Ecological Indicators 66 (2016) 416–427

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Introducing accessibility analysis in mapping cultural ecosystem services

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ARTICLE INFO

Article history:
Received 24 February 2015
Received in revised form 1 February 2016
Accepted 2 February 2016

Keywords:
Accessibility
Cultural ecosystem services
Service providing area
Finland
Geographical information systems
Least-cost path
Population distribution

ABSTRACT

In recent years, there has been an increasing interest in the study of the spatial link between service providing areas (SPA) and service benefiting areas (SBA). Understanding the spatial link between SPAs and SBAs is essential when studying the ecosystem service delivery and the fulfilment of ecosystem service demand. However, far too little attention has been paid to the user movement related ecosystem services and where people should be geographically situated in order to benefit from these services. In the movement related services, benefiting areas are equal to providing areas and the spatial link from residential area to SPA is important. The spatial link is addressed through the concept of accessibility which determines the opportunity to move from the area where beneficiaries are located to areas where ecosystem services are produced.

This study presents an accessibility approach to the ecosystem services research. Accessibility analyses offer an opportunity to identify the gap between the ecosystems' potential to produce services and the actual usage possibilities of such services. We demonstrate the suitability of the method by using outdoor recreation and cultural heritage as examples of cultural ecosystem services that people actively want to reach. Accessibility was calculated using a geographical information system-based least-cost path analysis, which measures travel time by car between residential location and the nearest SPA via road network.

The examples highlight that accessibility varies according to the ecosystem service and depends mostly on population distribution and travel possibilities. Our results demonstrate that the density of the analysed ecosystem service opportunities is higher near urban areas than elsewhere. The accessibility of different ecosystem services also depends on how much time people are willing to spend for reaching these services. Our study emphasised that, from a population perspective, accessibility analyses provide a powerful tool for illustrating the utilisation possibilities of spatially distributed ecosystem services. The accessibility approach offers great potential to assess the potential use of SPAs and respond to the need to develop a practical tool for ecosystem service research. It effectively shows, for example, the areas where the risk of overuse of ecosystem services is increased. Knowing about the regional differences in ecosystem service usage also gives background information for the decision-makers for drawing conclusions about how much and where it is sensible to invest in the maintenance of ecosystem services.

1. Introduction

The Earth's ecosystems create the foundation for the well-being of all human beings (Haines-Young and Potschin, 2010). However, during the last few decades people have been altering ecosystems faster than ever before (MA, 2005; Garcia et al., 2014). Awareness of the importance of key ecosystems in sustaining well-being and economic wealth has increased the significance of the ecosystem service approach in contemporary science (Fisher et al., 2009; Seppelt et al., 2011). In general, ecosystem services (ES) are defined as benefits that humans directly or indirectly obtain from ecosystems (Daily, 1997; De Groot et al., 2002; MA, 2005).

Recently, researchers have shown an increased interest to study the spatial link between areas which provide ES and the areas where beneficiaries are located (Syrbe and Walz, 2012). This spatial link, defined as service connecting area (SCA) (see Syrbe and Walz, 2012), delivers goods and services from 'service providing

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http://dx.doi.org/10.1016/j.ecolind.2016.02.013
1470-160X/

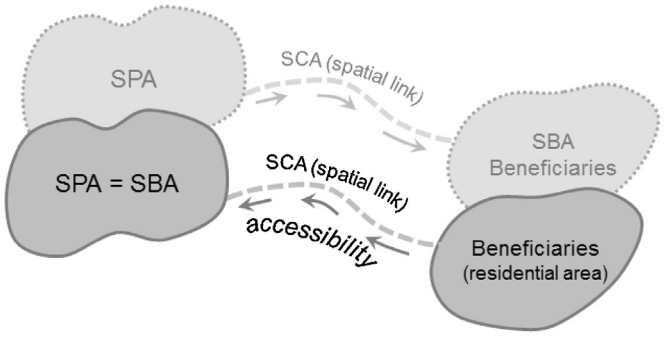

Fig. 1. Spatial relationship between service providing area (SPA) and service benefiting area (SBA) (according to Syrbe and Walz, 2012). *The light grey* areas describe the situation in which service connecting area (SCA) (dash line in the figure) connect providing and benefiting areas and deliver goods and services from SPA to SBA (the arrows illustrate the direction of the movement of e.g. water or food products). In this case, SPA and SBA may be distant from each other. *The dark grey* areas describe the user movement related ecosystem services such as recreation, where benefiting areas (SBA) are equal or similar to providing areas (SPA = SBA) because people must be in the SPA in order to benefit from the ES. SCA, such as a road network, connects beneficiaries (residential area) to SPA. Accessibility describes the beneficiaries' possibility to reach SPAs via road network. This study utilised the latter (dark grey) situation.

area' (SPA) to 'service benefiting area' (SBA) (e.g. Rodrigue et al., 2006; Syrbe and Walz, 2012; Burkhard et al., 2014; Wolff et al., 2015), either passively through biophysical processes (e.g. air regulation) or through anthropogenic flow corridors, such as road networks (Villamagna et al., 2013) (Fig. 1). Especially in the case of spatial disconnection between SPA and SBA, this spatial link plays an important role to understand the actual service delivery and the fulfilment of ES demand (Wolff et al., 2015). Sometimes SPA and SBA may overlap (Syrbe and Walz, 2012), which means that people need experiential interaction with those SPAs to benefit from the ES (Fig. 1).

Accessibility is a key aspect in spatial linkage and determines the opportunity to move from the area where beneficiaries are located to areas where ES are produced (SPAs). The possibility for people to reach SPAs is also related to the studies of ecosystem functions. Recently, it has been emphasised that ecosystem functions (the potential of an ecosystem to provide a service) become a service (the actual use of potential ES) only if there are people who benefit from those ES (e.g. Fisher et al., 2009). Hence, the delivery of some of the ES is strictly dependent on the presence of people. Costanza (2008) has defined those services as "*user movement related services*", which commonly require travelling between the place of residence and the SPA (see Rodrigue et al., 2006). For example, recreation and many other cultural ES depend quite strongly on the flow of people; to benefit from such services, people must be able to actively reach them (see Paracchini et al., 2014). If people are unable to access the SPAs, there is no actual use of services (Science for Environment Policy, 2015). Unfortunately, there is a lack of information on the accessibility of SPAs, hindering the possibility to indicate how well people can actually benefit from them. However, it is evident that poor spatial accessibility reduces the use of ES.

The concept of accessibility, which can be defined as how easily a location can be reached from another location (Rodrigue et al., 2006) or the possibility to reach spatially distributed opportunities (Páez et al., 2012), is a well-developed concept and serves as a common research framework within the field of transport geography (Rodrigue et al., 2006). More precisely, spatial accessibility measures the extent to which a land-use transport system enables (groups of) individuals or goods to reach activities or destinations by means of a (combination of) particular transport mode(s) (Geurs and Ritsema van Eck, 2001). However, this concept has rarely been applied in ES studies (see Brabyn and Sutton, 2013). In order for people to be able to reach different SPAs, more attention has to be paid to both the spatial distribution of ecosystems which provide services and accessibility properties, such as infrastructure (De Groot et al., 2010; Crossman et al., 2013; Paracchini et al., 2014), and the spatial structure of a population and its ability to reach such services. A recent study by Paracchini et al. (2014) suggested that accessibility via roads and related travelling time is one of the approaches to study the accessibility of ES. Additionally, Syrbe and Walz (2012) have proposed that network analyses of roads give insight into the accessibility of service providing areas and have several utilizations for evaluating benefiting areas.

The purpose of this study is to introduce the methodology of accessibility to ES research. Especially, we analysed what kind of opportunities people have in reaching the user movement related ES at broad scale (e.g. from a regional scale up to a continental scale, and even in specific cases, a global scale). We used geographical information system (GIS)-based least-cost path analysis, which measures the time (or distance) between population settlements and SPA along a road network. In our work, accessibility is seen as the approximate travel time to different ES opportunities.

In this study, outdoor recreation and cultural heritage were selected to represent the cultural ES that people have to be able to actively reach in order to benefit from them. The used ES indicators (SPAs) are based on the Common International Classification of Ecosystem Services (CICES) (Haines-Young and Potschin, 2013). The study aim is to answer the following questions: (1) How accessible are the studied SPAs at a national scale in Finland? (2) What proportion of the population is able to reach SPAs given the different travel times? Overall, we evaluated whether the accessibility approach would offer a new and efficient way to measure the potential usability of "*user movement related ES*". Finland is an ideal choice to introduce the accessibility method at a national scale due to the availability of GIS data with a high degree of spatial accuracy concerning the transport network, population and several SPAs. This is one of the first studies to assess the accessibility of different SPAs with respect to the overall population using least-cost path analysis (see also Brabyn and Sutton, 2013).

2. Material and methods

2.1. Study area: key characteristics of the Finnish population and its travel habits

Finland is located in northern Europe by the Baltic Sea (Fig. 2). The total land area of Finland is 303,891 km^2, of which only about 30% is inhabited. The country had a population of 5.5 million (17.9 inhabitants/km^2) at the beginning of the year 2014. Although Finland is relatively sparsely populated compared to most of the European countries, a significant proportion of the population lives in urban settlements (Statistics Finland, 2014a,b).

The road network of Finland is extensive and in a relatively good condition. In general, Finns have a good possibility to travel by car because most of the adults (84%) have a driving license (in 2013, two and a half million passenger cars were registered for traffic use) (Statistics Finland, 2013a). Indeed, Finnish traffic consists primarily of private cars, especially for short daily trips ranging from 1 to 150 km (National Travel Survey, 2010–2011). According to National Travel Survey results from the years 2010 to 2011, Finns made approximately two trips per day by car (total average length of the trips is 29.9 km during a day) and the average duration of each trip was approximately 21 min, depending on the area and the time of year (Table 1). Travel time is the total time a person has spent travelling from one place to another by car including all trip purposes (e.g. work and leisure-related trips). People make the longest trips in July, which is the general vacation season in Finland. During