URBAN GREEN SPACE: THE INCORPORATION OF ENVIRONMENTAL VALUES IN A DECISION SUPPORT SYSTEM

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SUMMARY: *This paper provides an overview of work undertaken on measuring the environmental values of green spaces, coupled with spatial analysis tools for aiding decision relating to the planning of urban green spaces. The work involved a complex array of data collection and analysis packages, including a case study inventory, public participation, methodological design, visualisation, and the analysis of survey results. A central aspect of the research aimed at providing the decision maker with data that combined the visualisation of open public green space with environmental economics. As part of a methodology using contingent rating which aimed to establish the values placed on specific green space sites, three dimensional computer models were used to produce visualisations of particular environmental conditions. The study demonstrates that visualisation tools are appropriate to represent a range of attributes for inclusion within environmental economic surveys, and that the resulting datasets can be used within GIS-based decision support models to indicate levels of preference and patterns of use. The focus of this paper is on the integration of the visualisations of green spaces, a contingent rating survey and the compilation of an open space inventory, as part of a GIS-based decision support system. Results from the study and its potential implications for future study and practice are discussed.*

KEYWORDS: contingent rating, GIS, visualisation, value, decision support.

1. Introduction

This paper reports on key methodological topics relating to the study of urban green spaces, and discusses where results from these topics are likely to have the greatest impact. The research is multi-disciplinary in nature, employing methodologies from environmental economics, visualisation, public participation studies, ecology and geography to form a wide ranging yet detailed analysis of the subject matter. The project is based on the hypothesis that urban green space makes an essential contribution to quality of life. As such, the research agenda developed to address this hypothesis is one that:

- facilitates the participation of all stakeholders in decisions regarding green space;
- facilitates the detailed valuation and understanding of associated economic, ecological and social values;

- provides a mechanism whereby often complex local decisions can be taken in a more informed and holistic manner.

The research has been undertaken via a series of closely linked work packages, the overall pattern of work of which has been as follows.

- A review of existing green space provision in the case study cities.
- A detailed survey of stakeholders (including focus groups).
- An environmental value assessment.
- The development of a Decision Support System (DSS).

Within the programme, there has been a strong emphasis on public participation, which has played a key role in the survey design, methodology, and the form taken by the DSS. The outputs from the research should provide an understanding of the strategic importance of urban green space, with issues addressed that range from a city-wide perspective, whilst aiming to provide guidance applicable at a micro level.

The aim of the work was to focus on a limited number of sites, to which end responses were sought from people who represent those sites (*e.g.* community groups), in addition to representatives from the municipal authority. Opinions were also sought, through focus groups, questionnaires and/or interviews, from residents and regular green space users as well as technicians such as landscape gardeners, landscape architects, and planners.

This paper outlines the steps taken in delivering a set of tools for supporting decisions in relation to the provision and management of urban green spaces.

2. Background

2.1.1. Role and provision of green space

The provision and standard of open space in the United Kingdom is formally recognised and protected by a range of planning devices, and through guidelines which have been adopted widely at the local level. Predominant among these are PAN 65 (Scottish Executive 2003) and in England PPG 17 (DETR 2001), each of which suggest a framework within which open spaces should be provided and managed. The extent to which these documents can be regarded as providing national 'standards' is limited in that a significant, although perhaps appropriate, emphasis is placed on locally determined strategies and solutions.

NPPG 11: Sport, Physical Recreation and Open Space (Scottish Office 1996) states that:

"*The Government's objective through the planning system is to seek to protect and enhance the land and water resources required for the nation's sport and physical recreation. All sports and recreation make some call upon Scotland's land resource, and many require special buildings or facilities. They may also be in competition for land with other uses such as housing, industry or open space. It is part of councils' responsibilities to take full account in their preparation of development plans and development control decisions of the community's need for recreational space and sporting facilities including the need for specialist facilities, to have regard to current levels of provision and deficiencies, and to resist the loss of unique resources or facilities with a wider role*."

The drive of that document is clearly to protect open space, with the suggestion being that '*councils should lead by example and generally resist development of open space and playing fields in their ownership*'. The document then goes on to suggest that councils should include views on the '*level of provision*' required for sporting and recreational facilities, the implication (implied or stated) being that such levels be determined by largely quantitative measures of distance (catchment) and accessibility (including further mention of the NPFA standard). Throughout, there is an emphasis placed on the completion of local audits, without which any measure of deficiency would be almost impossible to determine.

The revision of PPG17 (DETR 2001) adopted a new title encompassing 'open space, sport and recreation', and recognised the importance of informal spaces. At that stage, the Government stated that '*open space standards are best set locally. National standards cannot cater for local circumstances, such as differing demographic*

profiles and the extent of existing built development in an area'. Planning authorities were advised to adopt a strategic approach and plan positively for providing open space, provide strong protection for existing open space, resist new development opportunities which might diminish recreational provision, ensure accessibility, and to provide good quality open space and recreational facilities as a part of new communities. Coupled with this, there is a clear statement that such locally set standards should include:

- Quantitative elements (i.e. how much?)
- Qualitative components, to provide for an assessment of need for enhancement, and,
- Accessibility, which is defined as including distance *thresholds* and consideration of cost (the inference being to use variations on *travel cost* methods).

The importance of setting such standards, at the local level, is linked to an assessment of need, related to auditing, and to the formulation of development plans. An obvious problem associated with these requirements is that of the resources required to actually undertake the necessary audits and set standards which can be regarded as appropriate and comparable with other authorities. The associated guidance notes (DETR 2001b) suggest a process based on the following key elements:

- Identifying needs;
- Setting standards;
- Identifying deficiencies;
- Developing a strategy and related policies.

Clearly, it became apparent that a mechanism was required whereby a complex data set could be accessed and used by decision makers to derive valid conclusions with regard to open space provision at the specific local level, as opposed to via generic macro level models.

Within Scotland, there has been a growing acceptance of the need for a robust method for better understanding of public perceptions within public decision-making. Although public consultations have been required for well over 25 years in the UK, a move towards a deeper participation has been hampered by a lack of reliable, efficient and relevant methodologies.

Differences in opinion between design professionals and lay people have been the focus of much research (Hershberger 1969, Hershberger & Cass 1988, Hubbard 1997, Nasar and Kang 1989, Purcell 1986, Wilson 1996, Wilson & Canter 1990). Indeed, it is now a widely held view that design professionals hold a different system of constructs to lay people, through which they understand and evaluate the environment (Hubbard 1997, Wilson 1996).[1]

Factors such as social classes, cultures, and ethnic groups affect the way people evaluate their surroundings (Gans 1961, 1974, 1982). If social environments are designed according to the tastes of professionals, they often fail to satisfy the users (Nasar & King 1989; Newman 1973). As a result, decision-makers cannot rely totally on professional evaluations to provide guidelines for environmental quality (Hanyu 1997). Incorporating public participation into the design process is therefore necessary to ensure that needs of the public are met.

Hudspeth (1986) believes that public participation in the planning process is essential to achieve sensible environmental initiatives in development and revitalisation projects. The public should be given an active role in development process, if projects are to enjoy long term success. Nasar (1998) argues that communities should be able to express their preferences for future projects. They should be given the opportunity to express what it is they think should be preserved, what should be added, what should be changed, and what should be removed (Jones 1990; Sanoff 2000).

Research in disciplines as diverse as environmental economics and psychology has provided methods to engage the public in decision making. The methods emerging from that work can be applied readily within planning

[1] See also http://193.63.232.20/files/Final%20Report%20(small).pdf

procedures, if resources are available. The possible benefits of such work are that designs will be arguably more 'socially sustainable' where the end users have been involved in the planning process.

2.2 Decision support for green space planning

Development planning would normally be driven by a number of strategic issues. These might include the need to understand how green space and amenity open space contribute to quality of life (Dunnet *et al.* 2002, Urban Parks Forum 2002). Systems developed over the past three decades have established that spatial databases can contain and analyse both quantitative and qualitative data (recent work includes, for example, Yao and Thill 2004, Balram and Dragićević 2004), and as such should be included in plans to develop and manage open space standards.

The use of GIS to support decision making and participation in planning has gained significant recognition in recent years (recent relevant work includes that of Appleton and Lovett 2004, Herrmann and Osinski 1999, and, Phua and Minowa 2004). It can also be argued that open spaces across a wide range of typologies can be treated as public goods. Therefore, the distribution of these should be equitable, and they should be easily accessible to the communities they serve (Scottish Executive, 2003).

Thus, the principal aim of Decision Support Systems[2] (DSS), within the context of this study, was to provide support for decision-makers with responsibilities for strategic planning or design of green spaces. Bearing in mind the demands of guidance documents such as PAN 65 and PPG 17, they essentially tend to comprise:

- A geographical database, with access to an inventory of green spaces within the city (perhaps stored in a spreadsheet or database).
- A set of tools or models that, operating on the database, produce new information, relevant for the decision making process.
- A user interface.

It should be noted that the form of a DSS must be related to the questions requiring answers, for example, zoning, prioritisation or access. When developing a DSS, it is necessary to agree with the principal user on which current (or future), design or planning decisions require support. From this, a design process can identify the data, tools and models required to support the user's requirements.

Principal data sources for a DSS would comprise:

- An inventory of open spaces.
- The national topographic map-base.
- Data from qualitative research (i.e. focus groups and surveys).
- Data from quantitative research (e.g. preference studies, including choice experiments or rating studies)
- Attributes derived from the spatial modelling of green spaces (e.g. distances from the entrance to open spaces).

Following the focus group discussions, the key issues that a DSS should be capable of addressing are: awareness; use patterns; facilities; maintenance; accessibility; quality; and, neighbourhood specific issues. The surveys provide one source of data for the DSS, which can then augment them in combination with spatial modelling. Within the DSS, there was a need for standardised approaches to, or linkages between, some designations of park or green space (e.g. park typology).

The development of a DSS for supporting the planning and management of urban green spaces follows, with consideration first given to issues of the process by which such a tool would be populated, and the uses of such a system. A first step was to agree with the local authority (the principal user) on which current (or future), design

[2] Decision support systems have been developed within many fields, as diverse as but including marketing (Hess *et al* 2004), water resources (Holmes *et al* 2005) and wind energy (Cavallaro and Luigi Ciraolo 2005).

or planning decisions it should be support, from which a system design could be undertaken to identify the data, tools and models required to support the user's requirements.

3. Materials and Methods

3.1 Study area

The area used for this study was the City of Aberdeen, on the north-east coast of Scotland. It has a population of approximately 210 000, and covers an area of 185 km^2. Of this area, approximately 39% is urban land, with the remainder comprising farmland, forestry, and coastal land cover features. The traditional economic drivers of fishing and farming remain important, but since approximately 1970, the economy has become increasingly diverse, with a substantial component being built upon the energy industries, retail, financial and public services, resulting in relatively low rates of unemployment (Aberdeen City 2004).

The economic changes have had implications for the provision of housing and associated infrastructures, such as transport, public services and leisure and recreation. The local plan reports approximately 10 000 house completions between 1993 and 2002. The local authority estimates that another 9 300 households will be formed in the city by 2021 (Aberdeen City, 2004). Taking this estimate together with the guidelines on green space provision implies some pressure on existing green spaces, or on other land uses to ensure adequate supply of open and green space within the city. The following section describe the approaches taken to identify the key issues of concern to stakeholders in green spaces, a test of their attitudes to specific factors that may influence the use and value of a green space, and the development of a DSS to assist in the strategic planning of those resources.

3.2 Case study sites

A key research question concerned the extent to which visual representations of the environmental conditions within open space could be presented and evaluated using CR. The first stage in the addressing this question was to hold a series of qualitative interviews and focus groups (Laing and Davies, 2002[3]). Respondent groups were identified that represented the range of parties likely to influence the use and future of green space in Aberdeen. For example, parties were drawn from those with different stakeholders in green spaces, including people with different responsibilities within the local municipal authority for planning, maintenance and possibly design of green space, local residents and visitors from outwith the city.

The purpose of undertaking the qualitative data collection and analysis was to enable the identification of the issues considered to be of particular of importance to each of the groups. These issues were subsequently used to generate research questions to be addressed within the survey. The qualitative approach taken was that of focus groups to provide a reflective, rather than necessarily quantitative, analytical approach to understanding the issues.

As such, focus groups were held to establish residents' opinions of three detailed case study sites. It became clear that a number of the most prominent, and apparently important, reasons for respondents either liking or disliking a space related to variable environmental conditions. Additional suggestions regarding the arrangement and modification of physical objects within the case study sites were also made. The rationale for the selection of sites was that they represent different kinds of green space and therefore (in terms of planned use) serve different purposes. They are also located in different geographical and socio-economic parts of the city. The three case study green spaces chosen were (Figure 1):

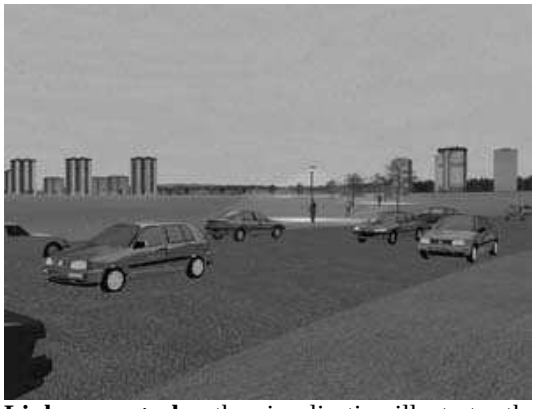
- Tillydrone (located within a large housing estate in the city);
- Aberdeen Links (a linear green space located along the seafront);
- Deeside River walk (a linear green space locate in the city and next to one of the city's two rivers).

[3] The full final report from that study is available via http://www.rgu.ac.uk/sss/research/page.cfm?pge=2532

Figure 1 - Images from the project

Images on the left are from the visualisation[4], and images on the right are photographs.


Deeside case study - the visualisation shows an image from the study with a configuration during winter. The site photograph was taken in late Spring.




Links case study - the visualisation illustrates the inclusion of both lighting and vehicular traffic in the study. The Links is a very open space, with little ambient light after dark from the nearby city outskirts.


Tillydrone case study - the visualisation illustrates the openness of the Tillydrone site. This particular green space is provided as general social and exercise space for the housing estate, but contains little in the way of vegetation or facilities. It can also be noted that the site is bounded on 3 sides by a 9-12ft high wire fence.

[4] Further examples from the study can be found via www.rgu.ac.uk/sss/ where details are available under research → projects → greenspace.

3.3 Testing public attitudes to green space attributes

3.3.1 Environmental economics

For the main data collection stage, stated preference (SP) techniques, developed within the field of environmental economics, were combined with 3D computer visualisation to establish the relative importance of environmental green space attributes. Environmental economics has been regarded as an established field within economics for a number of decades. However, an awareness of the valuation techniques specific to this field and how they may be applied within the built environment is limited (Chadwick 2002). Preservation of any environment, in both the built and natural form, may be facilitated through the promotion of sustainable development. Pearce and Markandya (1989) defined total economic value as being the total user benefit plus the total intrinsic benefits of an environmental good. It should also be noted that the assessment of total economic value also tends to rely on the knowledge of the respondent group.

Traditionally, SP techniques have been used to measure preferences and trade-offs in areas such as marketing, transport, health and environmental economics. With a small number of exceptions (e.g. Ahn & Ghosh 1989; Borgers et al. 1999; Fukahori & Kubota 2003; Laing 1999; Mazzanti 2001; Oppewal et al. 1994; Oppewal & Timmermans 1999; Timmermans et al. 1991; Timmermans et al. 1992; Wang et al. 2000) these techniques have not typically been applied within the built environment. Fewer studies still have attempted to incorporate technology such as computer-generated imagery or the Internet within SP research. Furthermore, little research appears to have been done to determine the extent to which respondents focussed on relevant attributes displayed within the images when they make choices, or whether 'other things' displayed in the images capture their attention. This academic question can also be placed within a wider policy framework which has emerged in recent years.

The contingent rating (CR) method was used to structure the main data collection survey undertaken in the study area of Aberdeen City. This method provided a mechanism whereby a complex set of attributes could be included within a range of computer models, then rated by respondents. Attributes and overall information for each site were presented using still images taken from photorealistic computer models.

3.3.2 Public views on issues of green spaces

In the three study sites the research was split into consideration of strategic and site-specific topics. Outputs from the survey design package included:

- The main findings from the focus groups, interviews and other data collection approaches.
- A comparison across respondent groups (where appropriate).
- Issues that could, or should, be included in subsequent work packages.
- The key of attributes or issues that could or should be included in the generation of research questions for subsequent choice experiments.

Key issues which emerged as being important from the focus groups were:

- specific recreational issues;
- availability and condition of facilities;
- climatic concerns;
- housing developments;
- concerns over traffic.

Prior to the contingent rating study, several focus groups were held with residents near to the three case study areas. The focus groups discussed a range of issues relating to sites including likes and dislikes as well as

safety[5]. In terms of physical changes to the sites, upgrading the existing facilities was the biggest request made by the residents. In two of the case study sites (Tillydrone and the Links) paths cutting through each of the sites to encourage use were suggested. For the purposes of the contingent rating study, a new path was added to the Tillydrone and Links areas, while the Deeside path was upgraded in some of the alternatives.

3.3.3 Visualising the case study areas

The identification of the issues raised in the focus groups provided a basis for designing a quantitative survey into public attitudes towards attributes of green spaces, for testing using a choice experiment. A survey format was developed in which the data requirements were identified for the methodology stage, including the approaches to be used eliciting attitudes and knowledge regarding green space.

The case study sites were modelled in three dimensions. The models for each site were constructed using the available national survey data (Ordnance Survey, 2003a) which provides boundary and contour information, with additional information added for smaller structures (e.g. boat house, skateboard ramp). Textures for natural surfaces (e.g. grass), were taken from available 'collections', which in some cases were purchased for use. The trees, bushes and people shown in the visualisations were also taken from available object collections.

For the visual models, a trade-off was made between rendering time required to produce the final visualisations and ecological accuracy. For example, the time taken to render plants in various stages of growth would have left insufficient time to develop a suitably sophisticated survey, or to even deal with more than one site.

Issues addressed in the CR study arose mainly from the focus group discussions, to which were added results from a preliminary green space survey distributed to a random sample of local residents. Predominant within the list of issues were concerns over safety, regardless of any particular green space. As a result, attributes likely to affect perceptions of safety were included in the CR study. Questions were also included to determine how these attributes affect perceptions of attractiveness and visiting patterns.

The four basic weather conditions that occur most commonly in Aberdeen include showers, overcast skies, clear skies and local fog. These types of weather therefore make up the four 'levels' of the attribute weather. Four periods throughout the day (10.00, 15.00, 18.00 and 22.00) were also modelled to represent the attribute 'time'. The times chosen reflected the changing position of the sun and thus the amount of light and shadows displayed in the images. The amount of natural light available at these times also depends upon the season.

It was hypothesised that lights, new trees and people could play a role in the appearance of safety of a green space. For example, lights are important if a green space is to be used in the hours of darkness (particularly in winter when sunset is in mid-afternoon). The presence of trees also affects safety by reducing visibility, and the presence of people may also have an effect on whether a green space appears to be safe or not. For simplicity, each of these attributes was given two levels – 'present' or 'not present'.

Traffic was raised as a safety concern in each of the focus groups and was therefore included. Traffic is represented in two levels 'light' and 'heavy'. It should be noted that vehicular traffic does not actually pass through any of the case study sites themselves, but is instead routed along the periphery.

Wind was included as an attribute since it is a major factor in Aberdeen's weather, and could have an impact on how people use green space. It was mentioned on several occasions in the focus groups. However, since this attribute is difficult to describe in any detail, only two levels were chosen including 'light to medium' and 'medium to strong'. Wind was described using text, rather than as part of the visual image. It is possible that the use of sound could assist with such attributes but this was not included in this research.

3.3.4 Combining images with the contingent rating questionnaire

From the experimental design, 96 design alternatives were generated. SYSTAT was used to generate the orthogonal design for the study, generating 32 profiles for each of the three case study sites (meaning 96

[5] See Laing and Davies (2002) for a discussion.

alternatives were used in the study). By ensuring that all profiles were used across the data collection phase, this ensured that the contribution of each attribute to preferences, and also the interaction of attributes with each other, could be identified. Each respondent was asked to evaluate six alternatives (i.e. two design alternatives from each case study site). This meant 16 unique surveys were needed in total to produce a complete replicate. Once all 96 models displaying the alternatives were constructed within 3D Studio Max, four views from each model were taken for use within the survey. Four views of each alternative were presented for three main reasons.

1. To provide respondents with alternative views of each combination of attributes in a scenario, to help them make better informed decisions.

2. The CR study was primarily conducted via a postal questionnaire meaning computer models of the green space sites could not be included. Computer generated images were needed in the absence of a more intuitive interaction.

3. In the Internet-based version of the questionnaire, problems with technology arise if data files (including walkthroughs) are too large (Laing et al. 2003).

3.3.5 Questionnaire format and response rate

Due to the number of questionnaires required to achieve an acceptable response rate, a paper-based version of the questionnaire was chosen as the primary method of data collection. Based on previous Internet studies undertaken by the research team in Aberdeen (Davies & Laing 2002; Craig et al. 2002) it was hypothesised that if responses were only collected from the Internet, the response rate would be insufficient. The Internet/PC version of the questionnaire was therefore viewed as complementary to the postal questionnaire.

The first page of the CR questionnaire introduced respondents to the purpose of the study. The following two pages presented some background information relating to each of the three case study areas and then asked some questions about previous knowledge and visits to those sites.

Following on from the site descriptions, respondents were presented with an example of the main CR questions, and some instructions on how they should be answered. The actual questions were then presented. Six alternatives were presented in each questionnaire, two from each case study site. Each alternative and the corresponding questions were presented in A3 size. On the top half of the page, a text description of the alternative displayed was shown in tabular form, as well as map of the site showing where the images relate to, the direction the camera is facing, and two of the four images. On the bottom half of the page, the remaining two images were presented along with three questions.

The questionnaire was distributed to 3000 Aberdeen households in February 2003. Of the 3000 questionnaires distributed, 46 were returned ‘undelivered’ and resent to different addresses, 13 were returned opened but unanswered, and six were incomplete and discarded. A total of 604 were correctly filled in, giving a response rate of 20%. Additionally, 22 complete responses were collected from the Internet/PC version of the questionnaire.

3.4 Findings and comments in relation to the images

Several open- and closed-ended questions were included in addition to the CR questions to give respondents the opportunity to make comments regarding the study, and provide feedback. Questions were also asked in relation to image quality, and ease of answering the questions. The first two questions asked respondents how realistic the images looked, and how easy or difficult they found the questionnaire.

The majority of respondents (80%) felt that the images were either realistic or very realistic. Respondents appeared to have little difficulty with the questions, as the majority (79%) stated the questionnaire was easy or very easy. Overall, the number of respondents who made additional comments was quite low suggesting that the majority of respondents were satisfied with the questionnaire. Of the comments that were made, respondents would have liked more information generally, especially in relation to the sites such as the types of users,

amenities available, parking facilities, etc. Respondents would also have liked more information about the crime rates in these areas. This is understandable given that one of the questions related specifically to safety issues. Respondents also wanted to know whether the proposed physical changes to the sites would actually be made, and if so, they thought more public consultation should occur in advance of work being done.

Respondents were asked if they thought anything was unclear in the questionnaire. In terms of the responses relating to specifically to the images, some respondents claimed the images were unrealistic in that the sites appeared 'too clean' compared to how they are in reality. Some respondents were also unclear of where the camera was positioned within the site, and had difficulty relating the snapshot images back to the location arrows on the map.

Nearly all attributes included in the experimental design had a significant[6] influence on attractiveness, safety, and visits, and most signs (i.e. direction of effect) were as expected. In addition to the combined sites model, site-specific models were also produced to see if the effects of the attributes changed depending on the site. This was particularly relevant for the Deeside River walk, as it had the largest effect of all attributes on 'attractiveness', and large effects on 'safety' and 'visits' in the combined sites model. However, major differences in the results were not found between the single and combined sites.

Looking at the individual sites, *night* had the biggest influence on attractiveness, safety and visits. The coefficient sign was positive in the safety and attractiveness models, meaning that alternatives which include this attribute are more likely to be rated unsafe and unattractive. Respondents were also less likely to visit during this time. *Morning* and *daytime* increase the probability of all three single sites and the combined sites being rated as attractive and safe, and have positive effects on visits. *Evening* is only significant in the safety model for the Deeside River walk. The negative coefficient sign suggests this attribute level increases the probability of it being rated safe.

In terms of season, *summer* and *winter* had the largest effects on each of the combined sites models and the single site models. *Summer* is negatively signed in each case, meaning that alternatives with this attribute were more likely to be rated as attractive and safe. Respondents were also more likely to visit during this time. As expected, *winter* had the opposite effect to *summer*. *Autumn* was only significant in the Deeside model and increases the probability of this site being rated as attractive. *Spring* increases the probability of the combined sites and Tillydrone and being rated unattractive.

Given the similarities in both the attractiveness and safety models in particular, a correlation test was performed on the three dependent variables. The test reveals significant correlation between each pair of variables. This suggests for example, that respondents who rate an alternative as safe, also rate it as attractive and would visit under those conditions. Jorgensen et al. (2002) had similar findings, as respondents from their urban forestry study gave images similar ratings in terms of safety and preference. They suggest the finding could be due to the relationship between concepts of safety and preference, and that some respondents find it difficult to distinguish between the two.

Upon completion of the contingent rating study, all data was inserted in the DSS, and related where possible to spatial and ecological data from the inventory of green space areas in Aberdeen.

4. Decision Support System

The principal audience consulted for the use of the range of tools presented is that of practitioners with a responsibility for strategic planning and the management of urban green spaces. In this role, the Parks and Recreation section of Aberdeen City Council have been the principal end-users consulted in the identification of tools to aid in tactical planning and design of urban green spaces. These practitioners have identified the key issues to be addressed, provided information for the development of an inventory of green spaces, and subsequent feedback on the presentation of the outputs.

[6] Minimum significance: 10%

In discussion with representatives of local authorities, some specific core questions were formulated, which are listed below, to guide the development of specifications for the DSS:

- What is the portfolio of official and unofficial green spaces in the city?
- How do access and facilities influence the use of green spaces, and which ones?
- What factors influence the feeling of safety and attractiveness of green spaces?
- Who and what are 'excluded' from green spaces at a city-level?

The analysis of green space provision is a variation on studies of facility or resource location with respect to accessibility and populations (*e.g.* Leonardi, 1981; Shen 1998), with parks and linear greenways acting as 'user-attracting' facilities. Parks, play areas, river walkways and other types of open spaces can all be treated as public goods, the distribution of which should be equitable, and the different type, functions and sizes of spaces should be easily accessible to communities they serve. Indeed, Scottish Executive Planning Advice Note 65 advocates a 'standards based approach', including quality and accessibility, specifying that particular types of open space should be '… within a specified distance *i.e.* a distance threshold' (Scottish Executive, 2003).

The CR survey, described above, identified the importance of factors that influenced choice in the use of green spaces, of which access (taken as distance to the entrances) to park facilities was one and the size and type of green space were two very significant factors. Therefore, measures of access via foot, car or bus routes, and information from the green space inventory, were considered as essential requirements in the development of the strategic tools.

The creation of tools that address these core questions are underpinned by the types of research published by a number of authors, and the new information coming out of other European research teams, such as 'BUGS', 'GREENSCOM', 'GREENSPACE', 'RUROS' and 'URGE' projects

(see http://www.groenemetropolen.nl/english/00_themas/11_internationaal/2003/greencluster.html for further details and links).

4.1 Tool Infrastructure

The DSS is comprised of software scripts which have been written to address specific tasks, but which can utilise the types of spatial data that are generic to most countries, and from public or private suppliers. These modules are problem oriented, designed to operate within widely available Geographic Information Systems (GIS) (*e.g.* the ArcView 3.x GIS), with associated desktop software packages (*e.g.* Microsoft Excel), or as stand-alone programs accessible in PC environments.

The DSS uses a combination of existing software functions (*e.g.* network analysis functions that are based upon roads or paths, and additional attributes, such as whether or not they also form part of a bus route) with additional functions, providing greater depth in the choice of analysis algorithm. In each case, the functions have been developed to enable end-users to consider city-wide analysis, or to target selected green spaces based upon the presence of different types of facilities or perceived values offered by different sites (*e.g.* the levels of safety). Almost as significant as the functionality of the DSS is the inclusion of 'Help' facilities, which are provided from the software interfaces and summarise all of the core functions and their operation.

To enable access to basic information on green spaces, inventories (compiled in Microsoft Excel) have been designed to be accessible from within DSS, thus providing a greater degree of flexibility in their use by practitioners, or supporting personnel, for whom a detailed knowledge of GIS may be an unnecessary overhead.

4.2 Spatial Data

Cognisance of the data requirements for tools that are designed for use at a strategic level is important if the tools are to be transferable across cities, countries and types of organisation. A principle behind the design of the tools

described here was the utilisation of generally accessible data for the target audience, but with the recognition that, to address some types of question, there is a requirement for enhancing the basic data available.

For the operation of tools within the United Kingdom, the core datasets (roadlines, urban features, address points) are vector or polygon spatial data extracted from the Ordnance Survey MasterMap product (Ordnance Survey, 2003a), all of which are accessed through a pan-government agreement with Ordnance Survey. However, additional data, such as an inventory of green spaces with associated attributes, and bus-routes, are required for analysis within the spatial modelling tools.

As inventories of green spaces are not generally available, at least in terms of detailed information on their content as opposed to the topographic extent and path networks, inventories have been compiled, with categories selected in discussion with the local authorities, informed by the work of CABE Space (2003). These inventories are based upon some of the variables that the literature suggests may be of significance in influencing public attitudes towards green spaces. In each case, the spatial basis of the inventory was a reputable list of local authority-owned, or managed, green spaces, together with boundary data where available. Boundaries were augmented by interpretation from an orthophotograph with the aid of Ordnance Survey MasterMap data (Ordnance Survey, 2003a). Park entrances to green spaces were also recorded, with the name of the green space as an attribute (most often with more than one entrance recorded). However, neither the type of access available at the entrance (*e.g.* a pedestrian gate or a road), nor any constraints such as opening times or entrance fees were available. The final definitions of the boundaries were accompanied by agreed names for each green space.

A spatial dataset representing the road and footpath network within the city, and its immediate surrounding area, was edited and processed to produce a topologically coherent basis for use in subsequent analysis. The data are of original scales of 1:1 250 or 1:2 500, derived from the Ordnance Survey OSCAR (Ordnance Survey 2003b) dataset, with additional information from interpretation of the orthophotographs and in discussion with the local authority parks and leisure department. Finally, the road centreline data have been complemented by data on bus routes and the locations of all bus stops within the city.

Data from the population census have also been incorporated to enable user queries of the population, described according to different categorisations, with respect to the green space resources (*e.g.* how many children under age 14 live further than 1 km from a green space?). These data are represented at the level considered most appropriate in each country, which in Aberdeen is that of the 43 electoral wards (*i.e.* relating to the constituencies of the elected representatives to the council). Other data that are included for purposes of knowledge-transfer and communication with members of the public include visualisations, panoramic photographs, video clips of green spaces (highlighting their use), and computer generated ‘walkthroughs’ of selected green spaces.

The data requirements identified should then enable answers to be provided to typical questions posed by managers of the green space resources. Example questions relating to the provision of green spaces, are: what is the area within a specified area? What types of facilities are within a specified area? Where are green spaces of particular characteristics? All of these questions should be addressable within a standard GIS, with relevant data. Functions have been developed that enable specific queries to be made of the inventory, combining spatial information from representation within the GIS and attributes recorded in the Excel spreadsheets or the underlying spatial databases. These functions enable queries such as that in Example Question 1 below.

Example Question 1: What are the characteristics of ‘Seaton Park’?

Figure 2: What are the characteristics of 'Seaton Park' in Aberdeen?

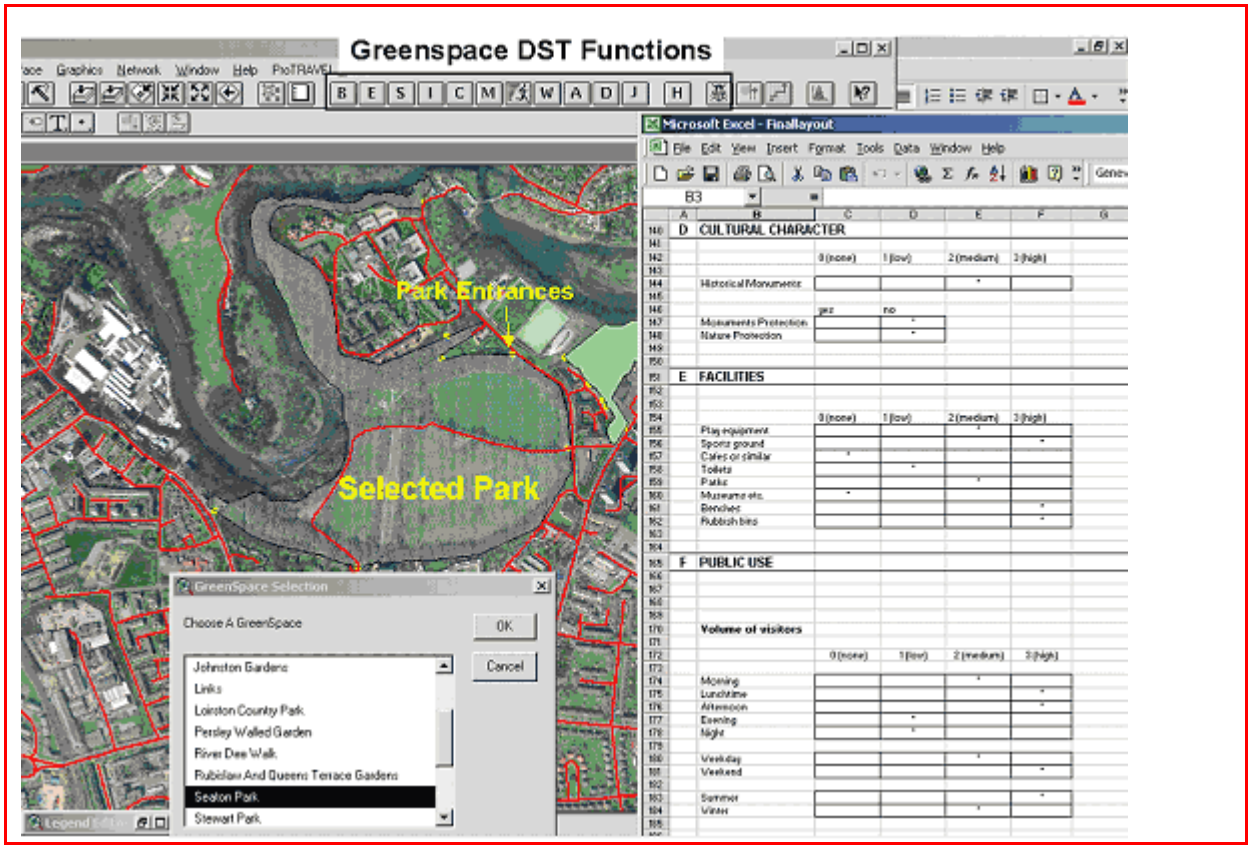


Figure 2 shows an extract from the interfaces of the software tools, for the output from an example question concerning access to a particular park. The output in Figure 2 shows a map, context provided by aerial imagery, and the associated worksheet from Microsoft Excel.

4.3 Assessment of green space access

Consistent with the importance attached to access, the basic analysis that underlies the functions of accessibility of green spaces is one of the length of route that follows the network of roads or paths, as opposed to a calculation of straight line distance. Several options are provided for assessing the proximity of green spaces from any given location, including a comparison of the distance to each green space that was identified as the first, second or third most visited site for individual respondents to the survey. Example Question 2, gives a more typical enquiry.

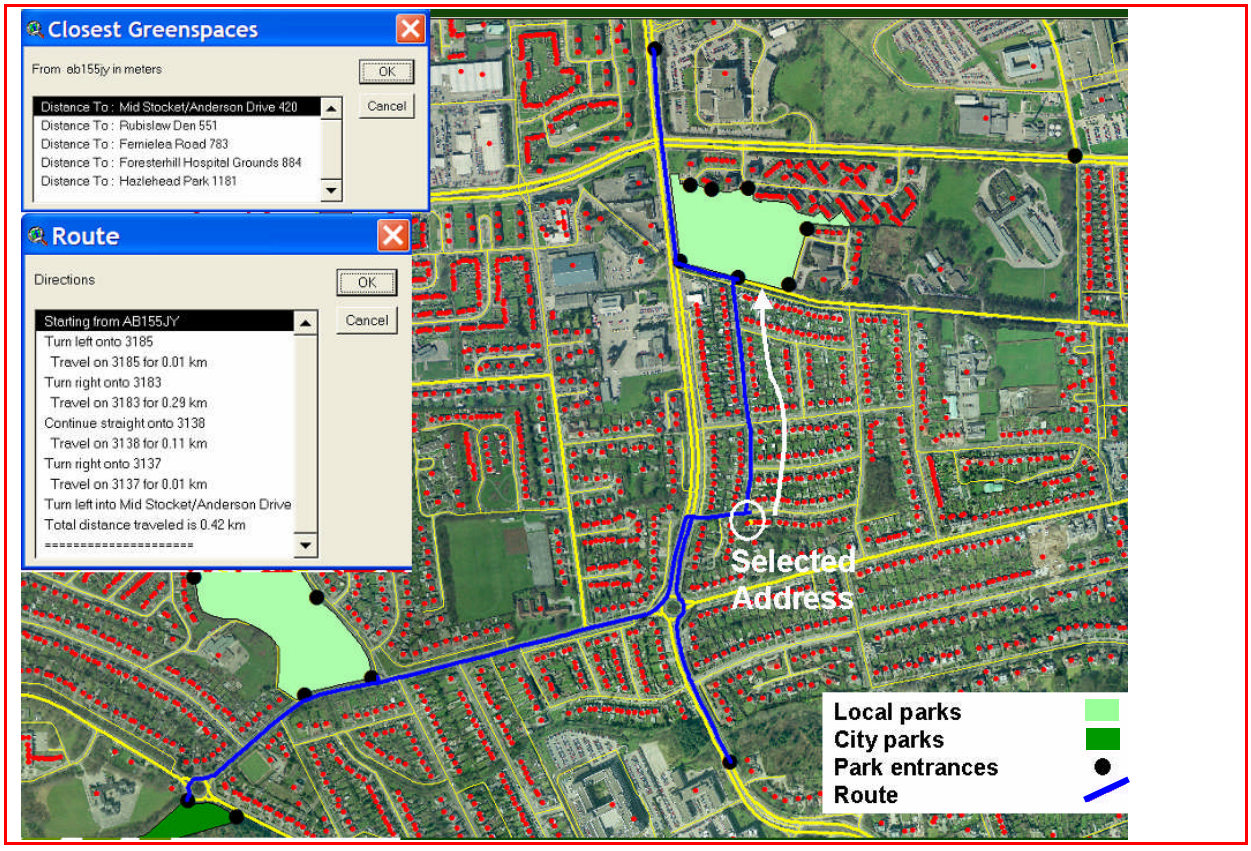
Example Question:2. What are the five closest green spaces to a given address?

The outputs from this enquiry would comprise a report of the distance to the closest entrance of each green space represented within the spatial database. The results are tabulated, and the routes plotted for the specified number of green spaces, together with directions between the address and the entrance to any green space selected from the list presented.

4.4.1 Single green space catchment – by foot or road

Consistent with the aims of some desired elements in green space planning at a macro-level, such as the wording of PAN65 (Scottish Executive, 2003), consideration is being given by the local authority to the distance that people have to travel to different types of facilities. The derivation of a catchment of households for any given green space is based upon an analysis of access by a selected means of transport with respect to distance or time. The basic calculation of the derivation of the neighbourhood for any selected green space has used an analysis of the road network, assuming access by car, to produce the minimum bounding box (referred to here as the 'catchment boundary') of the area within a set distance from the entrances to the green space. The addresses within the catchment of the green space were identified by clipping the address point data (Ordnance Survey 2003c) with the catchment boundary. Limitations to movement and access that are due to topography, such as uphill or downhill slopes, are not included at present.

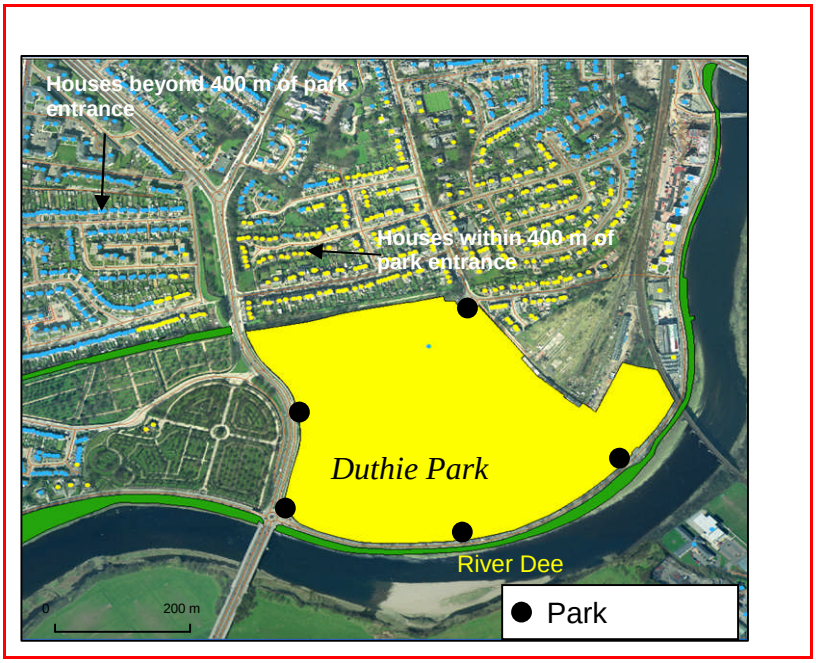
Figure 3. Locations, routes and distances of five nearest green spaces to a selected address in Aberdeen.



Example Question 3. How many addresses are within 400 m of any selected park?

Figure 4 shows the output for Example Question 3 for a selected park in southern Aberdeen (Duthie Park), showing its catchment derived using a distance threshold of 400 m, with a total of 441 addresses identified. In this example, there are a total of five entrances to the park, distributed around its perimeter, but residential housing is only located to its north side. Six houses are within 400 m of entrances to the west, and a few to the east, accessible from the southern entrances, but most houses are served by entrances in the north.

Figure 4. Duthie Park in south Aberdeen, with those addresses identified which lie within 400 m of a park entrance.



Using the inventory dataset as an input, rules can be applied to identify the areas of the city which have limited access to the green spaces, based upon initial policy guidelines from the City. Examples of these rules are listed in Table 1 as applied to three types of green space.

Table 1. Rules applied to test implications of different thresholds when developing policy options on green space access.

Type of Green space	*Distance from Each Address (m)*		
	Option 1	*Option 2*	*Option 3*
Neighbourhood	< 400	< 300	< 500
Local	< 600	< 500	< 700
City	< 1500	< 1300	< 1700

By comparing the outputs created by changing the threshold values, the sensitivity of the rules with respect to the distribution of addresses in relation to green spaces can be assessed. This has been done by varying the threshold values used to define green space access, as listed in Table 1, thus enabling identification of those households least well served by the current distribution of green spaces. A similar analysis has been undertaken to identify those areas of the city that are best served by buses for access to green spaces.

4.3.1. Local population and access

Overlaying outputs from the accessibility calculations with other data, such as that from the population census, enables the strategic planner to assess the level of provision of green spaces with respect to profiles of the local population. Such assessments include a targeted evaluation of the current, or future, provision of play facilities in green spaces for neighbourhoods projected to have greater needs for young families.

Census population data have been incorporated into the strategic tools at the level of the electoral ward. Following consultation with the end-user, it was considered to be the most relevant level of representation with respect to evaluating, and communicating, provision of green space for the local population.

Example Question 6: How many children under the age of 14 live further than 1 km from a city park?

Figure 5 shows the answer to Example Question 6 for one electoral ward ('Hazlehead'), highlighting those homes which are beyond 1 km of a city-level park. The outputs show one large cluster of addresses in the southern part of the ward which are furthest from a city park, and a smaller cluster to the right of the figure. Some of the addresses identified in the southern cluster are less than 1 km, when considering a straight line distance, but not when considering the footpath route. One limitation of the use of roads and footpaths as the basis of the calculation is that no account is taken of 'informal' footpaths which will enable access to parts of the park to those physically able to take advantage of such routes.

Figure 5. Addresses beyond 1 km of a city-level park in Hazlehead electoral ward

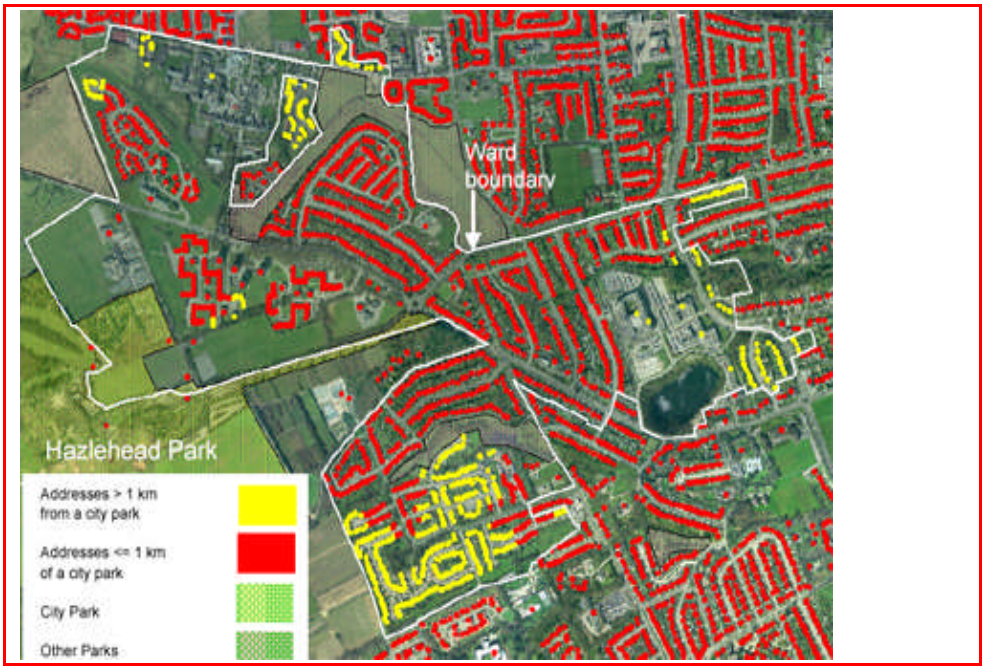


Table 2 summarises the output of the calculation of provision with respect to the category of population about which the query relates. However, it should be noted that, due to the use of the population data at the level of an electoral ward, and an assumption about the average age profile at a residential address, the results are an *estimation* and not an accurate figure.

Table 2. Summary of population of Hazlehead electoral ward in relation to distance from a city-level park.

Category	**Age (years)**		
	<= 14	**15 to 65**	**> 65**
Total Population	636	2776	1334
Population within 1 km of City park	489	2136	1026
Population beyond 1 km of City park	147	640	308

4.5 City-wide green space provision

Assessment of the provision of green spaces at a city-wide, or macro, level is predominantly based upon guidelines that relate to distance by foot from a residence to each type of park (*i.e.* city, local or neighbourhood park, nature reserve or forest). By means of querying the spatial data on green spaces or addresses, city-wide maps can be produced to show which areas are best or least well served by such resources.

Example Question 7: Which areas of the city are further than 400 m distance, by foot, from any city, local or neighbourhood park, nature reserve or forest?

Figure 6. Areas of the city further than 400 m from any of five types of green space by foot (*i.e.* city, local or neighbourhood park, nature reserve or forest).

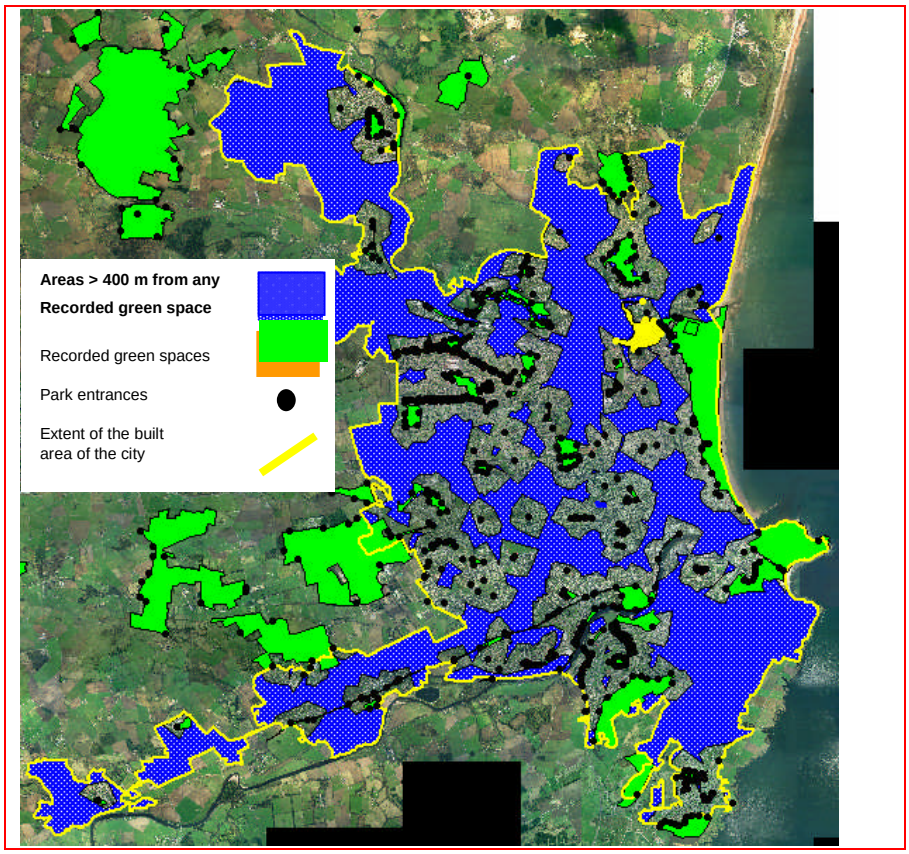


Figure 6 shows the outputs for an answer to Example Question 7' in relation to access to any of the five types of green space that have been included within the spatial database for the city. The most effective means of communicating the answers to such a question are not fully resolved, with both map and/or tabular information being of value on different occasions. The value of choosing to add to the functionality of a GIS is that the existing functions can be used to refine the outputs as required by the user. That is, the GIS system itself provides a stable and interactive platform, the interface for which can be defined and altered to suit the needs of the intended user group. It is anticipated that the example questions illustrated herein would be altered and added to as the demands and policy needs of decision makers change over time.

5. Summary and emerging issues

Changes in the physical environment in cities will lead to associated changes in the aspirations and demands placed upon green spaces. The approaches to the provision of aids to decision-makers, with tools such as visualisation and geographical analysis, as presented in this paper focus upon strategic issues of green space provision and content, tuned to the needs of the relevant local authority. However, in identifying the scope and specifications for such tools, it is acknowledged that (1) the aspirations of the practitioner could be too high, (2) the scope of the issues to be addressed could be wide, and (3) the applications could be site-specific, thus not immediately transferable between cities.

Such tools are subject to a number of limitations, and their use should be informed by an awareness of the constraints that may therefore be implied. The principal limitation is the comprehensiveness of a local green space inventory. There are issues as to what constitutes a green space, whether only 'official' green spaces should be taken into account in strategic planning, and how different types of open space transform into unofficial green spaces with changes in local land use (*e.g.* removal of a physical barrier to access).

Data quality is a key property of these tools, and their suitability for operational use requires that the design considerations extend beyond the functions, and include a strategy for data support and maintenance. The advantage of using data that are part of a national spatial data infrastructure is that there is an existing system by which updates to such data can be obtained. The importance of such a strategy is to ensure that the data quality is maintained, is consistent, and consequently that there will not be issues of propagation of error through different models. In this regard, ease of data update should not be under-estimated.

The provision of new types of information (*e.g.* a database linking individual addresses with their distances to local green space resources), or an individual's trade-offs between the attributes of green spaces, provides a contribution towards informing decisions by local planners on the implementation of policy. In Aberdeen, this is in terms of the development of the new, statutory local plan (Aberdeen City Council, 2004). In general, the types of tools presented can be used to facilitate changes being made to scenarios of urban development, or the maintenance of existing green spaces, accommodating the evolution of an urban environment, with changes in the portfolio of green space, in the transport network, or in the demographic profile of inhabitants. By enabling exploration of alternative scenarios of green space content, the modelling tools can be used to predict the impact of future planning actions on the functionality of urban green spaces, and their potential contribution to the quality of urban life. Specifically, it is anticipated that they will provide one basis for identifying potential spatial conflicts in land use.

The research raised a number of important issues which merit further development. As with previous work in the field, the results confirm that the use of 'virtual' environments holds potential for greater use within environmental economics studies. It is anticipated that research using immersive technologies (e.g. the delivery of imagery) could be used as a tool to identify key aspects of an environment more objectively. Additionally, it may also be useful to consider the use of technology to better study the extent to which specific parts of an image influence preference, perhaps using eye tracking equipment to monitor respondent activity.

Future work should begin to explore the extent to which more immersive environments could be used, or ways in which more interactive models could be used to capture data. The experience of this study has shown that advances in technology over a relatively short time period have enabled great advances in survey methodology and the range of options open to the researcher. Pertinent questions regarding the actual and relative importance of realism, immersion and cognition in themselves signpost what may be vital routes for research concerning the use of visualisation to assist decision making in the design of built and natural environments.

The extent to which the DSS presented is transferable across different cities may be limited by the data, but need not be limited by the framework used. Although it may be the case that certain questions can only be asked of data from certain types of cities or urban areas. The research signals approaches which can be used by designers and planners of green space in the future, to help ensure that the public space provided will be socially sustainable, and valued by the intended user groups. The desire and need to demonstrate legitimate green space benefits to people provides challenges to preconceptions, and helps support and drive a more sustainable decision making processes.

The overall objective was to assess the extent to which different types of open and green space contribute towards quality of urban life. Important factors considered included the various uses for green space, and an evaluation of the extent to which existing green space meets existing and future social needs. The use of computer visualisation provides a genuine advancement in the presentation and delivery of information. Attempts were made to move away from a position where the computer models are used to manipulate the physical configuration of public space, towards a much wider understanding of how a holistic environment can be modelled. With continuing improvements in the capabilities of software and hardware, the questions facing planners and designers can go beyond those relating to physical changes of spaces, and more towards how they might be used or perceived throughout the year or under different environmental conditions.

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