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Spatial characterization of landscape functions

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ABSTRACT

There is little information available on the spatial variation of landscape functions. We developed a methodological framework to map and quantify landscape functions depending on the availability of spatial information. In this framework three different methods were proposed (1) linking landscape functions to land cover or policy defined areas, (2) assessing landscape functions with empirical models using spatial indicators and (3) assessing landscape functions using decision rules based on literature reviews. The framework was applied to the Gelderse Vallei, a transitional rural area in the Netherlands. We successfully mapped and quantified the capacities to provide goods and services of eight landscape functions (residential, intensive livestock, drinking water, cultural heritage, tourism, plant habitat, arable production, and leisure cycling function) for this region. These function maps provide policy makers valuable information on regional qualities in terms of landscape functionality. Making landscape functions spatial explicit, adds an important component to research conducted in the field of quantification of landscape goods and services.

1. Introduction

Landscapes are able to fulfil many different functions. Based on the definitions of de Groot (1992) and the Millennium Ecosystem Assessment (2003) we define "landscape function" as the capacity of a landscape to provide goods and services to society. These include, for example, the provision of goods like harvested crops or timber, and services like landscape aesthetics, provision of habitat or regulation of water systems. The capacity to provide goods and services is not evenly distributed over a region as it depends on socioeconomic and biophysical variation of the landscape and the spatial and temporal interactions between the different components of the landscape (de Groot, 1992; Wiggering et al., 2006; Syrbe et al., 2007).

From the 1990s onwards, landscape functions and multifunctionality have become important concepts in policy making, in particular within the European Union (FAO, 1999; OECD, 2001; Hollander, 2004; Wilson, 2004; Bills and Gross, 2005). For example, the European Union's Common Agricultural Policy (CAP) reforms of 2003 were strongly based on the concept of multifunctionality (EC, 2004). Additionally policy makers nowadays have to deal with an explicit demand for landscape goods and services from local and national stakeholders (Hein et al., 2006). However, information on landscape functions is often lacking for policy making (Pinto-Correia et al., 2006; Vejre et al., 2007). Existing landscape models to support policy making mostly either deal with land cover patterns (Geertman and Stillwell, 2004; Verburg et al., 2004) or are strongly sector-oriented (Heilig, 2003; Meyer and Grabaum, 2008).

In the last decades considerable progress has been made in analysing and quantifying a multitude of landscape functions. A large number of studies have focused on various aspects of landscape functions and its multifunctionality (Costanza et al., 1997; Costanza and Farber, 2002; Dijst et al., 2005; Potschin and Haines-Young, 2006). However, an issue that is not yet sufficiently resolved is how the spatial heterogeneity of landscape functions can be accounted for (Troy and Wilson, 2006; Meyer and Grabaum, 2008).

Spatial information of landscape functions is scarce as only some landscape functions directly relate to observable landscape features (e.g. built-up area and residential function, or forest and timber production). Spatial information of other landscape functions depends on additional intensive field observations or cartographic work.

The objective of this paper is to present a methodological framework to quantify landscape functions and to make their spatial variability explicit. We present three methods to map and quantify landscape functions depending on the availability of spatial information, based on (1) linking landscape functions to land cover or spatial policy data, (2) empirical predictions using spatial indicators

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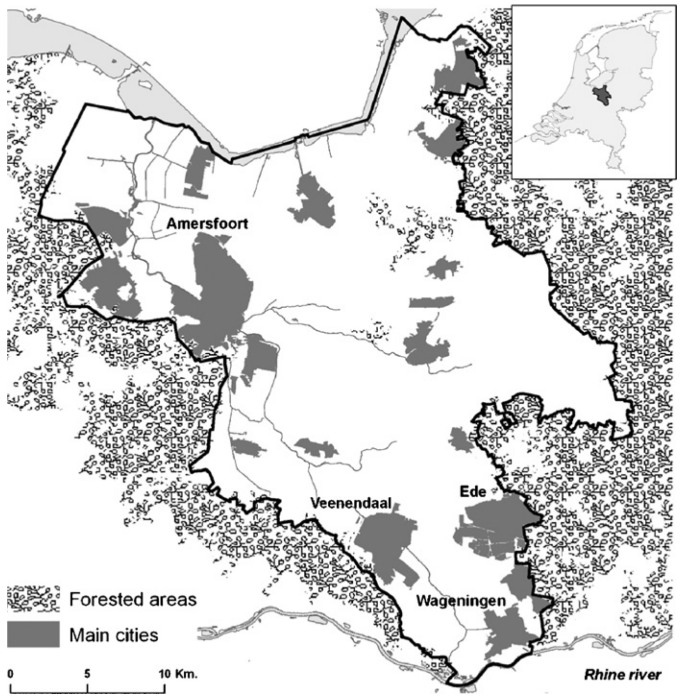

Fig. 1. Study area of the Gelderse Vallei; within the inset the location of the study area in the Netherlands.

and (3) decision rules based on literature reviews. An application of the methodology is illustrated for the Gelderse Vallei region of the Netherlands.

2. Data and methods

2.1. Study area

The Gelderse Vallei region (Fig. 1) was used to develop the proposed approach because of its high diversity of landscape functions. The Gelderse Vallei is a valley formed by a glacier which entered the Netherlands in the Saale period (approximately 150 ka BC). In this period moraines were formed by sediments pushed sideways, now bordering the valley. The difference in elevation in the study area causes a gradient in many biophysical conditions like hydrology and soils. This diversity in biophysical conditions forms a basis for a diverse land use and land cover. Of the total size of the study area (approximately 750 km^2), 71% of the land has an agricultural use, another part of the land is covered by urban areas (17%), housing some 600 000 inhabitants (CBS, 2000). Veining the rural areas, ecological corridors are connecting two national parks located on both side of the Gelderse Vallei. These national parks stimulated the development of a large tourism sector in the region (some 300 000 yearly overnight stays (Provinces of Gelderland and Utrecht, 2005). Additionally, the region contains a large part of the intensive livestock agriculture of the Netherlands (20% of the Dutch poultry production (CBS, 2000). Gradually this rural area is transforming to a more peri-urban region. In the end of the 20th century conflicts between different land uses led to problems in livestock production, disturbance and pollution of the environment and undesired urban development leading to losses of cultural–historical landscapes. A new spatial planning strategy was therefore introduced. The Reconstruction Act (Province of Gelderland and Province of Utrecht, 2005) focused on the specific multifunctionality of the Gelderse Vallei, aiming at separating conflicting functions and joining compatible functions as much as possible.

2.2. Landscape functions

In this study eight landscape functions were analysed, namely, the capacity of the landscape to provide, (1) areas for residential use, (2) locations for intensive livestock husbandry, (3) information on cultural heritage, (4) zones for drinking water extraction, (5) an attractive landscape for overnight tourism, (6) habitat for rare, endemic and indicator plant species, (7) arable agriculture production fields, and (8) an attractive landscape for leisure cycling. This selection of landscape functions was based on their different levels of spatial information availability and the current spatial planning policy focus of the case study region (Provinces of Gelderland and Utrecht, 2005).

All eight functions were assigned a so-called function proxy variable which could be quantified. Where possible, these proxy variables presented the function capacity measured in units relating to the anthropogenic use of the landscape (Table 1). In this paper when “landscape functions” are mentioned, we actually refer to the measurable proxy variable for that specific function.

2.3. Overall methodology

The overall methodological framework is based on the available data on the location of the selected landscape functions. Driven by the link between landscape functions and observable landscape features or policy delineation, three different levels of landscape function delineation, in terms of location and extent, can be distinguished (Fig. 2):

(1) Complete delineation: Landscape functions are directly observable from the land cover or are defined by policy regulations.
(2) Partial delineation: Non-directly observable landscape functions whose delineations are non-comprehensive or based on sample point data. Function data originated mainly from field observations.