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## Landscape Functions in a Changing Environment

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### Abstract

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Landscapes provide a broad range of services to society. To date, however, only few regional to continental scale studies assess the capacity of landscapes to provide these services under changing environmental conditions. This is required if the maintenance of current landscape multifunctionality remains a long-term goal. The presented mini review highlights and promotes the concept of landscape functions, defined as the capacity or potential of landscapes to provide services. Ultimately, spatially explicit landscape-function assessments may provide baseline information for society to engage in an open discussion on future landscape development and its potential impact on landscape character. Our mini review is supported with recent literature as well as insights gained at a symposium held at the IALE 2009 conference in Salzburg, Austria as well as a workshop held in Salzgau, Germany 2010 and the Global Initiative of the The Ecosystem Services Partnership (<http://www.fsd.nl/esp>, 30. May 2010)

### Keywords

landscape functions, landscape multifunctionality, ecosystem goods, ecosystem services, landscape ecology

## Landscape function assessment – urgently needed planning tool

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Landscapes provide a variety of services to society, e.g., food and fiber, regulation of environmental quality, as well as aesthetic qualities (Kienast et al. 2009; MA 2005). These “goods and services” are the flows of benefits to society and depend upon both the capacity of the landscape to supply these services and the demand from society for the benefits they provide. An implicit principle of sustainability is that flows in the form of ecosystem goods and services cannot exceed the long-term capacity of landscapes to provide them. Thus, assessing capacities is a difficult but necessary step to ensure long-lasting benefits for society. This is the major message of the presented mini review, which aims at embedding the landscape function concept into the sustainability discussion.

As initially proposed by de Groot (2006) and refined by Haines-Young & Potschin (2009) as well as Burkhard et al. (2009), landscape functions encompass the composite nature of the capital stocks represented by cultural landscapes. These stocks manifest themselves in the form of landscape structures (e.g., mountains, woodlands, cities) and ecosystem processes and functions (e.g., net primary productivity). In using the term landscape ‘function’ we recognize that the word function is overlain by many different meanings (Jax 2005), which often confuse means with ends (Wallace, 2007). We use the term landscape function to describe the capacity of land for ecosystem service production, and not, as for example published by Helming et al. (2008) or Pérez-Soba et al. (2008), to describe the flows of social, economic and ecological benefits that land may generate. We recognize that this notion of „capacity“ is very close to the carrying capacity concept (Vos et al. 2001).

The literature (Costanza et al. 1997; de Groot et al. 2002; Hein et al. 2006; MA 2005) suggests that a wide range of landscape functions and associated services

can be identified belonging to four major groups, namely: (i) production functions - delivering provisioning services; (ii) regulation functions – delivering regulating services; (iii) habitat functions for maintaining ecological structures and processes – delivering supporting services such as e.g. biodiversity-enhancing landscape structures; and (iv) information functions – delivering cultural and amenity services.

Wallace (2007) criticized the function concept heavily and developed an alternative classification scheme for ecosystem goods and services by avoiding the notion of “capacity” or “potential”. Instead, he clearly distinguished between means and ends. The means, however, are frequently treated synonymously to the potential of delivering a process, e.g. carbon sequestration. Nowadays, numerous studies and initiatives (see below) support - independently of the terminology - the idea of defining capacities of larger areas to deliver goods and services. This need is particularly strong in planning-oriented initiatives, such as e.g. reported in the Natural Capital Project (2010a) or in papers by Nelson et al. (2010a), Naidoo et al. (2008), or Willemen et al. (2008). We acknowledge however that assessing the capacities of entire regions to deliver goods and services is very difficult - often more difficult than assessing flows - and requires a concerted effort of planners, stakeholders and experts. Kienast et al. (2009), Chan et al. (2006), Troy and Wilson (2006) or Lesta et al. (2007) advocate spatially explicit function assessments to facilitate the broad use of the service approach by decision makers. It is suggested that spatially explicit assessments would better enable them to balance region-specific goods and services against other issues in public debates on sustainable development.

## Current trends in landscape functions research and application

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Based on a broad literature survey we identified major trends in current landscape functions research as well as in the corresponding applications. Bearing in mind our target audience of land managers who requi-

re simple assessment tools, we selected the following trends as being relevant:

- The landscape function paradigm gains momentum in many parts of the world. An increasing number of Environmental Agencies adopt them as planning principles (USGS 2010, EEA 2008, Natural Capital Project 2006). In the IALE Symposium of 2009 a broad variety of physical and socio-cultural environments were considered ranging from Western Europe (The Netherlands, Belgium, France, Switzerland, Germany, Austria) to Central Europe (Slovakia, especially Carpathian mountains), Eastern Europe (Poland, Ukraine, Russia), and Southern Europe (Malta, Italy), and to non-European countries such as China and Taiwan. A recent Conference in Salza, Germany (Ecosystem Service Partnership 2010b) on Ecosystem Services showed a broad acceptance of the paradigm globally. This is as well visible in the Ecosystem Services Partnership (2010b)
- The recent literature covering both ecosystem services and landscape functions has a strong bias towards production and regulation functions (Kienast et al. 2009). This is primarily due to the availability of (spatial) data and appropriate economic valuation methods (e.g. value transfer, direct valuations, (de Groot 2006; Troy & Wilson 2006). In particular there is a lack of appropriate methods and data to assess information functions (Willemsen et al. 2008). This knowledge gap is clearly visible in the IALE Symposium. Despite the fact that a wide spectrum of landscape functions research was addressed, the majority of functions deal with habitat and provisioning functions (19 presentations). Only 3 presentations dealt with information functions.
- There is an urgent need to elaborate up-front techniques to assess trade-offs between landscape functions and to generate broad-scale multi-functionality assessments (Brandt & Vejre 2004; Gimona & van der Horst 2007; Lorenz et al. 2001; Potschin & Haines-Young 2006). Promising approaches to analyze trade-offs and to finding optimum solutions are e.g. Willemsen et al. (2010), Edwards (2009), Haines-Young and Potschin (2009).
- Landscape functions and function changes must be assessed dynamically, i.e., historical and future land-use and land-cover change have to be

taken into account (landscape structure, landscape composition). Promising examples of this type of analysis are addressed by Hasselmann et al. (2010), Hersperger and Bürgi (2009), Houet et al. (2010), Verburg et al. (2010).

- There is an increasing number of studies that try to link function assessments with climate change (France & Duffy 2006) and to separate land use impacts from climate change impacts (Bradley 2010).
- An increasing number of studies provide methods to improve the participatory character of landscape functions assessments, e.g. the Natural Capital Project ([www.naturalcapitalproject.org](http://www.naturalcapitalproject.org), 30 May 2010). This is an important step towards more environmental stewardship.
- An increasing number of papers try to map landscape functions and their trade-offs over large areas, e.g. Kienast et al. (2009), Eigenbrod et al. (2010), Naidoo et al. (2008), Egoh et al. (2008). However, we feel that more could be done given the large remote sensing and GIS data repositories.

## Conclusions

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From results of our literature review as well as the talks and the posters of recent symposia, we conclude that landscape functions are a powerful tool to assess the potential of landscapes to deliver ecosystem services in a changing environment. However, many function assessments deal with one or only a few landscape functions and do not take into account trade-offs and feedbacks between functions. To gain an overall impression of changes in landscape multifunctionality and to allow identification of synergies/conflicts within a region, however, it will be necessary to increasingly address a whole suite of landscape functions. Also, we identify a considerable lack of spatial representations of landscape functions not only at the regional but also the national and continental scale. Maps of functions (see e.g. Kienast et al., 2009 or Eigenbrod et al. (2010) or Burkhard et al. (2009) would provide a powerful tool to visualise changes in landscape multifunctionality, especially at larger spatial scales (regional, national, continental scales). Additionally, it becomes evident that habitat

functions appear to dominate the landscape ecological community. In the future, increasing attention should be given to the anthropogenic dimension of landscape-change assessments by addressing and developing the yet limited availability of cultural/amenity (information) functions.

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