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Ecology in a multidisciplinary study of urban green space: the URGE project

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The URGE project is attempting to review urban green space systems and their planning across Europe. Evaluation is made using interdisciplinary criteria. Our goal is to produce an objective review and subsequently provide tools for improving urban planning policy, and in particular, to improve the provision and quality of urban green space. This paper presents background information to the project, the methodology used and some preliminary results from some of the ecological criteria used.

Introduction

Modern cities are composed of mosaics of areas which are constructed for residential, commercial, industrial and also transportational purposes, interspersed with green spaces. For the purpose of urban ecological studies, urban has generally been defined using estimates of population density, energy use or land use, for example (McIntyre *et al*. 2000). Urban green space includes for instance highly modified parks, gardens and recreation venues, as well as informal green space, consisting of remnants of less modified, indigenous vegetation types, as well as specifically urban habitats such as derelict industrial sites, and overgrown gardens and ruderal sites. Typically such remnant indigenous vegetation types are markedly dissimilar from their counterparts outside the urban region and they can, in extreme cases, be dominated by alien species or other factors which are characteristic of the urban environment (e.g. Pysek and Pysek 1990, Sukopp 1990, Pouyat *et al*. 1995, Niemelä 1999, Venn *et al*. 2003).

Green spaces are considered to provide diverse benefits for cities and their inhabitants. Besides providing venues for recreation and experiencing nature, they also significantly affect the quality of the urban environment (Pickett and McDonnell 1993) and enhance the value of property (Tyrväinen 2001, Rodenburg *et al*. 2002). A number of questionnaire studies have indicated that urban residents appreciate urban green space as somewhere to recuperate from both physical and psychological illness, as well as overcoming stress (Korpela and Hartig 1996, Takano *et al*. 2002).

Already in the 1700s and 1800s, enlightened philanthropists in different countries were aware of the importance of parks and green space for the well being of urban residents (Meller 2001). These were often wealthy industrialists, concerned about the welfare of their workforce. The urban parks which they founded and developed were based on their individual, instinctive feelings about what was beneficial. Thus some of these were extensively landscaped with artificial lakes, fountains and flowerbeds, to provide those better off with somewhere to "promenade" or those who worked and lived in smoky, oppressive conditions with the opportunity to breathe fresh air and to access and appreciate beautiful surroundings. Exotic features experienced during distant travels were also often incorporated into park design. Others were designed for particular forms of recreation, such as sport and hunting.

The actual proportion of green space found within cities is generally dependent on historical factors as much as contemporary planning and management. London, for example, contains many relatively large tracts of green space known as commons, which were originally preserved as grazing land for residents (Gilbert 1989). Whilst these are no longer used for the purpose of grazing, legislation to protect the grazing rights of residents has resulted in the preservation of these sites, which now represent invaluable urban green space resources.

Responsibility for contemporary design and management of urban green space is more systematic and is generally the result of work by different municipal departments (Randrup *et al.* 2001). The objectives, however, are not unlike those of former periods. Nowadays the greatest difficulty is to satisfy the diverse requirements of as many different user groups as possible. Municipalities are thus faced with the dilemma of efficiently and economically managing green spaces to accommodate the demands for maximum variety of recreation forms, to improve the quality of the urban environment and to satisfy the needs for conservation of nature and culturally important sites (Jönsson and Gustavsson 2002). Their role as places where the urban populace can learn about, experience and become familiar with nature is also highly significant. It is therefore essential that urban green space management addresses the challenge of providing green space resources which are sufficient to provide for diverse user requirements and also to withstand wear, in the face of growing urban populations and decreasing green space resources.

Workers in a number of disciplines have been investigating aspects of urban green during recent decades. A number of studies about the planning of urban green space have been made (Niemelä 1999). The fifth framework of the EU has been instrumental in encouraging multidisciplinary, large scale studies in this field. A number of scientific disciplines have produced studies on urban green during several decades now. These include economics (Rodenburg *et al.* 2002), sociology (Tyrväinen 2001) and ecology (e.g. Czechowski 1986, Gilbert 1989, Sukopp 1990, Niemelä 1999). Other scientific disciplines such as medicine and psychology have also yielded studies on the effects of the urban green environment during recent years (Korpela and Hartig 1996, Takano *et al.* 2002).

The name URGE is an acronym for, "Development of urban green spaces to improve the quality of life in cities and urban regions". The project is part of the European Union 5th framework programme, under the key action, "The city of tomorrow and cultural heritage".

Table 1. Consortium of URGE project.

Partner no.	Institution	Location	Role
1	Interdisciplinary Department of Urban Landscapes, UFZ	Leipzig, Germany	Project coordinator
2	Institute of Ecology, IOER	Dresden, Germany	Technical support, publications, ecology
3	University of Helsinki, UH	Helsinki, Finland	Ecology
4	Free University Amsterdam, ESI	Amsterdam, Holland	Economics
5	University of Central England, UCE	Birmingham, UK	Sociology
6	Comett Li. Sa.	Genoa, Italy	Planning
7	Hungarian Academy of Sciences, GRI HAS	Budapest, Hungary	ICC
8	Municipality of Budapest	Budapest, Hungary	City partner
9	Budapest Urban Planning Ltd.	Budapest, Hungary	City partner
10	Birmingham City Council	Birmingham, UK	City partner
11	Region of Liguria	Genoa, Italy	City partner
12	City of Leipzig	Leipzig, Germany	City partner

Fig. 1. The four case study cities and 11 original reference cities of the URGE project. Istanbul, Turkey, has subsequently been incorporated as the twelfth reference city.

Our goal is to improve the provision, both qualitatively and quantitatively, of urban green spaces, and thus enhance the quality of life for urban populations, as well as contributing to the sustainable development of European cities (Mathey and Smaniotto-Costa 2002a, 2002b). Our strategy is to conduct a review of urban green spaces and urban green policy in a representative selection of cities across Europe and subsequently develop tools for integrated urban green planning, which accommodate the need for a healthy and sustainable living environment for urban residents.

URGE is multidisciplinary, with the disciplines of ecology, economics, sociology and municipal planning being represented on the consortium and in the work of the project. The members of the project consortium are listed in Table 1.

Further information regarding the methodology, together with the complete list of criteria and indicators, is contained in the work packages of the URGE project and the manual,which includes full descriptions of the indicators and assessment methods (URGE team 2004). The aim of this paper is to present the URGE project and review some of the preliminary ecological results.

Description of project work

Data collection for the project was performed in four partner cities and 12 reference cities (Fig. 1 and Table 2). For each of the reference cities, a city profile was prepared, containing information which, in general, is available from municipal archives. These city profiles constitute the data from the reference cities and the basis of the projects analyses of the reference cities.

The four reference cities are partners in the project and they also participate actively in the collection of data. The four scientific partners initially developed sets of criteria, specific to their disciplines (i.e. ecology, economics, sociology and planning). These were further refined and amalgamated, by means of cooperative work involving all of the project partners, to form an interdisciplinary catalogue of criteria (ICC). The criteria contained in the ICC thus represent factors which the consortium considers to be relevant to the quality and provision of urban green space (UGS) and for which appropriate indicators have been developed. These indicators include hard data, such as size, isolation of sites and management costs, as well as fieldwork results for species diversity of selected taxa. Also included are indicators that are derived from questionnaire surveys or reviews of policy. These data are collected by the city partners and the subsequent assessment is conducted by means of cooperative work involving all of the partners. This implementation also constitutes part of the review process for the ICC. Thus, the objective is to produce, by the completion of the project in 2004, a set of criteria which are appropriate for the task of analyzing urban green space systems and which are applicable, as well as the actual results of their application in the four reference cities.

Two versions of the ICC have been developed to permit evaluation at two levels: the city level and the site level. Thus some of the criteria are applicable to the whole municipal green system, and are contained in the city level ICC (e.g. connectivity, contribution to city identity, urban green planning system), some are applicable only in individual sites, and are included in the site level ICC (e.g. local identity, location, naturalness) and others are included at both levels of the ICC, but with their indicators adapted to suit the different levels.

The evaluation of the partner cities' green systems, by means of the application of the ICC, is thus made for the whole city and for two sites located within the city. The only criteria imposed on the cities for their selection were that one site should be in the heart of the city and the other in the outskirts, one should be an established site and the other newly developed.

The role of the reference cities is to provide reference material for use when evaluating the results from the four partner cities. The cities were selected by the consortium according to geographical, cultural and economic diversity and their interest and willingness to participate in the work of the project. The project did not have resources for the collection of data from the reference cities, so this restricted their contribution to basic facts, such as size, climate and typical vegetation types, in the form of a city profile and questionnaire response data, though this contained mostly questions regarding sociology and planning. In addition, the reference cities suggested examples of what they considered to be best-practice examples from their UGS management. These best-practice examples will also be published in the manual, which is to be the main product of the project.

Calibration of the criteria

For the developed criteria to produce results which would be useful for improving green space management and planning, it is necessary to provide parameters for them, so that a city can see which aspects it needs to particu-

Table 2. Locations and sizes of case study sites, with area and population of city.

Country	City, area, population	Site	Size (ha)
Germany	Leipzig, 298.2 km^2, 493 208	Reudnitz	5.0
		Grünau	3.8
Hungary	Budapest, 525.0 km^2, 1 811 552	Naplas	150
		Szent Istvan	3.3
Italy	Genoa, 240.45 km^2, 636 104	Costarainera	4.8
		Genoa Pra	3.2
England	Birmingham, 267.85 km^2, 2 271 000	Burbury	11.0
		Newhall	67.0

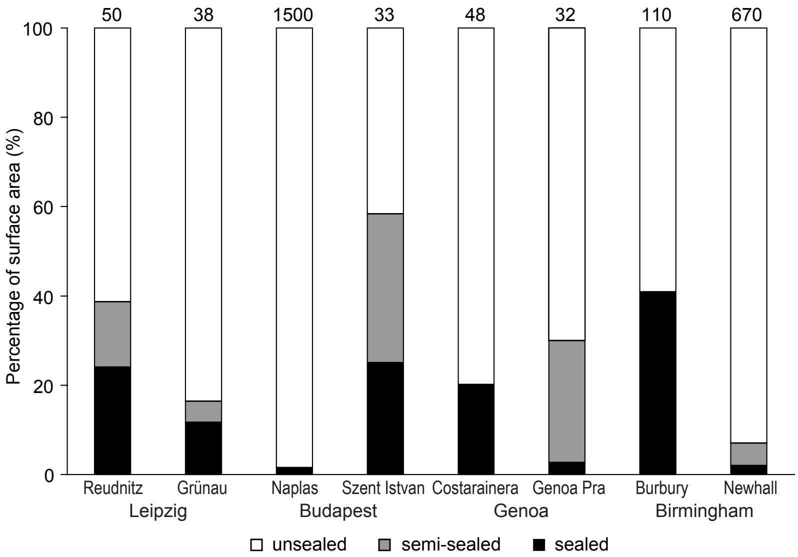

Fig. 2. Comparison of soil-sealing data for the case study sites. The figures above each column indicate the size of each site (× 1000) in m^2. The two largest sites expectedly have only a very small amount of sealed surface. Smaller sites generally contain larger amounts of sealed surface.

larly focus on to achieve improvement. To fulfil this requirement, we have provided benchmark values for as many criteria as we consider possible. In practice, there are many criteria for which it is impossible to provide benchmarks, such as many of the sociological criteria which were assessed by means of surveys and questionnaires. For instance, whilst sociological criteria, such as 'number of crime incidences or proportion of surveyed visitors reporting feelings of fear when using green space sites' provide data which is relevant to management practices and which could influence the potential value of green space to residents, these are not factors for which benchmark values could be provided. However, consideration of such data is essential for reviewing management practices which can improve the provision of green space, in this case by endeavouring to increase the proportion of the community which is likely to utilize the green space in question.

Supplementary information

The soil-sealing data were assessed using three categories of sealing (Fig. 2), and were based on data collected at the site level. Thus each of the four cities is represented by two sites and these results are not representative of the overall proportion of soil-sealing in those cities. The locations and sizes of the sites (Table 2) can be referred to when assessing these results from the site level criteria (Figs. 2 and 3). The categories of soil-sealing used in this assessment are unsealed (open soil or vegetated), semi-sealed (compacted surface, such as grit surfaced car-park or sports field) or sealed (hard surface or built upon), and the proportion of surface area in each site is measured for each category.

Isolation (Fig. 3A) is a measure of the edge-to-edge distance from a site to its nearest neighbouring green space site. Connectivity (Fig. 3B) refers to the number of connectivity elements connecting the considered site with other green space sites. Examples of such elements include hedges, lawn, river, riparian strip/riverbank, roadside verges, and any other equivalent feature. Each element was counted separately, so if there was a water course with a riparian zone on both sides, then that comprised three connectivity elements: the water course and both banks. Whilst the value of such connectivity elements will depend also on ecological quality and heterogeneity, as well as, for larger body-sized taxa in particular, the dimensions of such elements (i.e. width), these were not assessed here. These elements were considered here as being of potential benefit to all taxa, without attempting to distinguish their differential suitability for different species groups. It has also been reported that such connectivity is beneficial for human visitors

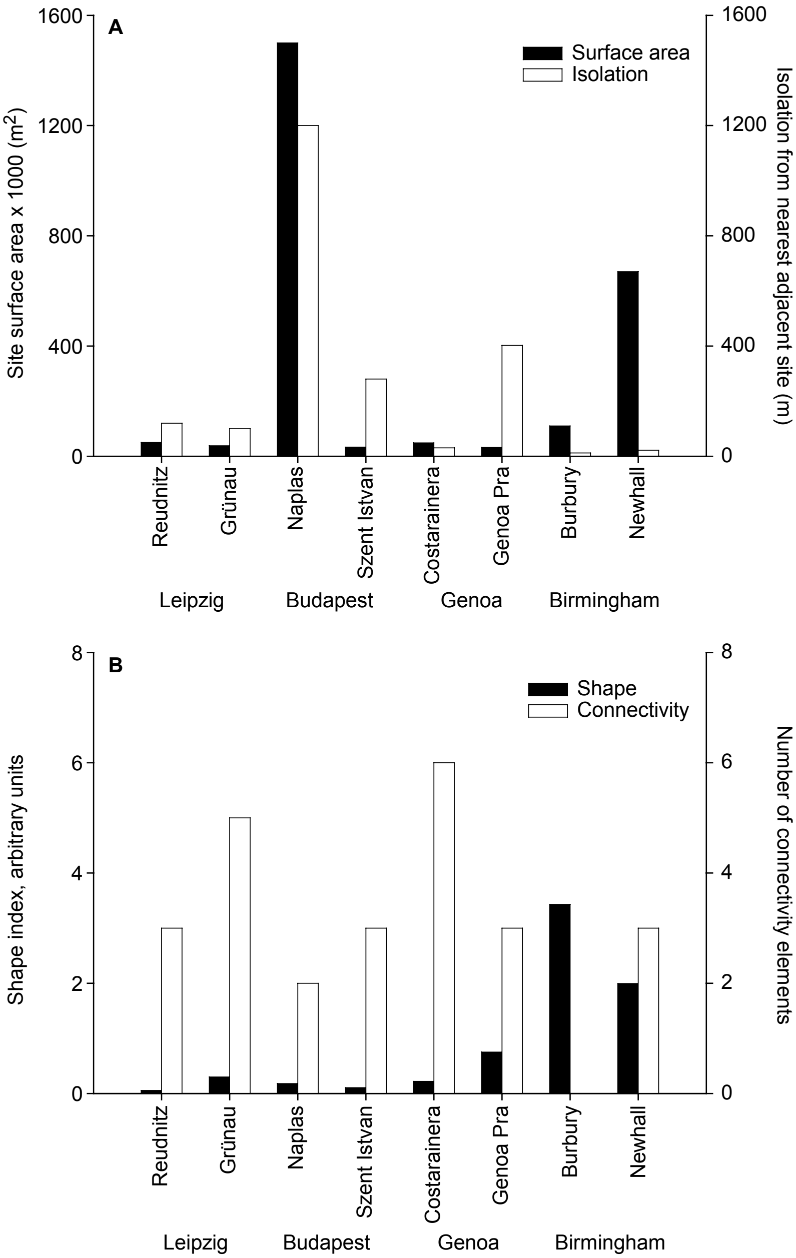

Fig. 3. (**A**) Isolation in metres from nearest green space and surface area of site. Larger sites are assumed to make the most significant contribution to the ecological condition of a city and their isolation (e.g. Naplas) reduces their potential contribution. The contribution of small sites is assumed to be much smaller and thus their isolation less significant. In **B**, high shape index value indicates broad sites with relatively little edge. A good shape index value can be considered a prerequisite of good ecological quality, as those in the form of narrow strips are invariably highly disturbed. Connectivity is a measure of the number of connectivity elements connecting the site to others. The scales of these two factors are very different and the intensity of effect shown by the indicators used are not directly comparable. Each of the four cities is represented by two sites.

for elements which they are able to utilize (Coles and Bussey 2000).

Shape (Fig. 3B) was assessed using an index derived by dividing the breadth of the site by its circumference:

$$\text{Shape index} = \text{breadth}/\text{circumference} \quad (1)$$

For sites of a more complex shape, the site was divided into regularly shaped sections and the shape index was calculated for each component part and then averaged to provide the value for the whole site. Thus a higher value indicates less edge and more core habitat, and suggests better ecological quality. We chose to use this method in preference to the more conventional Patton index (Patton 1975), because it is simpler to calculate and increases positively with improvement in

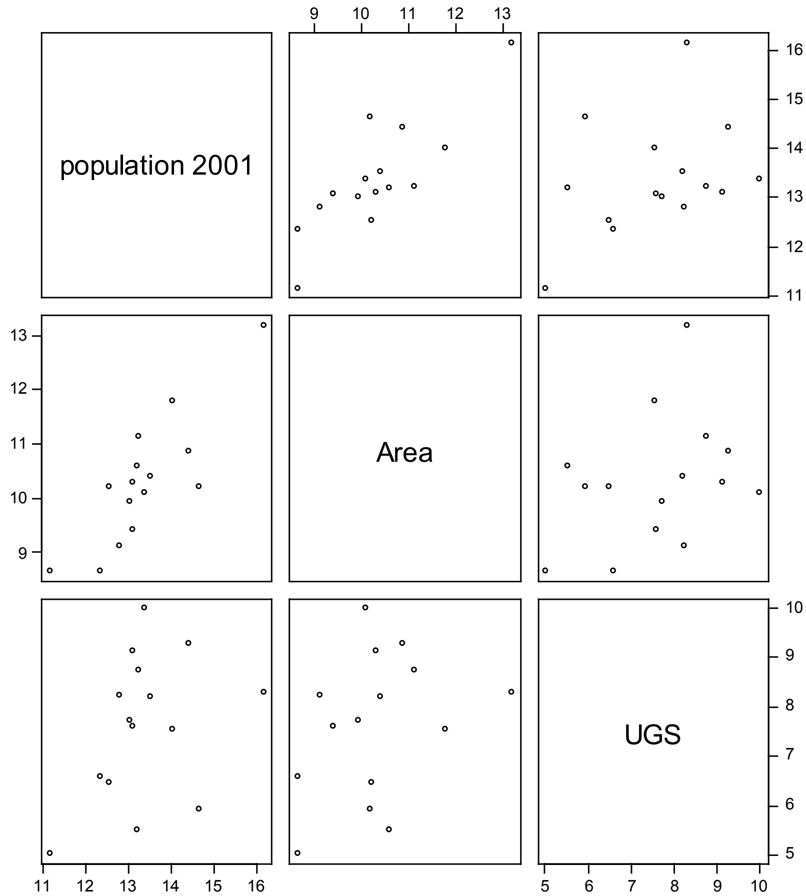

Fig. 4. Draughtsman's display of population, city size (ha) and amount of green space (ha) for the four partner cities and 11 of the reference cities.

shape. We assumed that this will apply to disturbed urban habitats as well as to the patches of ecologically valuable habitat which many cities also contain. In this instance also, sociological studies have shown that for human visitors too, the possibility to access core habitat and avoid edges is important (Coles and Bussey 2000).

Results and discussion

Pair-wise plots of population (2001), city area and amount of green space (Fig. 4), clearly show that population and area are strongly correlated. Regression analysis, however, showed that neither population (p = 0.27) nor area (p = 0.32) explain the amount of UGS (multiple $r^2 = 0.219$). This analysis was performed on log-transformed data to offset the strong bias from the largest city, Istanbul.

The most essential prerequisite for the development of a good green space system is adequate resources of green space. This amount should be adequate for the physical size (i.e. area) of the city and also for the size of the population. One would expect that as the population of a city increases then the area accommodating this population will also increase. This is born out in the correlation between area and population seen in Fig. 4. Whilst an increasing urban population will also require increasing resources of managed green space for its recreational needs and to avoid erosion problems due to over-use, no such trend is evident. Equally, as urban areas become increasingly developed, there is also an increasing need for unmanaged green space to ameliorate the urban atmosphere, maintain urban biodiversity and contribute aesthetically to the city's image. It can clearly be seen, however, that there is no relationship between amount of urban green space and population size, based on the sample of 15 cities used here (Fig. 4, data incomplete for Lisbon). Of course, if more land is being used up for development to accommodate, employ, feed and entertain the growing population, then total green space resources cannot increase. On the other hand, some cities appear to respond to the increasing demand for urban green space by increasing the amount of managed green space, by conversion of other green space resources. Thus increased amounts of recreational green space are provided but the conversion of unmanaged green space to more intensively managed forms of green space could mean loss of more ecologically valuable green space. In order to address this potential degradation of green space, and to maintain urban biodiversity, municipal planning policies should be managed to enhance the recognition and retention of ecologically valuable green space, in addition to that which is already protected.

Consideration of the partner cities showed that Birmingham has only a small relative amount of green space and a population density far in excess of the other three cities assessed. At the other extreme, Genoa appears to be generously endowed with green space. However, this is due to the fact that the municipal boundary includes a large amount of green space outside the city. The urbanized region of Genoa actually contains very little green space. Some of these large green spaces outside Genoa are rapidly accessible, via e.g. funicular railway, and thus constitute popular and intensively used recreational areas. On the other hand, they are not equivalent to what we would normally consider urban green space in the sense of green space within the city which contributes to, for example, the microclimate or biodiversity of the urban core. In subsequent studies it will be necessary for us to deal with this issue by differentiating between provision of green space at the periphery and within the urban core.

When considering the other three cities, i.e. excluding Genoa, they appear to show inverse proportionality, with green space provision decreasing as population density increases. The relationship appears to be linear, though such inference can only be speculated upon without data from a larger number of cities.

This pattern also depends upon the definition of what we should include in the term urban green space (UGS). For ecological purposes, all of the surface which can support vegetation, and also including bare soil, rock and water surfaces, would be relevant. In this multidisciplinary project, however, it was considered necessary to restrict our focus to those kinds of green space which are relevant to all of the disciplines involved. Clearly much ecologically significant green space is irrelevant sociologically and economically, for instance, and has been excluded from this study. It was also agreed to consider only green space with public access but excluding cemeteries, allotments and also excluding matrix features such as street green.

The soil-sealing criterion is only presented here for the site level, as the city level data still require considerable refinement. As might be expected, for the largest sites, Naplas and Newhall, the proportion of sealed and partially sealed surface is very small. Most of the small, 3–5 ha sites, expectedly have a larger proportion of sealed surface, though this varies considerably. Obviously the management objectives have a major impact on the values for this criterion, as many recreational pursuits require a relatively large area of sealed surface. In general, small popular sites will necessarily contain a larger amount of sealed surface to avoid erosion problems due to wear. However, the sites Grünau and Costarainera have managed to retain a large proportion of unsealed surface despite their small size and Genoa Pra is notable for the very small amount of completely sealed surface, by means of its use of semi-sealed surfaces. Burbury contains a surprisingly large amount of sealed surface for a 110 ha site. It might be useful to explore ways of converting some of this to less-sealed surfaces. To summarize, important considerations in regard to this criterion are the amount of sealed surface necessary for recreational pursuits which are practiced at a particular site and the amount of paving necessary to avoid erosion problems. Otherwise efforts should be made to keep the amount of unsealed surface to a maximum, and to favour partial sealing over total sealing.

There are a number of factors which can be used as indicators of ecological quality. Size, i.e. area, is a major one, as are site heterogeneity and species richness. At this stage, site size is the main such factor considered, and it is a prerequisite for ecological quality. Its importance has also been reported for sociology (Coles and Bussey 2000). Criteria such as isolation and connectivity indicate the potential of a site to contribute to the ecological condition of the city. Of course, though, if a set of sites is small and of poor ecological quality, then any amount of connectivity will not enhance the cities' ecological condition. Thus it is useful to consider site size together with these criteria. A small, poor quality site with poor connectivity is of little significance to the cities' ecological condition but it could be very important for local residents to exercise daily and thus be an important component of the UGS system. Large sites, however, have the potential to contribute to the overall ecological condition and thus their connectivity is more beneficial. A good protocol would be to identify sites with the potential to contribute to the ecological condition of the city and then see which other relevant factors can be consolidated to improve their overall contribution (*see* Niemelä 2000).

In this respect, the site Naplas seems to be a prime example (Fig. 3A), as it is large and also contains some regionally important habitat types. However, it is the most highly isolated of the eight case-study sites, with its nearest neighbour being 1.2 km (the indicator isolation) away. It also has quite poor connectivity and a very poor shape index. Naplas is situated at the periphery of Budapest and is adjacent to large areas of farmland. Whilst this farmland is not considered as urban green space and recognized in the assessment of isolation, it could be a highly significant contributor to connectivity with this site. Thus in subsequent work it will be important for us to consider, in addition to how isolated or connected a site is, also the nature of the other sites and the contribution of the surrounding matrix.

The two Birmingham sites, Newhall and Burbury are the second and third largest sites respectively, and both have "good results" for isolation and shape index. However, Burbury has a zero for connectivity, indicating that there are no elements connecting it to other green sites. Naplas is a large and broad site and would have been expected to score well for shape index. It is also a heterogeneous site, with large areas of very different habitat types. In the case of such potentially good quality sites as these, it would be recommended to look at ways of enhancing their potential contribution to the ecological quality of their cities. This analysis using the URGE criteria suggests that ways of improving ecological quality should focus, in their case, on enhancing connectivity. Thus, in the case of ecology at least, this review has shown that the URGE criteria are capable of identifying targets for improvement. The level of analysis is relatively coarse, so finer level assessment would also be advisable. Whilst site connectivity is a controversial topic within the ecological community (Simberloff *et al.* 1995, Niemelä 2001), we considered that in the face of the problem of habitat loss and fragmentation, maintenance of connectivity should be included in the objectives of this study.

At the onset of the project, each municipal partner had considered what were their expectations of the URGE project. At the closing stages of the project, they were asked to draft a document describing those initial expectations and how they plan to incorporate the findings and tools of the project into their urban planning practice in order to fulfil those expectations. This document, referred to as their "Obligations" and drafted separately for each partner, is thus effectively a contract in which they undertake to utilize the results of the URGE project to improve the provision of green space in their city.

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Appendix. The interdisciplinary catalogue of criteria.

Site level

1. Quantity of urban green
    - 1.1 Surface area of urban green spaces
    - 1.2 Extent of edge effects — shape index
    - 1.3 Isolatedness from other green spaces — nearest neighbour measure
    - 1.4 Connectivity to other green spaces — elements connecting green spaces
    - 1.5 Soil-sealing — three categories of sealing
    - 1.6 Integration in green system
2. Quality of urban green space
    - 2.1 Biodiversity — (i) rare and (ii) exotic species present in different taxa
    - 2.2 Surface disturbance — erosion
    - 2.3 Naturalness — indigenous biotopes
    - 2.4 Pollution — soil, air, water and noise
    - 2.5 Regulatory effects — Leaf Area Index, shade and wind amelioration
    - 2.6 Aesthetic effects — questionnaires and property prices
    - 2.7 Cultural aspects
    - 2.8 Local identity
    - 2.9 Awareness of physical, emotional benefits derived from UGS
3. Use of urban green space
    - 3.1 Catchment area — population within 500 m
    - 3.2 Accessibility — entrances, parking facilities, public transport, obstacles
    - 3.3 Daily recreational needs — forms, frequency, timing, and duration of use
    - 3.4 Sport and play facilities — use for sport, playground facilities, path quality
    - 3.5 Life strategies — socialization, incidental/secondary use
    - 3.6 Social inclusion — heterogeneity of social groups, level of maintenance
    - 3.7 Safety — security, incidents, fear
    - 3.8 Conflicts of use
    - 3.9 Multi-functionality — number of functions
    - 3.10 Policies for community events
    - 3.11 Educational resources — use in education, cooperation with schools
    - 3.12 Substitution — for own garden
    - 3.13 Production — products derived from UGS site
    - 3.14 Employment — green jobs with regard to UGS area and visitors
4. Planning, management and development of urban green space
    - 4.1 Legal and planning aspects — on management and planning of UGS
    - 4.2 Citizen's involvement in site planning and management
    - 4.3 Community ownership
    - 4.4 Inclusion in Local Agenda 21 plans
    - 4.5 Integration of green site planning with other kinds of planning
    - 4.6 Responsibilities within the administration
    - 4.7 Integration of private green spaces
    - 4.8 The importance of green site to public authorities
    - 4.9 Activities to create income — e.g. events
    - 4.10 Budget for urban green space
    - 4.11 Fundraising capacity
    - 4.12 Sustainable waste management

Further information on these criteria can be obtained from the author or via the web site www.urge-project.ufz.de.