al.* (2001)
Strategy tables	Organizes potential management actions into strategies	Integrating management actions into a strategy by considering connectivity between actions and efficacy	Gregory *et al.* (2012)
Decision trees	Models of decisions and potential consequences; estimates optimal choices	Characterizing choices and their implications and estimating the probability of outcomes	Regan *et al.* (2005)
Multiple criteria decision analysis	Structured method for evaluating choices based on multiple criteria	Managing conflicting objectives or ideals, e.g., multiple stakeholder groups, biological and economic trade-offs	Phua & Minowa (2005)
Simple multiattribute rating techniques	Calculates performance score for multiple actions based on weighted criteria	Choosing between potential actions by identifying distinct criteria, each with a certain value	Edwards & Barron (1994)
Bayesian networks	Models probabilistic interdependence of factors in a system, can integrate expert opinion in belief networks	Making predictions about how a system will respond to management actions	Marcot *et al.* (2006)
Information gap theory	Uses models based on nonprobabilistic decision theory to reduce probability of failure	Increasing robustness to failure in scenarios with high levels of uncertainty	Bradshaw & Borchers (2000)

2006) and information gap theory (Regan *et al.* 2005). Expert opinion is often the basis of quantifying these connections and making predictions about outcomes, and therefore structured expert elicitation can be an essential tool for minimizing opinion biases (Martin *et al.* 2012). Many of these tools are also applicable to other stages of the CDM process (Table 1), though none are sufficiently robust on their own to be considered complete systematic CDM frameworks.

CDM frameworks

Structured decision making

SDM is an organized approach to address complex problems, integrate diverse perspectives, and account for uncertainty to identify and evaluate alternative solution strategies (Gregory *et al.* 2012). Fundamentally, SDM relies on the integration of scientific information and stakeholder values to develop solution strategies, and as such, provides inclusion and transparency throughout the decision-making process. It is organized into six main steps that formulate the decision-making framework (Figure 1; see Gregory *et al.* 2012 for details on each step, and Schwartz *et al.* 2018 for details on framework functionality and comparisons).

Systematic conservation prioritization

Systematic conservation prioritization (SCP) refers to a broad set of tools for quantitatively ranking conservation actions to maximize outcomes given limited resources; all of these tools share a similar structure (Margules & Pressey 2000). Although often described as analogous to SDM, SCP is most suited to problems where options are chosen based on trade-offs among attributes that are quantified using consistent measurements across all units (Schwartz *et al.* 2018). SCP has been used extensively to prioritize management of landscapes (e.g., Australian

MPA network), species (e.g., Joseph *et al.* 2009), and threats (Carwardine *et al.* 2014).

Systematic reviews

SR were developed to provide consistent, rigorous summaries of literature to aid decision making (Sutherland *et al.*, 2004). Specifically, SR differ from traditional reviews in that the methodology is laid out a priori, and includes systematic search of both peer-reviewed and gray literature. The goal of SR is to clearly identify a positive, neutral, or negative effect of the management options reviewed as a direct answer to the review question, while also identifying knowledge gaps to direct future research (e.g., Pullin & Knight 2009, Abella & Springer 2015). As with SCP, the steps in implementing an SR are much like those of an SDM, and could be implemented as a framework within a framework (Figure 1).

Using and adapting CDM tools and frameworks

The basic processes from problem formulation to implementation monitoring are similar for CDM frameworks (Westgate *et al.* 2013). However, some key differences among them help to clarify the choice of an appropriate framework (Figure 1). The initial step of problem formulation is perhaps most important. If parties to the decision process do not have a clear, shared idea of the problem itself, then entering into an SDM process is recommended. Specific techniques outlined in Table 1 can then be used to help clarify problem formulation.

When the problem is well-defined and the choice involves actions among discrete units, then SCP, with its strong theoretical background (e.g., Moilanen 2007; Joseph *et al.* 2009) and quantitative outputs, is a logical choice. If the choice is not among discrete units, and the decision hinges on the synthesis of available data, then SR is recommended if possible. However, if sufficient data are unavailable, expert elicitation, provided adequate diversity of perspectives is considered, such as including management experience and stakeholder perspectives (Aspinall 2010). Data gaps may also be filled through citizen science programs (provided data are robust; Tulloch *et al.* 2013), or rapid assessments when feasible (e.g., Knight *et al.* 2006).

For the many other cases where decisions do not fit within an SCP or SR framework, we recommend using the SDM-type framework as the basis for decision making. A key strength of this framework is the rationale behind the suggested steps: clearly outlining and communicating the problem/question, working and communicating with groups of partners and stakeholders, and breaking down the overall conservation issue into actionable and operationalized pieces to help increase transparency and improve the likelihood of success.

Unfortunately, insufficient resources often constrain smaller conservation agencies' capacity for strictly following rigorous decision protocols. Truncated methods analogous to the three broad frameworks covered here are also useful in many circumstances for solving problems arising from resource trade-offs. For relatively simple issues an SDM process may be completed quickly (e.g., less than a day; Gregory *et al.* 2012). Small-scale SCP is also possible; Di Fonzo *et al.* (2017) conducted an SCP system using a simple spreadsheet, and implemented it for an Australian National Park using input from a single-day expert elicitation workshop. Solutions using transparent processes that minimize bias save time and resources compared to single perspective, ad hoc decisions that must later be revisited. In addition, if practitioners are unable to follow the exact protocols laid out in these processes, they can develop context-suitable steps that broadly follow those in the SDM-type framework. The Conservation Measures Partnership (Open Standards for the Practice of Conservation, Case Study 2) and The Nature Conservancy (Conservation Action Planning) offer two SDM-type examples among many existing alternatives.

Conclusions and recommendations

We have provided guidance to help practitioners decide among three of the most commonly used CDM frameworks. We emphasize, however, that there are many conceptual links among the frameworks, and that practitioners can combine them as necessary. Indeed, decision-making processes (e.g., Case Study 1) will often benefit from using multiple frameworks.

Crucially, each framework depends on a transparent and logical flow of steps. Thus, we strongly encourage practitioners and funding bodies to build transparency and information sharing into conservation plans by: (1) implementing clear and documented problem formulation; (2) following steps of CDM frameworks where possible (e.g., indicated in Figure 1); (3) adopting the use of standardized CDM terminology (such that methodologies and data are broadly comparable while remaining flexible to local context; Salafsky *et al.* 2008); (4) participating in global conservation CDM databases so practitioners may find analogues to their problems and access suitable proxy data for improved estimation and outcomes. We also recommend (5) supporting existing training initiatives and capacity development more extensively so practitioners can access affordable training in CDM. Funding bodies can support these efforts by valuing outcome reports preferentially over implementation reports (Kapos *et al.* 2008).

Case Study Boxes

Case Study 1. Combining SCP and SDM: The Saving our Species program in New South Wales

Office of the Environment and Heritage NSW (2013)

Conservation practitioners often face pressures to prioritize conservation of iconic species over those in greater need. Responding to a growing number of threatened species, New South Wales established the Saving our Species conservation program. Species are assigned to streams based on their ecology, threat and sociopolitical status, which are decided by expert managers and reviewed by scientific experts. This approach allows practitioners to evaluate species based on conservation need while also acknowledging the social value of iconic species. Projects are prioritized by integrating the predicted benefits, likelihood of success, and costs, which are estimated from structured expert elicitation and available cost estimates from similar projects. Post hoc analyses are conducted on these data to avoid motivational bias and account for uncertainty. Conservation projects are then assigned to priority bands based on the 95% confidence interval of the priority score, and projects are implemented by priority band.

The design of this SCP also incorporates several key elements of SDM. Critical management sites are identified using structured expert elicitation (commonly applied in the Problem Formulation phase of SDM), and management proceeds through a series of steps to implementation in an adaptive framework that resembles that of SDM (Government of New South Wales 2013). This flexibility allows for inclusion of new at-risk species or to change species between management streams when necessary (e.g., from data-deficient to either site- or landscape-managed once enough data have been collected). This program has successfully funded over 70 site-managed projects with $4.8 million AUD in its first 4 years.

Case Study 2. The Conservation Measures Partnership: Open Standards for the Practice of Conservation

Visual representation of the Open Standards process (Conservation Measures Partnership 2013)

Open Standards for the Practice of Conservation (OS), developed by the Conservation Measures Partnership (2013), is arguably one of the most commonly applied SDM-like frameworks as it can be used in both data-rich and data-poor situations. OS is analogous to SDM in form and is designed to be user-friendly, with each step broken down into actionable items. It is available online to conservation practitioners for free download. The supporting software Miradi is available for a free trial and for cost thereafter, but is not required to follow OS processes.

As part of the OS framework, The Cambridge Conservation Forum (CCF) has developed a questionnaire-based tool to help practitioners evaluate conservation impacts qualitatively and may be a viable option if funding is extremely constrained but immediate action is necessary (Kapos *et al.* 2008). Case study examples, including the Jane Goodall Institute's successful use of OS in generating a 26% increase in habitat protection for chimpanzees near Lake Tanganyika, can be found on the CDM website (http://cmp-openstandards.org/os-examples/case-studies/). If widely implemented, then analysis of CCF post action evaluation surveys would offer significant CDM support to practitioners.

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