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The five pillar EPPS framework for quantifying, mapping and managing ecosystem services

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ABSTRACT

This paper introduces an ecosystem services assessment framework with five pillars: ecosystem properties, potentials, services, benefits/values, and beneficiaries. In a case study in the district of Görlitz (Eastern Saxony, Germany), we present an exemplary application for two ecosystem services: crop food production and soil erosion regulation.

The farmland of the district can produce a total of about 518,000 t of crop food (rye) per year, depending on yield potential. Corrected for the mean price of the crop rye, this translates to a value of about 100 million € annually. At the same time, 606,000 t of soil loss must be calculated per year, which corresponds to 36 million € in damages. If 7% of the farmland were to be transformed into grassland or forest, the provisioning service would sink by 37,000 t of rye, for an income loss of approx. €7.4 million per year. On the other hand, soil erosion regulation would be enhanced and soil loss would be reduced by c. 20%, corresponding to on-site benefit of €7.1 million. Within a more intensively used partial study area (with dominating loess soils), the benefits of the erosion regulation service (€656,000) exceed the yield losses (€245,000) more than twice.

1. Introduction

The assessment of ecosystem services in a structured way needs suitable, flexible frameworks including robust procedures or guidelines for each working step, e.g. indicator selection, valuation rules, the consideration of space, scale and time aspects, stakeholder involvement, as well as a consistent, logical terminological system (e.g. Bastian et al. 2012a, 2012b; van Oudenhoven et al., 2012; Seppelt et al., 2012).

Recently the EPPS framework (*E*cosystem *P*roperties, *P*otentials and *S*ervices) for the assessment of ecosystem services was developed (Grunewald and Bastian, 2010; Bastian et al., 2012a), which is based on three interdependent and related pillars, and which highlights the differences between the biophysical prerequisites of ecosystems and their potential and real supply of ecosystem services. Here, we propose an extended EPPS framework with five pillars to emphasize more on additional aspects such as benefits/values, beneficiaries and management.

The goal of this paper is to describe and explain this new framework. Its practical application will be exemplified by way of two ecosystem services, one provisioning service (crop food production) and one regulation service (soil erosion regulation) in the district of Görlitz, eastern part of Saxony in Germany. Both services will be assessed by monetary terms in order to compare trade-offs. Management measures to enhance the supply of ecosystem services and to reduce risks are proposed. For this purpose, a special selection tool is developed, which helps to construct a data pool of areas where land use changes (e.g. afforestation of arable land or conversion into grassland) should take place.

2. Methods

2.1. The extended EPPS framework

The extended EPPS framework (Fig. 1) consists of five pillars, each requiring its own perspective and specific procedures to describe and map ecosystem services. On the left side of the extended EPPS framework are the *properties* of ecosystems – individual objects, parts of objects, and even entire ecosystem complexes – and the structures and processes (e.g. soil qualities, nutrient cycles, biological diversity) which form the basis for all ecosystem services, and moreover, for the existence of humans and of human society in general. According to van Oudenhoven et al. (2012), ecosystem properties are the set of ecological conditions, structures and processes that determine whether an ecosystem service can be supplied.

As a component of nature, this basis for services is materially manifest and can, in principle, be measured (Staub et al., 2011).

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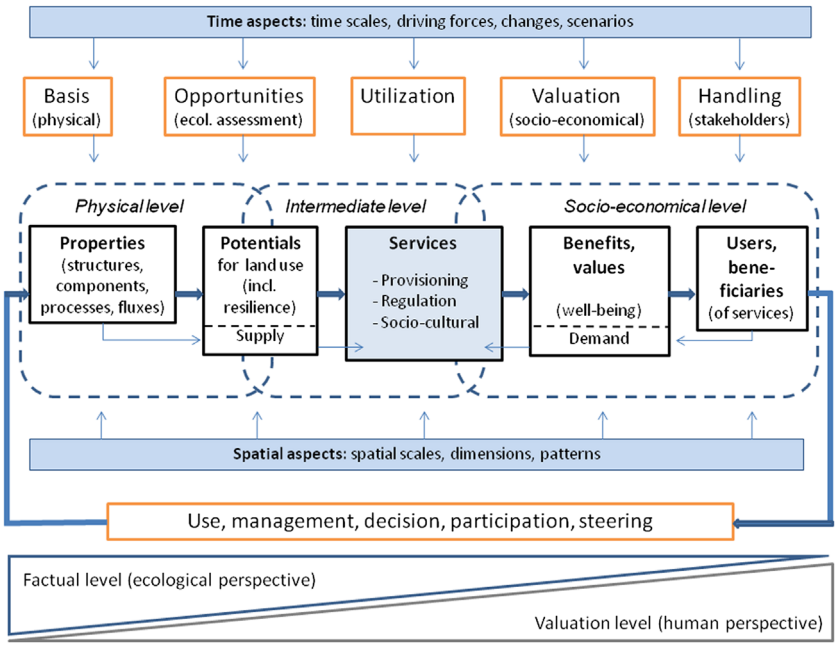

Fig. 1. Conceptual framework for the analysis of ecosystem services—the extended EPPS framework.

Hence, the analysis of ecosystem properties is predominantly driven by natural scientific methods, using analytical indicators. The results represent facts and data that are initially without any relationship to potential societal benefits, values or demands for services by society. Since this ecological endowment is first of all scientifically based, it has to be assigned mainly to the factual level. The analysis of ecosystems properties represents the starting-point of the work – the scientific-analytical basis – and an understanding of the functional principles of nature. Such more or less value-free ecological categories as complexity, diversity, rarity, ecological integrity, or ecosystem health, also belong to pillar 1, i.e. that of ecosystem properties.

Depending on their properties, ecosystems are able to supply services; they have particular *potentials* or capacities for that. Potentials have consciously been included as pillar 2, so as to distinguish between the possibility of use and an actual use, which is the expression of the real service (Bastian et al., 2012a). Potentials can be regarded and quantified as stocks of ecosystem services, while the services themselves represent the actual flows (Haines-Young et al., 2012). In terms of the ecosystem potentials, various preconditions need to be considered, e.g. the ecological carrying capacity and the resilience, which is defined as "the capacity of a system to absorb and utilize or even benefit from perturbations and changes that attain it, and so to persist without a qualitative change in the system" (Holling in Ring et al., 2010). The assessment of ecosystem potentials also pursues the goal of ascertaining the potential use of particular services, and is more normative than a mere accounting of ecosystem properties. It constitutes an important basis for planning, e.g. for the implementation of sustainable land use systems: the suitability of an ecosystem to carry different forms of land use can be established, the available but still unused potentials can be put to actual use, and risks can be estimated.

Only human needs or demands actually convert a potential into a real service. *Ecosystem services*, the third pillar of the framework, reflect an even stronger human perspective (value level), since the services (and goods) are in fact currently valued, demanded or used. In other words, the status of an ecosystem service is influenced not only by its provision of a certain service, but also by human needs and the desired level of provision for this service by society, which connects inseparably supply and demand of ecosystem services (Burkhard et al., 2012; Syrbe and Walz, 2012).

The analysis of ecosystem services always involves a valuation step, i.e., scientific findings (facts) are transformed into human driven value categories. The decisive factor is the combination of the various causal areas in the relationship between society and nature, e.g. (but not only) in the form of economic valuation (e.g. Costanza et al., 1997; Spangenberg and Settele, 2010). Through the link "ecosystem services", human beings benefit from ecosystems. That means, ecosystems yield *benefits and values* (pillar 4), which contribute to human well-being. The benefit is the socio-cultural or economic welfare gain provided through the ecosystem service, such as health, employment and income. Moreover, the benefits of ecosystem services must have a direct relationship to human well-being (Fisher and Turner (2008)). Value is most commonly defined as the contribution of ecosystem services to goals, objectives or conditions that are specified by a user (van Oudenhoven et al., 2012). Actors in society can attach a value to these benefits. Monetary value can help to internalize so-called externalities (impacts, side-effects) in economic valuation procedures so that they can be better taken into account in decision-making processes at all levels. It should be noted that not all dimensions of human well-being can be expressed in monetary terms, e.g. cultural and spiritual values.

An ecosystem service is only a service if there is a human benefit. Without human beneficiaries, there are no ecosystem services (Fisher et al., 2009). Accordingly, there is a disservice only if humans suffer harm. The stakeholders, providers, users or *beneficiaries* of ecosystems and their services (pillar 5) can be single persons, groups, or society as a whole. Not only do they depend or benefit from ecosystems, they in turn react upon ecosystems.

The use and management of services (often regulated and controlled by decisions and legislation tools) can modify or change the properties and potentials of ecosystems. Appropriate *management* has to bridge the gap between the present state and future targets for ecosystem services. Ecosystem management means treats areas at various scales in such a way that ecological services and biological resources are restored and conserved, while appropriate human uses are sustained (Schneiders et al., 2012).