Who benefits from access to green space?
A case study from Sheffield, UK

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Abstract

Green spaces play a crucial role in supporting urban ecological and social systems, a fact recognised in public policy commitments in both the UK and Europe. The amount of provision, the distribution of green space and the ease of access to such spaces are key contributors to social and ecological function in urban environments. We measured distance along the transport network to public green space available to households in Sheffield, and compared this with the distribution of private garden space. In addition, we used a geodemographic database, Mosaic UK, to examine how access to green space varies across different sectors of society. Public green spaces are chronically underprovided relative to recommended targets. For example, 64% of Sheffield households fail to meet the recommendation of the regulatory agency English Nature (EN), that people should live no further than 300 m from their nearest green space. Moreover, this figure rises to 72% if we restrict attention to municipal parks recognised by the local council. There is an overall reduction in coverage by green space when moving from neighbourhoods where green space is primarily publicly provided to those where it is privately provided. While access to public green space varies significantly across different social groups, those enjoying the greatest access include more deprived groups and older people. This study highlights the need for additional green space to be created and existing green space to be protected in light of increasing development pressure.
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1. Introduction

The condition of green spaces underpins the functioning of urban ecosystems. Public parks and private gardens play a critical role in supporting biodiversity and providing important ecosystem services in urban areas (Bolund and Hunhammar, 1999; Crane and Kinzig, 2005; Gaston et al., 2005; Smith et al., 2005). They also provide the primary contact with biodiversity and the 'natural' environment for many people (Jorgensen et al., 2002), may influence the physical and mental well-being of those people (Ulrich et al., 1991; Takano et al., 2002; Jackson, 2003), and, in the case of public green space, can offer broader social benefits as meeting places that give a shared focus to

diverse communities and neighbourhoods (Germann-Chiari and Seeland, 2004; Martin et al., 2004). Despite these benefits, many urban green spaces are disappearing (Hörnsten and Fredman, 2000; Pauleit et al., 2005; Yli-Pelkonen and Niemela, 2005). Householders moving away from the city of Leuven, Belgium, cited the lack of accessible public green space as the main reason for leaving (Tratsaert, 1998, cited in Van Herzele and Wiedemann, 2003). With growing and increasingly urbanised populations (Stanners and Bourdeau, 1995; ODPM, 2002), the demand for more land to be released for development can be intense. For example, a lack of regional co-ordination in green space provision accompanied rapid urban growth in Copenhagen during the 1990s, resulting in pressure on the green space network (Caspersen et al., 2006).

Regulatory agencies recognise the importance of safeguarding the provision of green space in urban areas. In Europe, the European Environment Agency (EEA) recommends that

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people should have access to green space within 15 min walking distance. A Europe-wide assessment of access to green space reported that all citizens in Brussels, Copenhagen, Glasgow, Gothenburg, Madrid, Milan and Paris live within 15 min walk of urban green space, as well as the residents of many smaller cities (Stanners and Bourdeau, 1995). More stringently, English Nature (EN), a UK government agency, recommends that "people living in towns and cities should have an accessible natural green space less than 300 m from home" (English Nature, 2005; see also Harrison et al., 1995; Barker, 1997; Handley et al., 2003; Wray et al., 2005). Also, the ease of access to local green space and countryside is one of the indicators devised for implementing England's Biodiversity strategy in towns, cities and other developments and, by this, ensuring that biodiversity conservation is integral to sustainable urban communities (Wray et al., 2005). However, we know of no objective accounting efforts that estimate whether the distance-based access conditions are met (see also Wray et al., 2005). When evaluating public policy commitments like these, it is not enough only to know what level of access to green space the "average" person enjoys. Rather, policy-makers want to know how access to public green space varies across society, and whether those who enjoy the greatest access include those who are most in need.

We measured the access to public green space available to households in a major UK city and examined how this varies across different sectors of society. We also contrasted levels of provision of public green space with the availability of private green space.

2. Methods

2.1. Sampling methods

Sheffield is the fifth largest municipality in the UK, and the ninth largest urban area, with a population of approximately 512,500 (Beer, 2005; ONS, 2005). The city's administrative boundaries extend over a region of more than 360 km^2 (Sheffield City Council, 1991), but we limited our study to the smaller predominantly urbanised area of approximately 160 km^2 in which nearly all of the population live (Fig. 1a). To the east, this is principally defined by the boundaries of Sheffield and the neighbouring borough of Rotherham; to the south by the Derbyshire/South Yorkshire county boundary; and to the north and west the area was limited to 1 km × 1 km British National Grid squares with more than 25% coverage by residential and industrial zones (Gaston et al., 2005). Sheffield contains a varied range of landscapes, and a substantial green space network that for historical reasons extended along river corridors, but that now also includes an extensive system of publicly provided spaces, both planned and unplanned (see Beer, 2005 for a comprehensive review of green spaces in Sheffield).

First, we defined public green space as every parcel of land classified as a natural surface by Ordnance Survey (OS) MasterMap topographic data (Murray and Shiell, 2003), which we judged to be publicly accessible. The use of natural surface as a criterion is in keeping with the requirement in Harrison et al. (1995: 2) that the surface in the green spaces be "predom-

inantly natural: earth, water and living things". This included municipal parks, public gardens, cemeteries, gardens associated with public buildings, and all school playing fields in which aerial photographs or OS data indicated a path in public use. We excluded all road verges. We mapped all green space located either within the urban area or within a 1 km buffer around it aided by the use of 25 cm resolution aerial photos produced by Cites Revealed (http://www.citiesrevealed.com) and 1:10,000, 1:25,000 and 1:50,000 Ordnance Survey maps. For each of the 179,844 residential addresses in the urban area, we used the Ordnance Survey Integrated Transport Network layer to calculate the distance through the road network from the address location to the nearest entrance to green space, including the shortest straight-line distances from the address to the road network and from the road network to the park entrance (Fig. 1a); use of footpaths would potentially reduce some of the distances, but they are not uniformly mapped or consistently used by different groups of people.

Then, we mapped the 87 municipal parks listed by Sheffield City Council (http://www.sheffield.gov.uk) that fall within the urban zone. Municipal parks are arguably more beneficial to local communities than other forms of urban green space. They are often quite large, frequently visited, well connected to public transport and provide facilities such as play areas and sports fields (Williams and Green, 2001). Furthermore, Sheffield's major urban parks attract over 25 million visits each year (Beer, 2005). By considering access to all green spaces and to municipal parks only, we span the spectrum of possibilities for access available to Sheffield residents. To reduce computation time, we calculated distances from households to the nearest entrance to a municipal park through the transport network for a random sample of 10,000 addresses from across the city.

We examined the relationship between the availability of public and private green space in Sheffield to evaluate the degree to which private garden space was acting as a substitute for public green space. The proportion of garden and public green space cover within a circular area of radius 500 m was calculated at a 100 m × 100 m grid square resolution, and coverage by gardens was obtained directly from MasterMap data.

2.2. Social diversity

To classify social diversity across Sheffield, we used Experian's Mosaic UK geodemographic database (http://www.business-strategies.co.uk). This classification is based on a hierarchical cluster analysis of 430 social, economic and demographic variables chosen for their explanatory power (Webber, 2004); 54% of these variables were derived from the 2001 census and the remainder from a variety of sources including Experian's own lifestyle surveys, the edited electoral roll, consumer credit activity and house price and council tax data. The classification assigns households to 1 of 11 groups and 61 sub-classes; for our analyses we use only the group level. Table 1 describes in more detail the characteristics of the 10 Mosaic groups. As well as spanning economic and demographic gradients, Mosaic provides an insight into the lifestyles of people in different neighbourhoods (Harris et al., 2005). Mosaic has previously been
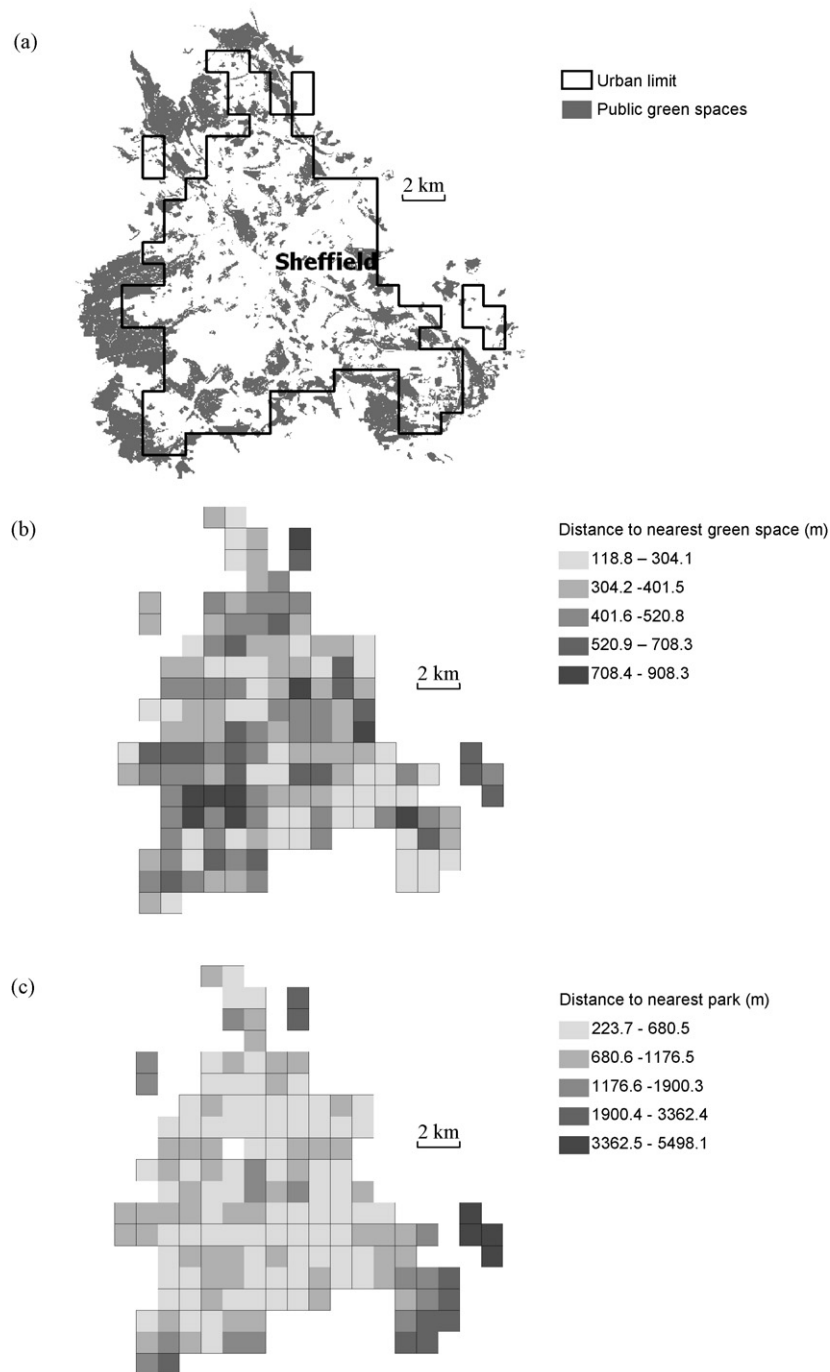
Fig. 1. Distances to green spaces across Sheffield. (a) Sheffield study site. Mean distances of Sheffield households to (b) public green space and (c) municipal parks across the urban area of the city of Sheffield. Values represent means for each 1 km × 1 km grid cell, however, calculations and analysis in the main text are at the household level.

used in diverse applications both in public policy design and in the private sector (e.g. Webber, 1985; Farr and Webber, 2001; Williamson et al., 2005).

We used orderings of Mosaic groups by deprivation, wealth and age. Mosaic provides a complement to the UK government's Index of Multiple Deprivation, a set of continuous indicators reported at super output area level (c. 800 households) covering seven deprivation domains (ODPM, 2004). An average score for each of the government's deprivation domains was computed for

each discrete Mosaic group, allowing the calculation of a single deprivation index value for each Mosaic group.

The same data used in the Mosaic clustering analysis to assign households to discrete categories were reanalysed using PCA-based methods, yielding continuous, statistically independent dimensions that span the variation in the data. One key axis separated households by wealth. The wealth rank is based on the average position on that axis for households of a given Mosaic group.

Table 1
Description of the 10 Mosaic groups

Mosaic group	Description
Symbols of success (6.1%)	Householders with well set career path and relatively high incomes. Their children now are less time consuming and lead more independent lives. Well built and spacious homes, in low density neighbourhoods in economically successful areas
Happy families (7.9%)	Households comprised people focused on career, home and family. Mostly young couples raising young children. Commonly in modern purpose-built family housing, either detached or semi-detached, in areas of rapidly expanding development
Suburban comfort (10.5%)	Comfortable homes in mature suburbs. Children becoming independent and householders planning for approaching retirement. Pleasant and homogenous semi-detached houses set back from the road in large plots with leafy gardens
Ties of community (22.5%)	Households in established, rather old-fashioned communities. Younger than the wider population and many couples with children. Strong social support networks, friends and family nearby. Older housing stock, comfortable but small with modest garden
Urban intelligence (7.8%)	Typically young, well educated and open to new ideas. Many in higher education, others moving into employment. Many foreign-born residents, encouraging ethnic and cultural variety. Inner areas of large provincial cities with popular universities
Welfare borderline (7.9%)	Households struggling to achieve material and personal rewards assumed to be open to all in an affluent society. Few with rewarding or well-paid jobs, most qualifying for state benefits. Small public sector flats with high levels of social deprivation
Municipal dependency (21.3%)	Households often lack the funds to buy their homes, relying on local authority housing. Commonly rely on buses for mobility and television for entertainment, and in general enjoy less choice than better off groups. Neighbourhoods built at low densities far from city centres, homes often short terraced or semi-detached houses with gardens
Blue collar enterprise (6.7%)	Householders practical and enterprising rather than well educated. Lifestyles improved in recent years becoming home owners and living in pleasant, low crime rate neighbourhoods. Often low density estates of terraced or semi-detached housing, usually with a garden
Twilight subsistence (6.2%)	People who have reached the late stage in previously independent lives and now require support for housing, many relying on state benefits. Often in small neighbourhoods that are pockets within larger areas of council housing
Grey perspectives (2.9%)	Households comprise retirees still independent and in reasonably good health. Typically own and run their own homes and are financially independent. Diversity of neighbourhoods characterised by high amenity value, good order and low crime

Common attributes were identified from the original explanatory variables and also from lifestyle surveys conducted by Experian. Percentage occurrence among households in Sheffield is also given.

The age ranking is based on the average age UK-wide of individuals found within that category. The average is calculated from Experian's person-level age model of the UK population that is derived from a variety of sources including census data and Experian's own lifestyle database.

We matched household addresses in Sheffield to their Mosaic group and excluded addresses of non-residential premises that were unclassified and non-urban residential addresses. From the 11 Mosaic groups, we also excluded "Rural Isolation", which only represented 0.13% of households on the fringes of our study area.

2.3. Data analysis

Distance to green space and municipal parks were analysed using a one-way ANOVA with social group as a factor with 10 levels (Tables 1 and 2). The response variable, distance to green space or municipal parks, was square root transformed to meet assumptions of normality and homogeneity of variance. The relationship between distance and wealth and that between public green space and private garden coverage was assessed using Spearman rank correlations. A binomial proportion test was used to examine potential differences in the proportion of households in different social groups meeting EN and EEA access targets for green space.

3. Results

3.1. Distance to green space

Distances of households to green space vary greatly across Sheffield (Fig. 1b). The frequency distribution of these distances is strongly right skewed (Fig. 2a), with a mean and median distance to public green space of 416.8 and 375.2 m, respectively. Only 36.5% of urban households in Sheffield meet English Nature's recommendation that each person should have green space no further than 300 m or 5 min walk from their home. The 95.6% of the households meet the European Environment Agency recommendation of access to green space within 15 min walking distance, which is roughly equivalent to 900 m (Stanners and Bourdeau, 1995).

Mean distance to green space varies significantly across different sectors of society as identified by the results of the social cluster analysis ($F_{9,179834} = 632.96$, $p < 0.001$; Fig. 2b; Table 2). Five groups differ consistently from all others (Bonferroni multiple comparisons, Fig. 2b). The wealthiest social group (labelled "Symbols of Success", see Table 1) lives furthest from public green space. The group labelled "Twilight Subsistence" lives the nearest; this is a less affluent group (position 8/10 in wealth rank, see Table 2) and has the highest percentage of people aged between 65 and 84. There are significant differences in the proportion of households in each social group living more than 300 m from green space ($\chi^2 = 263.32$, $p < 0.001$). Symbols of Success contain the highest proportion failing to meet this access condition (76%) and Twilight Subsistence has the lowest (53%; Fig. 2c).

Table 2
Socio-economic groups and access to green space

Groups ranked by wealth	Mosaic group	Mean distance to green space	% HH living further than 300 m from green space	% HH living further than 900 m from green space	IMD rank	Age rank
1	Symbols of Success	540 ± 306	76	13	10	7
2	Suburban Comfort	474 ± 275	71	8	8	8
3	Happy Families	413 ± 266	61	5	7	1
4	Grey Perspectives	422 ± 246	64	5	9	9
5	Urban Intelligence	469 ± 254	72	6	6	2
6	Ties of Community	401 ± 248	61	4	3	3
7	Blue Collar Enterprise	386 ± 228	59	3	5	5
8	Twilight Subsistence	347 ± 213	53	2	4	10
9	Municipal Dependency	395 ± 215	62	3	2	6
10	Welfare Borderline	378 ± 233	57	3	1	4

Mosaic groups ranked in terms of decreasing wealth, their mean (±S.D.) distance to public green spaces, % of households (HH) living further than 300 and 900 m from a public green space, deprivation ranking (IMD) derived from the national Index of Multiple Deprivation (see Section 2) (1, most deprived; 10, least deprived) and their age rank (1, youngest; 10, oldest).

There is a negative, but weak, correlation between the wealth rank of the Mosaic group and distance to green space ($r_S = -0.12, n = 179,844, p < 0.001$), wealthier groups tending to be further away from green space. A similar relationship is also found using the Index of Multiple Deprivation (DETR, 2000), with less deprived groups tending to live further from green space ($r_S = 0.11, n = 179,844, p < 0.001$).

3.2. Distance to municipal parks

The distances to municipal parks are much larger than those to green space in general (Fig. 1c). The distribution of distances to municipal parks is also right skewed with a mean and median distance of 889 and 688 m, respectively (Fig. 3a). Only 18% of Sheffield households are within the recommended 300 m distance, while the 900 m recommendation is met by 58% of the households. This large difference from the results for all green spaces demonstrates the importance of additional green space around the city (e.g. cemeteries, gardens of public buildings, churchyards and school playing fields). Mean distances of households from municipal parks differ significantly across Mosaic groups ($F_{9,9990} = 14.50, p < 0.001$; Fig. 3b), with less affluent groups tending to have greater access. In particular, "Welfare Borderline", the group living nearest to municipal
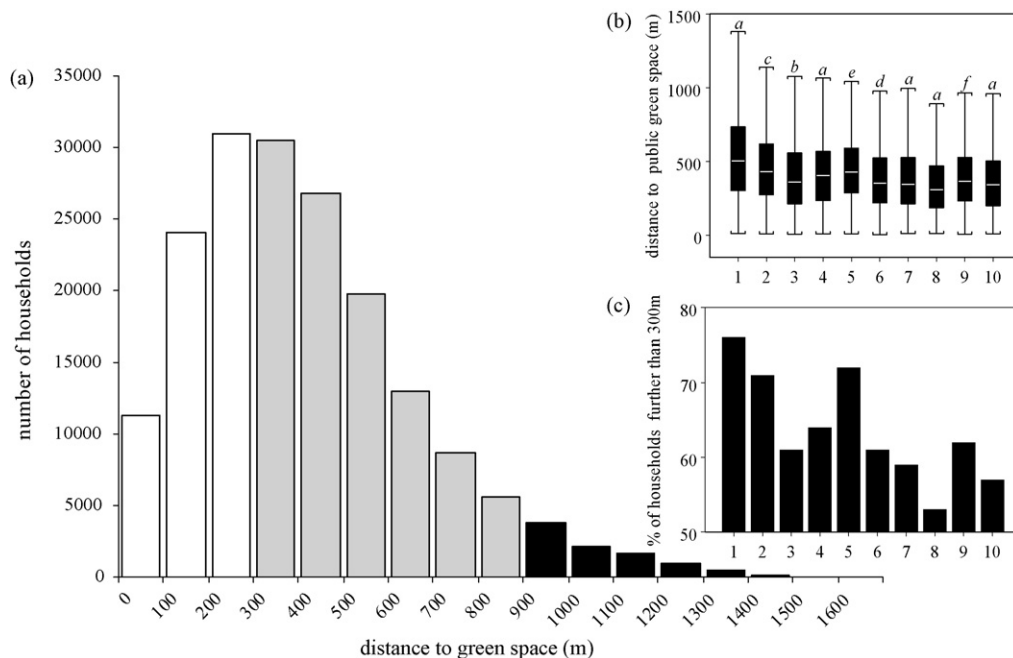

Fig. 2. Socio-economic groups and access to public green space. (a) Frequency distribution of household distances ($n = 179,844$) to public green space. Households meeting the English Nature recommendation for provision of access to green space (300 m), and the target proposed by the European Environment Agency (900 m) are indicated with white and grey bars, respectively, while households failing to meet either criterion are indicated with black bars. (b) Box plot for distance to public green space for Mosaic groups ordered by wealth (see Table 1). Letters indicate significant differences between groups; a: group differs with all others, b: differs with all but 4 and 7, c: differs with all but 5, d: differs with all but 2 and 7, e: differs with all but 3, f: differs with all but 2 and 4. (c) Percentage of households living further than 300 m from green space by Mosaic group ordered by wealth.
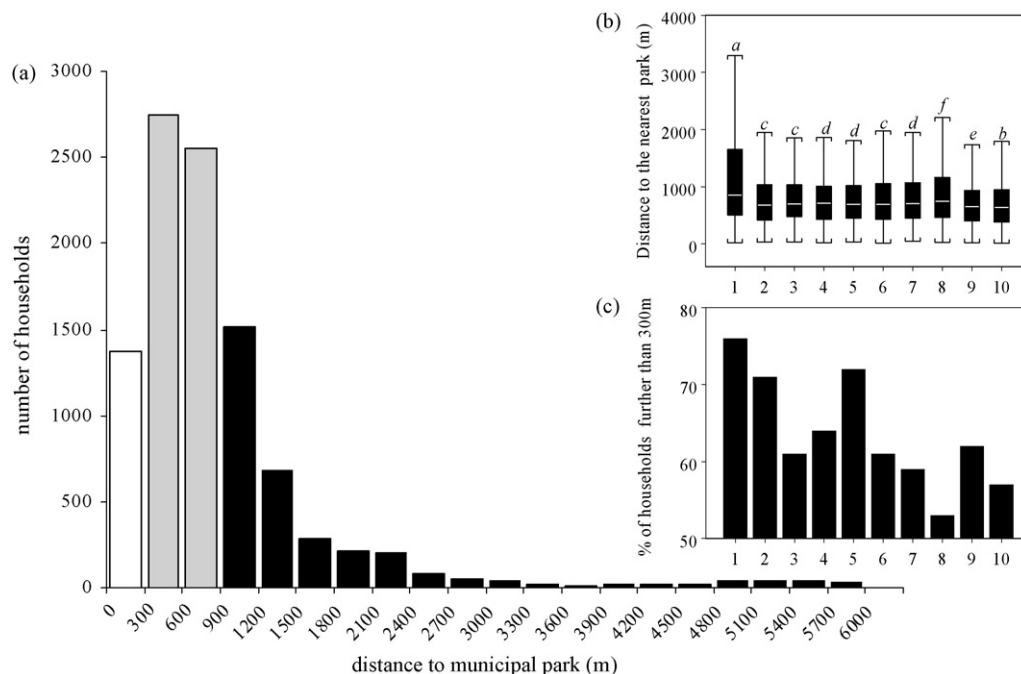
Fig. 3. Socio-economic groups and access to municipal parks. (a) Frequency distribution of household distances ($n = 10,000$) to municipal parks. Households meeting the English Nature recommendation for provision of access to green space (300 m), and the target proposed by the European Environment Agency (900 m) are indicated with white and grey bars, respectively, while households failing to meet either criterion are indicated with black bars. (b) Box plot for distance to municipal parks for Mosaic groups ordered by wealth (see Table 1). Letters indicate differences between groups; a: differs with all others but 8, b: differs with all but 9, c: differs with all but 1, 8 and 10; d: differs with all but 1 and 10, e: differs with all but 1 and 9; f: differs with all but 2, 3, 6, 9 and 10. (c) Percentage of households living further than 300 m from municipal parks by Mosaic group ordered by wealth.

parks, has the lowest wealth rank (10/10) and is the most deprived (Index of Multiple Deprivation = 48.0).

3.3. Private green space

Public green space and private gardens show an opposing pattern of occurrence across the city (Fig. 4). The relationship between the percentages of the city covered by private gardens and public green space is negative (Fig. 5; $r_s = -0.36$, $n = 10,000$, $p < 0.001$). But more interestingly, a given reduction in the availability of public green space corresponds to a smaller increase in the cover of private gardens, as indicated by the departure from the 45° line in Fig. 5. Therefore, there is an overall reduction in coverage by green space when moving from neighbourhoods where most green space is publicly provided to those where it is privately provided.

4. Discussion and conclusions

Green spaces play an important role in supporting urban communities both ecologically and socially. In the UK, their importance has been recognised in public policy commitments aiming to ensure ready access to green space for all. We assessed how well these policy targets are being met across a representative city in the UK. We also examined how green space provision varied across different sectors of society. To undertake this assessment, we examined access provision for two different cases: one in which we scored all suitable areas that we deemed publicly accessible and one in which we only considered munici-

pal parks recognised by the local administrative authority. These two extremes bound a spectrum of interpretations of green space provision. The former scenario could yield an overestimate of access, because some of the spaces included are small and likely to be of poor quality (in terms of habitat, security and provision of amenities). However, focussing solely on municipal green space is likely to underestimate green space provision, because many important and well-used spaces clearly do not fall into this category.

There is enormous variation in access to green space across Sheffield. Irrespective of whether one scores all green space or only municipal parks, many households do not enjoy government recommended levels of access to public green space. Performance against the UK-specific target set by English Nature is particularly poor. Depending on which definition of green space one uses, 64% or 72% of Sheffield households fail to meet this target. But even when considering the weaker EEA access recommendation, 42% of households do not have adequate access to green space if one considers only municipal parks. The distributions of distances of households from green space are heavily skewed (Figs. 2a and 3a). Therefore, as well as being concerned with the overall number of households having green space within a specified distance, policy-makers need to consider the tails of these distributions and the very large distances of some households from any public green space. For example, the distance to the nearest municipal park from some households in Sheffield is more than 20 times the EN recommendation. Also, the distance-based measures of access could be refined to include travel constraints, such as physical and

(a)

Green space coverage in grid cell
- 4.8%
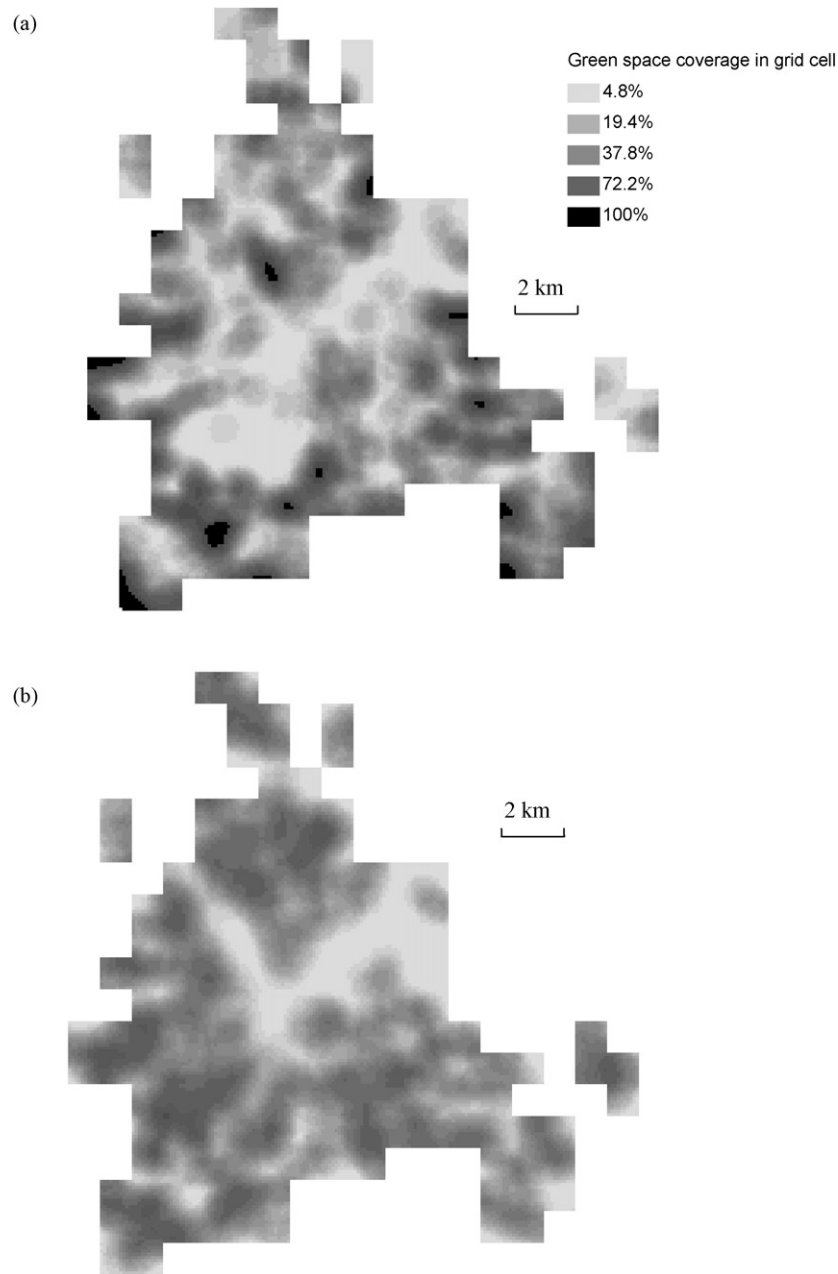- 19.4%
- 37.8%
- 72.2%
- 100%

2 km

(b)

2 km

Fig. 4. Public and private green space coverage across Sheffield. Proportion of (a) public green space coverage and (b) private garden coverage in a circular area of radius 500 m at a 100 m × 100 m grid square resolution. Legend is common for both figures, and indicates mid-point of the range of values associated with each of five shades determined using the Jenks natural break classification. Darker shades indicate greater coverage by green space.

psychological barriers to pedestrian movement (Handy, 1996; Sisiopiku and Akin, 2003; Brown et al., 2007). GIS models incorporating measures of friction have recently been developed and tested in other contexts (Dumont et al., 2005), and could be modified for this purpose.

Several studies have examined green space access in European cities. The Dutch government requires that sufficient opportunities exist for access to outdoor recreation, and a recent analysis of green space availability in the Netherlands found that 67% and 83% of neighbourhoods had ready access to recreational opportunities for walking and cycling, respectively (De Vries and Van Zoest, 2004).

To some extent private gardens may provide alternatives to access to public green space and indeed there is a negative correlation between the extent of public green space and private garden space across Sheffield (Figs. 4 and 5). However, the substitutability of public for private green space will only ever be partial as the two play different roles (Kellett, 1982). For example, public green space can provide social benefits by promoting community integration in a way that private gardens cannot; social interactions in gardens are focussed around a private social network. The persistence of privately provided green space also may be less secure. For example, wealthy neighbourhoods can be more prone to losing private green space due to infill densi-
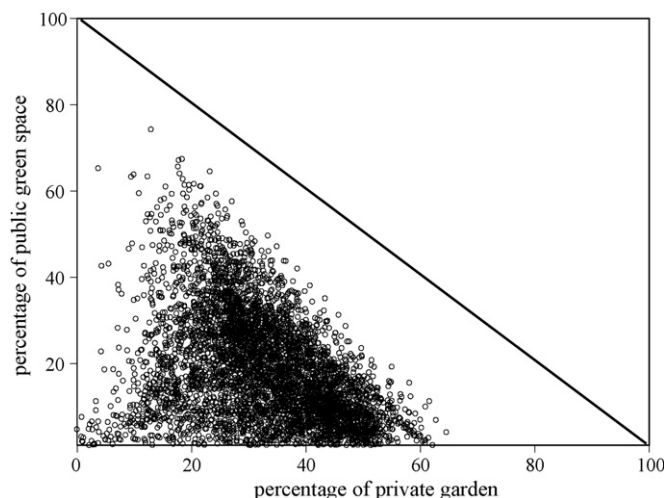
Fig. 5. Ownership of green spaces across Sheffield. Relationship between the proportion of private garden versus public green space coverage for a random sample of 10,000 addresses, in a circular area of radius 500 m at a 100 m × 100 m grid square resolution.

fication and paving of front gardens (Pauleit et al., 2005; Royal Horticultural Society, 2006).

Access to public green space varies significantly across different sectors of society whether considering only municipal parks or all green space. While a worrying proportion of Sheffield households fail the government's access targets, policy-makers and urban planners should note that those who appear to enjoy the greatest access to green space include those who might be considered in most need of publicly provided green space benefits, such as the least affluent and the elderly. Different types of households, for example those with young children, imply additional access requirements such as safe routes to nearby green space. Achieving some desired distribution of overall green space provision across society will be challenging, because households respond to variation in green space with their housing location decisions and with how they use their private garden space, to the extent that the set of available properties and their income and lifestyle constraints permit (see for example Cheshire and Sheppard, 1995, 2005; Wu and Plantinga, 2003).

We emphasise three important potential extensions of our work. First, we have considered only access to green space in this study. Follow-up work needs to examine actual usage of green space and how this varies across urban areas and social groups using on-site surveys. The contrast with actual usage is important, because others have found a positive correlation between the use of parks and access to private gardens (Handley et al., 2003), suggesting that public and private green space may not in fact substitute for one another and that the lack of public green space in wealthier neighbourhoods might be a more acute problem than variation in access alone suggests. A second important extension would recognise more fully the diversity of green spaces themselves, which will vary significantly in their size, vegetation cover, how they function and what benefits they offer (Van Herzele and Wiedemann, 2003). Quality of green spaces is one of the major determinants of park use (Jorgensen et al., 2002). For example, litter, signs of vandalism and lack

of management can give the impression that sites are potentially unsafe, which in turn reduces visitation rates (Coles and Bussey, 2000; Williams and Green, 2001). A better understanding of the extent to which the quality of local green spaces varies across different sectors of society will inform green space placement and management decisions. A final worthwhile extension would examine how urban green spaces sample social diversity. This would allow an assessment of whether green spaces are providing purported social benefits by bringing diverse communities together and promoting interactions between people from different socioeconomic and ethnic groups (Germann-Chiari and Seeland, 2004; Martin et al., 2004) or whether they instead function as green walls that keep different communities apart (Solecki and Welch, 1995; Gobster, 1998). Where suitable socioeconomic data are available, our approach could also be extended to evaluate green space provision in other cities around the world.

Despite the crucial ecological and social roles played by green space in sustaining urban communities, we found that green space in Sheffield was substantially underprovided relative to recommended targets. This is striking given that new UK policy guidance calls for an increase in the current density of new houses, from 20–25 to 30–50 houses per hectare (ODPM, 2002). Provision of urban green space might be further diminished if precautionary measures are not implemented.

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