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Applying ecosystem services indicators in landscape planning and management: The ES-in-Planning framework

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ABSTRACT

Applying ecosystem services (ES) concepts and indicators in landscape planning requires them to be linked with models for decision-making by practitioners. The objective of this paper is to introduce an ES-in-Planning framework, which combines ES assessment and valuation indicators with the widely used Driving Forces, Pressures, State, Impacts and Responses (DPSIR) model. Within this framework, ES indicators become part of landscape planning as a means of assessing the current state of the environment and for determining how it might change in the future. The implementation and added value of the framework is illustrated in a case study of planning issues in the Mardorf community bordering the Steinhuder Meer Lake, Northern Germany. Two scenarios of potential landscape changes and possible response measures are considered in terms of alterations in a set of ES indicators. The ES examined are food production (a provisioning ES), climate mitigation (a regulation ES), landscape esthetics (as the basis for many cultural ES), and biodiversity. The ES indicators employed distinguish between services valued by humans and those which are actually utilized. Valuation of changes in ES has shown to reflect societal objectives (as institutionalized in legal requirements) and expert-based estimates. However, these valuations could be further validated by including economic and social valuation of impacts. The added value of applying ES in the planning process lies in improved opportunities for developing targeted response measures, for communicating trade-offs between planning options, and for facilitating joint implementation by partners.

1. Introduction

Both scientists and policy makers are increasingly interested in applying ecosystem services (ES) concepts and indicators to support sustainable landscape development. Scientific interest is reflected in the growing number of publications utilizing ES concepts (Albert et al., 2014a), ranging from conceptual challenges (Cowling et al., 2008; Daily et al., 2009; de Groot et al., 2010b), to explorations of user requirements (Albert et al., 2014b; Hauck et al., 2013a; Mascarenhas et al., 2014), case study applications (Frank et al., 2014; Kopperoinen et al., 2014; Palacios-Agundez et al., 2014), and examinations of the effects of such integration on knowledge generation and cooperation among relevant actors (Fürst et al., 2014; Hatton MacDonald et al., 2014; Opdam et al., in press). Policy makers, on the other hand, increasingly call for a mainstreaming of the ES concept at all levels of policy making (Maes et al., 2012) in expectation of additional insights into the importance of biodiversity and ES for society, and thus greater support for strategies and measures for sustainable landscape development (Hauck et al., 2013b).

ES models and indicators to relate to the existing planning and governance frameworks in order to be applied in landscape management. An effective integration of ES models and indicators in planning requires recognition of democratically legitimized environmental objectives at all relevant levels, providing the means to evaluate anthropogenic pressures and impacts, and to identify locations where response measures are likely to be most beneficial.

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Most importantly, the application of ES models, indicators, and evaluation approaches needs to link to a comprehensive framework of intentional landscape change. One of the most widely used frameworks for landscape planning is the Driving forces, Pressures, State, Impacts and Responses (DPSIR) model originally proposed by Smeets and Weterings (1999) in a report to the EEA. DPSIR represents a framework for studying cause-effect relationships between socio-economic activities and the environment (Tscherning et al., 2012). Environmental indicators are required for all elements of this causal chain in order to meet the information needs of policy makers (Smeets and Weterings, 1999). Suggestions of how links between the DPSIR model and ES concepts could be made were proposed by Müller and Burkhard (2012) in the context of adaptive management cycles for human–environmental systems and by van Oudenhoven et al. (2012) regarding the effects of land management on ES. Schößer et al. (2010) suggest a model for linking typical analytical steps of ES analysis to the elements of the DPSIR approach and Helming et al. (2013) provide a way of linking the ES concept with impact assessment steps via DPSIR. Spangenberg et al. (2014) apply the ES concept in a DPSIR-based analysis of rice plantation management. Although these models and applications have made important contributions to the intellectual debate, they do not fully explore the potential of such integration in the context of landscape planning.

The objective of this paper is to integrate the definition, assessment, and valuation of ES indicators into landscape planning based on the DPSIR model. The paper addresses three research questions: (i) How could ES assessments and valuation be integrated in a DPSIR-based "ES-in-Planning" framework? (ii) Which indicators are most suitable for applying the framework in practice? (iii) What is the added-value of such integration for planning, decision-making, and implementation?

The first research question is addressed by revisiting the relevant literature on DPSIR and ES evaluation models, and by bringing the two approaches together in the form of an "ES-in-Planning" framework. The second research question is answered by reflecting upon indicators proposed in relevant literature from the German planning context (in particular Bastian and Schreiber, 1994; Gruehn, 2005; Jessel and Tobias, 2002; Mengel, 2011; von Haaren, 2004; von Haaren et al., 2008) and in discussions of ES concepts. To illustrate the added-value benefits mentioned in the third question, a landscape-level case study is presented concerning planning issues in the Mardorf community bordering the Steinhuder Meer Lake, Northern Germany.

The next section of this paper introduces an 'ES-in-Planning' framework as an integration of DPSIR and a recently proposed, practice-oriented ES evaluation model (von Haaren et al., 2014). Subsequently, a list of suitable indicators is proposed including references to relevant legislation, which is particularly important for planning practice. The following section describes methods and results of the case study in order to illustrate a conventional approach to landscape planning, and how ES assessment and valuation can be integrated in this process. Finally, the effects of such integration are critically discussed and conclusions drawn concerning future applications and research needs.

2. Combining DPSIR and ES evaluation in the 'ES-in-Planning' framework for landscape planning

We propose to integrate an evaluation of ES into the DPSIR model in order to provide a generic structure for a landscape planning process. A range of different framework methods for landscape planning exist (e.g. Kato and Ahern, 2008; Steiner, 2000; Steinitz, 1993; von Haaren et al., 2008) but all relate more or less obviously to the general DPSIR model for assessing intentional landscape change. Following the DPSIR model (see Fig. 1), landscape planners first identify the social and economic driving forces that exert pressures on the environment, thus causing changes in its state. The resulting alterations in the state of the environment over time (i.e. $state_{(t)} - state_{(t+1)}$) can have impacts on human well-being or implications for societal objectives (e.g. sustainable development). Information on such changes also provides the basis for designing responses, for instance new measures or management strategies. These responses may seek to reduce negative drivers or pressures, safeguarding or enhancing the state, or mitigating impacts.

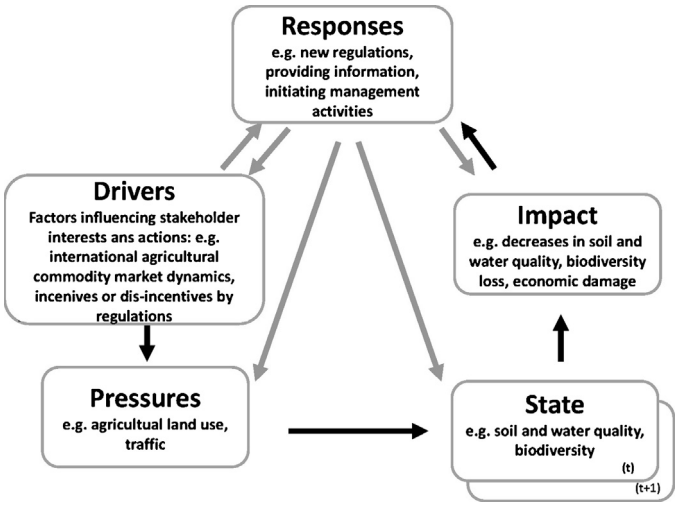

Fig. 1. The DPSIR model (Smeets and Weterings, 1999, adapted). The gray arrows represent the potential paths of influence by planning.

The second key model employed in this paper is an adapted version of the Practice-Oriented Ecosystem Services Evaluation (PRESET) framework (von Haaren et al., 2014) which is, in turn, based on the popular "ES cascade" originally proposed by Haines-Young and Potschin (2010) and further developed by de Groot et al. (2010a) and Potschin and Haines-Young (2011). The adapted model is specifically suited to the requirements of local and regional planning in Europe. It consists of five components as shown in Fig. 2. At the center are ES, understood as the direct and indirect contributions of ecosystems to human well-being (TEEB, 2010; UK NEA, 2011), consisting of both those 'offered' by ecosystems and those actually 'utilized' by humans. The offered ES represent the totality of ecosystem contributions that may provide benefits to humans today or in the future (but need not necessarily be used today). This provision is dependent on appropriate ecosystem elements (termed here Natural Capital), including relevant elements, processes, and structures as well as geo- and biodiversity. The utilized ES are those that are actually turned into goods or directly consumed by humans. This transformation often requires human input (UK NEA, 2011), with examples being fertilizer, energy, pesticide, labor, or knowledge (cf. Burkhard et al., 2014). The resulting benefits are positive changes in human well-being stemming from the direct or indirect contributions of offered and/or utilized ES. von Haaren et al. (2014) argue that distinguishing offered ES, utilized ES, goods and benefits presents different and complementary perspectives about planning and decision-making objectives, the choice of appropriate landscape development strategies and implementation that each can usefully inform plan- and decision-making (as represented in the lower box).

An important addition of the adapted model is the linkage of ES evaluation to both shared values (as expressed in legislation) and individual values and preferences (as reflected in actual uses