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Measuring the accessibility and equity of public parks: a case study using GIS

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Geographic information systems (GIS) can provide leisure service agencies with numerous opportunities to enhance the planning and management of their facilities. This paper demonstrates one such application, to the measurement of levels of accessibility and distributional equity offered by a system of public parks. The methods proposed are relatively simple; nevertheless, they do offer substantial improvements upon those previously utilized by leisure service providers. They facilitate identification of poorly served areas and populations, and suggest where new facilities might best be sited so as to maximize access and equity. These methods are illustrated by a case study of the park system in Bryan, Texas.

Many other applications of GIS to leisure service provision are available, several of which are briefly discussed. Together, they could enable agencies to function more effectively and, ultimately, to provide better levels of service to the public.

INTRODUCTION

The use of geographic information systems (GIS) in public planning and management has proliferated over the past decade, yet its adoption within the field of leisure services appears to have been relatively limited. Wicks *et al.* (1993) offered an appraisal of the potential applications of GIS for park marketing, management and planning, but the infrequency of subsequent articles devoted to GIS in the leisure services literature suggests that the potential they identified has not been realized.

Since 1993, the ease of implementing and using GIS has improved significantly. Great advances have been made in both the number and power of capabilities provided as standard functions in GIS packages, and the amount of easily available data, much of it downloadable over the Internet, has increased. These improvements have enabled the development of more sophisticated analytical applications, including many that are pertinent to researchers and professionals in the field of leisure services.

The primary aim of this paper is to illustrate the utility of GIS as a tool for measuring levels of accessibility and distributional equity within a system of public parks. Level of access to public parks is an important indicator of the effectiveness of their provision. Similarly, the degree of equity, or fairness, afforded by the distribution of facilities is a central concern of public leisure service providers.

Despite the inherently spatial nature of the concepts of access and equity, little research appears to have been conducted into the application of GIS technology to their measurement. While Nedović-Budić *et al.* (1999) do provide a sample of applications developed within the context of the Illinois Recreation Facilities Inventory, their contribution illustrates the breadth of these potential applications more than the specifics of their implementation. The focus of this paper is on explaining the methods available within a GIS

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environment to assess the levels of accessibility and equity of urban leisure facilities, and on the interpretation of their results. In addition, the use of a straight line and a network measure of distance are compared.

There are, potentially, many ways of carrying out such objectives. In this paper, relatively simple methods, in terms of the GIS functionality and level of computational complexity required, are utilized, the aim being to illustrate their everyday utility to practitioners with limited time and resources.

The paper is divided into five major sections. The first explains the concepts of accessibility and distributional equity, while the second provides a definition of GIS and a brief description of how this technology works. Next, methods of measuring accessibility and equity are discussed. The fourth section consists of a case study illustrating the application of GIS to the measurement of the two concepts of interest. The article concludes with a discussion of the case study results and of the potential of GIS for improving the planning and management of leisure services and facilities in other manners.

ACCESSIBILITY AND EQUITY

The case study presented here illustrates the use of GIS technology when assessing levels of accessibility and distributional equity in a system of public parks. These two principles were selected because they are both widely recognized as important indicators of a well-functioning urban system.

Accessibility refers to the ease with which a site or service may be reached or obtained; it can thus be said to measure the relative opportunity for interaction or contact with a given phenomenon such as a park (Gregory, 1986). Pred (1977) specifically relates the quality of life within a city to the accessibility of its inhabitants to nature and extensive recreational open space opportunities.

Traditional studies of accessibility approach this concept from a purely geometric perspective, founded in location theory, in which the aim is to maximize the efficiency of distribution networks so as to minimize system costs (McAllister, 1976; Morrill and Symons, 1977; Gregory, 1986). Such efficiency-based analyses do not take into account the distribution of outcomes or benefits among users. Rather, the seemingly value-free models that they utilize can result in significant discrimination against certain groups and areas (Morrill, 1974; Morrill and Symons, 1977; Harvey, 1988). It is, therefore, important to identify the social and economic dimensions of accessibility as they relate to users instead of concentrating solely on geometry and system profits. At this point, consideration of the concept of distributional equity becomes relevant.

The term equity refers to the fairness or justice of a situation or distribution (Smith, 1986). With respect to the distribution of public resources, it is concerned with the question, 'Who gets what?' or, normatively, 'Who ought to get what?' (Laswell, 1958, in Wicks and Crompton, 1986, p. 342). Equity is clearly a subjective concept, open to multiple, sometimes competing, interpretations. Indeed, Symons (1971, p. 59) has described questions regarding distributional equity as representing 'the scientific geographer's nemesis' precisely due to the difficulties of defining what is 'just' or 'fair'.

It is, nevertheless, necessary to adopt a definition of equity in order to analyse it. Typologies of equity such as those suggested by Lucy (1981) and Crompton and Wicks (1988) are useful guides when attempting to do this. Between them, these authors identify four major classes of equity with regard to the allocation of resources, each of which can be operationalized in one or more ways. As Fig. 1 illustrates, the four classes are: i) equality; ii) compensatory (Crompton and Wicks) or need (Lucy); iii) demand (including Lucy's category 'preferences'); and, iv) market (including Lucy's category 'willingness to pay').

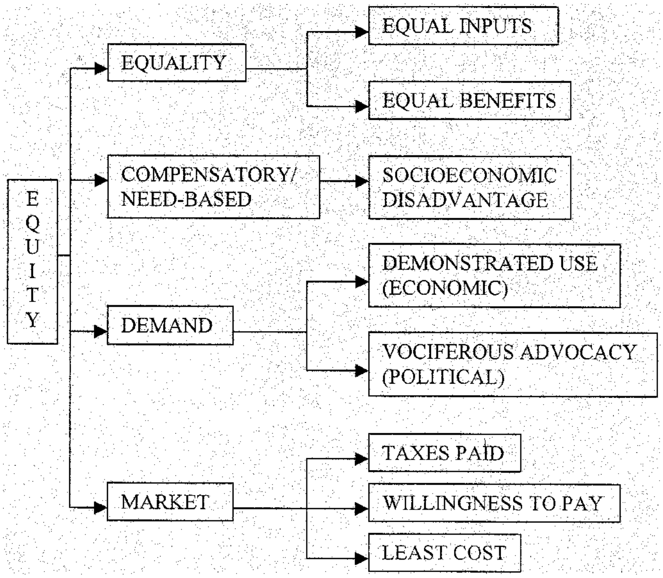

Fig 1. Taxonomy of equity models (after Lucy (1981), and Crompton and Wicks (1988))

Equity based on equality can be operationalized in one of two ways. The allocation of inputs to services in an equal manner, regardless of geographic area or the socio-economic characteristics of residents, is analogous to the notion of equal opportunity. All areas and residents receive equal facilities, whether measured in terms of expenditure, man-hours, or numbers of features. Output equality, in contrast, requires '*equality of condition* after receipt of service' (Lineberry and Welch, 1974; p. 709). It measures the benefits received by residents as a result of public service provision. Paradoxically, input equality rarely results in output equality, and *vice versa*, hence the notion of equality is compromized either way. Nevertheless, as demonstrated by Wicks and Crompton (1986, 1987) support for this approach to service provision is relatively high amongst US park and recreation departments, city council members, and the general public, a finding the authors attribute to prevailing traditions of equality and freedom of choice, and political and legal expediency.

A compensatory, or need-based, approach to equity implies, as Lucy (1981; p. 448) notes, 'that unequals should be treated unequally'. Thus, disadvantaged residents or areas are awarded extra increments of resources so as to provide these groups with opportunities that they might not otherwise have had. The role of the public sector is, therefore, to redistribute resources in a compensatory manner. While the identification of 'disadvantaged' or 'needy' groups may be subject to debate, they are usually designated according to socio-economic criteria such as income.

Demand as a conceptual basis for achieving equity involves rewarding those who demonstrate an active interest in a service or facility, whether through use (the economic model) or vociferous advocacy (the political model). The notion of producing goods and services to meet consumers' demands is grounded in microeconomic theory; this approach is also often favoured by elected officials who see it as an appropriate means by which to improve their public accountability.

The final group of equity models illustrates the potential influence of market forces on service distribution. Allocation of resources according to amount of taxes paid, willingness to pay (e.g., an entrance or user fee), or the least cost alternative are included in this category. Market determination of service provision is most appropriate in the commercial sector, and was not considered here.

Rather, a compensatory or need-based approach to the equitable provision of public leisure services was adopted. The least advantaged were defined according to the socio-economic characteristics of age, income, race/ethnicity, and population density of area of residence. The groups considered most in need with regards to the provision of public leisure services and facilities were, thus, the young, the elderly, minorities, and those living in areas of higher population density.

The choice of a need-based approach recognizes the National Recreation and Park Association's (NRPA's) call for increased attention to the lower-income and culturally diverse portions of society when planning and managing public leisure opportunities (Mertes and Hall, 1995). It is also rooted in the concept of social justice and the notion of socially just communities in which 'all individuals and groups are treated fairly' (Beatley and Brower, 1993; p. 18).

GEOGRAPHIC INFORMATION SYSTEMS

GIS have been defined as 'automated systems for the capture, storage, retrieval, analysis, and display of spatial data' (Clarke, 1995; p. 13). A GIS essentially consists of a set of spatial or map information and a database containing the attributes, both quantitative and qualitative, of this geographic information. For example, the database attached to a map of a park might contain information regarding its acreage, number of tennis courts and parking spaces, length of footpaths, and level of development These two sets of information are dynamically linked, using geographic location as the common identifier, such that the attribute data may be accessed through the map or *vice versa*. It is this embedded linkage between the spatial data and its non-spatial attributes that imbues GIS-based spatial analysis with a new level of value and meaning beyond that previously obtainable by using *either* spatial information accessible from paper maps *or* statistical analyses typically applied to databases, but with no means of efficiently combining the two. Moreover, the data utilized need not relate to only one specific theme, such as parks. An underlying principle of GIS is the ability to overlay different kinds of information for a specified geographic area (e.g. distributions of facilities and natural resources, transportation networks, and demographic data) so that spatial relationships between them may be assessed.

These computer-based systems offer a number of other advantages over the use of analogue, paper maps. For example, the existence of information in digital form allows for a dynamic environment in which the user can interact with the data, manipulating them at will and visualizing the results either on paper or on the screen. Another key benefit of GIS is the ability not only to map and assess current situations, but also to envisage future scenarios under different sets of hypothetical parameters. The speed and ease of this ability has prompted the adoption of GIS as a decision-making tool by many public policy makers and planners.

MEASURING ACCESSIBILITY AND EQUITY

To date, few authors have integrated the evaluation of accessibility and equity within a single study. Measurement issues related to each of these concepts are discussed individually before attention is turned to methods of combining their analysis.

Accessibility

Perhaps the most basic standard with regards to the provision of urban parks is the NRPA's recommendation that 10 acres (4.1 hectares) of open space be available per 1000 residents. This compares to the 6 acre (2.4 ha) standard advocated by the National Playing Fields Association (NPFA) in the UK. Many cities calculate this ratio to obtain a broad picture of the adequacy of their level of supply. Some also divide an urban area into smaller zones and calculate the amount of parkland available to residents within each of these units. The problem with this 'container' approach (Talen and Anselin, 1998) is that it assumes the benefits of services provided are allocated only to residents within the predefined zone in which they are situated, and that no spatial externalities to surrounding areas occur. Similarly, it assumes that residents of an area have sufficient access that they all benefit from the services provided within it, an unrealistic expectation. A major disadvantage of this quotient, therefore, is that it does not consider the spatial distribution of opportunities. The location of parks relative to their potential users is an important factor in the assessment of accessibility, as is increasingly being recognized by both NRPA and NPFA.

Some park and recreation departments do produce maps illustrating the accessibility of their facilities, thereby taking this spatial dimension into account. Access is typically defined according to each park's service area, represented by a circle drawn around the facility with a radius equivalent to the maximum desired distance of users from it. This distance might be determined according to NRPA's public park and open space classification scheme, which recommends the ideal location and size of various types of open space relative to the surrounding population (Table 1). This 'radius' method, as it is referred to here, is an example of the covering model of accessibility (Hodgart, 1978). Residents are said to be 'covered' by, i.e., have access to, a park if they are located within the specified maximum distance of it, but are deemed to have inadequate access if they are not.

This method does have advantages over the computation of ratios of parkland area to population, but several problems arise from its usage. First, the radius method can provide only an approximate representation of a park's service area since it assumes 'as-the-crow-flies' movement. In reality, potential users cannot travel in straight lines. They move instead along predefined public rights of way, and must avoid barriers to travel such as railway lines and rivers. Thus, the actual travel distance is almost always greater than the direct distance. Clift (1994), for example, in a study of the accessibility of grocery stores participating in a Women, Infants and Children's Program food checks scheme, found that while some recipients lived only 4500 feet from a store, their actual travel distance to it amounted to more than three and a half miles, or 18,480 feet. Such differences may cause considerable increases in time, cost and effort for those with limited means and mobility or for those with young children. This point is especially pertinent for mini and neighbourhood parks that should ideally be accessible by walking along residential streets and trails.

The second disadvantage of the radius method is that it assumes parks to be open to access at all points along their boundaries. This is not always true; in many cases, users must travel out of their way to reach a point of entry. These first two factors are both likely to lead to overestimation of the size of a park's service area. The third, however, may lead to its underestimation, and is related to measurement of the specified distance from the centre of the park rather than its boundary. As the size of a park increases, and the distance between its centre and its perimeter grows, underestimation of the service area becomes greater due to

Table 1 National Recreation and Park Association's Public Park and Open Space Classification Scheme

Type of Park	Description	Location Criteria	Site Criteria	Population Served
Mini Park	Used to address limited, isolated or unique recreational needs.	Service area usually less than a ¼ mile (0.4 km) along trails or low-volume residential streets.	Usually between 2,500 square feet and 1 acre (0.4 hectares); maximum 5 acres (2 ha).	500 to 2,500
Neighbourhood Park	The basic unit of a park system. Serves the recreational and social focus of the neighbourhood. Emphasis is on informal active and passive recreation.	Walking distance of a ¼ to a ½ mile (0.4–0.8 km), uninterrupted by non-residential roads or other physical barriers.	Minimum of 5 acres (2 ha), 7 to 10 acres (2.8 to 4.1 ha) optimal.	2,000 to 10,000
Community Park	Serves a broader purpose than a neighbourhood park. Focus is on meeting community-based recreation needs.	Usually serves 2 or more neighbourhoods within a ½ to 3 mile (0.8–4.83 km) distance.	Between 20 and 50 acres (8.1 and 20.3 ha).	10,000 to 50,000
Natural Resource Area	Land set aside for the preservation of significant natural resources, remnant landscapes, open space, and visual aesthetics/buffering.	Location determined primarily by resource availability and opportunity.	Variable	Variable
Greenway	Ties park system components together to form a continuous park environment.	Location determined primarily by resource availability and opportunity.	Variable	Variable
Sports Complex	Consolidates heavily programmed athletic fields and associated facilities to larger and fewer sites strategically located throughout the community.	Strategically located throughout community.	Usually a minimum of 25 acres (10.1 ha), with 40 to 80 (16.2 to 32.4 ha) being optimal.	Variable
Special Use Facility	Covers a broad range of parks and recreation facilities oriented toward single-purpose use.	Variable	Variable	Variable
Private Park/ Recreation Facility	Parks and recreation facilities that are privately owned yet contribute to the public park and recreation system.	Variable	Variable	Variable

Source: Mertes and Hall, 1995, p. 94

the inclusion of the park itself within this zone. The final disadvantage of drawing a circle around the centroid of a park is that it does not take into account the park's shape. The less regular this becomes the higher the degree of inaccuracy and misrepresentation of the service area; a linear park would provide a good example.

The configuration of a park, and the position(s) of its point(s) of access, as well as the realistic measurement of distance to it, are important factors not considered under the traditional, radius method. An alternative that minimizes these inaccuracies is therefore desirable. One such approach is based on the measurement of distance along the roads and other public rights of way surrounding parks so as to emulate as closely as possible the actual routes that users are likely to follow between their residences and designated points of access to facilities. This 'network analysis' approach appears to respond to all the disadvantages of the radius method. Distance can be measured to or from each of the access points to each park. In this way, distance is measured realistically, and from the boundary of the park rather than its centre, and the park's shape is also taken into consideration. This approach can be implemented quite simply in a GIS environment using a shortest path algorithm pre-encoded into the software.

In this study, both measures of distance, using the straight-line radius and the network procedures, were utilized. This allowed comparison of the levels of service portrayed by each, and discussion of the implications of any differences. These might relate to the accuracy of service assumed by agencies using the simpler, straight-line method, as well as to the degree of equity indicated since in this study equity is inherently dependent upon level and distribution of access.

Equity

Previous empirical equity analyses have been of two main kinds, which Scott and Cutter (1996) label 'outcome' and 'process' studies. 'Outcome' studies have focused on the distribution of various resources relative to the socio-economic characteristics of residents. Specifically, they have been concerned with the adherence or otherwise of distributions of various publicly provided resources to the 'underclass hypothesis' (Lineberry, 1977). This hypothesis purports that systematic and deliberate discrimination exists against certain socio-economically disadvantaged groups and areas in the distribution of goods and services, resulting in their receiving fewer and/or poorer quality resources relative to more advantaged citizens. Under the alternate view, 'unpatterned inequality', inequitable distributions are deemed to illustrate no systematic bias against certain groups, i.e., any inequities in terms of differential receipt of goods and services seem to be spread evenly throughout the population. Early examples of 'outcome' studies include Antunes and Plumlee (1977), who examined the quality of neighbourhood streets in Houston, and Mladenka and Hill (1977), who presented an analysis of the distribution of public parks and libraries, also in Houston. More recently, Koehler and Wrightson (1987) re-examined the distribution of Chicago's park and recreation services, an analysis originally completed by Mladenka in 1980, and were responded to by Mladenka (1989).

'Process' studies, in contrast, have been less concerned with who is or is not impacted by inequity, and more with the reasons underlying distributions of resources. Analyses such as those by Jones and Kaufman (1974), Mladenka (1980), and Cingranelli (1981) have attempted to account for variations in the distributions of public goods and services through factors including racism, political favouritism, institutionalized decision-making rules, certain historical events, and population shifts. They have discovered a complex variety of empirical patterns, differing both between the various cities studied and the services examined. In this study, however, the outcome of the distribution of public leisure services, in terms of variations between different socio-economic groups, rather than the processes underlying this distribution, is considered.

Despite the importance of both these types of study, there remains a lack of analysis of the spatial aspect of equity, i.e., of studies that have explicitly investigated the relationships between the spatial distributions of facilities or services and the spatially referenced socio-economic characteristics of the populations they serve. Although several authors (e.g., Mladenka, 1989; Wicks *et al.*, 1993) have analysed the equity of distributions of leisure services using various demographic characteristics such as age and income as independent variables, these studies have tended to utilize the 'container' approach to access and equity, as discussed above, which compartmentalizes leisure facilities and their users into discrete units, allowing no spatial interaction between them.

Combining accessibility and equity

Talen and Anselin (1998) have argued for the need to replace the container approach with one that measures levels of accessibility continuously over space. The level of accessibility to a set of facilities could then be used as the criterion against which the degree of equity is assessed. Investigating equity from a distinctly socio-spatial perspective, using levels of accessibility as the means of differentiation, directly responds to the type of analysis called for by critics of standard geometric studies of accessibility. To date, few authors have adopted this kind of socio-spatial approach to the analysis of equity, and only Talen and Anselin have investigated this issue in the context of parks (Talen, 1997; Talen, 1998; Talen and Anselin, 1998). Although the procedures these authors have employed are theoretically sound, they are somewhat complicated in terms of computational and software requirements and their results are not always easy to interpret. The aim of this paper is to demonstrate the utility of a much simpler method with regards to computation, interpretation, and map display.

The methods proposed consist of two stages. First, is the identification of levels of accessibility using a relatively straightforward buffering technique, with distance measured both as-the-crow-flies and along the street network. Second, is the assessment of the degree of equity based upon these levels of access. This involves comparing the characteristics of those residents within a service area and who are considered to have good access, with those of people outside the service area for whom access is deemed inadequate. This can be achieved using a standard, two-sample statistical test. The approach draws on the methodology used by Werner (1998) in his analysis of the equity implications of discontinuing a public bus service in Ramsey County, Minnesota.

CASE STUDY: LEVELS OF ACCESSIBILITY AND EQUITY OF PUBLIC PARKS IN BRYAN, TEXAS

The case study illustrates the application of GIS technology to identification of the levels of accessibility and equity provided by a system of municipal parks in Bryan, Texas. The Bryan Parks and Recreation Department (BPRD) manages 29 facilities in the city, including seven mini, nine neighbourhood and seven community parks as defined according to the NRPA's classification. These 23 facilities total 222 acres (89.9 hectares), which equals 4 acres (1.6 ha) per thousand of the population, a figure well below NRPA's 10 acre (4.1 ha) recommendation (Table 2). This amount does rise when all facilities within the city are considered; these additional amenities were not included in this paper, however, for reasons described below.

Single use (e.g., tennis courts) and special use (e.g., the athletic complex) facilities were

Table 2 Bryan Parks and Recreation Department Facilities

Type of Facility	Total Number of Facilities	Total Acres (Ha) of Facilities	Acres (Ha) Per Thousand of the Population
Mini Park	7	10 (4.1)	0.18 (0.07)
Neighbourhood Park	9	75 (30.4)	0.82 (0.55)
Community Park	7	137 (55.5)	2.49 (1.01)
Total For Mini, Neighbourhood and Community Parks	23	222 (89.9)	4.04 (1.63)
Regional Park	1	1060 (429.3)	19.27 (7.81)
Athletic Complex	2	112 (45.4)	2.04 (0.83)
Aquatic Centre	1	3 (1.2)	0.05 (0.02)
Tennis Courts	1	1 (0.4)	0.02 (0.007)
Golf Course	1	141 (57.1)	2.56 (1.04)
Total For All Facilities	29	1539 (623.3)	27.98 (11.33)

Source: City of Bryan Park and Recreation Department Staff, 1996

excluded from the analysis, as were private sector sites, since the emphasis was on the accessibility of everyday, outdoor recreation and open space opportunities. The regional park was also excluded since it is a long way from the centre of town and is only accessible by car; in this study, the main concern was for leisure sites within walking distance of one's residence.

The analysis was undertaken at two levels. First, neighbourhood parks, as the basic units of the system (as described in Table 1) were considered alone. Second, mini, neighbourhood and community parks were combined in order to include those areas lacking a neighbourhood facility but, nevertheless, able to offer some form of open space. In both cases, one half of one mile (0.8 kilometres) was used as the maximum recommended walking distance. While NRPA does specify up to 3 miles (4.8 km) as an acceptable travelling distance for a community park, this assumes the user is driving. In this study, the ability to walk to a park was emphasized. Thus, a distance of one half of one mile (0.8 km) was adopted throughout.

This distance compares favourably to those currently utilized by cities in the UK such as Dundee and London (both of which list 1.2 km as the desired maximum distance from local, neighbourhood-style parks), but is more generous than Aberdeenshire Council's 'ideal hierarchy' of open space, which recommends 0.5 km (Kit Campbell Associates, 2001).

Methods

The discussion of methods is divided into five subsections: GIS software; data acquisition; data preparation; implementation of GIS techniques; and, equity analysis.

GIS Software

The case study was carried out using ArcView GIS (Version 3.1), a package produced by the Environmental Systems Research Institute (ESRI). The network analysis technique was implemented in Network Analyst. This is an ArcView extension that can be used to solve many common network problems including the identification of service areas.

Data Acquisition

A variety of data sources, summarized in Table 3, were utilized.

Table 3 Sources of Data

Type of Data	Source
Street network	Texas Department of Transportation
Boundary lines (lots, etc.)	Brazos County Appraisal District (BCAD)
Park boundaries	BCAD and Bryan Park and Recreation Department
Park access points	Personal observations at each park
Socioeconomic information	U.S. Bureau of the Census Summary Tape Files (1990), ArcData Online
Geographic census information	U.S. Bureau of the Census TIGER Files, ArcData Online

A road map of Brazos County (in which Bryan is located) created by the Texas Department of Transportation (TxDOT), was downloaded from the Texas Natural Resources Information System (TNRIS) site (www.tnris.state.tx.us/pub/GIS/highway). The census data utilized in the analysis of equity were obtained from ESRI's ArcData Online (ADOL) web facility (www.esri.com/data/online/ tiger/ index). In this study, analysis was carried out on census blocks so as to obtain as fine a degree of spatial detail as possible. Since this is the lowest level of aggregation available, only a limited amount of socio-economic information is provided so as to maintain resident confidentiality. However, this provides a broad enough range of variables to analyse equity, as it has been defined in this study.

Data Preparation

Once all the relevant data had been collected, they were entered into the GIS as overlaying ArcView shapefiles. A 'shapefile' is the name given within ArcView to the geographical representation of a theme or layer of spatial information. In order for each separate layer to be superimposed correctly upon the others, each must be stored in the same geographic projection and co-ordinate system.

The next task was to locate all public parks in the study area and create a new ArcView shapefile to contain them. Sites were identified using paper maps and site diagrams provided by the BPRD (City of Bryan, 1996), and were then drawn into ArcView using property line data provided by the Brazos County Appraisal District as a base.

In addition, it was necessary to locate all the points of access to each of the parks in order to operationalize the accessibility measure based on the positions of points of entry. This involved extensive fieldwork rather than a simple reliance on paper maps. All potential entrances were identified and recorded so as to capture pedestrian points of access in addition to the primary, vehicular ones.

Implementation of GIS Techniques

The two methods of measuring accessibility, 'radius' and 'network analysis', were applied to each set of parks. The radius technique was implemented using the *Create Buffers* command under the *Theme* menu of ArcView. A distance of one half of one mile (0.80 kms) was specified, measured from the geographic centre of each park, and circular buffers, representing each park's service area, were created.

The network analysis technique also involved specification of the travel distance allowed for each type of park. This was then measured outwards from each park's specified points of access along the surrounding streets. Since neighbourhood parks are ideally accessible by walking along local streets, only this type of street was included in the analysis; travel along major routes was not permitted. A service area was created for every point of access, and these were then joined into a single service area for each park using the *Union* command in the *Edit* menu.

The *Select by Theme* function in the *Theme* menu was then used to identify those census blocks lying inside and outside each service area. To avoid the need for any form of areal interpolation, only those blocks with their geographic centre inside each service area were identified as being within it, i.e., the *Have Their Centre In* criterion was utilized. Although it should be recognized that this technique provides only an estimate of the true number and characteristics of residents located within service areas, it was deemed accurate enough for the level of detail likely to be needed by a public leisure services department.

Equity Analysis

The equity analysis was carried out using the Mann-Whitney U test procedure in SPSS. A non-parametric procedure such as Mann-Whitney was required due to the lack of normality, equal variances, and independence typical of spatial data. For each variable, the median value for census blocks outside the service area was compared to the median value for blocks inside it, and the extent to which the two medians differed was computed. The nine variables utilized in the equity analysis were: i) population density; ii) per cent non-White (i.e., Blacks, Asians, American Indians, and all other races); iii) per cent Black; iv) per cent Hispanic; v) per cent under age 18; vi) per cent over age 64; vii) per cent of housing units renter occupied; viii) mean housing value (for owner occupied units); and, ix) mean contract rent (for rental units). Housing tenure and value were used as a proxy for income since income data are not available for census blocks. Groups considered most likely to be in 'need' of better than average access to parks were non-Whites, those earning low incomes (approximated by those who rent as opposed to own their home, and those whose property or rental value is lower than average), the young and the elderly, and those residing in more densely populated areas and less likely to have access to a private garden. Percent Black and Hispanic were used to allow a more detailed analysis of any particular racial or ethnic biases found in levels of accessibility. For reference purposes, Table 4 contains a summary of socio-economic and demographic information for the city of Bryan as a whole.

Table 4 Selected Socio-Economic and Demographic Data for Bryan, Texas

Characteristic	**Value (1990)**
Total Population	55,002
Age Distribution	
per cent Under 18	27.0
per cent Over 64	9.8
Racial Composition	
per cent White	69.9
per cent Black	17.2
per cent Other	12.9
per cent Hispanic	19.8
per cent Non-Hispanic	80.2
Housing Tenure	
per cent Occupied Housing Units	48.3
Owner Occupied	51.7
per cent Occupied Housing Units	
Renter Occupied	
Median Housing Value (owner occupied units, $)	58,400
Median Contract Rent ($)	312
Income	
Median Household Income ($)	22,577
Median Family Income ($)	29,277
Per Capita Income ($)	11,691

Source: U.S. Bureau of the Census, 1990

RESULTS

This section is divided into two parts. First, levels of access to Bryan park facilities are discussed. Second, the equity of their distribution is examined.

Access

Figure 2 illustrates service areas for the nine neighbourhood parks in Bryan according to the radius and network analysis approaches. Access appears limited to those neighbourhoods immediately surrounding each facility, leaving large areas throughout the city without access. In most cases, as expected, the service area according to the network analysis technique is much smaller and more irregularly shaped than under the radius method. The two service areas for the park in the far north-west section of the city clearly illustrate the impact of a barrier, in this case the railway line, on reducing the actual degree of access to a facility.

The two sets of service areas for all mini, neighbourhood and community parks are illustrated in Fig. 3. Both indicate a lack of

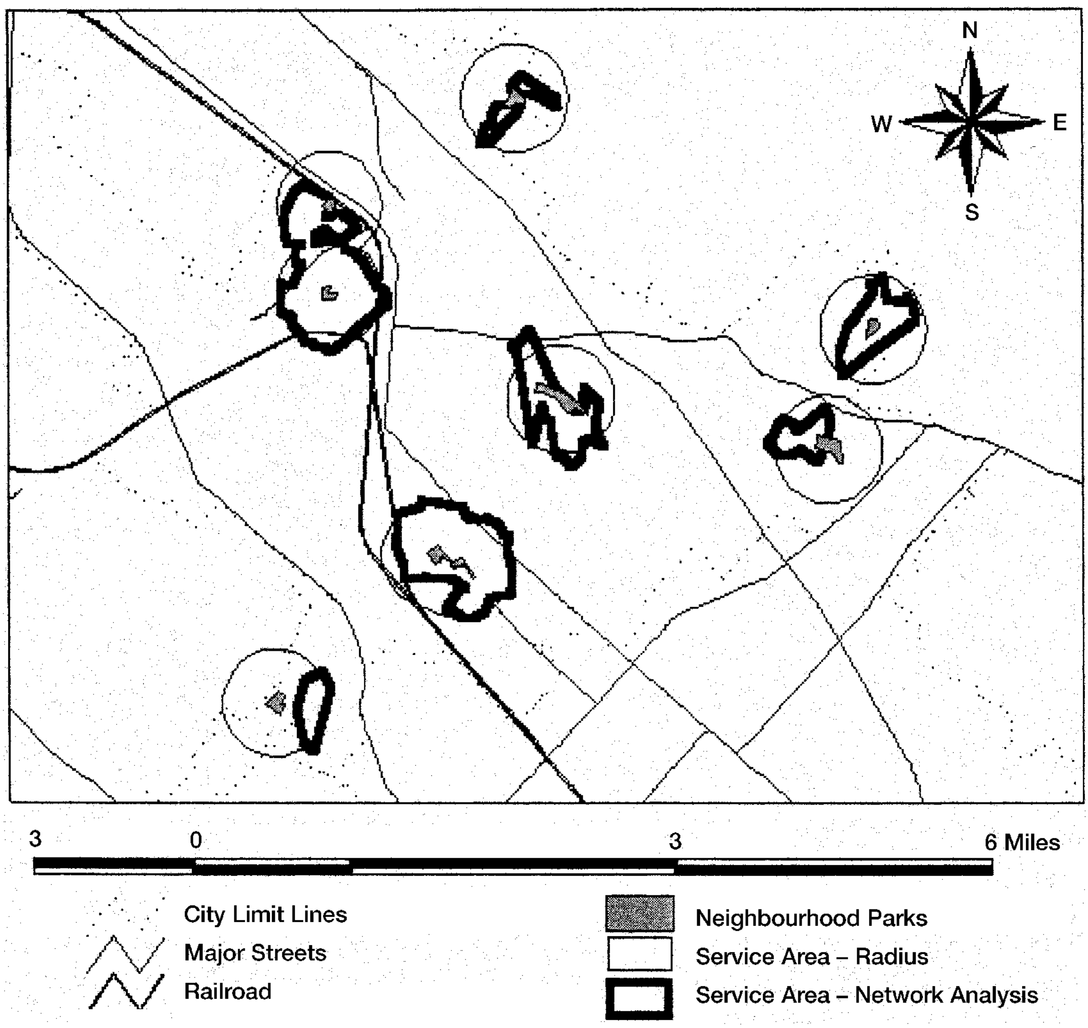

Fig. 2 Service areas for Bryan neighbourhood parks according to the radius and network analysis methods

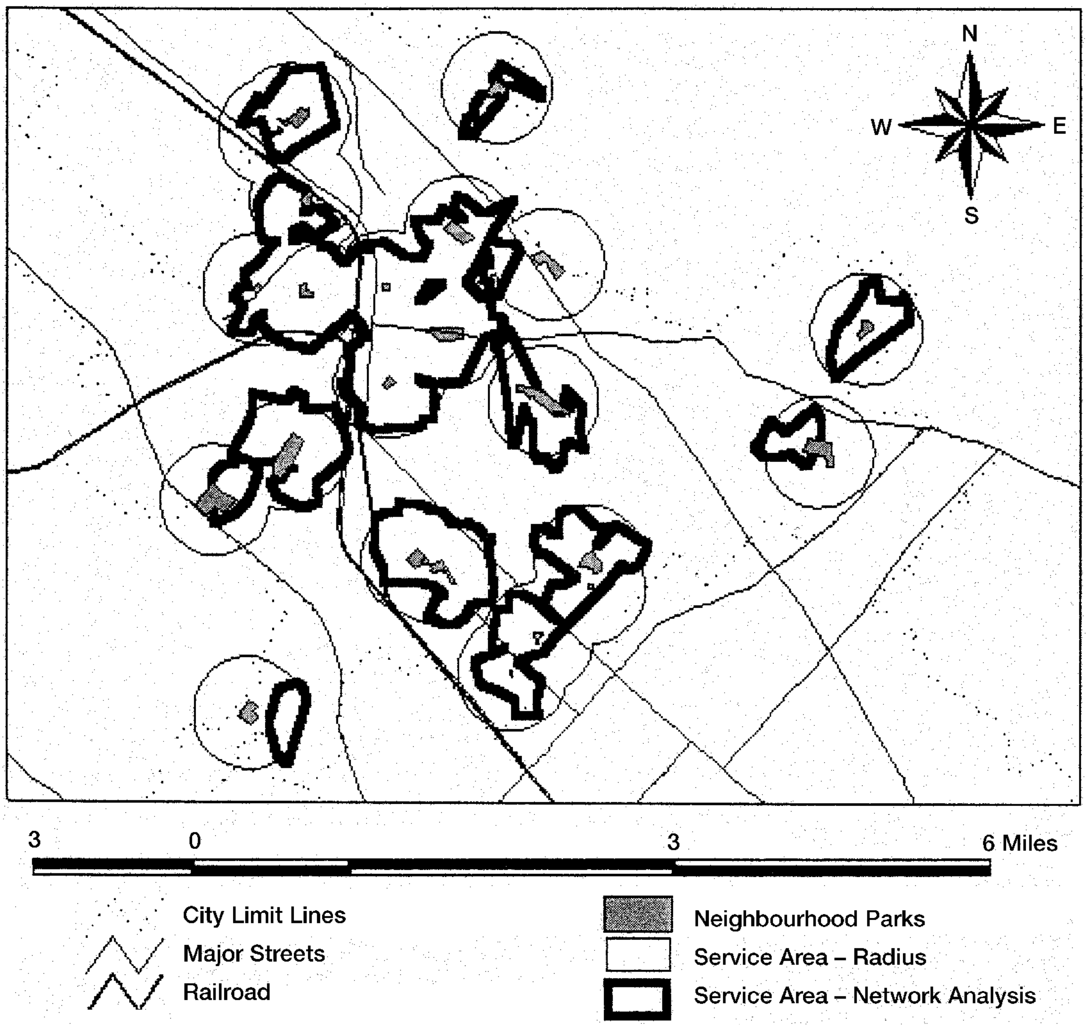

Fig. 3 Service areas for all Bryan parks according to the radius and network analysis methods

coverage in the far north-west tip of the city and in the east. In contrast, the northern and southern areas of Bryan appear to have good access to a park. Once again, however, the total service area as defined by network analysis is visibly smaller than under the radius technique.

The location of Bryan's park facilities, and, hence, of the patterns of access produced (whether under the radius or network analysis method), might be considered inconsequential if the unserved areas were sparsely populated. The ability to combine the accessibility maps with a map of the population distribution using a simple function in a GIS is, therefore, an effective means of more meaningfully representing the level of accessibility in numeric as opposed to purely visual terms. Table 5 shows the results of this procedure.

The proportion of the population covered by neighbourhood parks is small under both the radius (19%) and network analysis (12%) methods. The variation in service in absolute

Table 5 Number of Blocks and Residents With Access to Bryan Parks Based Upon NRPA Location Standard of One Half of One Mile

Type of Park	Access Method	Number of Blocks With Access	Number of Blocks Without Access	Number of Residents With Access	Number of Residents Without Access	Percentage of Population With Access
Neighbourhood	Centroid Radii	338	889	10,426	44,576	18.96
	Network Analysis	274	953	6,540	48,462	11.89
All	Centroid Radii	825	402	30,173	24,829	54.86
	Network Analysis	671	556	21,026	33,376	38.23

terms amounts to approximately 3,900 people. In the case of all three types of park combined, the proportions of the population served according to the radius and network analysis techniques are 55% and 38%, respectively. In absolute terms, the number of residents considered to have adequate access to a park is 8547 fewer under the network analysis procedure. The acceptability of such figures depends upon individual departments' service delivery objectives, but they do appear low.

Both the maps and the figures presented here demonstrate the differences in results that can be obtained by using two different methods of measuring distance. They suggest that if leisure service agencies use these kinds of techniques to assess levels of accessibility to their facilities, they should use the more accurate network analysis technique. If they continue to utilize the traditional circle method, they should recognize the degree of inaccuracy that may be portrayed.

Equity

Table 6 contains results of the Mann–Whitney equity analyses. Since SPSS only reports results of this test in a two-tailed manner, it was necessary to compare the median values of the variables inside and outside service areas to determine whether equity or inequity was indicated in those instances where a significant difference between the two groups was found ($p < 0.05$). Given the definition of equity adopted here, an equitable distribution was suggested when population density, the proportion of young or elderly residents, the proportion of minorities, or the proportion of home renters, was significantly higher within the service area than outside of it, or when the mean housing value or contract rent was significantly lower. In the opposite case, inequity was considered to be demonstrated. When no significant difference was indicated ($p < 0.05$), the results were interpreted as suggesting that those disadvantaged groups considered most critical in terms of their access to parks were receiving equal opportunities compared to other portions of the community. Thus, equality, rather than need-based equity, was evident.

As Table 7 shows, the distribution of parks in Bryan appears to be quite equitable. For neighbourhood parks alone, non-Whites (and Blacks in particular, though not Hispanics), as well as those with lower housing values or rents, have significantly higher levels of access to park facilities than do their White, higher income neighbours. There appear to be no significant variations in access with population density or age.

When all three types of parks are considered together, those living in more densely populated areas also appear to be particularly well served by park facilities, in addition to minorities and those on lower incomes. While the elderly appear to be more advantaged than other ages under the radius method, the young benefit more according to

Table 6 Mann–Whitney Analysis of Park Equity

Type of Park	Access Method	Variable	Median Value of Variable: Within S.A.	Median Value of Variable: Outside S.A.	Mann–Whitney U	2-tailed p
Neighbourhood	Centroid Radii	Pop^n density	3571.43	3809.52	100416.0	0.530
		per cent Non-White	66.67	13.16	60291.0	0.000
		per cent Black	16.00	0.00	71489.5	0.000
		per cent Hispanic	10.57	8.33	98571.5	0.272
		per cent Under 18	27.27	25.81	99045.0	0.338
		per cent Over 64	11.86	9.76	97065.5	0.151
		per cent RO	40.00	32.63	96000.0	0.111
		MHV	363.00	48300.00	76068.5	0.000
		MCR	198.00	292.00	72306.0	0.000
	Network Analysis	Pop^n density	3846.15	3768.12	90374.0	0.603
		per cent Non-White	72.22	14.29	53098.5	0.000
		per cent Black	19.35	0.00	63513.5	0.000
		per cent Hispanic	9.09	8.47	89920.5	0.515
		per cent Under 18	28.38	25.81	87796.0	0.240
		per cent Over 64	11.54	10.00	87848.5	0.244
		per cent RO	42.86	32.10	81450.5	0.007
		MHV	35800.00	47500.00	67429.0	0.000
		MCR	198.00	288.00	64440.0	0.000
All	Centroid Radii	Pop^n density	3846.15	3333.33	96781.0	0.010
		per cent Non-White	30.22	9.515	75543.0	0.000
		per cent Black	5.77	0.00	85321.5	0.000
		per cent Hispanic	9.09	8.37	106352.5	0.727
		per cent Under 18	27.24	25.00	101454.0	0.136
		per cent Over 64	11.11	7.75	99275.0	0.045
		per cent RO	33.33	28.83	100132.5	0.107
		MHV	40800.00	52500.00	85829.0	0.000
		MCR	246.00	311.50	82199.0	0.000
	Network Analysi	$sPop^n$ density	4032.26	3200.00	103866.5	0.000
		per cent Non-White	34.48	10.00	85318.5	0.000
		per cent Black	7.25	0.00	97989.5	0.000
		per cent Hispanic	10.30	7.92	116528.5	0.118
		per cent Under 18	27.78	25.00	111620.0	0.009
		per cent Over 64	11.11	9.09	119560.0	0.388
		per cent RO	36.36	28.57	111414.0	0.013
		MHV	39550.00	52250.00	97240.5	0.000
		MCR	238.00	298.50	99156.5	0.000

Note: S.A. = service area; Pop^n density = population density; RO = renter occupied; MHV = mean housing value; MCR = mean contract rent.

network analysis. In no instance is an inequitable distribution indicated; rather, if need-based equity is not evident, the situation appears to be one of at least equality.

Unexpectedly, the results of the equity analyses are fairly constant across both methods for both sets of parks, despite the differences in levels of accessibility found between them. The only noticeable difference is that for both categories of parks, the equity results under network analysis contain one more significant variable (housing

Table 7 Mann–Whitney Analysis of Park Equity – Significant Variables at 0.05

Type of Park	Access Method	Variable	Median Higher Within or Outside Service Area?	Indicates Equity or Inequity?
Neighbourhood	Centroid Radii	per cent Non-White	Within	Equity
		per cent Black	Within	Equity
		MHV	Outside	Equity
		MCR	Outside	Equity
	Network Analysis	per cent Non-White	Within	Equity
		per cent Black	Within	Equity
		per cent Renter occupied	Within	Equity
		MHV	Outside	Equity
		MCR	Outside	Equity
All	Centroid Radii	Population density	Within	Equity
		per cent Non-White	Within	Equity
		per cent Black	Within	Equity
		per cent Over 64	Within	Equity
		MHV	Outside	Equity
		MCR	Outside	Equity
	Network Analysis	Population density	Within	Equity
		per cent Non-White	Within	Equity
		per cent Black	Within	Equity
		per cent Under 18	Within	Equity
		per cent Renter occupied	Within	Equity
		MHV	Outside	Equity
		MCR	Outside	Equity

Note: MHV = mean housing value; MCR = mean contract rent

tenure) than do those for the radius method. The consistency of results between methods and across park type suggests that those groups considered most important with regards to their levels of access to park and recreation opportunities within the city of Bryan tend to be located closest to them and within relatively homogenous census blocks.

CONCLUSION

This paper has illustrated to leisure service professionals the utility of GIS as a means of visualizing and measuring levels of accessibility and equity. In addition, it has demonstrated the importance of measuring distance and access as accurately as possible, using network rather than straight-line distances, so as to provide more realistic representations of the geographic extent of service areas and their populations.

The case study of Bryan parks clearly indicated the differences in level of accessibility that the straight-line and network measures of distance can produce. If the latter is accepted, it appears that less than 40% of Bryan residents have good access to any form of everyday open space, with only 12% being able to reach a neighbourhood park within the distance specified. However, based on the low acreages listed in Table 2 and the even spread of facilities throughout the populated area, this deficiency can be attributed to a lack of sufficient open space rather than its poor distribution relative to the population.

Despite the paucity of access to leisure opportunities, however, the degree of equity associated with them is high. Thus, although Bryan is lacking in park and recreation resources in an absolute sense, those it has are well distributed relative to the needs of the population. Less advantaged groups (especially minorities and those whose housing tenure and value characteristics indicate lower incomes) do tend to have better access, indicating the existence of need-based equity. In no case is inequity found.

Whether this situation is the result of good planning or good fortune is beyond the scope of this 'outcome' paper. However, a 'process' analysis may well highlight the population dynamics of Bryan, with many of the more advantaged residents increasingly locating in new subdivisions with their own private leisure opportunities (individual gardens as well as communal facilities, such as playgrounds and swimming pools, funded by the local Homeowners Association), but with few publicly provided leisure services. As house prices in less desirable, older neighbourhoods, where public parks have, nevertheless, historically been located, increase less rapidly than in newer areas, so less advantaged residents are more able to afford them. Hence, an equitable distribution of public leisure provision may emerge.

The methods described here constitute a great advance over the use of ratios or circular buffers to measure the accessibility of park facilities. They could, however, be developed further to provide even more detailed pictures of levels of access and equity. For example, the use of one buffer of one half of one mile could be replaced with a series of concentric rings of access, in one quarter or one half mile increments, covering an entire area. This would create a surface of accessibility indicating the distance of all residents from their nearest leisure facility. Alternatively, maps might be generated to illustrate the number of facilities accessible within a specified travel time or distance from individual neighbourhoods or census areas, providing a surface of leisure opportunity for a city.

The methods employed in this case study do not take into account the characteristics of parks, they are concerned only with which areas and populations have access to them and which do not. Inclusion of information as to individual facilities' levels of development, number and types of facilities, and physical condition, in the form of an index representing their overall attractiveness, could add a more qualitative dimension to the analysis. Finally, it should be noted that there are many means of measuring accessibility and equity other than those utilized here, all of which are legitimate and capable of being implemented within a GIS environment.

It is evident that GIS offers leisure service practitioners a real opportunity to improve their methods of measuring accessibility and equity. This technology offers agencies a tool for the more efficient and effective planning and management of facilities in other ways as well. Potential applications include the dissemination of information to the public through interactive web sites in which they are able to locate facilities, look up details about them, and obtain directions to them; the automation of facilities management; and, the selection of optimum sites for new developments so as to maximize accessibility and equity using location-allocation models incorporated into Spatial Decision Support Systems.

Finally, the highly visual maps that GIS can provide may be useful tools for improving users' perceptions of public authorities' accountability and openness. Increased interaction and understanding between service providers and their clienteles are likely to decrease the perceptual gaps between them, ultimately leading to more satisfied users.

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