Biological Conservation 213 (2017) 135–145

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Review

Simplifying the selection of evidence synthesis methods to inform environmental decisions: A guide for decision makers and scientists

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ARTICLE INFO

Keywords:
Aggregative methods
Configurative methods
Decision support
Evidence synthesis
Environmental management
Management decisions

ABSTRACT

Achieving evidence-based environmental management requires that decision-makers have access to evidence that can help identify the most effective interventions for their management context. Evidence synthesis supports evidence-based decision-making because it collates, filters and makes sense of a sometimes large and often conflicting evidence-base, potentially yielding new insights. There are many approaches to evidence synthesis. They each have different strengths and weaknesses, making them suited to different purposes, questions and contexts, given particular constraints. To make sense of the wide array of approaches, we outline the important considerations when selecting the most appropriate method for a particular decision context. These include the purpose for the synthesis, the required outcomes, and the multiple constraints within which decision-makers must operate. We then critically assess a spectrum of approaches to evidence synthesis commonly used within environmental management, detailing the characteristics of each that can be used to determine when it is a suitable method. To guide this selection process we provide a decision tree for those commissioning (e.g., decision-makers or stakeholders) or conducting (e.g., scientists) evidence synthesis, which can be used to identify an appropriate method. The decision tree classifies evidence synthesis methods according to whether their purpose is to test or generate hypotheses, the level of resources they require, the level of certainty in the outputs, and the type and scope of the question being addressed. This tool is a major advance because it helps select an appropriate synthesis method based on the multiple constraints that impact the decision. We conclude that there is an approach to evidence synthesis that will suit all management contexts, but that selecting the right approach requires careful consideration of what is fit for purpose.

1. Background

Over the past decade, evidence-based decision-making has increasingly become the stated goal of environmental management agencies. To achieve this, practitioners need evidence to identify the most effective interventions for their management context. Recent studies suggest that evidence synthesis can be effective in changing conservation practice. Practitioners presented with a summary of the relevant literature indicated they would change their management actions to favour those with strong support for their effectiveness (Walsh et al., 2015). There is a large and rapidly expanding literature aimed at informing environmental management decisions (Fuller et al., 2014). Yet in many ways the sheer volume of evidence itself presents a challenge, and practitioners may face difficulties in accessing, filtering, interpreting and translating that evidence-base into information that can inform decisions (Cook et al., 2013a; Fuller et al., 2014; Young and Van Aarde, 2011). On top of this, studies often yield conflicting evidence, and it can be difficult to arbitrate among the various findings of different studies (Young and Van Aarde, 2011). Similarly, it can be difficult to apply findings from studies conducted in different places or relating to different target species or ecosystems (Cook et al., 2013a).

In response to the above challenges, many tools have emerged to help synthesise relevant evidence and distribute it to practitioners to be interpreted for their decision context (Pullin and Knight, 2001; Sutherland et al., 2004). The term evidence synthesis is used in different ways. However, we use the definition of evidence synthesis

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http://dx.doi.org/10.1016/j.biocon.2017.07.004
Received 5 December 2016; Received in revised form 25 June 2017; Accepted 3 July 2017

provided by Pullin et al. (2016): evidence synthesis is the process of identifying, compiling and combining relevant knowledge from multiple sources so it is readily available for decision makers. While this definition explicitly states that synthesis does not generate new empirical data (Pullin et al., 2016), we contend that evidence synthesis can provide novel insights into a topic by drawing together multiple data sources that can increase explanatory power (Mulrow, 1994).

The power of synthesising the evidence-base on a particular topic has long been recognised in the natural sciences. Literature reviews (i.e., qualitative summaries of multiple studies on a topic; Roberts et al., 2006) and meta-analyses (i.e., quantitative analyses of the results of multiple studies; Arnqvist and Wooster, 1995) have been used to synthesise evidence on a particular topic to advance understanding (Cadotte et al., 2012; Haddaway et al., 2015). However, these methods tends to be more widely used by the scientific community, who are not necessarily focused on informing environmental management decisions (Shah et al., 2015). They also pose similar challenges to those described above for practitioners in terms of access to and interpretation of the primary literature, reducing their value for decision-makers.

With a growing demand for evidence synthesis within many disciplines (e.g., health sciences, education and social welfare; Hansen and Rieper, 2009), there has been a proliferation of methods, often prompted by the need to ensure the product is fit for purpose within the decision-making context (Livoreil et al., 2016; Webb et al., 2017). However, the increase in different methods has often not been well coordinated within and between disciplines, despite specialist methodology groups operating within the bodies that promote evidence-based decision-making (e.g., the Cochrane Statistical Methods Group; McKenzie et al., 2013). As such, new methods have been developed with little reference to existing approaches (e.g., Eco Evidence; Norris et al., 2012). There is often a clear intent to use evidence synthesis to inform decision-making, but whether these approaches have the desired influence on changing policy and practice is uncertain (Cook et al., 2013b). Recognising these concerns, several authors have suggested improvements to evidence synthesis methods to increase their value to decision-makers (e.g., Bilotta et al., 2014; Cook et al., 2013b; Doerr et al., 2015). The result is a large number of methods for evidence synthesis, and an intimidating scientific literature, which has generated confusion among both scientists and practitioners about the strengths and weakness of different approaches and the circumstances in which they are likely to be most appropriate.

The aim of this paper is to provide guidance for those seeking to understand the variety of methods available to support evidence-based decision-making in environmental management. Recent work by Pullin et al. (2016) has provided an excellent starting point to assist decision-makers to understand a range of synthesis methods available and the importance of considering the policy context. Building on the contribution of Pullin et al. (2016), in this article we describe the important characteristics to consider when selecting appropriate methods for evidence synthesis, including the purpose (e.g., generating or testing hypotheses) and desired features of the synthesis (e.g., the level of certainty required). We do this with an explicit consideration of the interactions between the various constraints on decision-makers (e.g., the available funding, level of technical expertise, time constraints) that limit the types of synthesis that can be achieved. We then discuss a spectrum of commonly used methods for evidence synthesis for environmental management decisions, their strengths and weaknesses, and provide a decision tree as a tool to help identify suitable methods for a given decision context. While we present synthesis methods largely used in natural sciences, there are many approaches from social science, such as focus groups and discourse analysis, which can provide useful supplements to the methods we outline (see Pullin et al., 2016).

1.1. What are the different purposes of evidence synthesis?

Evidence synthesis typically aims to draw key messages from a body of evidence on a topic, often with an explicit goal of providing findings in a format that will support management decisions (Pullin and Knight, 2001; Sutherland et al., 2004). As such, evidence synthesis should be driven by the practical needs of decision-makers (Livoreil et al., 2016). Indeed, different decision-makers might have markedly different intended uses for the products of evidence synthesis, and these different purposes have implications for the selection of synthesis methods. One key issue driving the type of evidence synthesis required is whether the impetus is formulating new hypotheses (*configurative* methods) or testing existing hypotheses (*aggregative* methods) (Gough et al., 2012). Configurative methods use existing studies to generate hypotheses, or apply existing theories to different contexts, and often explore evidence about how a system functions (Gough et al., 2012). On the other hand, aggregative methods draw together findings from primary studies to test specific hypotheses (e.g., the effectiveness of an intervention) (Watt et al., 2008).

The decision-making context can be used as a guide as to whether configurative or aggregative methods are likely to be most appropriate. Configurative methods are suited to situations where decision-makers need to enhance or document of the body of evidence on how a system functions. This may be to inform policy development (Banks, 2009; Bilotta et al., 2014, 2015) or the investment of funds in a management program, or to consider the possible management interventions available (Walsh et al., 2015). Once this knowledge is developed, aggregative methods may be used to determine which intervention is likely to be most appropriate. Aggregative methods allow decision-makers to assess causal associations (Norris et al., 2012) and evaluate the effectiveness, cost-effectiveness (Tyler et al., 2006) and the probability of success (e.g., risk of failure or likelihood of perverse outcomes) of alternative interventions (Pullin and Knight, 2009). While rarely the sole purpose of evidence synthesis, both aggregative and configurative methods can also be valuable for revealing knowledge gaps that can guide the development of a management-relevant research agenda (Cook et al., 2013b).

1.2. What are the desired outcomes of the synthesis?

To be useful, evidence synthesis must meet the needs of the decision-makers who have commissioned the synthesis (Webb et al., 2017). It is therefore imperative that all aspects of the decision process are understood, including what the decision will influence, the target audience, the most appropriate format of evidence synthesis for the target audience, the resources available to undertake it, and the level of confidence required by the decision-maker. Once these needs are defined, an appropriate approach to undertaking the synthesis can be identified.

A key desirable outcome of evidence synthesis is confidence in the conclusions drawn. This confidence relates to how well the conclusions can approximate the 'truth' and how transferable the findings are to a particular context (Bilotta et al., 2014). While it is generally agreed that uncertainty in decisions can be reduced by using more information (Canessa et al., 2015; Kloprogge et al., 2007), the acceptable level of uncertainty within decision-making is highly context dependent (Nichols et al., 2017). This context will affect the choice of evidence synthesis method used by the reviewer or decision-maker. For example, some decisions are irreversible (or have greater consequence) and require a greater level of certainty. Decision-makers often seek to minimise the risk of negative outcomes by both identifying effective interventions and also those that may do more harm than good (Pullin and Knight, 2009). Methods that aim to minimise the bias in both the evidence and the process used to collect and synthesise evidence can increase the confidence in the decisions based on that evidence (Haddaway et al., 2015; Song et al., 2000). Approaches, such as the type of systematic reviews promoted by the Cochrane Collaboration (see below) employ rigorous, transparent, explicit and repeatable procedures to minimise bias (Gough et al., 2012). For example, extensive