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Discussion

Considering cost alongside the effectiveness of management in evidence-based conservation: A systematic reporting protocol

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ABSTRACT

Given the limited resources available to address conservation problems, decision-makers are increasingly seeking management solutions that provide value for money. Despite an increasing number of studies that generate estimates of the return-on-investment from conservation management interventions, the ways in which costs are reported are highly variable and generally aggregated. This prevents comparison between studies and the application of systematic tools to synthesize conservation evidence and evaluate the factors that modify costs and benefits. A standardised consensus on the type of cost data to collect and report in conservation science would help build a body of evidence to support decision makers. In efforts to improve evidence-informed decision-making, conservation has looked to health care for tools to support the integration of evidence into management decisions. Increasingly, health care uses economic evaluations of treatment options to estimate the return-on-investment from medical interventions. Here, we describe economic evaluations as a tool for evidence-informed decision-making in health care and draw parallels for how these evaluations could be integrated into conservation. We also suggest tools to help systematically report economic costs of conservation interventions, and illustrate this approach with a case study of turtle conservation. We describe the important elements of economic evaluations, and how these data can be used to greatest effect through tools for evidence synthesis, such as systematic reviews or synopses, to enable decision-makers to identify cost-effective interventions. We believe that a routine commitment from researchers to capture the costs of management interventions would help support evidence-informed decision-making by facilitating the economic evaluations that support cost-effective management decisions. However, this will require clear guidelines for how to capture these data and incentives for conducting the necessary economic evaluations. Being able to present results systematically as return-on-investment could be an important step in encouraging greater use of science by those making management decisions.

1. Introduction

The value of testing the effectiveness of potential conservation interventions is now widely acknowledged. Efforts to synthesize the best available evidence and disseminate it to environmental managers have grown significantly with the support of tools, such as systematic reviews (Pullin and Stewart, 2006), evidence synopses (Dicks et al., 2014), causal criteria analysis (Norris et al., 2012) and stand-alone meta-analyses (e.g., Cadotte et al., 2012). Providing decision-makers with the evidence for the effectiveness of potential management interventions is important, but by itself may not be sufficient (Cook et al., 2013). Constraints on decision-makers, including resource shortages (James et al., 2001; Murdoch et al., 2007) and competing priorities (Sheil, 2001), mean they must seek the most cost-effective strategies to achieve their management objectives. The distinction between the most effective and the most cost-effective management intervention is important because it may lead to different actions. For example, the most effective weed management option for *Rhododendron*

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ponticum (physical removal followed by herbicide application) is twice as effective as the alternative (e.g., herbicide application alone) (Tyler et al., 2006). However, the cost of labour means that physical removal is three times as expensive as herbicide application alone (Tyler et al., 2006) resulting in the less effective alternative providing a greater return-on-investment. Documenting the costs and outcomes of common conservation interventions can also reveal where widely used interventions are wasting resources (e.g., Walsh et al., 2012), with significant implications for policy and practice.

More efficient conservation outcomes are forecast when the costs of management alternatives are explicitly considered (e.g., Moore et al., 2004; Naidoo et al., 2006; Polasky et al., 2001). These benefits hold whether considering the heterogeneity of costs to prioritise different actions (e.g., priority threat management; Chadès et al., 2015; Carwardine et al., 2012) or the spatial heterogeneity of costs (e.g., systematic conservation planning; Balmford et al., 2000). These and other studies have increased the emphasis on economic considerations in conservation and translated into more studies attempting robust cost-effectiveness analysis of conservation interventions (e.g., Gjertsen et al., 2014; Murdoch et al., 2007; Kubasiewicz et al., 2016), albeit from a very low base (Fig. 1). Many studies must base cost estimates on coarse proxies (e.g., Armsworth, 2014) or use estimates from managers because data on actual cost and benefits are not available (e.g., Chadès et al., 2015; Carwardine et al., 2012). Where actual costs are reported, the details and level of aggregation vary dramatically. This large heterogeneity prevents comparisons between studies and precludes the use of methods for evidence synthesis (e.g., systematic reviews or meta-analyses), which could draw conclusions from the evidence base as a whole. A widespread, systematic reporting of conservation intervention costs would enable a significant advance in conservation evidence, providing decision-makers with a critical piece of the puzzle for determining how to act.

For more than a decade, conservation has been looking to health care for guidance on how to improve evidence-informed decision-making (Pullin and Knight, 2001; Sutherland et al., 2004). Pressure from governments to be accountable for the cost-effective use of public funds and the strategic allocation of finite resources has led to 'evidence-based medicine' identifying techniques to measure the return-on-investment from medical interventions (Brunetti et al., 2013). Despite adopting many lessons from health care (Dicks et al., 2014; Pullin and Stewart, 2006), at present, conservation lags well behind health care in reporting economic data and incorporating it into the evaluation of potential management interventions (Cook et al., 2013).

In this article we introduce economic evaluations as an under-utilised and critical tool for evidence-informed decision-making. We highlight the important features of rigorous economic evaluations by drawing parallels between conservation and health care, and describe the critical metadata studies must report to ensure they can be interpreted by others. Reporting standards for costs that assist conservation scientists and practitioners to systematically capture the economic costs of conservation interventions are currently lacking in conservation. Therefore, we adapt a reporting protocol used by the World Health Organisation and illustrate its use with a published case study of Pacific leatherback turtle (*Dermochelys coriacea*) conservation (Gjertsen et al., 2014). This is, to our knowledge, the first available cost reporting protocol for conservation interventions to support cost-effectiveness estimation. We also illustrate how evidence-informed conservation can take the critical step of integrating economics evaluations into evidence synthesis, a current omission from conservation evidence, to build a robust evidence base for decision makers. Through more consistent reporting of costs, conservation science can build an evidence base that enables conservation decision-makers to identify interventions that provide the greatest return-on-investment.

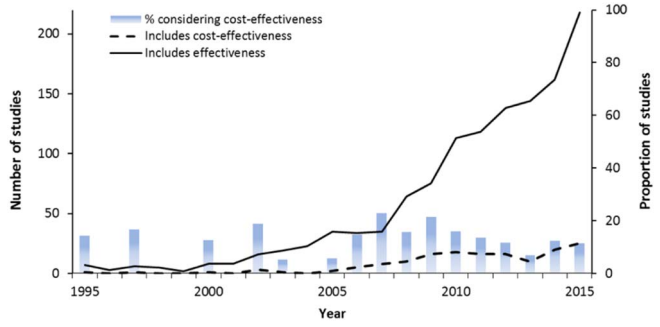

Fig. 1. The number of studies in the conservation literature that include the keywords "effectiveness" (solid line) and "cost-effectiveness" (broken line) over the past 20 years. Bars indicate the proportion of studies considering cost-effectiveness relative to the overall number considering effectiveness, demonstrating that any increase in number is likely a product of increasing number of papers published in conservation, rather than a net increase.

2. Economic evaluations

2.1. Types of economic evaluations

Methods for collecting data on the costs and outcomes of interventions are termed economic evaluations (Drummond et al., 2005). Economic evaluations determine the return-on-investment for different interventions (Shemilt et al., 2008). There are several forms of economic evaluations that use different approaches to help assess return-on-investment (Samuelson and Nordhaus, 2005), including cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA).

CBA is an approach to economic evaluation that uses monetary units to compare both the costs of an intervention and its outcomes (Hughey et al., 2003). Using monetary units to represent both costs and outcomes allows different interventions to be compared regardless of the types of benefits they provide. Estimating the monetary value of the outcomes of medical treatments can be highly subjective (e.g. measuring reduction in pain; Robinson-Papp et al., 2015) and it can be similarly challenging to monetise conservation outcomes (Laycock et al., 2009). The growing fields of environmental accounting and ecosystem services valuation continue to grapple with processes to place a dollar value on biodiversity and ecosystem services (Häyhä and Franzese, 2014). Estimates are often based on asking people what they would be willing to pay (a type of contingent valuation) to conserve a conservation target (e.g., a hectare of Amazon rainforest; Horton et al., 2003). Even when there are quantifiable, monetary benefits from natural systems, such as in the case of ecosystem services (e.g., carbon sequestration), there is still no consensus on how to estimate the monetary value of biodiversity (Häyhä and Franzese, 2014).

CEA considers the costs of an intervention in monetary units and the outcomes in relation to the objective for the intervention (i.e., natural units; Hughey et al., 2003). This allows an assessment of whether the desired outcomes can be achieved given a particular level of investment. Traditionally, CEA uses a single measure of outcomes. For example, in health care, CEA might use a single clinical outcome measure, such as the number of heart-attacks avoided (Brunetti et al., 2013). However, a more sophisticated type of CEA (sometimes called cost-utility analysis) uses a composite measure of outcomes. In health care, the composite measures for the value of an intervention are Quality Adjusted Life Years (QALYs), which measure the increase in patient survival (number of additional years) along with a measure of their quality of life (Shemilt et al., 2008) and Disability Adjusted Life Years (DALYs), which measure the number of years lived with disability and years lost due to premature death (Murray, 1994).

A key difference between health care and conservation is that conservation lacks a universally agreed outcome metric that would provide an equivalent to QALYs and DALYs. Conservation studies generally use single outcome measures in CEA, such as the number of species or the area of habitat protected. There have been some attempts