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Bigger, more diverse and better? Mapping structural diversity and its recreational value in urban green spaces

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ABSTRACT

Are bigger green spaces more diverse in terms of their natural and manmade elements? Does higher diversity mean they are more attractive to users and encourage more diversity of activities, and thereby provide a wider range of recreational ecosystem services? We assessed and classified the recreational services in green urban spaces in the city of Oslo, by combining multidimensional biophysical mapping based on the structural diversity index (SDI), with users' importance scores as an approach to non-monetary valuation of urban parks. Our results reveal that size is a weak and non-linear determinant of structural diversity. On the other hand, stated preferences are correlated with structural elements. Urban green spaces classification could be improved by combining structural diversity indicators with structural preference studies. At the same time, our structural diversity measure did not cover the full range of recreational services across the spectrum of urban green spaces. We discuss potential extensions of the structural diversity index for urban green space in order to cover a wider range of green spaces – from cemetaries to peri-urban forest – and the recreational opportunities provided by them.

1. Introduction

The presence of blue-green spaces and structures in cities contributes to the quality of life in many ways (Chiesura, 2004) involving a wide range of ecosystem services and benefits. Urban green spaces contribute to the quality of life in the city, such as aesthetic and recreation services (Bolund and Hunhammar, 1999; Martín-López et al., 2009). In a global context where more than half the world's population lives in cities, compared with about 14% a century ago (United Nations, 2001), those services are crucial for population well-being (Kaplan and Kaplan, 1989, Elmqvist et al. 2015). Understanding social and cultural values of recreation is important for urban planning (La Rosa et al., 2016), but also complex to study because urban areas have high environmental, cultural and social diversity (Gómez-Baggethun and Barton, 2013). Our study focuses on urban recreational services in the city of Oslo, Norway.

1.1. Recreational quality

Satisfying recreational experiences depends on the design of natural and manmade elements, and on amenities meeting visitors' interests and demands (Edwards et al., 2012; Manning et al., 2011). Recent studies dealing with the relationship between green urban areas' characteristics and visitors' activities and demands propose integrating methods to assess both the supply and demand of recreational services. For instance, integrated studies use indicators of preferences, use, and spatial composition of green spaces (e.g. Caspersen and Olafsson, 2010; Edwards et al., 2012; Tyrväinen et al., 2007; Voigt et al., 2014) which, when assessing the usability of urban green spaces requires high resolution of spatially explicit data (Farrugia et al., 2013; Sheate et al., 2012). Planning and designing green spaces' could be improved with better understanding of their characteristics and the relationship with use and enjoyment across diverse social groups of users (Arnold and Shinew, 1998; Chiesura, 2004; Faehnle et al., 2011; Schwab, 1993).

In recreation research, recreational quality is conceived as the degree to which environmental opportunities meet people's preferences (Manning et al., 2011). Understanding the diversity of opportunities provided by urban green spaces is important since even participants in the same activity may differ in terms of their environmental preferences (Edwards et al., 2012; Gundersen et al., 2015). Various research and planning efforts have elaborated systematic measurements of the recreational experience in urban green space. Based on how urban populations perceive and

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experience urban green spaces, concepts such as "park characteristics" (Grahn and Stigsdotter, 2010; Nordh, 2010), "social values" (Tyrväinen et al., 2007), "experience classes" (Caspersen and Olafsson, 2010), and 'sociotopes' (Ståhle, 2006) have been developed to help planners and designers understand the recreational qualities of these spaces. Many of the characteristics that have been identified to describe recreational quality of green spaces (such as "historicity", "visual scale", "coherence" and "ephemera" (Tveit et al., 2006)) are not possible to measure in a quantitative way. Thus, quantitative assessments that include the observable structural composition and diversity in recreational urban spaces, and their importance may be an alternative to map recreational values in an urban setting.

1.2. Structural elements of recreation experience

Recreational services from urban green spaces are co-produced by biotic, abiotic and constructed structures, all contribute to enhance the recreational qualities of urban space: variety of opportunities and physical settings, sociability and cultural diversity (Burgess et al., 1988). Criteria such as land use, ground and water, historic character, naturalness and spaciousness (Coeterier, 1996), as well as size and the presence of facilities (Coles and Bussey, 2000) have an effect on the level of use. Regarding the elements of urban green spaces, several authors report trees, forest and wooded areas as important determinants of the recreational value (Cohen et al., 2006; Kaczynski and Henderson, 2008; Nordh et al., 2011; Shores and West, 2008; Voigt et al., 2014), but other land-uses with a diversity of flowers, birds and other wildlife can be highly valued as well (Shoard, 2003). Nordh and Østby (2013) found that the structures that contribute the most to high ratings on psychological restoration in small urban green spaces were "natural" structures, including 'a lot of grass' followed by 'a lot of flowers/plants' and 'water features'. Dunnett et al. (2002), Nordh and Østby (2013), and Voigt et al. (2014) also found that proximity to water is highly valued. In addition to natural and water elements, other recreational infrastructures are also important for public use of green urban areas: sport facilities and pathways, toilet facilities, playgrounds, sitting features, lighting, dog facilities, drinking fountain and swimming areas, public transport access, and silence and tranquility areas (Gundersen and Frivold, 2008; Nordh and Østby, 2013; Nordh et al., 2011; Voigt et al., 2014; and references therein). Presence of people can affect the suitability of green spaces for recreation both positively and negatively depending on various factors; e.g. the expectations of the visitors, crowdedness, behavior, and kind of activities that are conducted (Edwards et al., 2012; Grahn and Stigsdotter, 2010; Gundersen and Frivold, 2008; Nordh, 2010; Tveit et al., 2006; Tyrväinen et al., 2007). Negative perceptions of green urban areas also occur, such as fear of forested areas, especially among female users (e.g. Skår, 2010).

Park quantity, measured as the percentage area covered by public parks, has been found to be a strong predictor of self-reported well-being in cities (Larson et al., 2016) and several studies reveal that the size of green urban areas influences the provision of ecosystem services. For instance, the provision of habitat quality for fauna depends on size (Bolund and Hunhammar, 1999), and a significant climatic function can only be expected when park size exceeds one hectare (Tyrväinen et al., 2005). Urban forest size appears to increase the quality of space for humans, as revealed by house prices (Kong et al., 2007). Studies in the UK have shown that urban parks have a minimum size of about two hectares to be attractive for visitors and that attractiveness increases when green spaces are connected by footpaths (Coles and Bussey, 2000). In addition, the literature suggests that the size of urban green spaces is related to the diversity of elements they contain (Voigt et al., 2014). However, the relationship between green urban areas' size and the diversity of structural elements present is not well studied.

Are bigger green spaces usually more diverse and if they are, does higher diversity mean that they are more attractive to users? Kaplan and Kaplan (1989) refer to the diversity of elements in green spaces as 'complexity', and suggest that preferences for complexity is bell-shaped, in thesense that too much diversity gives an impression of a "messy" environment and too little diversity of a "boring" experience. Therefore, more detailed knowledge of green spaces' functional diversity in terms of the recreational services perceived by urban dwellers should be useful for the establishment, maintenance and restoration of urban recreational areas.

A step in this direction is to systematize the information about the biophysical elements of urban green space. We followed the approach by Voigt et al. (2014) who proposed a classification of the structural elements in green spaces according to three dimensions: natural elements, abiotic site conditions and recreational infrastructure. To make the method rapid to implement in the field, the authors recorded structural elements as present/absent. Their method requires relatively modest data-collection effort at the same time as it provides sufficient detail for planning of urban green spaces, while covering a wide range of aspects of usability. We extended the approach by estimating a 'relative importance score' which combines the biophysical qualities and their functional importance for recreation as perceived by green space users. We discuss how the relative importance scores constitute a mapping of non-monetary values of recreational services from green spaces. The relative importance score for urban green space structures is inspired by functional diversity mapping (e.g. Craven et al., 2016).

We aimed to test four hypotheses about the recreational value of green spaces in Oslo: (1) whether there is an association between green space size and the diversity of biotic, abiotic and man-made elements. (2) If higher diversity of structural elements gives more opportunities to people with different recreational interests. (3) Whether people's activities and preferences for green space are associated to specific structural elements. (4) Whether the green space features and recreational opportunities are spatially structured in Oslo.

2. Methods

2.1. Study area

The City of Oslo's built-up area spans 15,270 ha, where 18.5% are urban green spaces, being 1% cementeries, 14.44% public open spaces and 3.1% parks. Parks are managed green spaces within the built zone. Public open spaces ("friområder" in Norwegian) are largely unmanaged green spaces within the built zone open to the public. In the following parks, public open space and cementaries are collectively referred to as "green space".

Six percent of the Oslo Municipality is fresh water, with ten main streams running through the urban area. The city is situated at the end of the Oslo Fjord, and is surrounded by seawater and islands to the south, and boreal forests to the North and East (Oslo European Green Capital 2016 Application).

Oslo had 624,000 inhabitants in 2013, and population projections indicate that the city will number about 800,000 people in 2030 (Oslo Municipality, 2015). National and municipal protected areas for conservation make up almost 10% of the area in Oslo municipality, and are located in the built-up area, on islands and in the surrounding forest. The fjord and the forests, combined with the city's green spaces, waterways and islands, constitute a unique blue-green infrastructure, providing multiple ecosystem services for Oslo's residents, including valuable habitats for biodiversity conservation in Norway (Fig. 1).

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