



## Are ecosystem service studies presenting the right information for decision making?



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### ABSTRACT

Monetary valuation is often used as a measure of ecosystem service value but is not appropriate for all Ecosystem Services. The ecosystem service literature has devised various formats to present monetary values together with other types of ecosystem service information, but these are rarely tested in a decision-making context. We search the literature to identify and classify formats used to present combinations of ecosystem service information types, and develop criteria to determine which features of these formats support instrumental and conceptual decisions. We find that many of the presentation formats present ecosystem service information in a way that supports conceptual discussions, but only a few formats present the information needed to make instrumental decisions. Furthermore, some of our assessment criteria are not met by any of the presentation formats. These gaps suggest further research areas to strengthen the usefulness of ecosystem service assessments in decision making.

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### 1. Introduction

Monetary valuation of Ecosystem Services (ESS) can play an important role in exploring ESS trade-offs and policies (e.g., Turner et al., 1998; Turner and Daily, 2008). Changes in some ESS, like cultural ESS may, however, be better expressed through other quantitative metrics or qualitative descriptions. Using such metrics or descriptions in combination with monetary articulation ('bundled information') brings issues of incommensurability of ESS information across value domains (Martín-López et al., 2014). This incommensurability may be affecting the outcomes of decisions about ESS management (e.g., Eppink et al., 2016). Various presentation formats for bundled ESS information have been proposed, but there has not been an assessment of whether these formats deliver ESS information in such a way to help decision makers select better policies. This paper presents a literature review of commonly used presentation formats for bundled ESS information, assesses the advantages and disadvantages of these formats for different types of decisions, and suggests research directions to improve the delivery of useful ESS information to decision makers.

Using monetary valuation techniques to provide ESS information may be inappropriate for some ESS and decision situations

(e.g., McCauley, 2006). When monetary valuation cannot capture all relevant ESS changes, other types of ESS information, such as biophysical indicators and narratives, can be used to communicate non-monetary values and preferences. Turner and Daily (2008) suggest that information may be insufficient for decision-making ('information failure'). A rigorous framework for producing ESS information, as proposed by Boyd and Banzhaf (2007) and Potschin and Haines-Young (2011), seems to still be out of reach (Seppelt et al., 2011). Martínez-Harms et al. (2015) suggest many ESS studies do not align with separate steps of decision-making, and recent reviews of ESS publications suggest that few ESS assessments have had a clear role in and impact on decision making (Daily and Matson, 2008; Billé et al., 2012; Spilsbury and Nasi, 2006).

The usefulness of ESS information to decision makers thus appears to be gaining research interest, although the question itself is not new (e.g., Weiss, 1979). Posner et al. (2016) conduct a survey among collaborators from 28 sites where the InVEST tool (Nelson et al., 2009) was demonstrated. They find that credible, salient and legitimate information increased ESS information uptake. The lack of use or uptake of ESS information in decision making may depend on whether ESS assessments provide the information that is appropriate for different stages of decision making (e.g., Bingham et al., 1995; Fisher et al., 2009; Laurans et al., 2013).

It may be assumed that all information collected during an ESS assessment is seen by stakeholders to be relevant to the issue at

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hand. Nonetheless, it may be difficult for decision makers to evaluate the implications of bundled ESS information, or to do so neutrally. For example, information might not be presented in comparable units, or be presented in complex schematics leading to significant cognitive burden or bias (Kaufmann et al., 2013; Cason and Samek, 2015). We are aware of only a few quantitative investigations of the role of presentation formats for ESS information in decision-making (e.g., Klein et al., 2015, Eppink et al., 2016).

There is a need to understand better how different presentation formats for ESS information are perceived, processed, and used by decision makers. Without such understanding, the use of ESS information in decision-making may remain marginal. In this study, we search the literature for different formats for presenting bundled ESS information. The purpose of the search is to investigate the extent to which presentation formats of bundled ESS information succeed in providing the information that decision makers need. We do not seek to compile a complete list of studies presenting ESS information, but rather identify distinct formats and to identify where they may not meet the needs of decision makers. From this review and comparison, we propose new research directions that we hope will lead to new research that will promote the use of ESS information in real-world decisions.

## 2. Framework for literature review

### 2.1. Decision making and uses of Ecosystem Services information

Different decisions place different demands on ESS information and its presentation. ESS information needs will also likely differ between different government levels and departments (MacDonald et al., 2014; Jordan and Russel, 2014), with the behaviour of regulatory organisations being determined in part by legislative requirements for ESS information. In addition, organisations are made up of individuals who are influenced by their own values and priorities (O'Neill and Spash, 2000).

As Jones et al. (2014) emphasise, ESS experts and decision makers may have different opinions about what constitutes reliable evidence, a convincing argument, procedural fairness, and the appropriate characterisation of uncertainty. To better assess objectively the contribution ESS information can make to decisions we develop, in this section, a framework to help illustrate the strengths and weaknesses of different ways to present ESS values for different decision contexts.

Building on work by, for instance, Weiss (1979) and Owens (2005), McKenzie et al. (2014) identify three different uses for ESS information in by decision makers: instrumental use, conceptual use, and strategic use. For our purposes, we interpret these different types of information use as follows: *instrumental* use involves decisions between alternative policy options on the basis of ESS gains and losses; *conceptual* use of ESS information concerns broadening and deepening the understanding of topics and shaping the way decision makers and stakeholders think about ESS policies; and *strategic* use supports a particular ESS policy, promotes new policy options, or justifies previously held beliefs and values.

Instrumental use is often the focus of research about ESS information uptake, although in the academic literature there are few demonstrable examples of information being practically applied in this way (Daily and Matson, 2008; Billé et al., 2012; Spilsbury and Nasi, 2006; Laurans et al., 2013). Conceptual use of ESS information can prove to be very useful and influential in policy development (e.g., Laurans and Mermet, 2014). Conceptual use can help expand the range of benefits that stakeholders acknowledge, including those that they may already have considered subconsciously. Furthermore, conceptual use of ESS information can show

connections and give a voice to those stakeholders who would otherwise not have been heard, for example indigenous groups, by strengthening arguments with credible scientific information (McKenzie et al., 2014).

ESS information is used strategically when it supports, promotes or justifies a specific intervention or belief. For the purposes of this study, strategic use of ESS information is problematic because it is an intention that can apply both to making a decision (instrumental use) and to formulating a strategy (conceptual use). We therefore exclude strategic use of ESS information from further consideration in this review.

In the following sections, we use the terms *instrumental decisions* and *conceptual discussion* to describe instrumental and conceptual use as defined in McKenzie et al. (2014). We utilise slightly different terminology to emphasise that instrumental use of ESS information concerns the consideration of concrete decision options, while conceptual use implies the consideration of ESS information in exploratory policy discussions.

### 2.2. Criteria and metrics for different uses of Ecosystem Services information

To assess how well ESS information is presented to support the two types of ESS information use we start from three criteria, salience, credibility, and legitimacy, proposed by Cash et al. (2003) and shown by Posner et al. (2016) to be determinants of the uptake of ESS information. Salience is the relevance of the assessment to the needs of the decision maker; credibility concerns the scientific adequacy of the information included (i.e. that information has been correctly measured); and legitimacy of ESS information comes from a perception that the information brings together diverse beliefs and values in an unbiased and fair manner.

Heink et al. (2016) discuss that due to the potential for mutual dependencies and even semantic overlap between these criteria, they often need further specification when used in policy evaluations. We further describe a number of sub-criteria and metrics to aid with the evaluation of the different approaches for articulating ESS information to each of these three criteria. For the sub-criteria with which we evaluate presentation formats of ESS information, we build on Martinez-Harms et al. (2015) suggestions for aligning ESS research better with decision problems, such as: stronger consideration of trade-offs; improved modelling of biophysical and social processes and contexts; comparison of predicted outcomes with explicitly stated objectives and appropriate performance measures; and assessment of policy alternatives in consultation with stakeholders (see also Rodriguez et al., 2006; Cowling et al., 2008).

The role of presentation formats for ESS information is to convey information to decision makers in a way that can be easily understood and used to make better decisions. In other words is the information salient, or relevant, to the type of decision. The other two criteria of credibility and legitimacy relate more to the analytical and data gathering processes. ESS information is credible when the technical evidence and arguments are scientifically adequate while legitimacy implies that the information has been gathered in a way that is respectful of all stakeholder values and beliefs.

For each of these criteria, Table 1 presents sub-criteria and metrics, as well as the expected range for instrumental decisions and conceptual discussions for each criterion. These sub-criteria and metrics are intended to distinguish between concepts that can be hard to separate (Heink et al., 2016), and the ranges are to an extent stylised to facilitate the evaluation of the presentation formats for different decisions.

Salience is separated into two sub-criteria: comprehensiveness and performance. Comprehensiveness is described by three metrics related to the number of trade-offs and synergies, the spatial

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