

## REVIEW AND SYNTHESIS

# Linking ecosystem characteristics to final ecosystem services for public policy

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### Abstract

Governments worldwide are recognising ecosystem services as an approach to address sustainability challenges. Decision-makers need credible and legitimate measurements of ecosystem services to evaluate decisions for trade-offs to make wise choices. Managers lack these measurements because of a data gap linking ecosystem characteristics to final ecosystem services. The dominant method to address the data gap is benefit transfer using ecological data from one location to estimate ecosystem services at other locations with similar land cover. However, benefit transfer is only valid once the data gap is adequately resolved. Disciplinary frames separating ecology from economics and policy have resulted in confusion on concepts and methods preventing progress on the data gap. In this study, we present a 10-step approach to unify concepts, methods and data from the disparate disciplines to offer guidance on overcoming the data gap. We suggest: (1) estimate ecosystem characteristics using biophysical models, (2) identify final ecosystem services using endpoints and (3) connect them using ecological production functions to quantify biophysical trade-offs. The guidance is strategic for public policy because analysts need to be: (1) realistic when setting priorities, (2) attentive to timelines to acquire relevant data, given resources and (3) responsive to the needs of decision-makers.

### Keywords

Ecological production functions, ecosystem management, ecosystem services, endpoints, environmental policy, sustainability, trade-offs.

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## INTRODUCTION

Governments worldwide are considering using ecosystem services in public policy to advance sustainability goals. As of 2013, 68 countries worked on ecosystem services with activities ranging from convening task forces to implementing new policies (Waage & Kester 2014). Mexico and the United Kingdom (UK) conducted national assessments (Sarukhán *et al.* 2010; United Kingdom National Ecosystem Assessment (UK NEA) 2011), and the European Union (EU) asked Member States to map and assess ecosystem services for accounting systems (European Commission (EC) 2011). China is implementing national policies on ecosystem services, and the United States (US) formally incorporated ecosystem services in a new national forest planning rule (United States Department of Agriculture Forest Service (USDA FS) 2012). Vietnam, Brazil, Costa Rica, Columbia and Peru are creating payment for ecosystem services (PES) programmes at municipal and state levels (Waage & Kester 2014). Recent government activities have created a demand for standardised practices to measure, value and map ecosystem services (Haines-Young & Potschin 2009; Maes *et al.* 2012; Landers & Nahlik 2013; Lü *et al.* 2013; Waage & Kester 2014). To meet

these needs, scientists must first address a data gap: the lack of biophysical measurements linking ecosystem characteristics to final ecosystem services (now referred to as final services) – the things society values directly (Fig. 1). Second, the information must represent legitimate needs presented in terms of trade-offs to aid decision-makers in determining courses of action on multiple services.

In recent years, the number of publications on ecosystem services grew exponentially (Fisher *et al.* 2009; Liu *et al.* 2010; Zhang *et al.* 2010), but progress on the data gap has been slow. Research has centred on management end products like economic values (Liu *et al.* 2010; Zhang *et al.* 2010) and service maps (Seppelt *et al.* 2011; Martínez-Harms & Balvanera 2012), which has advanced categorisation, valuation and mapping techniques (Ouyang *et al.* 2004; Troy & Wilson 2006; Polasky *et al.* 2008; Nelson *et al.* 2009; De Groot *et al.* 2010a; Tallis & Polasky 2011; Ruckelshaus *et al.* 2013). However, there has been minimal improvement on understanding the relationships between ecological mechanisms and ecosystem services to create the realistic end products that managers need (Kremen 2005; Fisher *et al.* 2008; Bennett *et al.* 2009). The dominant method to address the data gap is benefit transfer using species (ecosystem function) values for a particular

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