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Methods for landscape characterisation and mapping: A systematic review

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ABSTRACT

Due to the multidisciplinary nature of landscape research, many different systems and methods for landscape identification and classification exist. This paper provides a systematic review of 54 contemporary landscape characterisation approaches from all over the world, with the aim of identifying major methodological strategies. Multivariate statistical analyses revealed segregation of the approaches according to the landscape concept applied, the degree of observer independence and various other factors involved in the landscape characterisation process. Our review confirmed a major distinction between approaches rooted in the natural sciences and approaches rooted in the arts and the humanities. Three substantially different methodological approaches or strategies were identified: 1) 'holistic' landscape character assessment approaches, by which visual perception and socio-cultural aspects of the landscape are emphasised; 2) landscape characterisation methods based on *a priori* selection of geo-ecological and land-use-related properties of the landscape; and 3) biophysical landscape characterisation approaches which rely strongly on statistical analyses in order to identify gradients of variation in the presence and/or abundance of landscape elements and properties. Assessment of landform and the composition of natural and human landscape elements was a central part of all of the reviewed methods. A trend towards increasing observer-independence over time was identified.

1. Introduction

There is an increasing need for planning and management strategies that combine preservation of landscape diversity with sustainable use of land resources (Council of Europe, 2000; Wascher, 2005; Kim and Pauleit, 2007; Mücher et al., 2010; Hazeu et al., 2011). 'Landscape' is often regarded as a unifying concept within integrated environmental research (Fry, 2001; Sayer et al., 2013), and 'landscape approaches' to integrated land management have recently gained considerable attention, both in the scientific literature and in other international fora (Reed et al., 2017). In addition, the landscape level is central in specialised scientific studies, e.g. as a main level of organisation within the hierarchy of biodiversity levels (Noss, 1983, 1990).

The European Landscape Convention (ELC; Council of Europe, 2000) leaves it to the parties (the countries that have ratified the convention) themselves to identify the landscapes of their territories, to analyse their characteristics, to identify the forces and pressures that may impact them, and to implement strategies for landscape management, planning and protection. All of these tasks are challenging and call for a foundation that consists of systematised knowledge about the variation at the range of spatial scales that define the landscape level, i.e. a typology of landscapes. With nation-wide coverage, such a typology may provide a framework for landscape research, monitoring, management and planning (Blankson and Green, 1991; Bastian, 2008; Brabyn, 2009; Chuman and Romportl, 2010; Mücher et al., 2010; Erikstad et al., 2015).

The complex, varied and continuous landscape can be understood better when classified in types and spatial units (Christian, 1958; Antrop and Van Eetvelde, 2017). Regardless of approach, any system for spatial landscape characterisation inevitably implies a strong simplification of the almost infinite variability in landscapes, into spatial units suitable for communication in management and research (Bunce et al., 1996b; Hazeu et al., 2011). Critical for typologies to gain general acceptance, for landscape units as well as for all other properties that can be generalised into types, is that they are developed by use of explicitly stated rules by repeatable procedures (Brabyn, 2005; Mücher et al., 2010). Establishing such rules and procedures is a challenging process because landscapes share with ecosystems (Whittaker, 1967; Økland, 1990) the property that, by and large, their composition, structure and processes vary in a gradual, continuous manner along multiple 'directions of gradual variation'. The multidimensional structure of the physical landscape makes all approaches involving

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classification artificial, because they involve drawing boundaries in a basically continuous environment, with its correspondingly continuous change in composition of landscape elements. The numerous characterisation approaches that have been, and are still in use, for description of the structure of the landscape are per se a proof that no single correct characterisation method exists. Alfred Hettner mentioned already in 1928 that there are no right and wrong landscape classifications, but appropriate and unsuitable ones (Hettner, 1928). Thus, choice of characterisation method and spatial resolution should rely on user needs, and which information is available with full area coverage for the study area.

Due to the multidisciplinary nature of landscape research, different systems and methods for landscape identification and classification exist. These are rooted in different traditions and mostly also in different, related disciplines such as geography, geology, geomorphology, ecology, history, archaeology and landscape architecture. Depending on their scientific rooting, these systems and characterisation methods emphasise different aspects of the landscape to variable degrees, and address variation in landscape properties on different spatial and temporal scales (Wascher, 2005; Mücher et al., 2010; Sayer et al., 2013).

In any discussion of landscape characterisation, 'the elephant in the room is the question of just what a landscape is' (Olwig et al., 2016): there has been, and still is, considerable debate about how the term should be understood and the term's legitimacy (Jones, 1991; Bastian, 2008; Sandström and Hedfors, 2018). Several authors (Antrop, 2000; Bastian, 2008; Brabyn, 2009; Sarlöv Herlin, 2016) divide landscape research into two different traditions: a) a biophysical approach to landscape characterisation rooted in the natural sciences, and b) a landscape character assessment tradition rooted in arts and the humanities. The former, adopted by physical geographers and landscape ecologists, define landscape units as tangible and physically delineated areas on the Earth's surface (Bastian, 2008). The biophysical tradition is consistent with the German meaning of the word 'Landschaft', originally used to describe the physical content of an area or a region (Antrop and Van Eetvelde, 2017). The scientific history of biophysical landscape research dates back to the systematic landscape descriptions during the naturalistic explorations (e.g. von Humboldt and Bonpland, 1807). Important contributions from the period up to 1990 include references such as Berg (1915); Schlüter (1920); Troll (1939); Solnetsev (1948); Christian (1958); Vinogradov et al. (1962); Neef (1967); Noss (1983); Forman and Godron (1986) and Zonneveld (1989).

The latter tradition contrasts definitions of landscape commonly used in landscape ecology and natural geography (Jones et al., 2007; Erikstad et al., 2015) by making the landscape units dependent on human perception and sociocultural relations to areas. This concept is implicit in the definition of landscape adopted by the ELC (Council of Europe, 2000), as '(…) an area, as perceived by people (…)', with resemblance to the British meaning of the word 'landscape', namely a scenery (Antrop and Van Eetvelde, 2017). This concept has roots in fields such as landscape painting, aesthetic theory and cultural geography (Plieninger et al., 2015). Classical references include e.g. Sauer (1925); Granö (1929); Lynch (1960); Litton (1972); Cosgrove (1984); Zube (1984) and Bourassa (1991), while good overviews are provided by Zube et al. (1982) and Tveit et al. (2006).

Landscape characterisation and assessment (LCA) methods developed in the UK and France in the early 1990s (e.g. Swanwick, 2002) and have become central in landscape characterisation throughout Europe (Van Eetvelde and Antrop, 2009; Butler and Berglund, 2014). LCA-methods aim to integrate natural and cultural aspects of landscapes, and people's perceptions, whilst forming a spatial framework for planning and development. While many perception-based approaches explicitly deal with identification of landscape values, LCA-approaches draw an important distinction between two stages: the relatively value-free process of characterisation and the subsequent making of judgements and value assessment based on knowledge of landscape character (Swanwick, 2002).

Testing the validity of the result is one of the most problematic aspects of any landscape characterisation (Bunce et al., 1996b; Alcántara Manzanares and Muñoz Álvarez, 2015). Traditional landscape characterisation methods are inductive; knowledge of the landscape emerges from a general-purpose, intuitive and descriptive investigation by the expert, guided by approaches of available maps and other sources (Bunce et al., 1996b). No hypothesis is formulated initially, and no statistical testing of the results occurs. Furthermore, the validity of a method needs to be measured against the purpose of the characterisation process. Within a biophysical landscape concept, validity means whether the landscape is correctly classified according to the applied method, and to what extent the method is based upon empirical evidence. Within methods that put emphasis on human perception and cultural relations, validity may be evaluated by different means, e.g. whether the results of the characterisation is in concordance with how a representative sample of the population actually perceive the landscape, or relate to it. A major challenge with the ELC landscape definition has been to operationalise and validate the phrase 'as people perceive it': persons with different backgrounds, attitudes and interests will tend to perceive landscapes differently (Kaltenborn and Bjerke, 2002; Erikstad et al., 2015), and human perception may also vary with landscape type (Tveit et al., 2006; Sevenant and Antrop, 2009).

Briefly summarised, the landscape may be studied as an object in the natural sciences, as a social construct, or as an aesthetic object (Cosgrove, 2008). Each of these ways has its proper definitions, vocabulary and methods, and each way demands proper skills and specialisation (Antrop and Van Eetvelde, 2017). No single method for landscape characterisation can possibly suit all purposes. A comprehensive analysis of landscape typologies in Europe (Groom, 2005) showed considerable differences between typologies adopted for different European countries. Several sets of landscape properties, which are referred to as six 'dimensions' by Groom (2005), are addressed in landscape-type mapping and landscape character assessment: (1) the biophysical dimensions; (2) landscape ecological issues; (3) socio-economic-technical dimensions; (4) historical dimensions; (5) human-aesthetic dimensions; and (6) user participation and policy dimensions.

A proliferation of approaches to landscape characterisation has taken place in the recent decades, with a rapid increase in the number of publications since 1990 (Groom, 2005). This proliferation has continued also after 2005, as indicated by comprehensive overviews (Antrop and Van Eetvelde, 2017) and reviews in landscape research and comparable fields (Tveit et al., 2006; Brunetta and Voghera, 2008; Hazeu et al., 2011; Vallés et al., 2013; Plieninger et al., 2016; Vogiatzakis et al., 2017). One reason, among others, is the improved availability of advanced statistical analysis methods in combination with geographical information systems (GIS) and area-coverage of information relevant for the landscape scale in open databases, which have provided new opportunities for systematising landscape variation in a more observer-independent manner (Alcántara Manzanares and Muñoz Álvarez, 2015). By 'observer-independent' we mean that a method is transparent and repeatable, in the sense that any person, accepting the method and the evidence, is likely to reach the same conclusion in the study (McHarg, 1969). A high degree of observer-independence is a prerequisite for specific research questions within landscape ecology and physical geography, such as the spatial distribution and abundance of landscape types and landscape elements, quantification, assessment and predictions of landscape changes and studies of patterns, structure and processes in the landscape. Degree of observer independence is thus of particular interest for scientists within these fields, because this attribute will directly affect the relevance of a landscape characterisation study for their purposes.

Older and more recent approaches to landscape characterisation have evolved within different traditions. The various methods and approaches therefore differ in landscape concept applied, spatial resolution, complexity, degree of observer independence, and the extent to which the different elements in the landscape are taken into account in