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Mapping landscape services: A case study in a multifunctional rural landscape in The Netherlands

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ABSTRACT

The wide variety of landscape services, e.g. food production, water quality, and recreation, necessitates the use of a wide range of data sources for their identification. Subsequently, an array of approaches is required to analyse and map differ different landscape services, which we have explored in this study. Approaches to identify and map four landscape services are illustrated for the municipalities Deurne and Asten in province Noord-Brabant, The Netherlands: wetland habitat, forest recreation, land-based animal husbandry, and recreation for hikers. The landscape services were identified through ground observations at 389 locations. Spatial indicators were used to identify and map the landscape services. Based on the ground observations, correlations between the landscape services and spatial characteristics (e.g. elevation, soil, road-type) were calculated within a neighbourhood with a radius of 0 m, 50 m, and 100 m. These correlations identified several site-specific indicators to map the landscape services. The accuracy of the landscape service maps created was assessed. The indicators proved to be adequately reliable for forest recreation and reasonably reliable for land-based animal husbandry and recreation for hikers. Only landscape service map forest recreation was shown to be highly accurate. The four landscape services rarely coincide, but within a 1 km radius it is apparent that some occur closer together. The approach that we have used is applicable for a wide range of different services and establishes a fundamental basis for determining their spatial variation. As such, it should provide vital information for policy makers and spatial planners.

1. Introduction

The importance of landscape services, provided by both natural and cultural landscapes, is increasingly recognised (e.g. Costanza et al., 1997; MA, 2005; de Groot, 2006; Termorshuizen and Opdam, 2009; Verburg et al., 2009). Landscapes are spatial social-ecological systems that deliver a wide range of functions, which are valued by humans in terms of economic, sociocultural, and ecological benefits (DeFries et al., 2004; Termorshuizen and Opdam, 2009). A landscape service is defined here as 'the goods and services provided by a landscape to satisfy human needs, directly or indirectly' (Termorshuizen and Opdam, 2009). We prefer the term landscape services over ecosystem services, as it infers pattern-process relationships, unites scientific disciplines, and is better understood by local practitioners (Termorshuizen and Opdam, 2009). Examples of landscape services include food production, pollination, water regulation, and provision of recreation.

Increasing attention is paid, both by policy makers and scientists, to the multifunctionality (Fry, 2001; Holmes, 2006; Wilson, 2008) and the potential synergies and conflicts that may arise. Policy makers and spatial planners are gradually directing their policies and plans to provide and strengthen desired landscape services. To support the establishment of these policies and plans, geographical maps of existing and desired services are required to identify where services border each other or coincide and, thus, lead to possible synergies or conflicts. In this way, they may be used to determine optimal solutions. Hence, it is necessary to develop methods and tools to quantify and map the different services across the landscape.

The spatial distribution of intended landscape services that are related to the intended land use (e.g. food and fibre production) are often documented. However, the spatial distribution of landscape services that are often an unintended consequence of land management (e.g. provision of aesthetic beauty), are commonly unknown. Additionally, they may be unrelated to a single land-cover or land-use type, which makes them more difficult to quantify and map. It is postulated that landscape analyses based on land-cover and land-use are inadequate for landscape characterisation

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of such unintended services, since these approaches are specifically related to the intended use of the land (Verburg et al., 2009). Hence, common observation techniques, available land cover maps and spatial datasets, are insufficient for quantifying and mapping these landscape services (Verburg et al., 2009). Consequently, various spatial attributes, mainly biophysical, but also economic and social, are used as indicators to quantify and map the spatial extent of landscape services (e.g. Gimona and van der Horst, 2007; Egoh et al., 2008; Willemen et al., 2008; Kienast et al., 2009). Yet, indicators related to landscape services are often unknown or based on general assumptions. Identifying suitable indicators is essential for the improvement of landscape service maps. Therefore, the quantification of relations between site-specific attributes and landscape services are required in order to develop reliable indicators. Yet, site-specific indicators for landscape services are hardly investigated.

The vast array of landscape services is delivered across a great range of temporal and spatial scales. Examples of services that apply to different temporal scales are carbon sequestration (long-term carbon storage) and seasonal recreation (short-term visits). Examples of services that apply to different spatial scales are water supply (up to many km^2) and cultural heritage, such as monuments of architecture (as small as m^2). Therefore, the development of a standard procedure to quantify and map landscape services is hampered by the fact that the appropriate spatial scales differs greatly amongst landscape services (de Groot and Hein, 2007; Pérez-Soba et al., 2008).

The objective of this study is to develop an approach to identify and map various landscape services, by using indicators and considering spatial scales. Correlations between observed landscape services and spatial characteristics of the surrounding landscape were analysed to ascertain site-specific indicators for landscape services. These indicators were extrapolated into landscape service maps. The methodology and results are illustrated for four landscape services (i.e. wetland habitat, forest recreation, land-based animal husbandry, and recreation for hikers) in the municipalities of Deurne and Asten, province of Noord-Brabant, The Netherlands. This case study aimed to obtain insights into the relations between landscape services and the surrounding landscape. The indicators derived are specific to this area, but highlight linkages between landscape services and their surroundings.

2. Data and methods

2.1. Study area

The study area comprised the municipalities of Deurne (120 km^2; 5 villages; 31.496 inhabitants; May 2009) and Asten (72 km^2; 3 villages; 16.398 inhabitants; May 2009) in the province of Noord-Brabant, The Netherlands (Fig. 1). Both municipalities are part of *De Peel* region (approximately 600 km^2), which is known for its intensive livestock production and nature reserve ‘De Groote Peel’ (peat-bog that has remained partly untouched by peat cutting). This area has to deal with various conflicting services in the landscape. For example, intensive animal husbandry has an impact on the environment, such as odour emission, which has a negative impact on recreation, such as farm camping. As a result, the national and regional authority has assigned this region as a ‘reconstruction area’ with high priority, in order to improve the environmental quality of the rural area (Provincie Noord-Brabant, 2005).

2.2. General design of methodology

At first, point observations of landscape services were made. Based on relations between the occurrence of landscape services and the spatial characteristics of these locations, an extrapolation of these services to the whole study area was conducted. The methodology consists of four components: (1) point observations of landscape services; (2) point observations of spatial characteristics; (3) correlation analysis and selection of indicators; and (4) extrapolation of indicators for mapping landscape services (Fig. 2). The four components are described in the paragraphs below. First, we described the sampling method that was used to obtain point data for the observation of landscape services and the spatial characteristics. The study area was divided into grid cells of 1 km^2. Within each grid cell, two points were selected approximately 500 m apart. This structured sample design provided an equal distribution of data points, resulting in a total of 389 points. Per data point, existing landscape services were identified using ground observations, sometimes complemented with information from governmental databases or management strategies (Table 1). In addition, the spatial characteristics (Table 2) were assembled at a radius of 0, 50, and

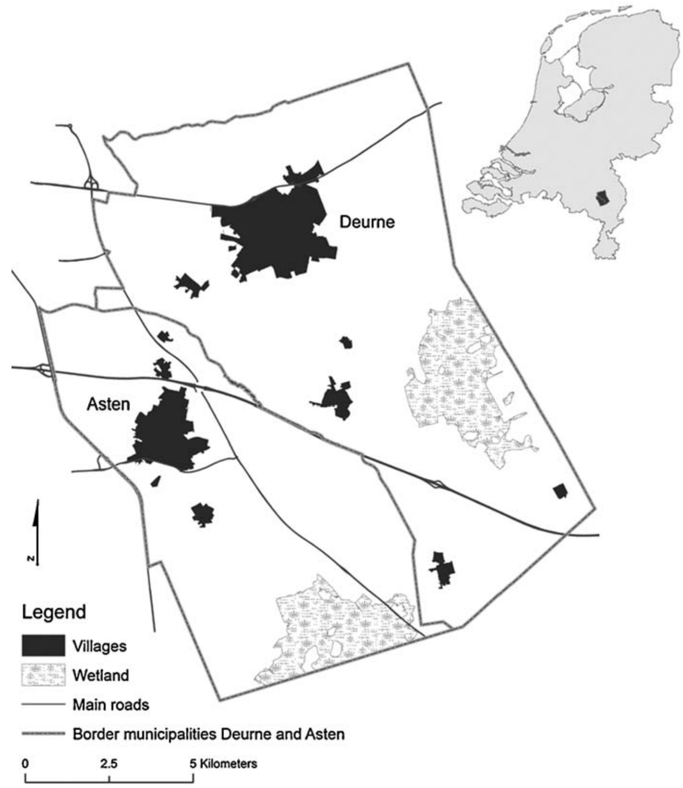

Fig. 1. Study area comprising municipalities Asten and Deurne. At the top on the right, the location of the study area (black mark) in The Netherlands is shown.

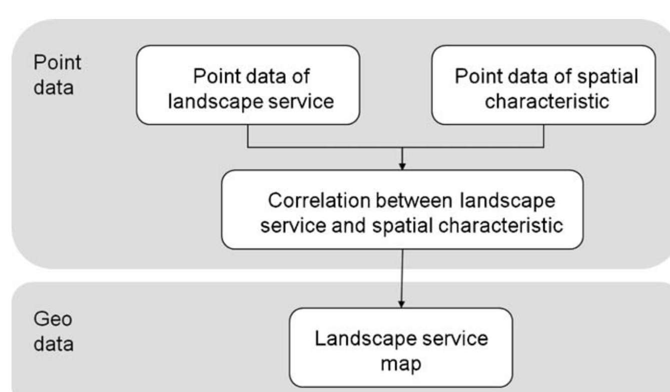

Fig. 2. Overview of the overall methodology.