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Landscape sustainability in terms of landscape services in rural areas: Exemplified with a case study area in Poland

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ABSTRACT

This study aimed to characterize the landscape sustainability in terms of landscape services (LS) provided in seven study areas with different characteristics located in Malopolska Province. The results of the qualitative categorization of LS using an assessment matrix were juxtaposed with the results of the quantitative assessment using indicators.

As a result, study areas were divided into three groups regarding the bundle of provided LS. In multifunctional landscapes characterized by moderate flow of most LS and often high flow of cultural LS, there were: high landscape diversity, moderate connectivity of forest patches and moderate values of regulating LS. Mountainous landscape with a high flow of regulating LS was characterized by moderate landscape diversity, high connectivity of forest class and high values of erosion control and climate regulation. In agricultural landscapes with a high flow of agricultural production LS, there were: low landscape diversity and connectivity of forest patches, low values of erosion control and climate regulation, but high values of nutrient retention. Consequently, all analyzed landscapes may be described as sustainable in terms of LS, as every landscape provides a specific bundle of LS and a reasonable level of landscape diversity, connectivity and regulating LS.

The qualitative categorization of LS provided the most complete perspective on LS provided in the study areas. Landscape metrics (LM) allow the significance of landscape diversity and connectivity to be emphasized, whereas the quantitative analysis of regulating LS allow to compare the results of quantitative assessment and qualitative categorization. These two types of indicators are especially useful when threshold values are required. Composition metrics (proportion of forest and arable land) allow a determination of landscapes dominated by regulating and provisioning LS, whereas configuration metrics (especially Shannon's Diversity Index and Contagion Index) allow landscapes with a high flow of cultural LS to be identified.

1. Introduction

Rural areas, due to their multifunctionality, are often an arena of conflicting interests (Carreno et al., 2012, Laterra et al., 2012). This is due to the fact that, they, as the main service providing units for urban areas, are responsible for providing regulating, provisioning and cultural landscape services (LS), which often tend to be contradictory. Apart from this, rural areas are extremely dependent on the environment, as they provide environment-based livelihood for people (provisioning and cultural LS) (Biggs et al., 2012). In the rural areas, the needs of different stakeholders (e.g., farmers, foresters, inhabitants, representatives of protected areas, tourism managers) with respect to land use clash. It is worth emphasizing that rural areas encompass contrasting landscapes, e.g., agricultural landscapes or mountainous ones. According to Turner et al. (2013) and Wu (2013), different types of landscape provide different types and amounts of LS, which require different management. Landscape management aims to provide all LS desired by society, causing, at the same time, the lowest possible losses in the environment. Landscape assessment provides a starting point for such a management.

In this study, we combined the LS approach (described below) with the sustainability concept in order to characterize the landscape sustainability in terms of the LS provided. The term LS is applied here instead of ecosystem services as it underlines the significance of spatial patterns, landscape elements and landscape character and is more appropriate to landscape planning (Termorshuizen and Opdam, 2009; Bastian et al., 2014; Fang et al., 2015).

The LS concept is being integrated into decision-making processes and spatial planning in the EU (e.g. Maes et al., 2012) as it underlines the multidimensional character of the LS provided (Zaucha et al.,

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2016). Moreover, it shows values and opportunity costs and deals with external effects (non-market services and goods) of benefits obtained from nature. Additionally, it has a strong visualization potential. It is especially valuable for raising the awareness of stakeholders of the impact of their activities on environmental functions, also economically.

The concept of sustainability, used as a synonym of sustainable development (Wu, 2013), was popularized by the report of the United Nations' World Commission on Environment and Development (WCED), "Our Common Future (1987). This term refers to global development policy and its implementation in national policies. A strong emphasis is placed on the capacity to adapt to global environmental change, especially global climate change, and the global exploitation of resources.

By contrast, landscape sustainability refers to the local or regional scale. Based on the concept of LS, Turner et al. (2013) defined landscape sustainability as the capacity of socio-ecological systems to provide a desired set of LS for current and future generations in the face of human land use and a fluctuating environment. In some analyses, the ecological branch of sustainability is also regarded as ecological integrity (e.g. Müller, 2005; Kandziora et al., 2013).

On the one hand, there are many theoretical discussions concerning landscape sustainability in terms of LS (e.g. Carpenter et al., 2001; Müller, 2005; Blaschke, 2006; Walker and Salt, 2006; Cumming, 2011; Slootweg and Jones, 2011; Biggs et al., 2012). On the other hand, as was underlined by Biggs et al. (2012), there is a gap between the very general research and specific research concerning, e.g., the species level (e. g. Nyström et al., 2000, Hughes et al., 2007). Thus, more research on sustainability at the landscape level is needed.

In general, specific indicators for landscape sustainability are missing (Janssen et al., 2006; Biggs et al., 2012). Most of the authors agree, however, that there are some principles which impact landscape sustainability (e.g. Walker and Salt, 2006; Slootweg and Jones, 2011; Biggs et al., 2012; Turner et al., 2013; Wu, 2013). The properties influencing landscape sustainability include ecological (e.g., landscape diversity, connectivity and slow variables) and social components (e.g., learning capacity, participation) (e.g. Biggs et al., 2012; Cumming, 2011; Slootweg and Jones, 2011; Walker and Salt, 2006). In this study we focused on the ecological factors, i.e., landscape diversity and connectivity including, however, regulating LS and human land use.

Diversity, understood as spatial heterogeneity of landscape mosaics, influences not only the occurrence and abundance of species but also the ecosystem processes. It also increases the likelihood of preservation of some habitats during disturbances (Biggs et al., 2012). Many authors (e.g. Cumming, 2011; Palomo et al., 2014) agree that for landscape sustainability, variety of land use, i.e. the landscape mosaic, is the most favourable feature. However, as stated by Blaschke (2006), the exact amount of landscape heterogeneity which would be desirable is unknown.

Connectivity provides the possibility of migration, dispersion and interaction between landscape elements (Biggs et al., 2012). High connectivity contributes to resilient and sustained LS provision (Janssen et al., 2006). Moreover, connectivity of remnant patches determines the possibilities of recovery after disturbance (Biggs et al., 2012). However, at the same time, highly connected systems may be less resilient to disturbances, which propagate faster in such systems (e.g. Biggs et al., 2012; Slootweg and Jones, 2011).

Numerous studies indicate that enhancing regulating LS also increases the value of provisioning and cultural LS (e.g. Pimentel et al., 1995, Ricketts et al., 2008). Consequently, according to Bennett et al., (2009) regulating LS may serve as indicators for landscape sustainability. This is due to the fact that a certain flow of them is required for the landscape to be sustainable.

Although it is widely recognized that specific types of landscape provide specific bundles of LS, only little research focuses on the character of this relationship. With respect to the above, the aim of the paper is to link the qualitative categorization of landscapes in terms of the LS provided with the quantitative indicators of landscape sustainability with reference to ecological criteria, i.e., diversity, connectivity and the values of regulating LS. Specifically, the following questions were considered and evaluated using a quantitative assessment:

(1) How can the landscapes of study areas be categorized in terms of the LS provided?
(2) What is the relationship between qualitative categorization of LS and landscape metrics (diversity, connectivity) and values of regulating LS?
(3) Are all analyzed indicators equally important?

2. Characteristics of the study areas

We have chosen Malopolska Province (Poland) as a study area as this relatively small region varies considerably in terms of both ecological and social components. It consists of different types of rural landscapes, and the diversity of landscape types was the major criterion for the selection of the study area. At the same time, this region presents a certain level of landscape sustainability, especially regarding agricultural land use (e.g. Nowak and Schneider, 2017). We focus on the local-regional scale, as the study areas are seven rural administrative units with different characteristics in the Malopolska Province. The seven study areas provide (as field labs) an appropriate number of application tests and the possibility of a spatial comparison of results between them.

The Malopolska Province (located in Southern Poland) is internally diversified regarding environmental characteristics, type and intensity of land use. The seven selected study areas (Fig. 1) are located in six different geographical regions, which cover 90% of the area of Malopolska Province (German, 2001). Because the administrative units located in the areas differ in terms of population, their area ranges from 369 ha in the uplands to 1311 ha in the mountains. Similarly, their shape is varied. Two of the study areas (Jurków and Łosie) represent a landscape of mountains of medium height. Forests dominate here in the land use structure, followed by grasslands (Table 4). The other three (Dobranowice, Łazy and Polanka Hallera) represent an upland landscape (Fig. 1). Dobranowice is characterized by arable land dominance, whereas in Łazy and Polanka Hallera there is a similar share of forest, grasslands and arable lands. The valley bottom landscape of Bogucice is characterized by a high share of arable lands and grasslands. The landscape of the Krempachy study area is divided between a landscape of valley bottoms and the low mountains (Fig. 1). The dominant type of land use here is arable land, but there is also quite a high share of forest and grasslands (Table 4).

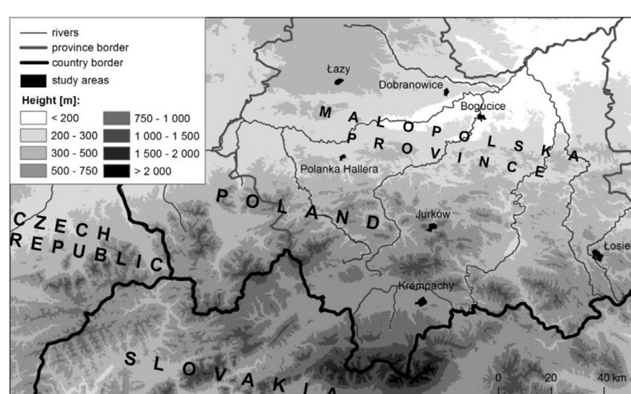

Fig. 1. Location of the study areas.