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Indicator for a monitoring of Germany's landscape attractiveness

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ABSTRACT

Landscape attractiveness describes a landscape's capacity for nature-based recreation. In this contribution an indicator is proposed, which was derived from eight equivalent parameters for the determination of human use and landscape structure. It was supposed to be applicable with already existing geodata. A five-tier scale hereby assists with the requirement to provide a coarse classification of municipalities in regards to landscape attractiveness.

The data provides a first overview, e.g. for the planning process regarding major powerlines as part of the German 'Energiewende', the national transformation policy towards a sustainable energy production, or as a measure for the meaning and potential of a region for nature-based tourism. The result maps clearly show that the selected eight parameters are suitable for the depiction of the most relevant features of an attractive landscape. Hereby, the coastal and alpine regions, as well as the low mountain regions and lakelands can be clearly distinguished from regions with intensive settlements and agricultural use. An evaluation of the provision of cultural ecosystem services for landscape-oriented recreation becomes hereby possible.

1. Introduction

The provision of an attractive landscape for nature-based recreation is an important Ecosystem Service (ESS). One of the objectives of landscape planning in Germany is to ensure the conservation and development of the recreational value of nature and landscape (Article 9 (3) No. 4 German Federal Nature Conservation Act – BNatSchG) and hereby to sustainably secure this ESS. Landscape planning is generally unable to influence important landscape aspects, such as topographic diversity or coastline percentage. It can, however, make an impact on landscape structure and diversity of landscape elements. In order to evaluate this steering effect, the development of a Germany-wide indicator on landscape attractiveness was called for (see also Stein et al., 2014a, 2017). Landscape attractiveness in this context is the natural potential of a landscape to support nature-based recreation (Marks et al., 1992). How attractive a landscape is for nature-based recreation depends on the one hand on factors if e.g. natural open spaces are available, but on the other hand also on the perception by the people of landscape and the structural arrangement. Aesthetic aspects plays an important role. Therefore, attractiveness for nature-oriented recreation is not synonymous to touristic attractiveness, for which also culturally relevant features (e.g. prominent visitor attractions) or recreational infrastructure would need to be taken into consideration.

Landscape planning covers the cultural ecosystem service of the provision of a highly attractive landscape, which is suitable for nature-based recreation. Robust evaluations on the steering effect of local landscape planning, also in regards to the attractiveness of landscapes, are still largely non-existent. The implementation of specific landscape planning measures has been evaluated in studies by Wende et al. (2005, 2012) with random sampling on site. Due to the immense workload, only small sample batches could be processed and despite these efforts, the derived propositions have very little representative quality for the effectiveness of local landscape planning. Therefore a research project (see also Stein et al., 2014a, 2014b, 2017) was supposed to validate the effectiveness of regional landscape planning in Germany with the aid of geographical information data. This, among other things, required the indicator on landscape attractiveness presented in this paper, as up to this point no data on the municipal level was available.

There are already a number of assessment methods, which attempt to capture the attractiveness of a landscape, or its recreational suitability/utilisation in Germany (BBR, 2005; Chen et al., 2000; Frank et al., 2013; Roth and Gruehn, 2012; Walz and Berger, 2004). However, these have only been implemented on a district or rather small-scale level, or for smaller areas within Germany. Internationally, a wide range of studies has been conducted and a multitude of methods have been developed on the perception and evaluation of landscapes. There are, for instance, findings on the landscape attractiveness of the Netherlands (Roos-Klein Lankhorst et al., 2011), Spain (Real et al., 2000) or

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for alpine landscapes (Schirpke et al., 2013), e.g. in Switzerland (Buchecker et al., 2013; Kienast et al., 2012; Lindemann-Matthies et al., 2010), Australia (Kane, 1981) or Great Britain (Briggs and France, 1981). Coeterier (1996), for example, examined parameters, which determine the perception and evaluation of landscapes for the Netherlands. He points specifically to "the nature of the landscape as a whole (unity), its function (use), maintenance, naturalness, spaciousness, development in time, soil and water, and sensory qualities such as colour and smell" (see also Arler, 2000). Therefore, a whole range of research deals with landscape aesthetics (e.g. Augenstein, 2002; Cassatella, 2011; Frank et al., 2013; Hoisl et al., 2000; Nohl, 2001b; Schüpbach, 2003).

The methodology utilised in our study, should allow for a standardised nationwide evaluation based on spatial data and should be repeated in terms of a regular monitoring to make changes over time visible. This is the basis for steering current processes so that an attractive landscape can be maintained or developed. Therefore we use, based on the literature cited above, spatially explicit parameters that describe the structure of the landscape and if there is a relation to the perception of landscape by humans. This article presents the methodology, as well as first results on the indicator "landscape attractiveness".

2. Methodology for the determination of landscape attractiveness

The determination of landscape attractiveness is here based on a methodology, in which attractiveness is derived from the natural landscape features and the technically characterising impacts on site, for example wind turbines and photovoltaic power plants (Augenstein 2002, p. 33). Cultural elements, such as monuments, are not taken into account. The chosen approach essentially constitutes a capability analysis of an area for nature-based recreation (Chen et al., 2000). It is based on the assumption that certain landscape characteristics have a positive, respectively negative impact on landscape attractiveness and on recreation.

2.1. Parameters and data basis

Following Walz and Berger (2004), Chen et al. (2000) and BBR (2005: 209) topographic diversity, percentage of open space, hemeroby index, density of ecotones dominated by woody plants, ratio of riparian areas (without coasts), as well as coastlines were regarded as positive parameters for landscape attractiveness. Selected as parameters with a negative impact on landscape attractiveness were the proportion of unfragmented open space larger than 50 km^2 and the technically characterising impacts from renewable energy infrastructure (solar fields, wind turbines), as well as high-voltage power lines.

Data was collected based on the Official Topographical-Cartographic Information System (ATKIS Base-DLM), respectively the German land cover model (LBM-DE) at the 2010 period. It is officially collected land use data from state and federal surveying authorities in a vector format. The parameters of topographic diversity, percentage of open space, hemeroby and ecotone density are already freely available on the IOER Monitor (Monitor of Settlement and Open Space Development, www.ioer-monitor.de), with a documented algorithm.

Topographic diversity (3D/2D ratio) (Walz, 2015) does not only reflect the maximum altitude difference (relief energy) but also the cumulative altitude differences. The relief contributes significantly to the diversity of a landscape and to the hereby resulting variety for human use (Walz and Berger, 2004). A high value promises a good overview of the landscape, offers vistas and makes for a lively visual landscape. Vistas, according to Augenstein (2002), have a positive effect insofar, as they create new visual relationships, which invite exploration and interpretation of the landscape.

The proportion of undeveloped areas is specified with the percentage of open space. A low percentage of open space indicates urban, respectively strongly built-up rural areas, which may reduce landscape attractiveness through a dominant presence of technical artefacts. With a higher percentage of open space, the perceived naturalness increases (Augenstein, 2002), and hereby the attractiveness. This includes forests, grassland, but also arable land. Nohl (2009) notes that landscapes rich in grassland have a traditional significance for tourism in Germany, whereby this essentially results from an aesthetic and attractive landscape.

The *hemeroby index*, as a measure of human influence on nature, is a spatially-weighted mean value of hemeroby levels across all land uses. Through the hemeroby index, the percentage of open space is complemented with a weighting in respect to the naturalness of the land use. Naturalness is an important factor in landscape attractiveness (Augenstein, 2002; Coeterier, 1996; Real et al., 2000). Applied is data by Walz and Stein (2014), based on the LBM-DE and the potential natural vegetation in Germany.

With the density of ecotones dominated by woody plants, justice is given to landscape diversity and structure. This parameter mainly characterises variety and edge effects. With the term ecotone, ecology describes a transition zone between two different ecosystems. Woodland and forest edges, rows of trees and hedges play hereby an important role. The more there are of these in a landscape, the stronger it is structured. Numerous studies and methodologies on the perception and evaluation of landscapes (Marks et al., 1992; Nohl, 2001a, p. 107) suggest that landscape diversity, which is mainly influenced by edge effects such as ecotones (Nohl, 2001a, p. 146), raises the recreational and experiential value. This parameter describes linear objects, which represent woodland and forest edges, as well as rows of trees and hedges. For the parameter, ecotone density (km/km^2) is determined for the reference area. The fewer lines are straightened in their course and the more lines are present, the higher is the density of linear elements. A high density suggests a pronounced complexity, which communicates the impression of an undisturbed spatial expansion and hereby naturalness (Walz and Berger, 2004).

Equally a measure for landscape diversity and structure is the *ratio of riparian areas*. Bodies of water have a significant influence on the visual landscape and consequently on its attractiveness (Kiemstedt, 1967; Marks et al., 1992). Hereby transition zones, especially from water (blue) and vegetation (green), are particularly appealing. In regards to lakes, shore length is crucial for recreational users (see also Kienast et al., 2012). Due to the inclusion of riparian areas, lakes and particularly water courses, also receive consideration. This parameter reflects the density (km/km^2) of all riparian areas.

As coasts play an important role in regards to attractiveness and recreation (Real et al., 2000), they are represented by the separate parameter *coastlines*. This parameter's values add to the indicator with "1" (coastal parts present) or "0" (no coastal parts present).

The *proportion of unfragmented open space larger than 50 km^2* within a surface area, gives consideration to the interference caused by the fragmentation of the regional transport network and hereby the fragmentation of an area. Contiguous forests, forestry areas, heathlands and other ecologically valuable areas have great significance as habitats for animals and plants, and also as human recreation areas (Walz et al., 2011). Proportions are high in sparsely populated regions with a low road density. However, aside from ecologically valuable areas, many large unfragmented areas also present with an intensive land use (e.g. agriculture or surface mining) (Walz et al., 2011).

The *characterising impacts of technical infrastructure on the open landscape* include high-voltage power lines but also infrastructure for the production of energy from renewable sources, such as wind turbines and photovoltaic power plants, which have an increasingly characterising influence on the landscape (see also Megerle, 2013). In this context, the characterising impacts of infrastructure for the production of renewable energy and the transport of electricity are taken into account through the number of wind turbines, the spatial percentage of solar fields and the length of high-voltage power lines per reference unit (see