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The potential of school green areas to improve urban green connectivity and multifunctionality

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ABSTRACT

Urban green infrastructure supports resilience in cities and promotes sustainable resource management. Small green areas, including school green areas (SGAs), are an important component of urban green infrastructure, playing a key role in supplying cities with educational services. This article describes how SGAs can amplify an urban green area's connectivity and multifunctionality. The analysis was performed in Bucharest as a case study. A survey based on questionnaires was used to obtain data regarding green spaces within public schools. A total of 411 administrators from 461 public schools participated in the survey for a response rate of 89.1%. Information from the questionnaires was augmented with spatial data of SGAs and public green spaces, i.e., parks and city gardens. Using parametric and nonparametric statistical analysis, we first identified the variables that determine an SGA's presence and size. Potential connectivity assessment results showed that most of the schools that lack or have small-sized SGAs have the possibility to cover their green space deficit by developing activities within nearby public green spaces. A structural connectivity assessment of SGAs toward other public urban green areas revealed that SGAs are an important element of the urban environment by serving as stepping stones to species flow. The multifunctionality of the SGAs was emphasized through the educational services they provide, being involved in pupils' daily activities. The increased connectivity and multifunctionality of urban green infrastructure through small, specialized green areas, such as SGAs, is an indicator of the fact that such areas can be used to ameliorate the deficit of green space in major urban areas.

Introduction

Ecosystem services support a city's resilient behavior and sustainability (Jabareen, 2013). The MEA (2005) classified these services into supporting, provisioning, regulating, and cultural services. The provision and variety of these services in urban environments depends on the naturalness and biodiversity, as well as on the variability, size, design, structure, form, and distribution of green areas (EEA, 2010).

Green infrastructures in urban areas provide goods and services and support resilience in the system (EEA, 2011; Lafortezza et al., 2013; Larondelle and Haase, 2012). They also form a connected network of multi-functional, predominantly undeveloped land that supports ecological and social activities and processes (Kambites and Owen, 2006).

Green infrastructures exhibit connectivity and multifunctionality as underlying features (Madureira et al., 2011) and include parks, forests, open air museums, street trees, public and private gardens, graveyards, sport facilities, urban drainage systems, a variety of urban agricultural spaces (e.g., allotments, greenhouses, and plant nurseries), roofs, and vertical gardens (Cameron et al., 2012; Niţă et al., 2013; Schäffler and Swilling, 2013; EEA, 2010). Their characteristics are the result of incremental changes within human settlements.

Natural conditions (Thaiutsa et al., 2008), rapid urbanization, landscape history (Kabisch and Haase, 2013; Zhou and Wang, 2011), and the evolution of planning ideas concerning the role of green space (Tudor et al., 2013; Wolch et al., 2014) are important drivers to be considered. Local determinants, such as municipal policy, neighborhood features (Conway and Bourne, 2013), the age of city districts (Kendal et al., 2012), and housing density (Luck et al., 2009), are also shaping green space coverage and floristic diversity.

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Generally, connectivity can be differentiated as follows: (a) structural connectivity, which entails an indices of the spatial configuration of patches, without incorporating data on the movement of individual organisms among these patches; (b) potential connectivity, which incorporates basic or indirect knowledge about organisms' dispersal ability; and (c) functional or actual connectivity, which refers to the real movement of organisms among patches (Fagan and Calabrese, 2006; Magle et al., 2009). All types of connectivity can be quantified using metrics and indicators that span different ranges of complexity, which can be very useful when applied to the assessment of urban green infrastructures.

In urban environments, potential connectivity is measured in the context of transportation system characteristics that can either reduce or increase one's commuting potential toward different urban facilities (e.g., including urban green areas). Much emphasis is placed on active transportation (i.e., walking or cycling) as it relates to children's transport to and from school. The walkability (and cyclability) of available routes can be determined based on variables such as street connectivity, traffic exposure (Giles-Corti et al., 2011), the presence of sidewalks and controlled intersections, the number of roads crossed and traffic density/speed (Davison and Lawson, 2006).

Studies focusing on different types of green areas, such as green rooftops (Braaker et al., 2014) or green areas that are part of business sites (Snepa et al., 2009), have shown these area's broad ecological role, consolidating their structural connectivity by serving as stepping stones that permit the movement of species between remaining habitats (Kong et al., 2010).

Multifunctionality is defined by the Landscape Institute (2009) as a range of different functions provided by an area from which "societal, environmental, and economic benefits" are delivered. Such areas can be composed of many small patches dedicated to specific uses, contributing to the area's complexity, as is the case of green areas (Hersperger et al., 2012). Multifunctionality in the case of urban green infrastructure also consists of concurrent uses that are either alternatively scheduled or simultaneous. The multifunctionality of green infrastructure can cause usage conflicts (Iojă et al., 2011), if not properly managed.

Small green areas, such as domestic gardens, located in squares, on roofs, or at some public institutions (including school green areas (SGAs)), are part of urban green infrastructure and play an important role at the local level (Landscape Institute, 2009; Loram et al., 2007).

Small green areas are heterogeneous in shape and function, and their ecosystem services contribute to human welfare and the sustainability of cities (Cameron et al., 2012; Charlesworth and Booth, 2011). Peschardt et al. (2012) noted the importance of small green spaces in the green morphological structure of a city in relation to the distances traveled and people's daily need for social interaction and mental restoration.

As part of urban green infrastructure (EEA, 2011), SGAs are characterized by a multifunctional role in that they are involved in many daily activities apart from their function as urban environmental moderators. The benefits of the presence and use of green school grounds are evident and complex for children. They generate positive effects on health by favoring moderate physical activity (Dyment et al., 2009) and improving "motor fitness" (Fjørtoft, 2001, 2004) as a consequence of various play activities. Science scores and behaviors (Blair, 2009), such as socializing and learning (Dyment and Bell, 2008; Mårtensson et al., 2013), are enhanced by activities developed within SGAs. SGAs also act as a barrier to the overexposure to solar ultraviolet radiation (Boldemann et al., 2011) and provide various esthetic functions (Moore et al., 1992). Moreover, a well-managed green space can be considered a positive way to improve a school's image and to make it more attractive. All of the mentioned benefits are key elements in connecting SGAs, as important green infrastructure components, to other functional urban infrastructures (Ahern, 2007).

The multifunctionality of SGAs can also be expressed in terms of educational services. Educational services can be defined as the benefits achieved from educational activities (such as courses and subjects) based on the educational program. These activities are designed to provide knowledge by learning and work experience, with the general objective of developing individuals to become useful in society (UNESCO, 2000). SGAs provide important educational benefits for children by offering a framework for a greening curriculum (Lucas and Dyment, 2010) and supporting environmental learning (Malone and Tranter, 2003). Teachers are positively helped in their jobs by increasing the efficiency of their teaching practices (Dyment, 2005).

Many studies analyze the role of major green areas to assess the different types of natural and social services that they provide at the urban level (Breuste and Qureshi, 2011; Chiesura, 2004). However, few studies (Peschardt et al., 2012) have focused on the potential of small green spaces in increasing the connectivity and multifunctionality in urban areas. We selected SGAs as an example of small green spaces due to their multiple uses (educational, recreational, and inspirational) and associated benefits.

The aim of this study is to illustrate the potential of SGAs to amplify the connectivity and multifunctionality of urban green areas. Considering the public schools in Bucharest as a case study, the objectives of the paper are to (a) identify the characteristics of SGAs (quantitative and qualitative) and the predictors that determinate their presence and size; (b) determine the structural and potential connectivity of SGAs toward other public urban green areas; and (c) emphasize the multifunctionality of SGAs through their potential to offer educational services.

Methodology

Study area

Bucharest is the largest urban center in southeastern Europe, with a population of 1.6 million (Nae and Turnock, 2011), of which 14% are between the ages of 3 and 19 years old (EUROSTAT, 2009). There are a total of 253,159 pupils, a number that is rapidly decreasing (BSI, 2012). The city is characterized by a continental climate, with an average annual temperature of 11 °C and annual rainfall of 550 mm. During the summer, the temperatures frequently reach 35 °C, the humidity stays under 40%, and the urban heat island has an intensity of 3–4 °C, with an expanding manifestation area (Cheval and Dumitrescu, 2009).

Named "the city of gardens" during the interwar period due to the numerous public small gardens and vineyards located inside the city and its suburbs, Bucharest suffered significant changes during the communist regime (Light, 2000). The expansion of administrative boundaries in the 1970s, the industrialization process, and the construction of large collective living quarters led to a decrease in green areas. In the post-communist period, the loss has been accentuated by the fast development of commercial, individual, and collective residential spaces, especially in the suburban areas (Niţă, 2012). Currently, green spaces cover 2275 ha and represent 9.5% of the urban area (Iojă et al., 2011). The presence within the city of large areas that lacked public green spaces reduced the connective capacity and usability of these areas (Iojă et al., 2010).

In Bucharest, there are a total of 461 public (Fig. 1) and 223 private schools (BSI, 2012). Schools enclose a variety of land uses within their perimeter. The built up spaces include one or more buildings used for teaching activities and the gymnasium, whereas open spaces are comprised of impervious outdoor sport fields, playgrounds, SGAs, parking lots and alleys. The proportion of these

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