Integrating ecology and society in the Urban Green Structure planning: evaluation of UGS patches quality in the city of Porto, Portugal

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Introduction

Cities are complex entities, with their own rules and dynamics of growth, behaviour and evolution, which result from interactions between biophysical and socioeconomic forces (Alberti *et al.*, 2003). They have their own structure and functions. While the urban structure comprises its elements, its functions are based in the variety of services that cities provide (Pickett and Cadenasso, 2008). Its physical structure is composed by four main elements: buildings, build infrastructures, technical infrastructures and green infrastructures (Sandström *et al.*, 2007), being complemented by the society component. These elements form a complex mosaic of patches, in a matrix of infrastructures, organizations and social institutions (Alberti *et al.*, 2003).

The Urban Green Structure (UGS) is a component of the urban system. Like other systems, it has a function and a structure, which result from interactions between its elements and with their surroundings (Flores *et al.*, 1998). According to the Portuguese Law-Decree 380/99 (which establishes the legal basis of the spatial planning instruments), the UGS consist of areas, values and networks which are fundamental for the urban system equilibrium.

The UGS contributes to an healthy environment for residents and users of the city (McPherson, 1992), as well as an entire set of ecological, economic and social benefits which allow the liveability, quality of life and sustainability of urban areas. It is an opportunity of spatial planning based in ecological, constructed, cultural and mobility elements, aiming to obtain a sustainable urban landscape.

Despite its crucial value, these areas have received little interest in the spatial planning policy-making, due to the lack of understanding of its importance, potential and fragility, particularly in the urban systems. In Portugal, this planning element has been considered mandatory since 1999. However, it was only applied to a restrict group of municipalities (Quintas and Curado, 2009), which proves the need of a strategy to promote the UGS in the planning process.

In order to understand the functional dynamics of landscape, the ecological and social processes should be considered, being essential in the holistic comprehension of the territory and its planning (Turner *et al.*, 2001; McHarg, 1969). The ecology-society relation is important for the analysis of the UGS, and "(…) *since ecological networks consist of both ecological and human components, the interaction between*

nature and culture is a priority to consider in both nature conservation and sustainable development" (Jongman and Pungetti, 2004:5).

The Urban Green Structure is a system, composed by elements and fulfilling a vast diversity of functions. It can be analyzed as a landscape structure, using landscape metrics concepts, such as patch, matrix, edge and corridor (Forman and Gordon, 1981), which allow an evaluation not only of its ecological character, but also of its social value. "*Assessment of ecological network viability can be undertaken by analyzing the inherent characteristics of the landscape elements, the interrelationships between landscape elements and external factors affecting the functioning of the ecological network*" (Cook, 2002:270).

The UGS is organized in patches (with a core and an edge) and corridors. The patch characteristics are responsible for the correct performance of its functions. Thus, the patches should have qualities and have easy access, allowing natural processes and social activities to occur. The attractiveness of one patch is dependent on their access and their qualities (Figure 1).

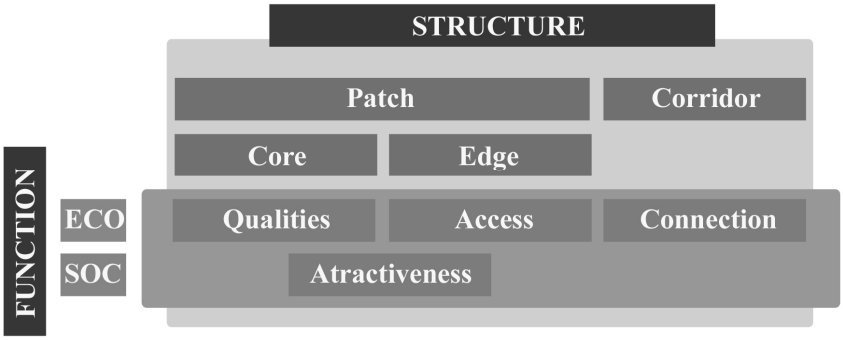

Figure 1. Components and functions of the Urban Green Structure.

In a patch core, indicators such as size, heterogeneity, diversity, typologies and dynamics of elements can be evaluated, both in social and ecological level. These factors, that determinate the quality of the patch, influence the movement to that patch and also the willing to stay. The edge effects take into account the relationship between patches and their surroundings, which influence the local character. They should allow a good ecological connectivity, and also attractiveness and access to people. "*The availability of accessible and attractive green spaces is an integral part of urban quality of life*" (Van Herzele and Wiedemann, 2003:109).

The corridors (and stepping stones) allow the continuity and the different connections in landscape, with the flux of matter, energy and organisms, but also regarding the transport systems and movement of people.

The analysis and evaluation of these components of the UGS will increase the knowledge of its importance in the urban system, the assessment of its state and provide basis for strategies of landscape planning and management in urban areas.

Goals and objectives

This research aims to analyze, evaluate and compare the components and functions of the Urban Green Structure, in an ecological and social perspective, using landscape metrics concepts, such as patch, edge, corridor and matrix. This paper will focus particularly on the quality of patches that integrate the UGS, on their ability to allow natural processes, and also for the capacity to provide human activities.

With this integrated research, it will be possible to compare the ecological and social values and to evaluate the Urban Green Structure, providing scientific support to environmental and social policy-making in urban areas.

Methods

The landscape elements that integrate the UGS, through their character and organization, fulfill ecological and social functions. The patches should be attractive places, both to the biodiversity and also for the human species, resulting from their qualities (patch qualities) and their accesses (edge qualities).

The patches provide habitat, shelter and a source of food and water, which allow the survival of species and the preservation of habitats. They are also places for human leisure and recreation, having effects in the health, education, culture, social interactions, aesthetics, and well-being of the population (Figure 2).

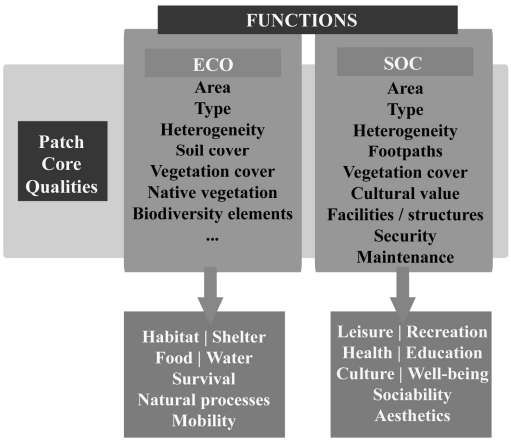

Figure 2. Indicators of the patch core qualities, regarding the ecological and social functions that the UGS fulfils.

In order to evaluate the patches qualities, a system of indicators was developed, which reflect the ecological and social functions, including area, type and heterogeneity of the patches, and also the presence of vegetation and social equipments.

These attributes are responsible for the fulfillment of the needs and desires of biodiversity and society and promoting a better quality of life. The analysis was made with cartographical analysis (ArcGIS and photo interpretation), literature review, and field visits, being also complemented with interviews and behavior mapping of the places users.

Study area

The methodology was applied to the Urban Green Structure of the city of Porto. This is the second most important city in Portugal, and it is the center of the Porto Metropolitan Area. It is located in the northwest of the country, occupying an area of 4.150 hectares, inhabited by 220.000 persons. Its Urban Green Structure comprises about 20% of the municipality surface (815 ha), representing 37m^2 green space/person. However, these areas are very fragmented and most of them are private areas or spaces with no public access.

The city of Porto can be divided in three main zones, with different characteristics, resulting from the distinct process of development and evolution, being a "*consequence of a constant evolutionary process fuelled by economic, political, demographic and social change*" (Hough, 1995:19). These are: the historical center (the most ancient zone of the city, with an UGS constituted mainly by small gardens and backyards), the primary expansion zone (resulting particularly from the XIX.th century development, with the creation of several public parks and gardens), and the secondary expansion zone. Due to the complexity of data and indicators evaluated and the diversity of character of the UGS spaces, this paper will focus in 3 parishes, each one representing a different zone of the city: Vitória (in the center), Cedofeita (primary expansion zone) and Nevogilde (secondary expansion zone) (Figure 3).

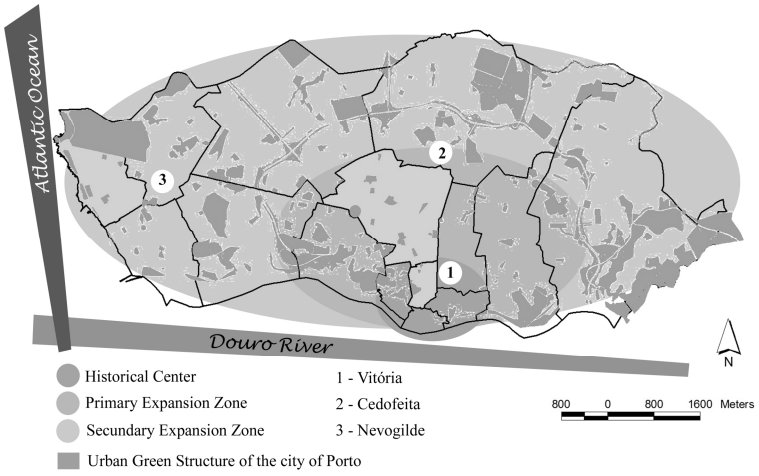

Figure 3. The Urban Green Structure of the city of Porto. The figure shows the 15 parishes of the municipality and the three main zones of the city.

Results

In the three analyzed parishes, the Urban Green Structure has different typologies of patches, with different proportions, resulting from its distinct character and their relation with their surroundings (Table I).

Vitória, in the historical center, presents 3 patches, comprising 8% of the total parish area: 1 private and 2 public spaces. Cedofeita, in the primary expansion zone, presents 11 patches (7 private and 4 public spaces), although comprising only 5% of the parish area. Nevogilde, in the secondary expansion zone, presents 8 patches: 5 private and 4 public spaces, comprising 45% of the parish total surface.

Table I. Typologies of patches of the Urban Green Structure of Porto, in the parishes of Vitória, Cedofeita and Nevogilde.

	PARISH					
	Nevogilde (45 % parish in EEU)		Cedofeita (5 % parish in EEU)		Vitória (8 % parish in EEU)	
Typology of patches (classes)	Number of patches per class	Patch mean area (ha)	Number of patches per class	Patch mean area (ha)	Number of patches per class	Patch mean area (ha)
Private space - garden	5	1,11	5	1,03		
Private space - backyard			2	0,46	1	0,18
Civic space - square			2	2,04	1	0,16
Equipment space – trade, school	1	7,04	1	2,01		
Recreation space – public garden	2	2,31			1	2,18
Recreation space – public park	1	79,98 (64,71 in the parish)				
Urban void – future public park			1	0,71		

To emphasize the relation between ecological and social/recreational qualities of the patches, and due to the elevated number of data, the results here presented refer only to some evaluation indicators of public spaces, which are listed in Table II.

The analysis (Figure 4) shows that there is a major significance of Parque da Cidade (1), the greatest public park in the city, both in terms of biodiversity and social functions. The field surveys confirm these results by the great amount of people that visit the park every day, and also by the large diversity of flora and fauna that can be observed. The public gardens (3 and 4) do not have great conditions to allow human activities or biodiversity, although having an elevated cultural value and being considered historical gardens. They have a function which is related with the public walk and leisure near the sea. The public garden (9), also with high cultural value, has better conditions to allow biodiversity and human activities.

Table I1. Public patches of the Urban Green Structure of Porto in the parishes of Vitória, Cedofeita and Nevogilde.

Name	Parish	Tipology	Subtipology	Patch area (ha)
1 - Parque da Cidade	Nevogilde	Public Recreation Space	Public park	79,98
2 - Edifício Transparente	Nevogilde	Equipment Area	Shopping	7,04
3 - Jardins Montevideu	Nevogilde	Public Recreation Space	Garden	4,01
4 - Jardins Brasil	Nevogilde	Public Recreation Space	Garden	0,61
5 - Rotunda da Boavista	Cedofeita	Civic Space	Square	2,99
6 - Liceu Carolina Michaelis	Cedofeita	Equipment Area	School	2
7 - Praça da República	Cedofeita	Civic Space	Square	1,09
8 - Praça Carlos Alberto	Vitória	Civic Space	Square	0,16
9 - Jardim Cordoaria	Vitória	Public Recreation Space	Garden	2,18

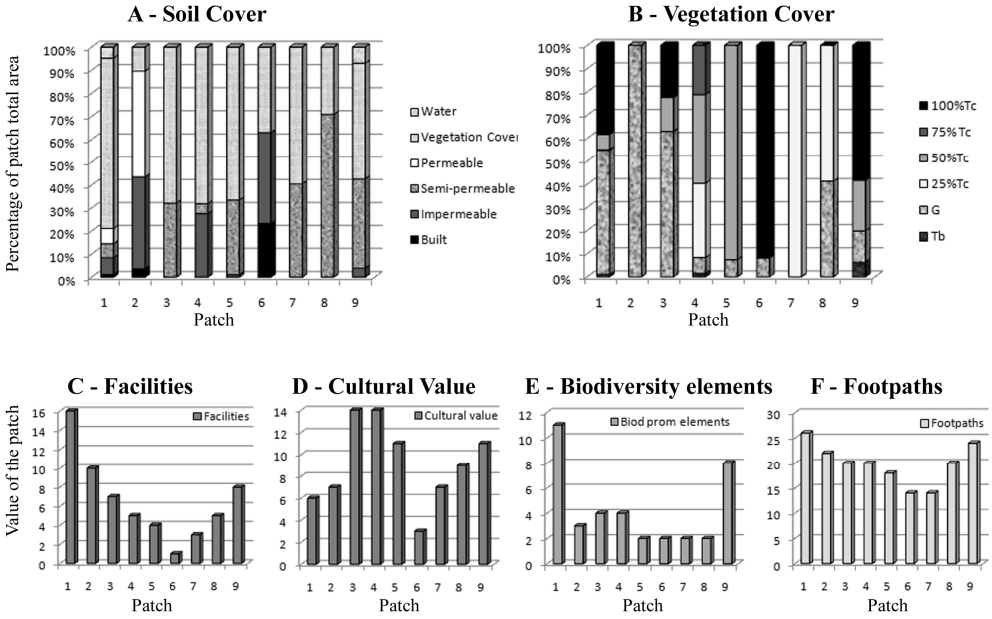

Figure 4. Evaluation of the public patches of the Urban Green Structure of Porto, in the parishes of Nevogilde (patches 1, 2, 3, 4), Cedofeita (patches 5, 6, 7) and Vitória (8, 9), for the indicators: Soil cover (A), Vegetation cover (B), Facilities (C), Cultural value (D), Biodiversity promotion elements (E) and Footpaths (F). Patch typologies: Public park: 1; Public Garden: 3, 4, 9; Civic space (square): 5, 7, 8; Equipment area: 2, 6.

The squares (5, 7 and 8) are civic spaces whose major function is to permit the crossing and connections. In general, these spaces possess semi-permeable soil cover, allowing the movement of the people that cross them. The vegetation is sparse, giving more security, but does not allow a great ecological value. The equipment areas (2 and 6) present less permeable soil and vegetation covers. Their functions concern mainly the framing and aesthetic, giving also support to the

infrastructures. They present a few conditions to accommodate human presence, although not being much oriented to recreation and leisure.

Discussion and conclusion

The obtained results show that in different parts of the city of Porto, the Urban Green Structure is constituted by distinct patch typologies, with different qualities and functions. In the analyzed examples, the variety of elements present in the patches (both with ecological and social functions) is dependent not only of the area and typology, but also of the surroundings. In general, the areas with more social facilities, present also more opportunities for urban nature, although it must be a conciliation of uses.

The assessment of the quality of the patches provides clues to the needs and potential of the spaces, particularly in terms of ecological and social value. In some cases, already exist some political intentions to provide better and more green spaces, contributing to an enhancement of the quality of life. This is the case of the urban void in Cedofeita, which is assigned to be a future public park. It is essential to consider these future strategies in the UGS analysis.

The results here presented, in conjugation with the evaluation of the other indicators of patch quality, will be compared with people perception and behavior, regarding the urban green areas and Urban Green Structure. These, together with the other elements of UGS (patches, edges and corridors) and the matrix will provide a better evaluation of the UGS and also a better understanding of its importance in the urban area. It is fundamental to analyze not only the components of the Urban Green Structure, but also to consider this network as a whole and coherent system. The areas where the relationship between social and ecological processes is more relevant and effective will be identified, as will also the problematic areas which could be improved by incorporating an articulated strategy.

Through this integrated analysis, also the relation between natural and social systems can be assessed, providing scientific knowledge to understand how the Urban Green Structure should be planned, in order to integrate the two systems in a more complete, sustained and sustainable way.

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