Mapping physical and visual accessibility of greenspace

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Summary: Positive associations between human health and well-being have been shown for both physical and visual access to outdoor natural environments. This paper presents the development of spatial analysis tools for assessing physical and visual access to green and open spaces with respect to population data. Results are presented for Edinburgh, UK. We discuss the opportunities and limitations of spatial outputs and their future development in planning of urban change.

KEYWORDS: Human health and well-being, accessibility, greenspace

1. Introduction

Expanding urban areas put pressure on ecosystem services (ESS) such as biodiversity, and the number, size and configuration of green and open spaces (UKNEA, 2011), and in turn on human health and well-being (Takano et al., 2002). Positive effects of the natural environment for human health and well-being depend on social interactions stemming from cultural understandings as well as contact with nature and the natural environment (Kaplan et al., 1988; Maas et al., 2009). In economically deprived areas, greenspaces are a resource for alleviating stress, with evidence that people in the vicinity of more greenspace have lower levels of self-reported stress (Ward Thompson et al., 2012). Increased availability of different types of spatial data enables analysis to explore the provision and accessibility of greenspaces. This paper presents the use of spatial modelling for providing information on physical and visual access to green and open spaces, and linking that to data on population.

2. Background

Many underlying determinants of inequalities in health are environmental. Positive associations are reported between human health, well-being and access to outdoor natural environments (Di Nardo et al., 2010), and between physical activity in natural environments and lower risks of poor mental health (Mitchell, 2012). The significance of accessibility of greenspaces from homes is reported by authors (e.g. Stigsdotter et al., 2010) noting that living <1 km of a greenspace was linked to significant reductions in risk of cardiovascular disease or stress. Van den Berg et al. (2010) report that the amount of greenspace within 3km of people's homes showed a relationship between stressful life events and perceived general health.

Reviews of benefits of contact with nature for human health and well-being (e.g. Bowler et al., 2009) identify gaps in the evidence base for policy makers, suggesting that evidence of health benefits of views of nature is better established than those of direct contact with nature. Ulrich et al. (2008) noted that views of built environments can have adverse impacts on levels of stress, and that nature-dominated views provide 'pleasant distractions' and block

'worrisome, stressful thoughts'. Other studies report positive effects of views of trees (Ulrich, 1984) or natural situations.

In this paper we consider physical and visual access to greenspaces at the property level, and discuss issues associated with deriving spatial outputs, limitations and areas of future development.

3. Methodology

3.1 Greenspace data

Data were compiled from Ordnance Survey Mastermap (19 classes land cover and use), grouped according to Scottish Government Planning Advice Note 65, for Edinburgh (Figure 1). Verification used aerial imagery (Google maps, Bing), and Google Streetview, with attributes recorded on quality, content and uses of greenspaces.

Table 1. Classification of types of accessible greenspace for City of Edinburgh

Class	Description	Area (ha)	% of City
1	Accessible Play spaces for Children & Teenagers	**5.71**	**<0.1**
2	Accessible Parks & Gardens	**5,95.1**	**3.2**
3	Accessible Parks & Gardens, Playspace, Playing Fields, Golf Courses, Green Corridors, Semi-natural Greenspace	**2,769.4**	**13.8**
4	Accessible Parks & Gardens, Playspace, Playing Fields, Golf Courses, Green Corridors, Semi-natural Greenspace, Amenity Greenspace >0.1ha	**2,769.4**	**15.0**
5	All significant accessible Open Space	**4,101.8**	**22.2**

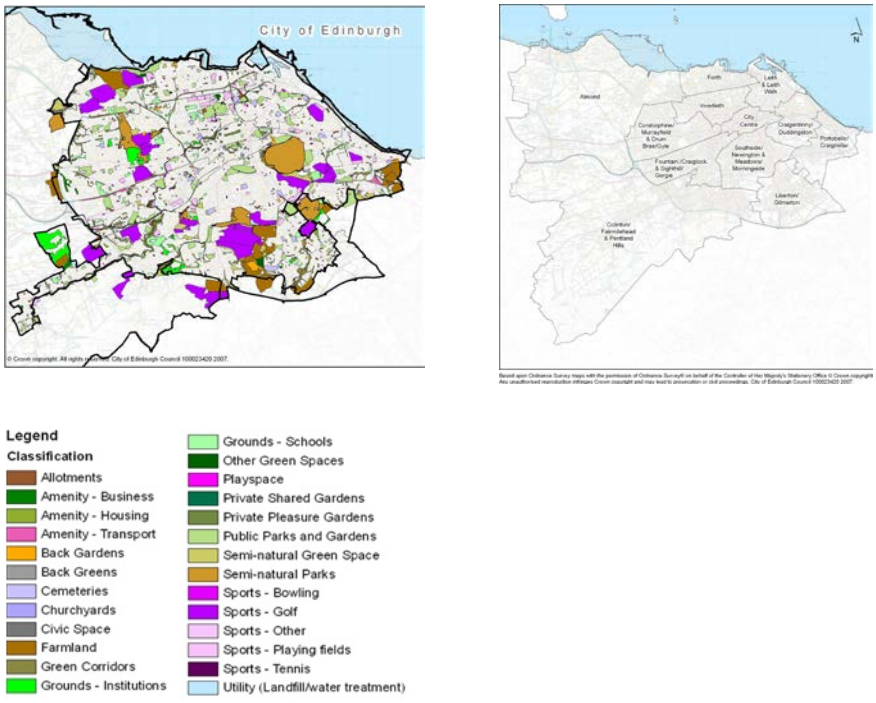

Figure 1. (a) Distribution of greenspaces for City of Edinburgh (2007), classified by type and use. (b) Neighbourhood Partnership Areas (NPAs)

3.2 Physical accessibility of greenspaces

To derive data on the levels of physical accessibility of greenspaces by walking or driving, the data on greenspaces were augmented by those on roads and paths. The input data were those on roads from the Ordnance Survey Integrated Transport Network (ITN) (Ordnance Survey, 2012b), and footpaths from the Urban Paths Theme (Ordnance Survey, 2012c), to which significant footpaths were added from aerial imagery and on-site records.

Access points to greenspaces were recorded where a footpath linked with a greenspace, i.e. 'formal access', or open space is adjacent to a footpath, pavement or road and no physical barrier to access exists, i.e. 'informal' access. For informal points of access, estimates were made of locations where there may be indications of a path having been developed. Travel distance along road and path networks, between dwellings and the closest accessible open space in each category, used network analysis tools in a Geographic Information System (GIS, ArcGIS; Comber et al., 2008). The outputs were distances stored in attributes for each type of greenspace for each property in the database, thus enabling queries to be made of the number of properties within certain distances of different types of greenspaces.

3.3 Visual accessibility of greenspaces

Visual accessibility was derived using lidar data of heights for the buildings and urban land-use data. Visibility indices were then derived of: (i) greenspaces from individual properties, (ii) different types of greenspaces from different types of properties. The calculation used viewpoints at 5m intervals around the upper floors of every property, to every 5m x 5m cell at ground level or shrub and tree canopies. Properties were then classified according to visual access to greenspaces.

4. Results

4.1 Physical accessibility of greenspaces

Figures 2 and 3 show the distribution of greenspace types and physical accessibility residential properties in two neighbourhoods: Forth and Inverleith. Figure 4 shows the proportions of properties <300m from an accessible greenspace, compared with Edinburgh overall. This enables comparisons of physical accessibility of greenspace categories between neighbourhoods, e.g. accessibility in Forth is higher than Inverleith, with 75% of properties <300m from significant open space (Category 5) in Forth compared with 53% in Inverleith.

For interpretation of accessibility with respect to population, the 2001 census data were joined to individual properties using postcodes. This used the population attributes reported per postcode averaged over the number of properties in the post code area. The database produced supports queries relating to population profile (e.g. age, ethnicity, vehicle ownership) with respect to access to greenspaces, providing estimates of accessibility of population to different types of greenspaces, and linked to other property level data such as visibility.

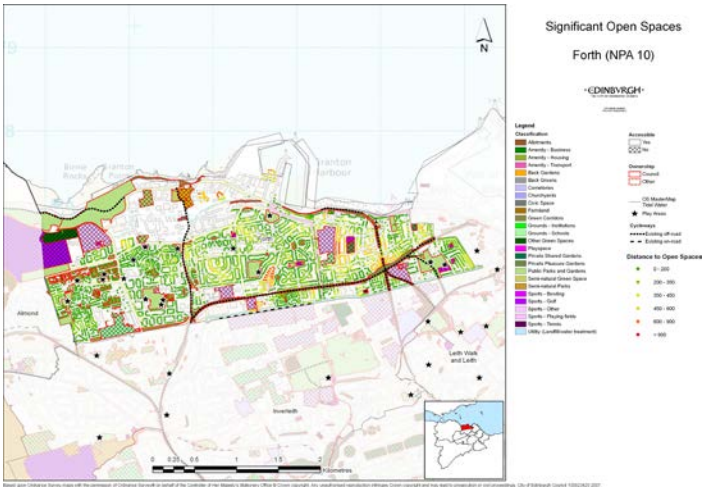

Figure 2. Accessibility of significant open spaces from each property in Forth NPA, Edinburgh

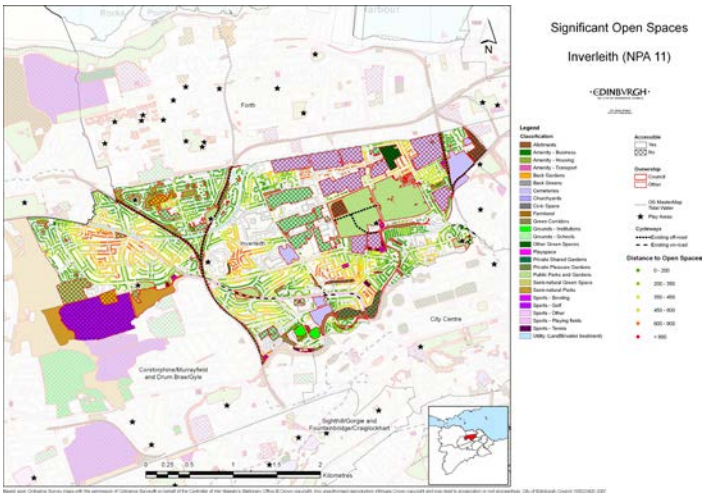

Figure 3. Accessibility of significant open spaces from each property in Inverleith NPA, Edinburgh

Figure 4. (a) Percentage of residential properties <300m walking distance from accessible open spaces: (a) Forth NPA, (b) Inverleith

4.2 Combined physical and visual accessibility of greenspaces

Data on physical and visual access were combined to assess overall access to greenspaces. Figure 5 shows this for 5,907 properties in north Edinburgh. Properties were classified to show geographic distributions of relative accessibility to greenspaces. Each classification used a mid-point to split visibility into 'high' and 'low', and split physical distance at 300m (class 1) and 200m (class 2) thresholds. Table 2 summarises properties for each classification, and Figure 5 their geographic distribution.

Results show more properties grouped in the lower (56.7%) compared to higher visibility class (43.3%). With respect to distance, 84.5% of properties are <300m of accessible greenspace (class 1), compared to 62.2% <200m (class 2). The threshold for 50% of properties is 169m from a greenspace entrance. The effect of different thresholds of physical accessibility is highlighted by those properties coloured black (i.e. > 300m) in Figure 5(a) and yellow (i.e. > 200m) in Figure 5(b). Properties coloured blue and red (i.e. higher levels of visibility) are predominantly to the west, reflecting the distribution of greenspaces, more open views of such spaces, and taller buildings (i.e. views of bigger areas). Interpretation of the maps identifies deficiencies of public greenspaces (private gardens were excluded). Table 2 shows estimates of population for each classification, categorised by visual and physical accessibility, enabling identification of where and how many people have limited accessibility to greenspace.

Table 2. Estimated population for properties in each of two classifications with respect to physical and visual accessibility to greenspaces

			Visibility			
			High		**Low**	
		Classification	**No. properties**	**%**	**No. properties**	**%**
Distance	**High**	1	615	5.1	1237	10.3
		2	1607	13.3	2971	24.7
	Low	1	4578	38.0	5613	46.6
		2	3585	29.8	3879	32.2

Further analysis is required to test implications of visibility thresholds, and the interpretation of these data with respect to the management and provision of green and open spaces in urban areas.

Figure 5. Combined physical and visual accessibility of greenspaces to properties in Pilton, Edinburgh: (a) Class 1; (b) Class 2

5. Discussion

Different definitions and classification of greenspace enables greater consideration to be paid to a range of issues of public interest. The data in this study continues to be updated with new releases of the national mapping by Ordnance Survey, to enable measurement of changes in extent of greenspaces. These data are being updated to reflect the PAN 65 classification, with units split or combined where land use changes for only part of a greenspace, such as semi-natural greenspace converted for sports or playspaces, or greenspaces converted into housing and amenity greenspace.

Limitations of the analysis include no account taken of physical and social factors, such as topographic inhibitors to movement, and inhibitions to uses certain spaces; therefore maps of minimum distances may not equate to minimum travel time. Calculations of distance relate to entrances to greenspaces, thus the use of estimates for specific features (e.g. children's playspaces within greenspaces) may be underestimated.

When suitable data from the 2011 population census are available, estimated for summer 2013, they will be used to provide comparisons of accessibility to greenspaces. This will enable analysis with respect to changes in population, properties, greenspaces and points of access.

The methods presented show how calculations of visibility of greenspace can be derived for individual properties. Further development is testing hypotheses of potential significance of views of greenspace in relation to human health and well-being. Factors being analysed include: (i) levels of detail of greenspace and the means of calculating the proportion of the view it occupies, (ii) temporal effects (e.g. the significance of foliage and growing season), (iii) levels of visibility from different storeys of a building.

6. Conclusions

The method and findings illustrate how physical and visual accessibility of greenspaces can be combined at individual property level, and linked to population data. It shows the scope for spatial modelling to provide information to take account of different factors of relevance to the planning and assessment of greenspaces, in both two dimensions and three. The outputs can accommodate updates to the input datasets to support the monitoring of changes from a new population census, and in land uses. A challenge is to maintain the contemporary nature of these data, and their use in relation to planning for environments consistent with human health and well-being.

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8. Biographies

David Miller is the leader of the Realising Land's Potential Research Theme, studying natural resources, land use and landscapes. His background is in spatial modelling and remote sensing, with 27 years experience the development and application of tools for monitoring rural and urban land use, and assessing impacts of change.

Paula Horne has a background in handling digital map and satellite data and has extensive experience in the use of Geographic Information Systems (GIS) and image analysis software for studying changes in urban and rural landscapes. She navigates stakeholders through landscape models in the VLT, explaining land use change.

David Donnelly is a researcher with responsibilities for the development of novel means of

spatial analysis for public sector and commercial clients. He has a background in Topographic Science and surveying, and works on GIS applications in urban and rural environments.

Jane Morrice is a researcher with expertise in spatial analysis and applications in landscapes and Environmental Impact Assessments. She has worked on mapping natural resources using GIS and remote sensing, modelling impacts of renewable energy and developing tools for spatial planning.