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How much green is needed for a vital neighbourhood? In search for empirical evidence

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ABSTRACT

In this paper, we attempt to find empirical evidence for the proper size of the Polish eco-spatial index, known as the Ratio of Biologically Vital Areas (RBVA). The objective is to establish the minimal proportion of green space required for good environmental performance in neighbourhoods.

Eighteen neighbourhoods (representing the most popular type of residential areas consisting of multi-storey buildings) located in Warsaw and characterised by different RBVA values (varying from ca. 20% to ca. 70%) were chosen as the study area. Different types of measurements and calculations were performed to verify the relationships between the size of the RBVA and selected environmental features (e.g., air temperature and humidity, floristic diversity, butterfly species richness, surface outflow, etc.). Based on these values, a threshold of 45% RBVA was recommended as the minimum, which guarantees environmental performance in the neighbourhoods to certain extent. Eco-spatial indices can be recommended as a useful planning tool for new projects and for evaluation and enhancement of existing urban structures, including residential areas. It should be stated that these indices are not the only measures for green space planning, because they do not refer to the major residents' needs (e.g., social interaction, recreation).

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Introduction

Urban green spaces provide many environmental and social services that contribute to the quality of life in cities, i.e., air filtering, microclimate regulation, noise reduction, rainwater drainage, recreation and social interaction (Gill et al., 2007; James et al., 2009; Thompson, 2002). Because more than half of the Earth's population resides in cities, the need exists to develop urban structures that are more resilient, sustainable and liveable. From the birth of urban planning practices, the challenge of protecting and developing green spaces has played an important role. Many different concepts that aim to safeguard and enhance urban green areas have been applied in urban planning history, i.e., green belts (Amati, 2008; Self, 2002), green wedges (Caspersen and Olafsson, 2010; Gordon et al., 2009), greenways (Fábos, 2004; Turner, 1995), open space area percentages and catchment area standards (Turner, 1992; Byrne and Sipe, 2010), ecological networks (Jongman et al., 2004; Opdam et al., 2006) and green infrastructures (Benedict and McMahon, 2006; Hostler et al., 2011).

In recent decades, traditional urban planning approaches have moved from separating different functions into different spaces to more diverse land uses located in the same space, including more biodiverse landscapes (Puppim de Oliveira et al., 2011).

Land-use integration principles are closely related to densification of urban areas and development of high-density urban structures. However, this situation represents one of the paradoxes of sustainable development principles. Densification is essential for protection of the landscape/environment outside of cities and

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sustainable use of resources. However, the question arises as to what extent of densification should be permitted in urban areas, taking into account the built environment conditions, environmental processes and quality of life for urban citizens. Tratalos et al. (2007) asked whether it is possible to build dense and compact cities that maintain areas of natural habitat and provide useful levels of ecosystem services. This problem has also been considered from the point of view of climate change and the role of green space in the mitigation of urban heat islands, improvement of air quality, reduction of storm water runoff, creation of habitats for animals and enhancement of biodiversity (Alcoforado et al., 2009; Gill et al., 2007; Makhelouf, 2009; Pauleit and Duhme, 2000). Gill et al. (2007) noted that little is known at present with respect to the quantity and quality of green spaces required to adapt cities to climate change.

History emphasises different approaches intended to establish relationships (a sort of balance) between green and built-up areas. A review of approaches and methods of planning for open space, also understood as areas dominated by a "natural environment", was presented by Maruani and Amit-Cohen (2007). These researchers identified nine approaches, but for urban areas, only a subset could be considered as relevant, i.e., opportunistic, space standard, park system, garden city and shape-related models. All these models play different roles and contain certain limitations for establishing relationships between green and built-up areas in cities. Space standards are particularly important when densification discourse is taken into consideration. The aims for implementation of these models have varied and evolved over the history of urban planning. Maruani and Amit-Cohen (2007) noted their chief limitation, which is a lack of reference to site features, resulting in underestimation of the nature and heritage values of the plan site. However, these models are easy to put into practice and are therefore popular in many countries. A creation of places for recreation, particularly for children has been the most important aim for their implementation (Byrne and Sipe, 2010).

In recent decades, due to the development of ecological/biodiversity discourse in spatial planning and problems created in cities by climate change, a new type of space standard has appeared and is known as 'eco-spatial indices'. This concept consists of indicating a proportion between the built-up and green areas and/or establishing development rules related to the type of greenery and occurrence of open water, permeable paving, vegetated walls and roofs, and storm water infiltration facilities over existing vegetation, etc. on the site. The rationale for these types of indices the retention of as much space as possible for the sake of environmental performance within the built environment.

Eco-spatial indices have been introduced as a planning measure (usually as a component of planning provisions) in certain cities, i.e., Berlin (Biotope Area Factor), Malmo (Malmo Green Factor), Seattle (Seattle Green Factor) and Singapore (Green Plot Ratio).

Most eco-spatial indices, i.e., the Biotope Area Factor (Hagen and Stiles, 2010), the Malmo Green Factor (GF) (Hagen and Stiles, 2010), and the Seattle Green Factor (SGF) (Hirst et al., 2008), express a ratio of the area covered by greenery, open water, permeable paving, storm water infiltration facilities, etc. to the total site area.

Scoring systems also include other green solutions, such as the protection of existing trees, use of harvested water for irrigation or the presence of drought-tolerant plants. Each of the elements mentioned above is weighted according to its environmental value. The most valuable sites are areas covered by plants and open water.

A different approach is represented by the greenery provision (GnP), which was introduced in Singapore. The GnP is weighted according to the Green Plot Ratio (GnPR) value as defined by Ong in 2003. The GnPR is based on a biological parameter known as the Leaf Area Index (LAI), which is defined as the single-side leaf area per site area (Ong, 2003).

In Poland, an eco-spatial index known as the Ratio of Biologically Vital Area (RBVA) was first introduced in 1997 by Warsaw's Voiwoda in an ordinance aimed to establish Areas of Landscape Protection in Warsaw's Voiwodship (not in force at the moment). The RBVA reported the ratio between the areas covered by vegetation or open water (not sealed areas) to the plot size and was introduced as a standard for built-up area development within the Areas of Landscape Protection. The minimal size of the RBVA was set as 70% of the plot.

The debate that occurred among planners on the legal basis and precise definition of the ratio led to a new regulation, the Environmental Protection Act of 2001. This act introduced the obligation of establishing the RBVA (more precisely, the proper proportion between green and built-up areas) in planning documents to enhance environmental performance and living conditions. The legal definition and minimum size of the RBVA (set as 25%, but only for housing and health services) was established in the Ordinance of the Minister of Infrastructure in 2002.

The main problem in applying this ratio is the lack of an empirical basis to inform decisions as to what should be considered 'the proper' share of BVAs for different land uses. Decisions on establishing the size of the ratio (70% in Warsaw's Voiwoda Ordinance, 25% in the Minister of Infrastructure Ordinance) were made without input from any previous research.

Analysis of planning documents indicates that planners applied the RBVA concept according to their own views and beliefs rather than by set principles. In many cases, it is difficult to explain why such different RBVA sizes appear under comparable conditions.

In this paper, we present an attempt to find empirical evidence for the proper size of the Polish eco-spatial index known as the Ratio of Biologically Vital Area (RBVA). Our objective is to establish a minimum proportion of green space required for good environmental performance in neighbourhoods. In this paper, we define a neighbourhood as a housing estate consisting of multi-storey blocks of flats. This type of neighbourhood is the most frequent type in Polish cities, accounts for the largest amount of city space and is known to be important to a large portion of the population.

Methodology

Research concept

To investigate how the proportion between "vital" and "sealed" areas may influence the environmental processes at a site, we decided to study selected processes in existing neighbourhoods.

We assumed that the results of this survey would allow us to find the minimum ratio that should be recommended as 'proper' for planning practices.

The indicator variables that were chosen to inform the environmental performance of an area are presented in Table 1.

The Polish Environment Protection Act emphasises ecological balance as a primary reason for introducing the RBVA. However, the term "ecological balance" is a bit misleading because it can be used in many different contexts. In ecosystem theory, ecological balance refers to ecological stability (e.g., Grimm and Wissel (1997) described 163 definitions of 70 different concepts of ecological stability), but in sustainable development theory, it refers to the 'ecological footprint' used to analyse the supply-demand balance (e.g., Dong et al., 2011). In the Polish Environmental Protection Act, this term is used as a metaphor to indicate the sustainment of environmental performance in an area. Although this performance is closely linked with quality of life, the RBVA concept is based on quantity and not quality, of green spaces. Therefore, in this study, we were interested in if and how the quantity of biologically vital

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