Proceedings of the Fábos Conference on Landscape and Greenway Planning

Volume 4
Issue 1 *Pathways to Sustainability*

Article 47

2013

Green Space Typologies in the City of Porto – Portugal: Identifying Nodes and Links for Greenway Planning

Paulo Farinha-Marquesa
Dep. of Geosciences, Environment & Spatial Planning, Faculty of Sciences, University of Porto

Cláudia Fernandes
Dep. of Geosciences, Environment & Spatial Planning, Faculty of Sciences, University of Porto

José M. Lameirasa
Dep. of Geosciences, Environment & Spatial Planning, Faculty of Sciences, University of Porto

Filipa Guilherme
Research Centre in Biodiversity and Genetic Resources, University of Porto

Isabel Leal
Research Centre in Biodiversity and Genetic Resources, University of Porto

See next page for additional authors

Green Space Typologies in the City of Porto – Portugal: Identifying Nodes and Links for Greenway Planning

Cover Page Footnote
This work was supported by Fundacão para a Ciência e Tecnologia under the research project by the PTDC/AUR-URB/104044/2008 "Urban Green Structure: Study of the relation between public space morphology and flora and fauna diversity in the city of Porto".

Authors
Paulo Farinha-Marquesa, Cláudia Fernandes, José M. Lameirasa, Filipa Guilherme, Isabel Leal, and Sara Silva

Green Space Typologies in the City of Porto – Portugal: Identifying nodes and links for greenway planning

Paulo Farinha-Marques[a,b]; Cláudia Fernandes[a,b]; José M. Lameiras[a,b]; Filipa Guilherme[b]; Isabel Leal[b]; Sara Silva[b]

[a] *Dep. of Geosciences, Environment & Spatial Planning, Faculty of Sciences, University of Porto*
[b] *Research Centre in Biodiversity and Genetic Resources, University of Porto*

Introduction

In the XIX century, Porto was a small and compact urban centre surrounded by a large belt of agriculture and forest. Since the mid XX century, as a consequence of the industrial revolution, the city sprawled throughout the rural fringes up to its administrative limits creating an urban continuum with the adjacent municipalities. As a result, the current green structure of the city lacks a long-term planning strategy with resulting breakdown of the rural matrix, fragmentation and discontinuity of main green systems.

Functioning as habitat and corridors, urban greenways are very effective strategies for minimizing overall impacts of ecological fragmentation: habitat loss and habitat isolation. A greenway system articulates ecological structure and function, providing simultaneously recreational opportunities, biodiversity protection and assuring present and future open space needs (Ahern, 2002). Currently, greenways are being established in cities worldwide, proving their relevance, especially in rapidly changing urban contexts.

Supported by these assumptions and the results of current studies on Porto green structure, this work aims at proposing a greenway network for the city, grounded on an integrated and coherent system of multifunctional green areas. The adopted approach relies on the premise that a structure of green nodes and links (corridors) should act as the framework for that greenway system.

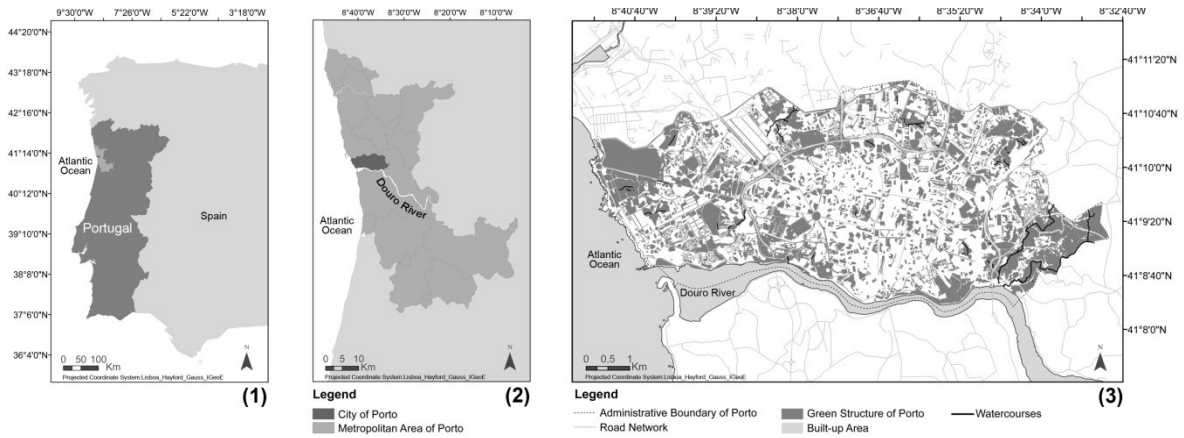

Fig. 1. Study area: (1) Greater metropolitan area of Porto (GAMP), Portugal; (2) Administrative boundaries of Porto; (3) Green Structure of Porto.

Background and Literature Review

The concept of urban greenways and networks emerged in the 19th century, with the purpose of protecting major green areas and their wildlife from the urban sprawl and fragmentation (Jongman 2003). Greenways have been defined by Ahern (1995) as "networks of land containing linear elements that are planned, designed and managed for multiple purposes including ecological, recreational, cultural, aesthetic, or other purposes compatible with the concept of sustainable land use". An urban network is thus composed by strips of green areas, with a strong linear character, connecting larger green units with socio-ecological relevance in a sustainable system.

Multi-functionality is an important aspect of greenways. One of the main goals of greenway planning is directed at wildlife and habitat conservation (Linehan et al 1995, Briffett 2001). Greenways have a significant role in urban biodiversity protection: they fulfill the needs of several fauna and flora species, by acting as dispersion and migration corridors and by providing suitable habitats (Briffett 2001, Ignatieva 2011). Additionally, these areas help to maintain urban ecosystem services at healthy levels (Tzoulas et al, 2007), by controlling flood damage, enhancing water quality, balancing nutrient cycles and mitigating the heat-island effect (Searns 1995, Ahern 1995, Pauleit and Duhme 2000).

Recently, there's also a growing focus on the direct benefits for the human population. Many of the greenways traditionally have a recreational purpose on their origin and often include trails or bicycle paths. These structures promote not only the physical health and but also psychological well being brought by the visualization and overall experience of natural sceneries (Tzoulas et al 2007). Greenways in close proximity to the urban residents may also become an important resource for environmental education and nature conservation awareness (Searns 1995).

The coexistence of varied land covers and land uses supports the multi-functionality of the green infrastructure. Different land cover types can accommodate multiple human activities and can create diverse opportunities for wildlife (Pauleit and Duhme 2000, James and Bound 2009, Farinha-Marques et al 2011).

Porto's green structure has suffered major modifications, especially in the last century, which resulted in a highly fragmented landscape comprised of small and isolated patches of different typologies of green spaces. The urban core green areas are historically dominated by residential yards and private gardens, whereas the larger peripheral belt of woodlands and agricultural areas that once existed are highly reduced and fragmented nowadays. Contradicting the general trend of green space decline, public parks, gardens and squares became more frequent and developed an important role as part of the urban green structure (Madureira et al 2011).

Goals and objectives

- Provide a framework for greenway planning, supported by a system of multifunctional green centres (nodes) and green corridors (links) for the city of Porto;

- Propose a systematic methodology for the definition of nodes and links;
- Outline the areas with greater ecological potential, aiming at preserving green spaces with higher ecological interest, improve their accessibility and protect them from urban development.

Methods

Aiming at defining a framework for greenway planning in the city of Porto, a methodology was adopted concerning three main features: 1) Porto's green structure and green space typologies 2) Node analysis 3) Link analysis

1) Porto's green structure and green space typologies

The present study relied on green space typologies defined in the ongoing research project "Urban Green Structure: Study of the relation between public space morphology and flora and fauna diversity in the city of Porto". According to this project Porto's green structure represents 39.8% of total urban area, mainly distributed by wasteland/vacant lots (W/VL, 18.7%), public parks and gardens (PPG, 12.7%), green spaces associated with civic buildings (CBGS, 12.4%) and urban yards (UY, 10.4%); these typologies represent 54.2 % of the total green structure.

Private gardens (PG) and agricultural areas (AA) are also relevant with a proportion, respectively of 9.3% and 8.2%. The remaining green space typologies are distributed as follows: tree lined streets (TLS, 6.9%); urban woodlands (UW, 6.8%); multi-story housing green spaces (MHGS, 6.1%); green spaces associated with main roads (GSMR, 5.4%); public squares (PS, 1.1%); cemeteries (CE, 1.1%) and cliffs (CL, 0.9%). Additionally, there are approximately 22 km of open watercourses, 3.8 km of Atlantic shore and 9.2 km of River Douro banks.

2) Node analysis

Nodes are non-linear elements with prevalence of open green spaces whose area and ecological value are considerably relevant when compared to the scale of the city. Criteria used for node definition:

- 70% of the area is occupied by green spaces;
- High diversity of green space typologies
- Non-linear to a semi-globular shape (landscape metrics indicate a high value of circularity and low aspect ratio);

The comparison between the node area and the total area of the city allowed the definition of two node typologies:

a) Main nodes - node area is higher than 1% and contains at least 8 typologies - half of the identified typologies
b) Secondary nodes - node area is lower than 1%

3) Links analysis

Links can be understood as green corridors; they are defined as linear spatial elements that promote connectivity and facilitate the flow of energy, matter or species (Linehan, Gross, & Finn, 1995). Within the city frame four types of links were identified; the criteria used is as follows:

a) Natural Blue Link:
- Defines greater ecological continuity;
- Includes Douro River and the Atlantic Ocean coastal areas;

b) First Order Links:
- Display a very high connectivity (high continuity, no gaps between green spaces in the link)
- Connect the main nodes to each other;
- Connect the main nodes with the Natural Blue Link;

c) Second Order Links:
- Display a very high connectivity (high continuity, no gaps between green spaces in the link);
- Connect main and secondary nodes;
- Connect secondary nodes;

d) Third Order Links:
- Display lower level of connectivity (these include stepping stones);
- Connect links to each other.

In Fig.2 a proposed framework for greenway planning is presented: supported by the green space typologies map, a proposal for nodes a links was outlined.

Results

Eight main green nodes were identified as well as nine secondary nodes (Fig. 2, Table 1). Main nodes have, on average, 75.7% of green area and ten different green space typologies; secondary nodes have on average 78.7% of green area and close to five green space typologies. Major green nodes and secondary nodes accomplish 25.5% of the area of the city of Porto and correspond to 64% of its green structure.

With regard to their spatial arrangement, main nodes occupy a peripheral position, distributing along, and close to, the administrative boundaries of the city. Yet, the secondary nodes tend to appear closer to the inner city.

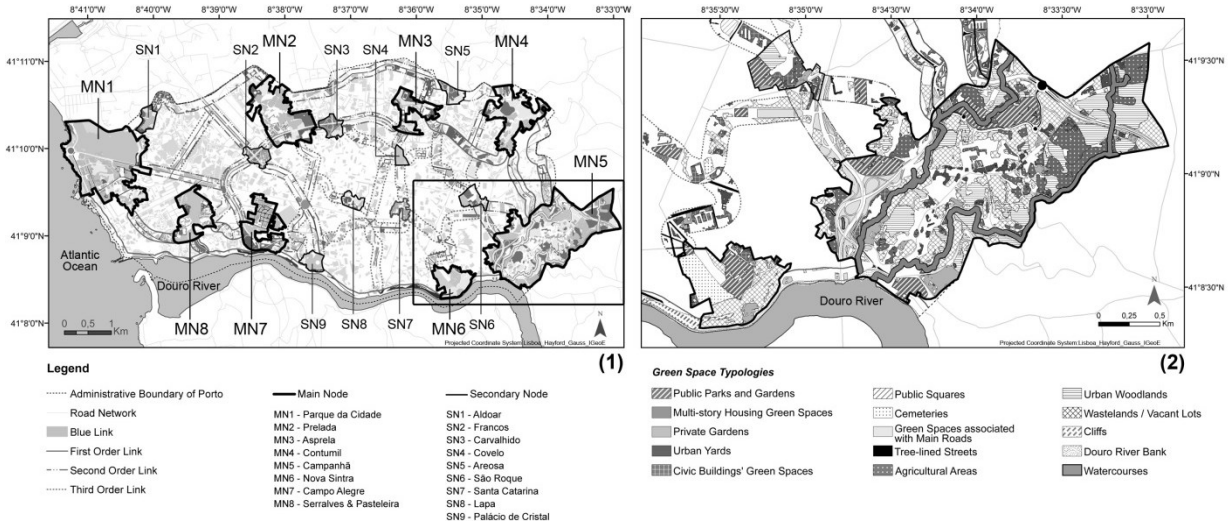

Fig. 2. (1) Areas with greater ecological potential (main nodes and secondary nodes) and links between them. (2) Detail of the southeast area of the city revealing the green spaces typologies composition of nodes and links.

The identified nodes are very heterogeneous regarding their green space typologies: 1) southern and western main nodes are dominated by public parks and gardens, private gardens, multi-story housing green spaces as well as some wasteland/vacant lot patches; 2) northern and eastern main nodes are dominated by wastelands/vacant lots and civic buildings' green spaces but, in here, urban woodlands, agricultural areas and water courses are of great importance.

According to Table 1, *wasteland/vacant lots* and *public parks and gardens* are, on average, the leading typologies in main nodes (23.5% and 18.9%, respectively); secondary nodes display a slightly different composition being led by *public parks and gardens, green spaces associated with main roads* and *wasteland/vacant lots* (23.5%, 17,5% and 17,0%, respectively). *Green spaces associated with main roads* have also relevance in secondary nodes (17.5%). A common feature shared by all the main nodes is the presence of *civic buildings' green spaces*, *wasteland/vacant lots* and *tree-lined streets*. *Cliffs*, *cemeteries*, *public squares*, *Douro River banks* and *beaches/coastal zones* were the less represented typologies. In secondary nodes it should also be highlighted the ecological value of *urban yards* (11.2%) particularly in Santa Catarina Node where they occupy 91.7% of the green area.

A total of 41 links were identified and hierarchized as follows: the natural blue link (Douro River and the Atlantic Ocean coastal areas), six links of first order, eighteen of second order and sixteen of third order. Although it was not a criteria for their delimitation, a gradual increment in the green area of the links, according to their order, was detected, starting in third order links with 28.6%, second order links with 34.4% until first order links with 42.5%.

The average length of links is 1.1 km, excluding the blue link that extends along 13 km. Links have, on average, 33.3 % of green area and nearly seven different green space typologies. The most frequent typologies are *multi-story housing green spaces* which dominate in first order links (22.4%), *green spaces associated with main roads* (25.4%) leading in second order links, and *urban yards* (19.9%) that, along with *civic buildings' green spaces* (19.3%) and *private gardens* (15.2%) are the most relevant typologies in third order link. Despite their natural linear configuration, *watercourses* were not relevant in links delimitation, partially because the most part is piped and those that remain in open air were absorbed in the main nodes.

The Atlantic Ocean and the Douro River act as the main corridor ensuring connectivity in southern and western limits of the city. Additionally, the occurrence of a large number of different types of green space proves its multifunctional quality: *beaches*, *banks* of the river, *cliffs*, *tree lined streets*, *parks and gardens* and *public squares*, guarantee, further than its contribution to the promotion of biodiversity, wildlife migration, flood control and water quality, an important performance in the recreation of Porto habitants.

First order links provide important connections between the main nodes located in the southwest and in the northeast areas of the city; second order links ensure connectivity especially along the periphery while the third order links are concentrated in the city center, more densely urbanized.

Discussion and conclusion

The proposed network was built upon the existing urban green space pattern (Kong et al 2010) and assumes the form of a closed loop consisting of complex organization of highly differentiated nodes and a myriad of links with distinct capacity of connection. The uniqueness of each node as well as the differentiated character of the links, addresses additionally challenges to their planning process but at the same time reveals emerging opportunities for the greenway planning purposes.

Two leading nodes, Parque da Cidade and Campanhã were identified in the west and east limits of the city. Because of their size, location and green space composition (they include the two largest public city parks), these two nodes act as the largest biodiversity spots of Porto; they are fundamental to its green structure and therefore should be carefully addressed by all planning regulations from the municipal level to regional level.

W*asteland/vacant lots* is a very important typology in both main and secondary nodes. As they are often considered as spaces without a clear function, they are the less stable and very susceptible to urban sprawl of the considered typologies. However they act as important seed banks for wild species colonization of neighboring patches, and in that sense, should be considered as significant conservation spots. *Green spaces associated to the main roads* are present both in nodes and in links; this raises the attention for the importance of such typology and the need to improve its spatial quality and diversity.

The protection of agricultural land and urban woodland is also a relevant matter in the planning of the city not only because of the ecological services they provide but also because they have an important as a food production strategy and source of natural resources.

The compact historic city center reveals a significant absence of green areas either integrated in nodes or in links. The green structure of the inner city is much supported by *urban yards* and *private gardens*. This fact brings about sensitive issues in the planning process, as these are both private areas. Nevertheless, they play an essential ecologic function by ensuring permeability, clean air, habitats and visual amenity, and therefore they should be effectively preserved and new green spaces should be promoted to strength connectivity.

The proposed green network may contribute for the framework of a more ecologically oriented planning program for Porto. In its current form it provides an initial identification of the major green areas in the city, the existing or potential connectivity between them, and which green

space typologies provide higher contribute for the multi purposes goals of this promising urban greenway system.

				% Green Space Typologies (GST)															
MAIN NODES	Area (ha)	% Green area	Numb. GST	PPG	MHGS	PG	UY	CBGS	PS	CE	GSMR	TLS	AA	UW	W/VL	CL	WC	DRB	B/CZ
MN1 - Parque Cidade	226.3	79.2	14	44.4	1.0	16.3	6.1	1.3	0.8	0.1	0.8	4.5	4.0	0.4	14.7		1.1		4.4
MN2 - Prelada	112.3	70.8	10		8.6	4.7	1.8	12.0			2.9	3.2	33.4	12.2	17.4		3.8		
MN3 - Asprela	42.8	72.9	8		1.0	0.7		41.7			10.2	3.7	7.7	0.0	30.2		4.9		
MN4 - Contumil	86.4	80.2	9		0.7	2.6	3.8	5.1				1.3	14.8	21.1	48.4		2.3		
MN5 - Campanhã	298.9	75.3	13	7.5	0.3	3.7	3.2	0.9			5.1	0.6	15.7	20.8	27.7		14.1	0.3	
MN6 - Nova Sintra	39.9	84.6	8	19.7		4.3		4.3		25.6		0.1	0.5		43.3	2.2			
MN7 - Campo Alegre	68.0	70.0	11	18.7	2.3	17.1	12.1	15.4			9.1	12.0	1.5	8.3	2.9		0.4		
MN8 - Serralves	61.7	72.6	9	60.6	16.3	0.9	5.5	11.0				1.4		2.3	0.9		1.1		
mean	117.0	75.7	10.3	**18.9**	3.8	6.3	4.1	11.5	0.1	3.2	3.5	3.3	9.7	8.2	**23.2**	0.3	3.5	0.04	0.6
SECONDARY NODES																			
SN1 - Aldoar	15.1	93.9	7			1.7		17.1				1.5	38.3	18.6	19.7		3.2		
SN2 - Francos	17.1	60.5	4		33.9						56.0	0.6			9.5				
SN3 - Carvalhido	17.3	78.8	4		0.6						68.0		8.8		22.6				
SN4 - Covelo	8.0	95.4	1	100.0															
SN5 - Areosa	14.6	87.2	5								30.7	7.1		22.4	37.8				
SN6 - São Roque	17.4	73.3	8	31.2		7.6	4.5	10.0			2.8		13.3	20.2	10.4				
SN7 - Santa Catarina	10.8	64.1	2			8.3	91.7												
SN8 - Lapa	12.2	71.7	5				5.0	38.3					9.2		45.8		2.0		
SN9 - Palácio Cristal	15.6	83.4	5	80.5		6.0						0.9			7.3	5.3			
mean	14.2	78.7	4.6	**23.5**	4.3	2.6	11.2	7.5			**17.5**	1.1	7.7	6.8	**17.0**	0.6	0.6		
	Length (km)	% Green area	Numb. GST	PPG	MHGS	PG	UY	CBGS	PS	CE	GSMR	TLS	AA	UW	W/VL	CL	WC	DRB	B/CZ
LINKS (means)																			
First order	1.3	42.5	7.8	2.3	22.4	3.4	5.0	12.6			5.0	12.6	4.8	20.4	22.1		0.1		
Second order	1.1	34.4	6.4	4.3	5.2	10.1	10.3	9.8	1.6	0.3	25.4	11.1	2.3	2.0	16.1		1.5		
Third order	1.1	28.6	6.3	5.3	3.5	15.2	19.9	19.3	3.2	2.0	2.6	12.8	0.7	3.0	12.4				
mean	**1.1**	**33.3**	6.6	4.4	7.1	**11.1**	**13.4**	**14.0**	2.0	1.0	**13.2**	**12.0**	2.1	3.8	**12.4**		0.7		
Natural Blue Link	13.0	74.1	13	2.3	0.4	0.9	0.2	0.7	1.5		0.2	3.6	0.1		0.3	5.7			5.9

Table 1. Green space typology composition of nodes and links (see Methods, pag. 3)

Acknowledgements

This work was supported by Fundacão para a Ciência e Tecnologia under the research project by the PTDC/AUR-URB/104044/2008 ‘‘Urban Green Structure: Study of the relation between public space morphology and flora and fauna diversity in the city of Porto’’.

References

Ahern, J. (1995). Greenways as a planning strategy. Landscape and Urban Planning, 33, 131-155.

Ahern, J. F. (2002). Greenways as Strategic Landscape Planning: Theory and Application. Doctoral thesis. ISBN 90-5808-605-4. Wageningen University, The Netherlands.

Briffett, C. (2001). Is managed recreational use compatible with effective habitat and wildlife occurrence in urban open space corridor systems?. Landscape Research, 26(2), 137-163.

Farinha-Marques, P., Lameiras, J.M., Fernandes, C., Silva, S., Guilherme, F., (2011). Urban Biodiversity: a review of current concepts and contributions to multidisciplinary approaches. Innovation – The European Journal of social Science Research, Vol. 24, No. 3, 247-271.

Ignatieva, M., Stewart, G. H., Meurk, C. (2011). Planning and design of ecological networks in urban areas. Landscape and Ecological Engineering, 7(1), 17-25.

James, P. & Bound, D. (2009). Urban Morphology types and open space distribution in urban core areas. Urban Ecosystems, 12, 417-424.

Jongman, R. H. B. (2003). Ecological networks and greenways in Europe: reasoning and concepts. Journal of Environmental Sciences, 15(2), 173-181.

Kong, F. Yin, H., Nakagoshic, N., Zong, Y. (2010). Urban green space network development for biodiversity conservation. Identification based on graph theory and gravity modeling. Landscape and Urban Planning, 95 16–27.

Linehan, J., Gross, M., & Finn, J. (1995). Greenway planning: developing a landscape ecological network approach. Landscape and Urban Planning, 33, 179-193.

Madureira, H., Andresen, T., & Monteiro, A. (2011). Green structure and planning evolution in Porto. Urban Forestry & Urban Greening, 10(2), 141-149.

Pauleit, S. & Duhme, F. (2000). Assessing the environmental performance of land cover types for urban planning. Landscape and Urban Plannning, 52, 1-20.

Searns, R. M. (1995). The evolution of greenways as an adaptative urban landscape form. Landscape and Urban Planning, 33, 65-80.

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kazmierczak, A., Niemela, J., & James, P. (2007). Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. Landscape and Urban Planning, 81, 167-178.