



Creating win-wins from trade-offs? Ecosystem services for human well-being: A meta-analysis of ecosystem service trade-offs and synergies in the real world



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ARTICLE INFO

Article history:

Received 13 February 2014

Received in revised form 7 July 2014

Accepted 15 July 2014

Available online

Keywords:

Ecosystem service(s)

Ecosystem benefit(s)

Human well-being

Win-win(s)

Trade-off(s)

Synergy(ies)

ABSTRACT

Ecosystem services can provide a wide range of benefits for human well-being, including provisioning, regulating and cultural services and benefitting both private and public interests in different sectors of society. Biophysical, economic and social factors all make it unlikely that multiple needs will be met simultaneously without deliberate efforts, yet while there is still much interest in developing win-win outcomes there is little understanding of what is required for them to be achieved. We analysed outcomes in a wide range of case studies where ecosystem services had been used for human well-being. Using systematic mapping of the literature from 2000 to 2013, we identified 1324 potentially relevant reports, 92 of which were selected for the review, creating a database of 231 actual or potential recorded trade-offs and synergies. The analysis of these case studies highlighted significant gaps in the literature, including: a limited geographic distribution of case studies, a focus on provisioning as opposed to non-provisioning services and a lack of studies exploring the link between ecosystem service trade-offs or synergies and the ultimate impact on human well-being. Trade-offs are recorded almost three times as often as synergies and the analysis indicates that there are three significant indicators that a trade-off will occur: at least one of the stakeholders having a private interest in the natural resources available, the involvement of provisioning ecosystem services and at least one of the stakeholders acting at the local scale. There is not, however, a generalisable context for a win-win, indicating that these trade-off indicators, although highlighting where a trade-off may occur do not indicate that it is inevitable. Taking account of why trade-offs occur (e.g. from failures in management or a lack of accounting for all stakeholders) is more likely to create win-win situations than planning for a win-win from the outset. Consequently, taking a trade-offs as opposed to a win-win approach, by having an awareness of and accounting for factors that predict a trade-off (private interest, provisioning versus other ES, local stakeholder) and the reasons why trade-offs are often the outcome, it may be possible to create the synergies we seek to achieve.

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1. Introduction

One core idea from the Millennium Ecosystem Assessment (MA) is that human well-being is tightly linked to environmental conditions and therefore good environmental management could, in principle, also deliver better outcomes for people, resulting in

win-wins (Tallis et al., 2008). While win-wins may be attractive, they are not inevitable and several lines of evidence suggest they may be unlikely in practice (Bennett et al., 2009), at least in the absence of carefully designed interventions. Pressures on all ecosystem services (ES) worldwide are likely to increase (Rodriguez et al., 2006) as a result of increasing demands on natural resources from a growing human population, and model-based estimates of future worldwide ES suggest intensification of trade-offs between ESs increasing globally and certain regions experiencing rapid changes in ES (Alcamo et al., 2005).

While win-win language has become common in international conservation and development organisations to describe the simultaneous achievement of the conservation and development

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outcomes (Lele et al., 2013; McShane et al., 2011) many studies are now starting to question the underlying assumptions behind win-wins especially for the many situations on the ground that involve competing rather than complementary social, economic and ecological goals (McShane et al., 2011). It is important to note, however, that in the context of this paper win-wins or trade-offs do not refer to conservation and development exclusively, but relate to the competing use for ES, whether that is the same ES or multiple ecosystem services within an area.

Trade-offs occur when the provision of one ES is reduced as a consequence of increased use of another ES, or when more of a particular ES is captured by one stakeholder at the expense of others (Rodríguez et al., 2006). Trade-offs occur among stakeholders as well as among the ES being delivered in any location, and they can be understood in disparate ways, influenced by social norms and life experience (McShane et al., 2011). Such changes may be the result of explicit choices or arise without pre-meditation or awareness. Trade-offs can occur spatially (across locations) or temporally (over time) and ES perturbations may or may not be reversible (Rodríguez et al., 2006).

ES ultimately depend on the ecological communities and functions within ecosystems, and so a good knowledge of the underpinning processes can indicate where there are likely to be trade-offs. Ecological syntheses show that because multiple species traits affect different ecosystem services, and individual ES often depend on multiple traits, there are in practice clusters of linked traits and services within which there are both positive and negative feedbacks that are currently poorly understood (de Bello et al., 2010). A priori it may be difficult to define the circumstances under which win-wins will result, though functional trait approaches afford, to some degree, generalisations about expected win-wins from an ecological perspective (Lavorel and Grigulis, 2012).

ES have been typically presented as being site-based on static maps, without dynamics (Tallis et al., 2008), however, environmental change, ecosystem feedbacks and food-web dynamics can lead to unexpected consequences (Dobson et al., 2006; Nicholson et al., 2009; Rodríguez et al., 2006). These ecological feedbacks can intensify human modification of ecosystems, creating a spiral of poverty and ecosystem degradation (Carpenter et al., 2006). ES functions may also lag by decades, in contrast to economic signals that respond much more quickly (Tallis et al., 2008). Ignoring dynamics may increase the risk of regime shifts that alter the ability of an ecosystem to provide goods and services for future generations (Bennett et al., 2009; Carpenter et al., 2006; Coggan et al., 2010; Nicholson et al., 2009). Thus, more recent approaches consider both capacity (static) and flow (dynamic) of ES, such as Villamagna et al. (2013).

The majority of ES studies focus on single services but understanding trade-offs requires broader studies that consider several ES in the same system (Bennett et al., 2009; Suich et al., submitted for publication; Tallis et al., 2008; Zhang et al., 2007). An understanding of the ecological mechanisms underpinning ES delivery and therefore trade-offs and synergies is evolving and frameworks, such as that developed by Bennett et al. (2009), help in framing mechanistic analyses. One principal challenge in managing ES is that they are not independent of each other and relationships may be highly non-linear, with unintentional trade-offs resulting when we are ignorant of the interactions among them (Rodríguez et al., 2006). For example, changing ecosystem components which generate regulating services may undermine the long-term existence of provisioning services (Carpenter et al., 2006).

Different groups of people derive wellbeing from a variety of ES, with different stakeholders valuing different management options for particular resources. Thus, winners and losers are created as ES

change and trade-offs between different ES can also lead to trade-offs in the wellbeing of different groups of people (Daw et al., 2011). The explicit inclusion of stakeholders in the consideration of trade-offs makes values intrinsic to ES, whether or not those values are monetised (Brauman et al., 2007) and regardless of whether or not users are actively involved in ES changes.

Different actors have different perceptions of and access to ES and therefore they have different wants and capacities to manage directly or indirectly for particular biodiversity and ecosystem characteristics (Díaz et al., 2011). Mechanisms of access are dynamic and determine which individuals or groups can benefit from different ES (Daw et al., 2011), and there can be vast geographic, economic and cultural disconnects between those who control land use and those who benefit from services produced on that land (Brauman et al., 2007). This fact highlights the importance of the role of power in ES trade-offs, of which there are three layers: agency (the capacity of agents to mobilise resources to realise the most desirable outcomes), institutional (institutions as sets of rules that define such things as which norms are legitimate) and structural (macro-societal structures that shape the nature and conduct of agents) (Takeda and Røpke, 2010). Although multi-stakeholder planning can improve the assessment of under-appreciated services and users it does not eliminate the effect of unequal power relations between the stakeholders of different ES (Lebel and Daniel, 2009).

The influence that external forces and global markets, including corruption and governance, have on the likelihood that ES projects will achieve win-wins cannot be ignored (Tallis et al., 2008). For example, agricultural management, primarily influencing the ES related to food supply, is influenced by both biophysical and socio-economic variation and management practices, and access to markets and patterns of trade (Power, 2010). Socio-cultural preferences (such as those related to gender, education, and rural versus urban) also influence what people are willing to trade-off (Martin-Lopez et al., 2012). Management choices often lead to trade-offs between private financial gains and social losses (Zhang et al., 2007) and as either the temporal or spatial scales increase, trade-offs become more uncertain and difficult to manage (Rodríguez et al., 2006).

Unfortunately, planning is conventionally based on supposedly neat physical and institutional separation into conservation and use (Lebel and Daniel, 2009), with (unanticipated and perhaps unintended) trade-offs resulting when management focuses on only one ES at a time (Bennett et al., 2009), although it is important to note that trade-offs may also occur when considering bundles of ES. Similarly, focusing on individual-level management structures, such as farms, can lead to trade-offs, at least for the ES that transcend borders between them (Goldman et al., 2007), for example, the quantity and quality of the water supply.

The complexity of these linked ecological, social, physical and economic factors mean that generalisations about trade-offs and synergies in ES are hard to draw from theory, case studies or in principle. Thus, the purpose of this research was to perform a systematic mapping of the literature on trade-offs and synergies in ecosystem services for human wellbeing and to test a number of hypotheses regarding potential key indicators for a trade-off occurring.

Trade-offs between provisioning and almost all regulating and cultural ES have been demonstrated at the landscape scale (Raudsepp-Hearne et al., 2010), whilst recent empirical evidence from China demonstrates that while economic growth and its associated provisioning services have been progressively enhanced, regulating services have been declining continuously over time (Dearing et al., 2012). Consequently, we predict that one key condition for a trade-off is when at least one stakeholder is utilising a provisioning service. Another core ES concept is that the

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