Available online at www.sciencedirect.com

SciVerse ScienceDirect

Current Opinion in Environmental Sustainability

Linking ecosystem processes and ecosystem services

Bojie Fu[1], Shuai Wang[1], Changhong Su[1] and Martin Forsius[2]

The metaphor of ecosystem service may blind us to the complexity of the natural systems which underpin and produce services. We reviewed key references and propose a framework to illustrate the social system relying on the ecological system and the relationships between ecosystem composition, ecosystem structure, ecosystem processes and ecosystem services, in order to reduce this complexity. We argue that plans to manage ecosystem services will not be successful without a deep understanding of their link with the ecosystem processes that support them. By linking ecosystem processes and ecosystem services, we explore the possible determinants of the biodiversity components on the quantity, quality and reliability of ecosystem services at all levels, and its usefulness in making targeted decisions. Disentangling the complex interrelationships among multiple ecosystem services from the driven processes is helpful in lowering the risk of unwanted trade-offs, and taking advantage of synergies. In landscape management, it is advisable to design suitable ecosystem structures for maximizing ecosystem services based on knowledge of the natural ecosystem processes.

Addresses
[1] State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, P.O. Box 2871, Beijing 100085, PR China
[2] Natural Environment Centre, Finnish Environment Institute, P. O. Box 140, FI-00251 Helsinki, Finland

Corresponding author: Fu, Bojie (bfu@rcees.ac.cn)

Current Opinion in Environmental Sustainability 2013, **5**:4–10

This review comes from a themed issue on **Terrestrial systems**

Edited by **Bojie Fu**, **Martin Forsius** and **Jian Liu**

For a complete overview see the Issue and the Editorial

Received 19 July 2012; Accepted 11 December 2012

Available online 1st January 2013

1877-3435/$ – see front matter,

http://dx.doi.org/10.1016/j.cosust.2012.12.002

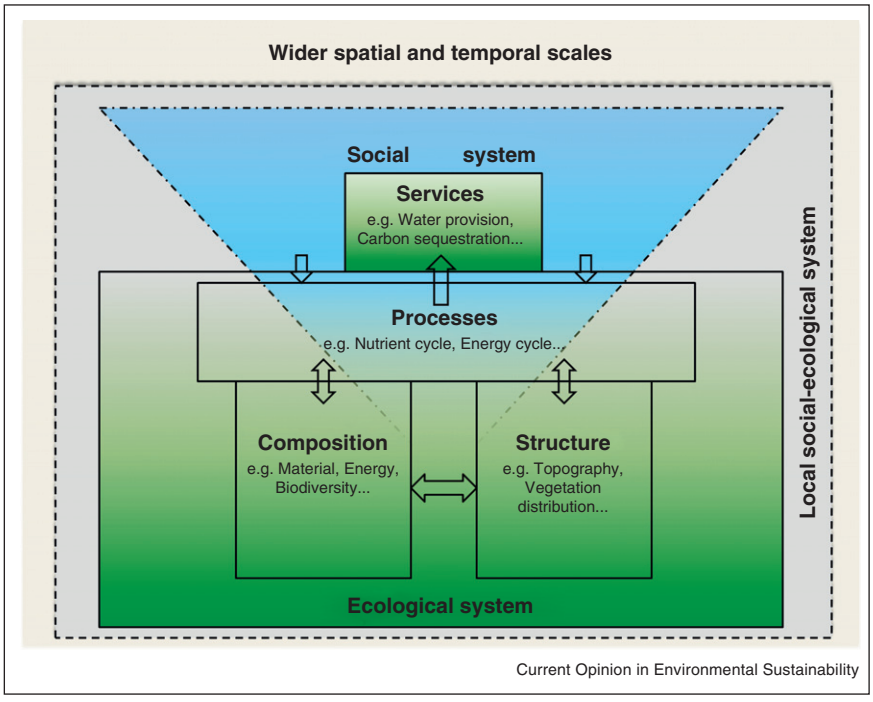
Introduction

The ecosystem service concept was proposed to attract public attention initially and to balance competing interests on natural resources [1,2]. During the past few decades, progress has been made in understanding the ecosystem services' generating mechanism [3,4••], calculating its value [5,6], mapping its supply and demand [7,8], as well as analyzing threats faced by ecosystem services [9,10], and its future consequences [11]. Current research has put much emphasis on ecosystem services assessments at regional and national scales, trade-off analyses and its role in decision making [12••,13,14]. Although the concept of ecosystem service conveys the social dependence on ecological life support systems and facilitated interdisciplinary research, it may blind us to the complexity of the natural systems underpinning the ecosystem services. The generation of ecosystem services relies on the ecosystem composition, structure and processes [15,16]. Accurately predicting the dynamic provision of ecosystem services requires a considerable understanding of ecosystem composition, structure and the processes that sustain them [17•], especially the links between ecosystem processes and ecosystem services. We would like to contribute to the ongoing debate with some proposals and analyses by examining these interrelations, based on reviewing the research progresses for a better understanding of the Coupled Human and Nature System (CHANS) and better environment management.

Ecosystem composition, structure, processes and services

Ecosystem services are benefits that people obtain from ecosystems; in the absence of people there are no services [18,19]. The framework (Figure 1) illustrates how the social system relies on the ecological system and the relationships between ecosystem composition, structure, processes and services. Ecosystem composition refers to 'the comprising types and abundance of biotic and abiotic elements in a defined ecosystem' [15]. These interacting biotic and abiotic components constitute natural biodiversity [20]. In other words, ecosystem composition is the material base and driver of ecosystem processes and services. Ecosystem structure refers to the distribution and arrangement of ecosystem components [15], which is subject to both physical and anthropogenic influences. Ecosystem processes are the interactions among the biotic and abiotic elements [21]. Some key ecological processes, such as energy transfer, nutrient cycles, and oxygen and water fluxes [15] are always regarded as synonymous with ecosystem function. Ecosystem services are the conditions and processes that sustain and fulfill human life [22]: the contents of which vary depending on the social-ecological context. Ecosystem processes are the means to deliver ecosystem services; for example, pollination, soil formation and water regulation provide the services of food and potable water. Given the complexity of ecosystems, the processes and services cannot be completely separated; some processes are themselves also services, such as flood regulation by vegetation, while

Figure 1



A framework linking ecosystem processes with ecosystem services. The blue triangle represents the social system and the green rectangle represents the ecological system. The interactions among compositions, structures and processes of the ecological system underpin the social system with various ecosystem services.

others are not, such as evapotranspiration by forest. On the basis of the classification system of Millennium Ecosystem Assessment (MA), within the process-services chains, supporting and regulating services are mainly intermediate, while provisioning services are definitely at the end point [23].

The biophysical components and structure underpin the ecosystem processes. When the latter are consumed by humans they are translated into ecosystem services [24]. Ecosystem processes interact with ecosystem components and structure. Humans manage ecosystem processes through arranging the ecosystem components and structure to deliver ecosystem services that better meet their needs, such as altering land cover/land use to safeguard a human's well being. In the Loess Plateau of China, a vast area of natural vegetation has been reclaimed as farmland in the last century for grain production. The past three decades saw the inception of a series of large-scale reforestation projects, which significantly increased the vegetation coverage percentage from 6.5% in the 1970s to 51.13% in 2010 and improved the ecosystem services of soil conservation, water regulation and carbon sequestration [25]. As the ecosystem processes, ecosystem services and their driving mechanisms are the key components of the CHANS [15], understanding the links between ecosystem processes and ecosystem services is essential for making a prudent ecological policy.

Basic ecosystem processes and services

Ecosystem composition, structure and processes can be summarized as ecosystem integrity, which depict the ecosystem resistance and resilience, represent its capacity or potential to provide ecosystem services. Within the ecological factors, water, soil and carbon play central roles in regulating ecosystem processes with strong spatial/temporal scales dependence, and providing key services for human beings.

Water-based services

Water is an important ecosystem factor, as it can provide the medium for multiple ecosystem processes. At a microscopic scale, researchers have done a multitude of explorations on water movement, especially within the Soil-Plant-Atmosphere Continuum (SPAC). The challenges lie in the spatial heterogeneity of the transporting medium (e.g. root and branch structure) and the temporal variability of the external drivers. Stable-water-isotopes tracing is widely used in capturing water movement. Braud *et al.* [26] integrated the isotope method with the Soil-Vegetation-Atmosphere (SVAT) model and