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Discussion

Decision triggers are a critical part of evidence-based conservation

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ABSTRACT

Conservation managers face complex decisions about if, when and how to intervene in managed systems. To support these decisions, approaches are needed that utilise the best available evidence to guide actions when a system is moving into an undesirable state. Assigning some form of critical threshold that if crossed would trigger action (a decision trigger) is growing in favour in the scientific community. Likewise, there is increasing interest from the conservation management community in using decision triggers as part of evidence-based management. In this article, we reinforce calls for the use of decision triggers and highlight how they can complement many approaches for evidence-based conservation. There are many benefits to using decision triggers to link evidence to action. For management organisations, decision triggers offer a way to improve the clarity and transparency of management decisions. There has been recent progress in developing methods to set robust decision triggers that utilise rigorous biological monitoring data, such as receiver operating characteristic curves, control charts and participatory modelling. When monitoring data are not readily available, approaches that set decision triggers based on utility thresholds (i.e., value-based judgements) or expert elicitation methods, and refine trigger points over time, hold promise. Despite the many benefits, there remain challenges for both developing and implementing decision triggers. There is a pressing need for a process that can guide organisations in setting defensible decision triggers based on the best available science, and that can be used for a wide range of management contexts. We believe decision triggers can be integrated into existing management processes within organisations to improve decisions about when and how to act to protect biodiversity, and to support managers to achieve evidence-based conservation.

1. Progress towards achieving evidence-based conservation

The international community has committed to halting the rate of biodiversity loss by 2020 through the effective management of natural systems (Aichi Targets 11 & 12; CBD, 2010). Achieving these goals requires that conservation organisations have systematic management processes in place to support effective management action. The value of evidence-based management to support effective conservation action has been given increasing emphasis in recent decades (Dicks et al., 2014). These changes have come from a desire for increased transparency of management outcomes and to facilitate responsive and effective management practices (Leverington et al., 2010; Ferraro and Pattanayak, 2006).

Evidence-based management involves using the best available evidence to support effective management decisions (Dicks et al., 2014). There are many approaches that promote evidence-based decision-making in conservation management (Table 1). Some of these broadly address the whole management process, from preparing for action, implementation and evaluation of management outcomes (e.g., Conservation Action Planning; Open Standards for Conservation Practice; Table 1). Other approaches focus on some steps within the broader management process, such as selecting the most appropriate management actions (e.g., evidence synthesis; project prioritisation protocol; Table 1), or improving management through the evaluation of outcomes (e.g., Vital Signs monitoring; Table 1) or governance processes (e.g., management effectiveness evaluation; Table 1).

Several approaches to evidence-based management focus on providing a structured process to select among a range of alternative management actions (Table 1). Management strategy evaluation and structured decision-making assist managers to predict the outcomes

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Table 1
Approaches to promoting evidence-based management in conservation management that are commonly discussed in the literature.

Approach	Description	Focus*
Conservation Action Planning	A process to guide conservation teams to develop focused strategies and measures of success (Groves et al., 2002; TNC, 2007)	Preparing for action; on-going management; monitoring
Open Standards for Conservation Practice	Systematic approach to planning, implementing, and monitoring conservation initiatives (CMP, 2013; Schwartz et al., 2012)	Preparing for action; on-going management; monitoring; evaluation
Adaptive management	A decision-making process to develop, trial and select among multiple potentially effective management options (Walters and Hilborn, 1978)	Ongoing management; monitoring
Structured decision-making	An approach to identify and evaluate alternatives that focuses on engaging managers, policy makers, stakeholders and experts (Gregory et al., 2012)	On-going management; monitoring; evaluation
Project prioritisation protocol	A tool to identifying the most cost-effective options with the greatest probability of success (Joseph et al., 2009)	Preparing for action; on-going management
Systematic conservation planning	A structured approach to prioritising action across a landscape, particularly for selecting the optimal reserve design to maximise a particular conservation objective (Margules and Pressey, 2000)	Preparing for action
Evidence synthesis	Used to draw together the best available evidence on alternative management strategies to identify the most effective management actions for a given management context (e.g., Pullin and Stewart, 2006; Dicks et al., 2014)	On-going management
Management strategy evaluation	Modelling-based approach to assessing the consequences of different management strategies or options to assist in determining which approach will be the most appropriate to meet the operational objectives (Butterworth and Punt, 1999; Sainsbury et al., 2000). This approach is predominantly applied to the ecosystem-based fisheries management (Smith et al., 2007).	On-going management; monitoring
Vital Signs & ecological integrity monitoring	Long term resource monitoring of parks (Fancy et al., 2009), focused on identifying and tracking key indicators of ecological integrity to infer the overall health of ecosystems (Timko and Innes, 2009).	Monitoring; evaluation
Management effectiveness evaluation	An assessment tool designed to assist conservation managers to understand, learn from and improve conservation management efforts (Hockings et al., 2006)	Evaluation

* Preparing for action refers to setting objectives for management in relation to key attributes and areas of interest. On-going management refers to determining the most appropriate actions to take. Monitoring refers to measuring the outcomes of on-going management relative to the objectives. Evaluation refers to assessing how effective the processes for planning and on-going management have been in achieving management outcomes.

of different management alternatives before they are implemented, using available monitoring data, expert judgement and predictive models (Butterworth and Punt, 1999; Gregory et al., 2012; Table 1). Prioritisation approaches, such as project prioritisation protocol (Joseph et al., 2009; Table 1), are used where multiple actions are desirable but resources are limited; while evidence synthesis is focused on selecting the most effective action for a specific management context (Pullin and Stewart, 2006; Dicks et al., 2014; Table 1). When critical uncertainty exists in conservation management, adaptive management (AM), offers a rigorous and intensive process to develop, trial or experimentally test and select among multiple potentially effective management options (Walters and Hilborn, 1978; Table 1).

Management effectiveness evaluation (MEE) facilitates evidence-based management by providing a structured approach to assess the strength and weaknesses of the management process (from planning through to outcomes) to assist decision makers to learn from and improve management efforts (Hockings et al., 2006; Leverington et al., 2010). While there is increasing interest in evaluation, the implementation of MEE continues to be challenged by poor access to data (Cook et al., 2010), difficulty linking inputs (e.g., staff time and money) to actions and outcomes (Cook and Hockings, 2011), and difficulty "closing the loop" to integrate the results of evaluations into improved management practices (Jacobson et al., 2008; Addison et al., 2015a).

Vital Signs monitoring (Fancy et al., 2009; Table 1), Conservation Action Planning (TNC, 2007; Table 1) and the Open Standards for Conservation Practice (CMP, 2013; Table 1), focus on monitoring management outcomes as a means to improve conservation actions. While monitoring biodiversity to track changes in key ecological attributes over time is an important element of evidence-based management (Magurran et al., 2010), it is often poorly implemented. Poorly designed or implemented monitoring programs can lead to important ecosystem changes going undetected (Legg and Nagy, 2006). Even when changes are detected, the failure to link monitoring programs to management actions can mean decision makers fail to respond to observed declines (Lindenmayer et al., 2013). These criticisms highlight the need to consider *a priori* the management response to monitoring data and the importance of defining the point at which an ecological attribute crosses from acceptable to unacceptable (Lindenmayer et al., 2013).

2. Decision triggers as part of evidence-based management

A relatively poorly developed component of evidence-based management is supporting decisions about when and how conservation managers should act if a system enters an undesirable state (e.g., Nie and Schultz, 2012; Lindenmayer et al., 2013). To this end, there has been increasing focus on the need for some form of decision trigger that links monitoring data to management action to support environmental management (e.g., Biggs and Rogers, 2003; Martin et al., 2009; Addison et al., 2015b; Table 2). Similarly to other authors (Table 2), we define a decision trigger as a point or zone in the status of an ecological attribute that when crossed triggers a management decision. The primary aim is to help managers determine the optimal time to intervene in any managed system through a systematic, *a priori* consideration of the desired status of the system and the management interventions that can positively influence that status. Discussion of decision triggers is often linked to concepts that seek to understand how ecological systems function, such as ecological thresholds (Groffman et al., 2006). However, our definition of decision triggers extends well beyond ecosystems that display detectable ecological thresholds.

Decision triggers promote proactive evidence-based management, where the best action to take depends on the current state of the system. Setting a decision trigger requires that an ecological attribute be identified, which can serve as an indicator for the state of the system or the threatening process that is the target for management. Managers must agree on the range of attribute values that distinguish desirable and undesirable states. The boundary between the zones of desirable and undesirable states becomes the trigger point for action, informed by monitoring the ecological attribute (Fig. 1a). A more nuanced view of the system may identify multiple states (e.g., desirable, acceptable, undesirable and unacceptable), with trigger points for different actions associated with each of the boundaries between these zones (Fig. 1b). The benefit of multiple states is that different corrective actions can be assigned to different trigger points, potentially offering early