Quantifying visual landscape quality in rural Wales: A GIS-enabled method for extensive monitoring of a valued cultural ecosystem service

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ABSTRACT

Landscape views and the enjoyment people derive from them, represent an important cultural ecosystem service (CES) as recognised in frameworks such as the Millennium Ecosystem Assessment (2005) and TEEB (2010). We present a method to evaluate the quality of the landscape view, created for the assessment and monitoring of Welsh rural landscapes. This consists of: (i) a Visual Quality Index (VQI) and (ii) a viewshed model to calculate a Zone of Visual Influence (ZVI). From existing literature, we selected 19 landscape components commonly found to influence landscape quality ratings. Using vegetation surveys and GIS datasets each component was measured and assigned a numeric value based either on presence or quantity and/or extent for 150, 1 km^2 survey sites across Wales. Totalling these values, then scaling and weighting them provided an index for each site between 0 and 1 (VQI). Each site was then evaluated for a range of potential users (pedestrians, cyclists, car-users) to calculate a modelled viewshed (ZVI). By combining the VQI and the ZVI, we capture two elements: firstly the intrinsic landscape quality (its aesthetics) and secondly, how much of the landscape can be seen by the public in order to enjoy the view.

1. Introduction

Cultural ecosystem services (CES) are services provided by our environment that have a cultural, social or historic value to people (MEA, 2005; UK National Ecosystem Assessment, 2011). They are often abstract in nature and include social benefits such as spiritual well-being, inspiration, identity, heritage and aesthetic appreciation (Daniel et al., 2012; Tengberg et al., 2012) but are central to many published ecosystem service frameworks (see reviews by Hernández-Morcillo et al. (2013); Milcu et al. (2013) and La Rosa et al. (2016)) Although CES provided by landscapes are difficult to quantify, their importance to people has long been acknowledged in the field of landscape studies (Tveit et al., 2006; Fry et al., 2009); indeed landscape aesthetics can be considered a major component of the CES provided by a landscape (Clay and Daniel, 2000; Dramstad et al., 2006; Uuemaa et al., 2009; Frank et al., 2013).

Although the ecosystem services paradigm was primarily conceived as a pedagogical tool for engaging public interest in issues of natural science (Gómez-Baggethun et al., 2010) the concept has evolved into a lynchpin of political and socioeconomic frameworks for land use management and planning (MEA, 2005; Portman, 2013). Although critiques exist, particularly from economists (Simpson, 2011), the work

of projects such as TEEB (2010) have kept the approach foremost in many policy-related and land management fields. As such, ES frameworks remain current in natural and social science. One example is the Common International Classification of Ecosystem Services (CICES) published by Haines-Young and Potschin in 2013, which has two sub-classes of CES related to landscapes: the physical use of landscapes in different environmental settings (walking, climbing etc.) and a specific class related to aesthetics (Mononen et al., 2016; Potschin and Haines-Young, 2016). These two components are central to the work presented in this paper as both are concerned with these cultural aspects of landscape quality.

Landscape science has been wrestling with the intellectual and practical challenge of how to quantify landscape quality for decades. Measuring landscape quality through aesthetics could be thought of as a perceptual approach to this challenge, the landscape being considered a visible stimulus which interacts with human psychological processes (Dakin, 2003; Wu et al., 2006). It has some foundation in the early sensory mapping work of geographers such as Granö in the 1920s (Jones, 2007) and finds expression in the influential preference matrix approach of Kaplan and Kaplan (1989) and the holistic approaches exemplified Kellert and Wilson (1993). Meta-analysis by Stamps (2004) and more recent statistical modelling undertaken by van der

Jagt et al. (2014) have re-evaluated these tools but their contribution to the measurement of CES remains valid. With a focus on pattern, colour and arrangements, the quantification of visual landscape quality retains strong connections to the discipline of landscape architecture where the aesthetics of the view are explored in detail (see Motloch (2001)). The concept of 'imageability' as developed by Lynch (1960) is also relevant here and refers to the ability of a landscape to make a strong impression on the viewer linking it to theories of place and identity. Responses to the landscape are personal and affected by ephemera such as weather, timing and the season in which the view is enjoyed (Tveit et al., 2006). Whether a person rates a landscape highly, may vary depending on when and where they are asked, and all such ratings could potentially be biased by age and life-experience (Jorgensen and Anthopoulou, 2007) and familiarity with the view (Stewart and Strathern, 2003; van den Berg and Koole, 2006).

Perceptual approaches to the assessment of landscape aesthetics often rely on qualitative forms of data collection including focus groups and semi-structured interviews (Fletcher et al., 2014); expert-based scoring (Moore and Hunt, 2012) and photographic preference surveys (PPS) and could be characterised as a "bottom-up" approach to landscape assessment which is firmly rooted in the unique character of each specific location. The value and consistency of PPS has been vigorously debated but it remains a favoured technique in such evaluations (Gyllin and Grahn, 2015).

In contrast, the biophysical approach to landscape quality assessment assumes that overall visual appeal is controlled by inherent landscape characteristics such as topography, water or vegetation and that this is independent of human perceptions (Fig. 1). These physical elements are referred to as 'environmental spaces or settings' in the UK National Ecosystem Assessment (Church et al., 2011) and provide places where people can engage in activities such as walking or bird-watching (Tratalos et al., 2016) As distinct biophysical entities they offer an opportunity for quantification, with frequent use made of tools like Geographic Information Systems (GIS) (Sherrouse, et al., 2011), remote sensing and field survey (see Gobster et al. (2007), Ode et al. (2008) and La Rosa et al. (2016) for further discussion of approaches and frameworks). The biophysical approach can be characterised as 'top-down' or 'expert-led' with trained experts making informed decisions as to the value of landscape elements. Some have characterised this as a reductionist approach to the landscape and a classic example is found in the work of Lewis undertaken in Wisconsin in the USA in the 1960s (Lewis, 1964, 1996). Contemporary critics of this 'component' approach such as Crofts (1975) argued that the choice of elements to measure was highly subjective, whilst later authors remind us that these 'experts' cannot escape their own socio-cultural biases (Chiesura and de Groot, 2003; Gruehn and Roth, 2010; Frank et al., 2013). However, this spatial quantification of landscape components remains a mainstay of many landscape evaluations and the widespread availability of digital data and GIS has aided this.

These two approaches possess different characteristics and there

has been considerable discussion as to their pros and cons (Dakin 2003; Schirpke et al., 2013). It is tempting to think of them as two ends of the subjective/objective continuum, but in reality this distinction is somewhat artificial. Indeed, many PPS do explicitly contain questions relating to specific biophysical components (Kienast et al., 2012; Tenerelli et al., 2016). The elements of a landscape that we like looking at (determined by aesthetic quality) will inevitably influence what we decide is worth measuring (its biophysical properties). We know that heterogeneous landscapes can be better at fulfilling the life needs of a greater number of species than homogenous ones (Benton et al., 2003; Fahrig et al., 2011) and provide a greater array of ecosystem services (MEA, 2005). However, the appearance of an ecologically functioning landscape may not actually meet our aesthetic ideals and the challenge of reconciling these two has been highlighted by many (Nassauer, 1995; Gobster et al., 2007; Yang et al., 2014). That said, perceptions are not random and there is wide agreement amongst individuals with a shared cultural background, as to what is a high quality landscape and vice-versa (Arriaza et al., 2004; Tveit, 2009).

This study contains components of both approaches but with an emphasis on the quantitative/biophysical approach to assessment. We detail a method to quantify visual landscape quality which has been developed for use within the Glastir landscape management programme of Wales, UK. The method draws heavily on the perceptual studies presented in the literature to determine what components of a landscape shape its aesthetic quality and then uses a GIS-based quantification of such to evaluate landscape quality, methodologically, it shares some parallels with work undertaken by Wu et al. (2006) in Melbourne, Australia and work undertaken by Tratalos et al. (2016) in Nottingham, UK.

1.1. Landscape quality assessment in Wales and the wider UK

Wales (UK) is situated in north-west Europe and is surrounded to the north, west and south by the Irish Sea and borders England to the east (Fig. 2). A relatively small country, with an area of approximately 21,000 km² it has a population of 3.11 million people, most of whom live in a few large settlements along the north and south coasts. It is a rugged landscape, dominated by sheep and beef farming on the hills with much smaller areas of arable land in the lowlands. Although small in area, Wales has some of the finest mountain and coastal scenery in Europe and contains three of the UK's National Parks: Snowdonia, the Brecon Beacons and the Pembrokeshire Coast, which attract tourists from across the UK and Europe.

Different approaches to the issue of mapping and assessing landscape quality have emerged over the last decades in Wales and the UK (Selman and Swanwick, 2009). For example, the National Character Areas (NCA) in England, contain a detailed narrative which includes: history, geology, drainage, land-use, industry as well as an assessment of key ecosystem services (National Character Areas, Natural England, 2016; Norton et al., 2012). Wales has its own unique landscape dataset called LANDMAP which shares many of the characteristics of the English NCAs but provides this through a detailed spatial database which contains five landscape themes: geological, habitats, visual and sensory, historic and cultural (Scott, 2002; NRW, Natural Resources Wales, 2013), but systematic monitoring using this dataset is complex due to its scale and the variation in the units of assessment.

1.2. Cultural ecosystem services (CES) and the Glastir scheme in Wales

Glastir is the main land management scheme currently operating in rural Wales (NAW, 2011) and is managed and funded by the Welsh Government. Through direct payments to farmers and other rural land owners, it pays for the delivery of environmental goods and services including those which combat climate change, improve water and soil management, maintain and enhance biodiversity, protect the landscape
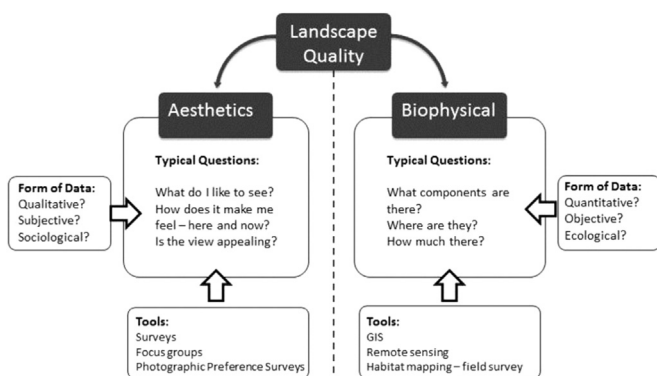

Fig. 1. Theoretical framework for the evaluation of landscape quality.