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Indicating ecosystem and landscape organisation

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Abstract

This paper presents a brief outline of the theoretical and conceptual fundamentals for the derivation of an ecosystem oriented indicator system to demonstrate the state of ecological entities on a holistic basis. There are two branches of argumentation: on a normative level, the sustainability principle is interpreted from an anthropocentric point-of-view; sustainability in this context means to provide ecosystem services on a broad scale and a long-term basis, including the attempt to avoid unspecific ecological risks. A second line-of-argumentation bases on the principles of ecosystem analysis and the theory of ecological orientation. Consequently, the aspired indicandum is the self-organising capacity of ecosystems, and the indicator sets represents an aggregate of structural and functional ecosystem features in a developing environment. The indicator set is demonstrated by one case study from the Bornhoeved Lakes ecosystem research project.

Keywords: Ecosystem analysis; Ecosystem organisation; Ecological indicators; Landscape indicators; Ecological orientors; Sustainable development

1. Introduction

The guiding principle of contempory environmental management is a holistic principle: the idea of sustainable development implies several demands which can only be fulfilled within an interdisciplinary, systems-based framework that takes into account the social, economic, cultural and ecological features of many interacting temporal and spatial scales, reaching up to long-term (intergenerational) and global (intragenerational) issues (Hauff, 1987; WCED, 1987). An important lesson from ecosystem analysis and ecosystem restoration states that these pretentious holistic requirements can only be met if indirect, chronical and de-localised effects are treated as focal elements of the respective scientific investigations and political activities (Costanza, 2000; Daily, 1997; Joergensen, 1992; Patten, 1992). Otherwise the long-term aspects of the sustainability principle cannot be transferred correctly, decision supporting scenarios cannot be conducted reliably, and the resulting political concepts will be incomplete and short-sighted. Thus, besides the demanded spatial and temporal extents, sustainable development also requires deep substantial extents, considering multiple subsystems and elements as well as the prevailing interrelations between them.

These theses may provoke various consequences for environmental indication, i.e. they underline the

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necessities for holistic conceptions and for the application of ecological systems analysis. The following paper is an attempt to present one approach for a holisitic indication of ecological items on the ecosystem and on the landscape scale. Realising the basic requirements for indicators (e.g. political relevance, representativity, validity, sensitivity, transparency, applicability, etc.; see Wiggering and Müller, 2003), the described concept tries to represent the organisational states of ecological systems using a minimum set of indicators, which have been derived on a holistic ecosystem theoretical basis. The target of the indicator set is to provide a general quantifying representation for the integrity of ecological systems. The focal questions of the paper are the following:

(1) Is it possible to represent ecosystem and landscape states on the base of a small number of variables?
(2) Is it possible to formulate eco-targets for ecosystem and landscape management on the base of ecosystem theories?
(3) Is it possible to derive applicable indicators from applied theoretical considerations?
(4) Which problems will arise concerning the indicators' applications?

The paper will start with a terminological discussion. It includes a sequence of expressions leading through the concepts of ecological sectors, structures, functions and organisation. Throughout that ''zoom'' over ecological levels-of-integration there will be the attempt to build a bridge to the socio-economic side of sustainability with the concept of ecosystem services. On this base, a holistic indicandum will be introduced: ecological integrity as an ecological branch of sustainability. Thereafter, the guidelines of the indicator derivation and the proposed indicator set to represent ecosystem organisation will be described. After brief descriptions of some case studies, the introductory questions will be discussed and some conclusions will be drawn.

2. The starting point: what is ecosystem organisation?

Taking into account the targets of this volume—a discussion of functional and structural landscape indicators, and the goals of this paper—the development of a holistic indicator set to represent ecosystem and landscape states, some basic terms have to be pointed out in the beginning, i.e. due to the extraordinary multitude of comprehensions concerning the focal conceptions of this approach. Therefore, we will start with a short definition of the expressions sector, structure, function and organisation.

Traditionally, ecologists are investigating different *sectors* of ecosystems: they try to find out basic characteristics of isolated ecosystem compartments, such as vegetation, fauna, microflora, soils, aquifers or other—often smaller observer defined subsystems. The fundamental features of these units are illuminated in a very detailed style, often reducing the number of potential influences between the elements of the investigated systems. Most of the actually used indicator systems can be assigned to this sectoral, mono-disciplinary approach and also the interpretations of the achieved indicator values mostly are restricted to the fate of very specific subsystems of the observed ecological entities from an isolating, reductionistic viewpoint.

If we look at the integral composition and the spatial arrangement of such subsystems, *structural investigations* are conducted. Typical questions of this approach are the following: Which are the relevant components, elements or subsystems to answer the observer's questions? Which are the relevant spatial or temporal patterns of these elements? Which is the species composition of the investigated system? Which are the significant habitat features and which determining abiotic patterns can be found in the landscape? Such questions are leading to indicator sets about slowly changing variables, which are established on inventories, regional accountings or other geographical methods (see Golley, 2000).

While these structural approaches are analysing the ''processors'' of the system, the investigation of ''pure'' *ecological functions*[1] aims at the processes

[1] Of course, the term ''function'' implies many different comprehensions, such as the general activity or performance of a system, the role of an object, its specific task, the purpose of an entity or mathematical interrelations (see Jax, 2000; Müller and Windhorst, 2000). In the context of the approach described in this paper, ''ecosystem functions'' are reduced to the processual interrelationships between the elements or subsystems of an ecological entity. This renunciation of a normative, utilitaristic or teleological component in the understanding of ''function'' has lead to the attribute ''pure''.