Visualizing Fairness
Equity Maps for Planners

Emily Talen

The achievement of equity in the distribution of public resources is a goal of paramount importance to planners. Deciding the distribution of benefits ("who gets what") and costs ("who pays") is something planners do almost daily, as they attempt to guide the allocation of scarce public resources. In planning, equitable distribution entails locating resources or facilities so that as many different spatially defined social groups as possible benefit—i.e., have access.

The allocation of public resources was once termed the "hidden function of government" (Jones, Greenberg, and Drew 1980), but in the past fifteen years it has received considerable attention. Crompton and Lue (1992) attribute the change to judicial involvement (the oft-cited case of Haekins v. Town of Shrew), the perception of scarcity, the increase in citizen action groups, improved techniques to evaluate benefits and costs, and a rising insistence that patrons bear some portion of delivery costs.

The complexities involved in the equitable allocation of public resources include not only methodology (how can equity be measured?), but also a multitude of value judgements about who should benefit, the nature of social justice, and the definition of political consensus. The stakes are high: since public resources are, in some sense, part of each individual's income, their spatial distribution directly affects the distribution of public welfare (Pahl 1971; Harvey 1973).

Considering these complexities, it is not surprising that planners have tended to approach distributional equity in a rather ad hoc fashion. Examples of distributive policy explicitly based on equity criteria, such as that in Savannah, Georgia (Toulmin 1988) are few. Usually, resources are distributed according to predefined standards such as per capita allocation (e.g., 1 acre of park land per 1,000 residents) without conscious attention to distributional fairness. While such an approach minimizes the costs of decision-making, it ignores the social geography of urban areas. Alternatively, resources may be allocated in response to political activism or the ability of neighborhood groups to mobilize support for a particular facility. While this method may appear superior to a unidimensional distributional standard, it rewards political savvy at the expense of legitimate need.

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Planners continue to be called on to act as disseminators of social justice (see, for example, Krumholz and Forester 1990), and the allocation of public facilities is one arena where social inequities can be mitigated, or at least offset by compensatory distribution. To the extent that disadvantaged groups can be spatially defined, the locational distribution of public facilities affords planners a rare opportunity to relieve the condition of those with fewer resources.

The question then arises: how can the spatial equity of public resource distribution be analyzed and incorporated into public decision-making? What I propose here is equity mapping, a method that relies on the visualization techniques embedded in geographic information systems (GIS). Using a case study, I demonstrate a prototype method for interactive use of GIS in which mapped distributions of (a) access to facilities and (b) socioeconomic characteristics are used for exploratory analysis of spatial data. The mapping process ties directly into state-of-the-art procedures in which dynamically linked windows allow the analyst to fully exploit the display capabilities of GIS. (See, for example, Anselin, Dodson, and Hudak 1993; Batty and Xie 1994.) The implementation is straightforward; all that is required is the necessary software: a standard GIS package capable of importing data and performing overlay functions, and a statistical package; locational information on any appropriate public facility or resource; and socioeconomic data such as population and housing characteristics, readily available in digital format from the census bureau or a local library.

For planning purposes, what is of fundamental importance is that planners—and also their constituents—recognize the distributional principles underlying any geographic arrangement of public resources. The use of maps can elucidate equity variation and perhaps demystify it. By analyzing the spatial incongruity between resource need and resource distribution, planners can explicitly reveal the distributional choices being made about “who gets what.” As a basis for planning, revelations about who benefits, presented in visual, spatially-oriented terms, enable communities to evaluate their distributional preferences and see whether or not they are in line with broader community goals and with notions of fairness.

Objectives

The purpose of this paper is to present a method planners can use to readily generate and evaluate various “equity maps” of resource distribution. The paper’s methodological contribution uses a case study as the framework within which to clarify the application of the method. The results of the case study analysis are not meant to be generalizable; rather, they demonstrate a particular application of the method.

The paper presents a brief background on the measurement of equity and a summary of the empirical demonstrations of accessibility in the literature. An outline of the various definitions of equity germane to planning is presented. The methodology section describes the basic technique of equity mapping, including the interactive process. The accessibility measures used here are explained, and the methodological difficulties are identified.

With this analytical and methodological background in place, a number of equity maps for the city of Pueblo, Colorado are examined. I attempt to guide the reader through an interactive, exploratory process of assessing some aspects of distributional equity. There follows a comparison of the different ways of measuring access, and how they produce different analytical results. The paper’s conclusion presents a brief, step-by-step “how to” of equity mapping, and then assesses the limitations as well as the value of equity mapping for planners.

Background

The role of equity in resource distribution has engaged the efforts of a wide array of disciplines. A recent overview by Marchi and Schilling (1994) on the measurement of equity in facility location analysis lists the contributions of political scientists, sociologists, economists, geographers, and management scientists. Many divergent modes of analysis are discernible. Policy analysts discuss the morality of political choices in resource allocation, the preferred structure of government for fulfilling service needs, the fiscal requirements, and the administration of service production (Merget 1979). Much research has focused also on the political ramifications of planning for unwanted public facilities (sometimes criticized as “environmental racism”), which presents an entirely different set of impact assessment methodologies and locational strategies (Seley 1983; White and Ratliff 1989). Staeheli (1989) has analyzed the reasons for providing services in terms of their maintaining the legitimacy of capitalism. Indeed, the multidimensionality of equity in providing services or facilities is at times overwhelming. For the purposes of this paper, I will briefly discuss both the definition and the measurement of equity, as well as empirical demonstrations of geographic variations in the accessibility of desired facilities.

The Definition and Measurement of Equity

In the purest sense, equity can be achieved only after society has arrived at a consensus about what is
fair. This state is virtually unattainable, however, since what one group deems equitable is often seen as inequitable by another. In other words, many different definitions of equity could be operationalized in defining distributational equity. This is analogous to Arrow’s impossibility theorem (1951), which showed that a community welfare function cannot be logically derived. It is also important to note the conflicts inherent in equity definitions: for example, how social equity conflicts with territorial justice (Pinch 1985), and how equity in risk distribution conflicts with equity in access to services (Humphreys 1988).

In planning, the provision of resources according to locational equity has been variously interpreted. Fifteen years ago, Lucy identified five categories of equity that are relevant to planning for local services (1981). Subsequent taxonomies relevant to planning have been offered by Crompton and Wicks (1988), Truelove (1993), and Marsh and Schilling (1994). At least four separate categories are distinguishable. In the first category, equitable distribution is defined as equality, in which everyone receives the same public benefit, regardless of socioeconomic status, willingness to pay, or other criteria; residents receive either equal input or equal benefits, regardless of need. In the second category, equity in the distribution of public benefits can be according to need, termed “compensatory” equity by Crompton and Wicks (1988). Lucy refers to this as “unequal treatment of unequals,” which is based on indicators such as poverty and race, and ideally would factor in the nature of the benefit. Savannah, Georgia, for example, directs city resources into the neighborhoods judged to be “the worst off” (Toulmin 1988). A closely related notion, equity planning—a procedure for mitigating the inequity of class distinctions—has been promulgated through the writings of Norman Krumholz (1975; 1982), and more recently by Krumholz and Forrester (1990).

The third category is the equitable distribution of services or facilities according to demand. Active participation in distributive decisions is “rewarded” by increased user benefit. Squeaky wheels have better access to public goods conferred on them. Demand may be conceptualized as economic (demonstrated use) or political (“vociferous advocacy”). (See Crompton and Lue 1992.) The distributional outcome based on demand differs sharply from need-based distributions. For example, Mladenka and Hill (1977) concluded that according to the demand criterion, library location patterns should favor wealthier neighborhoods, since consumption is higher there. A need-based criterion would produce an entirely different equitable arrangement.

Finally, equitable distribution can be defined by market criteria that make the cost of the service a key factor in distribution. In particular, willingness to pay may be operationalized, in which case the equitable distribution of services is defined according to the degree to which people use (and therefore pay for) a particular service. Alternatively, allocation may be based on the amount of taxes paid or on least cost (on the basis of lower land costs, for example). Applying this approach summons up the conflict between efficiency and equity, which pits aggregate quantities of services (output) against considerations of who the beneficiaries are. It is unlikely that distributions based on efficiency can be made to coincide with need-based distributions.

In this paper, I analyze the location of public facilities according to a need-based distributional standard. This is done for two reasons. First, although the concept of need can be entirely relative, involving individual assessments of deprivation (Harvey 1973), it is nevertheless valid to characterize need on the basis of the socioeconomic characteristics of the population. This characterization of equity can be accomplished easily from census data, and can be integrated easily into a GIS framework. In contrast, the determination of equity based on demand or market considerations relies on data that may not be readily available or easily interpreted. For example, without rigorous analysis of constituency preferences and demonstrated use surveys (which are beyond the means of many planning agencies), achieving equitable distribution as defined by demand is not likely.

Second, on a more philosophical level, defining equity without regard to socioeconomic status may offer equality of opportunity, but leaves in place the inequalities of the existing social structure. Planners are in the business of offsetting the burdens imposed by unchecked “free” market economies, and one approach to this vocation is to administer territorial equity in a compensatory way. This view is closely related to the notion of equity planning (Krumholz 1975; 1982; Krumholz and Forrester 1990).

Methods and Empirical Demonstrations of Geographic Variations in Accessibility

Despite the procedure’s obvious link to planning, there have been few empirical examples of mapping the spatial equity of a facility system or other public resource for planning purposes. Particularly absent from the literature on planning are assessments of the relationship between the spatial distribution of urban facilities and spatially referenced socioeconomic characteristics.

A study by Knox (1978) was perhaps one of the
earliest examples of how mapped accessibility patterns can be used to assess the equity of resource distribution. Using several gravity-based measures of proximity to urban services, Knox demonstrated how they could be used as indicators of social well-being in cities. Territorial variations in opportunity were assessed in terms of proximity to urban resources, in order to obtain an overall measure of "relative personal accessibility" to be used for comparisons. An isometric map was produced that indicated the relative levels of access to a specific urban service (in this case, medical care). More recently, Martin and Williams (1992) conducted a spatial analysis of the variations in access to primary health-care centers.

A basic approach to mapping spatial equity was recently demonstrated by Truelove (1993). Counting the number of opportunities within a defined range of a particular facility can identify regions that are locationally advantaged (or disadvantaged). (See also Toulmin 1988.) To demonstrate how spatial equity is evaluated, Truelove presented several maps showing regions of Toronto that are not "covered" by day-care facilities. He then compared the socioeconomic characteristics of the areas with divergent spatial proximities, to characterize distributional bias.

Pacione (1989) examined differences in access to secondary schools by compiling mapped indices of access. Using a gravity-based model, the author revealed different "undulating" surfaces, which provided a basis for comparing the effects of school closings on access. In addition to visual comparison of spatial variation, Pacione derived an overall coefficient of variation, by which the aggregate effect of different spatial patterns of facilities can be compared. The socioeconomic characteristics of the neighborhoods that fared better and those that fared worse, in terms of facility provision, were presented to reveal any underlying patterns of distributional bias.

More recently, Geertman and Ritsema Van Eck (1995) have demonstrated how accessibility maps (generated using GIS) can be used in planning applications. Moving beyond the traditional GIS methods of overlay, buffering, and network analysis, the authors showed how to produce maps of "potential surfaces," using the gravity potential method of measuring accessibility. Although socioeconomic variables were not included, the authors showed how the maps can be used to visually identify, for example, potential building sites with enough public transport.

Each of these studies offers something toward the refinement of method explicated in this paper. But while each is concerned with making mapped, visual comparisons of spatial variations in access to services, none has investigated access and equity by mapping access patterns and socioeconomic patterns simultaneously, nor examined how planned equity patterns differ from actual ones. The paper also offers a method by which planners can explore spatial equity in an interactive, GIS-based environment.

Methodology

Defining what is meant by equity must be coupled with deciding on the rules to gauge whether or not equity has been achieved. In this paper, I employ a need-based determination of equity, arguing that distributive policy should recognize the fact that some citizens are more able than others to offset reductions in public facilities and services. There are two broad analytical questions to be asked in interpreting equity maps structured this way. First, is there any indication that the facilities provided match the needs of the population? Second, is there a characteristic difference—in terms of socioeconomic makeup—between those areas with higher provisions for their needs and those with lower provisions for their needs? The first question asks whether or not needs are met; the second question asks whether or not distributional biases appear.

The basic methodological approach to equity mapping is to map both the distribution of accessibility measures and the distribution of socioeconomic data in such a way that spatial variation in equity can be scrutinized. This method is essentially spatial univariate, bivariate, or multivariate analysis, which reviews the mapped distribution of data and the spatial patterns in order to characterize spatial association. For example, indicators of socioeconomic status are mapped relative to access (high or low access) as a way of discovering any indication of distributional bias.

For planners, it is useful to evaluate proposed (i.e., planned) as well as achieved distributional patterns (Talen 1996). Analyzing the "equity map" of proposed plans reveals the distribution preferences of a community. Obviously, this is not as ideal as survey-based approaches, since plans quickly become outdated, and distributions shown in plans do not necessarily reflect constituent preferences adequately. However, to the extent that plans are developed to reflect community intent, they are a useful proxy for community preference. Comparing planned accessibility patterns (based on the planned distribution of facilities) with actual (achieved) accessibility patterns offers insights into the nature of plan implementation.

The Interactive Process

As noted, the analysis here is meant to be interactive and investigatory in the sense that the results of one type of analysis—for example, mapping park ac-
ccessibility and housing value—should lead to exploration of other types of relationships. The process is dynamic; maps do not yield definitive answers; they expose relationships and guide the investigator to probe further correlations. The flowchart presented in figure 1 illustrates the interactive nature of the equity mapping process.

In building equity maps, the three types of variables ("data input") can be altered to fine-tune the methodology and allow for a wide range of application. These types are (1) locational information (e.g., distance between residents and parks); (2) population/housing characteristics (socioeconomic data); and (3) facility characteristics. In the interactive process of constructing equity maps, these data are modified to reflect alternative measurements of access and definitions of need. For example, the accessibility measures can vary in terms of the spatial unit used or of how the measure is computed. Population/housing characteristics may be variables indicative of potential discrimination (race and housing value, for example), or may simply reflect certain types of needs (based on age of population, for example). Facilities can be characterized by size, range of services, or quality. If park facilities are being analyzed, the data may characterize the more intensive space needs of higher-density areas, areas with smaller lot sizes, or areas with fewer opportunities for recreation. Any of these definitions can be employed in the interactive process of constructing equity maps.

Various spatial data analysis techniques (univariate, bivariate, multivariate) are used to compare (i.e. map) the data inputs. Spatial clusters are then identified, leading the analyst to interactively investigate how modifying the data changes the observed equity patterns. Variation in how equity is characterized drives the analysis.

To some extent, the differences in measurement and in how the variables are compared are dictated by data availability and software capabilities. For example, if data on facility characteristics are detailed, comparative analysis of how specific population needs are being met by the geographic distribution of facilities—and how this has improved or worsened over time—can be accomplished. As another example, if the particular GIS package being used supports network analysis, distance measures can be based on the existing street pattern between supply (facilities) and demand points (population/housing), perhaps weighted by type of road (in which speed is accounted for).

**Accessibility Measures**

If need-based equity in public facility planning is adopted as the criterion, the measurement of equity looks at the locational distribution of facilities relative to the locations of different socioeconomic groups. To relate the locations of facilities and population groups to each other in a meaningful way, accessibility between the locations must be measured.

There are a wide variety of accessibility measures from which to choose. In the case studies included here, four different accessibility measures are employed: the well-known gravity potential formula, and three other measures taken from facility location...
modeling, termed “objective functions” (defined below). The measures were selected for their ease of interpretation, their prolific use in the literature, and their lack of computational burden and data requirements. The use of these less mathematically complex measures (the “common sense approach”) was urged by Koenig (1980), who found a “remarkable convergence” between common sense measures and those using more detailed mathematical expressions of consumer surplus and behavioral utilities. He wrote: “[T]he [common sense approach] can be clearly and readily understood by policy planners and decision makers. Such direct understanding is not provided by mathematical models used in some other approaches” (147). Of course, simplicity must be treated with caution: while the less elaborate measures constitute a useful proxy for accessibility, the reduction of complexity can create limitation and weaknesses in the measures.³

The formal expressions of these access measures are available on request.

Gravity Model. In the gravity model, which is perhaps the most widely used model of spatial interaction, interaction between locations is weighted by the frictional effect of distance, similarly to the interaction between objects in Newtonian physics. In the specific use of the model here, the “force of attraction” between resident location and park location is proportional to the attractiveness of the park (e.g., park size), and inversely proportional to the square of the distance between them. Therefore, demand for parks (the “force of attraction”) is expected to fall at a negative rate with distance. In these terms, the computed accessibility score characterizes the use (or demand) of every park. Therefore, the higher the score, the better; the access score will be lower where distances to parks are greater.

Minimizing Travel Cost. The travel cost measure, adapted from locational optimizing models, is simply a measure of the average distance between each origin (for example, census block) and each destination (i.e., public facility). How this distance is computed can, of course, vary widely. In this paper, the travel cost measure for each block is the average straight-line distance between that block and every park in the city. Since the goal of improving accessibility is to minimize the cost of travel, the lower the score, the better.

Covering Objectives. In the covering model, a certain critical distance or covering radius is defined, and a binary coefficient is used to identify the facilities that are included within the critical distance for each demand point (in this application, census block). The covering objective seeks to maximize the number of people “covered,” so that as many people as possible have a facility located within a given distance. This assumes that the facility is equally enjoyed within this covering range, and that beyond the specified radius, use of the facility is diminished.

In this demonstration, a tally of the number of parks located within a critical distance—defined as one mile—is given as a way of characterizing access. This distance is justified using the criteria for park access given in DeChiaro and Koppelman (1982). The higher the score (i.e., the higher the number of parks within the critical distance), the better.

Minimum Distance. Inequity of access is inevitable, since some blocks will always be closer than others to any given facility. In locational modeling, “equity” models seek to minimize inequality by choosing a location that reduces the longest journey of any consumer (in this case, census block) to a minimum (Hodgart, 1978). In this paper, the equity model is defined simply as the minimum distance between each point of origin (i.e., census block) and the nearest park facility.

Software

In this paper, ArcView version 3.0 software is used to construct the equity maps. It should be noted that virtually any of the other available GIS software packages could be used. The statistical package used is SpaceStat (Anselin, 1994), which was written specifically for spatial data analysis. SpaceStat is used to obtain the accessibility measures, and can be used to construct the formal indicators of spatial association.

Case Study

The city of Pueblo, Colorado was selected as a case study to demonstrate the process of equity mapping in planning. The city was selected according to the following criteria: existence of a comprehensive plan that includes proposed park development, and existence of data on actual park locations and recreational facilities both at the time the plan was prepared, and at a future date (the “planning horizon”).

To demonstrate the analytical process, I analyze the spatial equity of one particular kind of public facility: parks. Parks are a public resource particularly germane to planning applications because of their pivotal role in comprehensive planning efforts as well as their capacity to improve neighborhood quality.

Both planned park locations and the park locations existing in 1990 are included in the example equity maps. Figure 2 shows the generalized location of

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park facilities planned for the city in 1966, along with 1990 existing park locations. Specific data on facilities are limited to park acreage. Parks information was obtained from the following sources: *Parks, Recreation and Beautification Report* (National Recreation and Park Association 1966), for planned park locations; and *Recreational Activities and Facilities Guide* (Pueblo Parks and Recreation Department 1990), for the location of 1990 parks. Census data at the block level were obtained for 1970 and 1990.

Pueblo is a city of just over 100,000, located in southeastern Colorado. Since the mid-1970s, there has been no population growth within the City of Pueblo, and, in fact, between 1980 and 1990 there was a slight loss of population. As in many other United States cities, growth has occurred in outlying residential areas, while population growth in the core of Pueblo has been stagnant. Since there are no clearly defined areas in need of new resources (as a function of significant growth), the equity map of facility distribution for Pueblo is of particular interest.

Figures 3 and 4, in addition to showing the location of 1990 parks, show the spatial distributions of a population and a housing characteristic: percent Hispanic and housing value. In figure 3, it is clear that higher housing values are in the north and west of the city, and lower housing values in the south and east. The city is almost diagonally split. Figure 4 can be interpreted similarly. The eastern and southeastern sections of the city have higher proportions of Hispanic population, and lower percentages of Hispanic population are found in the north and west.

A comparative analysis of two distributions, shown in figure 5, shows one approach to equity mapping. For this figure, need per block in 1990 is subtracted from the covering access measure per block for 1990, and this amount is compared with the covering access measure on the plan. Thus, equity intentions
(i.e. plans) are compared with equity accomplishments (i.e. 1990). Need is calculated as population per census block multiplied by an estimate of the park acreage required per person. It should be noted that “high” and “low” access scores on the plan refer to their relative magnitude, that is, whether they are above or below a measure of the central tendency of the data (i.e. median or mean). Alternatively, scores could be mapped according to quantile distributions, or whether they are positive or negative, or any other desired categorization of the data.

The lighter shaded blocks in figure 5 show those areas with relatively high provision on the plan (above the median score) and low provision relative to need (below zero) in 1990. The darker blocks show areas with high provision on the plan and high provision relative to need in 1990. Thus figure 5 shows those blocks where the plan “missed” its intention—that is, had planned above-average accessibility, but by 1990 had an accessibility relative to need that was below zero—as well as those blocks where the plan was “successful” in terms of its accessibility goals: the darker shaded blocks are those that the plan intended to have higher than average provision and that actually did exhibit more provision relative to need (above zero) in 1990.

To reiterate: the purpose of equity mapping is to stimulate further inquiry. Why were the blocks with relatively higher access on the plan targeted for more park facilities (or at least better access to parks)? How
quickly, if at all, did the selection of these targeted areas become outdated with respect to need? What role did infrastructure constraints play in deciding on park development? Certainly, the question of distributional bias has to be considered. Traditional critiques of planning would postulate that the blocks that fared well both on the plan and in actuality probably have a higher socioeconomic status than do the blocks that did poorly despite the plan’s call for higher provision. It might further be postulated that the areas that acquired the higher provision called for on the plan are likely to be more influential in a political context, through either neighborhood activism or interest group domination. Critics might surmise that the blocks that did not do well in spite of the plan had less political clout to effect change on their behalf.

It is difficult, however, to draw conclusions about socioeconomic bias when the aggregate data for the two distributions are compared. Table 1 summarizes the differences between the two categories of blocks shown in figure 5, for a few socioeconomic characteristics. For the lighter shaded blocks, the distribution of selected blocks covers some areas of higher housing value (as shown in figure 3), and as a result the median housing value is higher for these blocks as compared to the darker shaded blocks. Thus for darker shaded blocks, which did well in terms of covering access based on need, and in relative terms—it cannot be shown that provision (covering access) was based on the location of higher-income areas (as indicated by higher housing value). For blocks where provision minus need was relatively high, mean housing value was
in fact lower. Only in terms of housing density is there some potentially undesirable dissimilarity: in figure 5, selected blocks with higher provision relative to need in 1990 were lower in housing density than the lighter shaded blocks, in terms of number of housing units per block (for single-family and owner-occupied). In a more equitable (i.e. need-based) distribution, one would expect that higher provision would be associated with higher housing density. Of course, this may or may not be a function of infrastructure constraints, which for higher housing densities in more built-up areas of the city preclude additional parks development.

Figure 6 is an example of an equity map in which sociodemographic variables that could indicate bias in terms of distributional choices are more directly incorporated into the investigatory procedure. Need is therefore based on the presence of higher-than-average percentages of traditionally disadvantaged groups—racial minorities and lower-income groups, for example. Relationships between access, and race and income (as opposed to population and number of housing units) signify the existence or nonexistence of spatial equity more overtly, by revealing the relationships between the distribution of resources and spatially defined socioeconomic groups. For example, maps that show the blocks with relatively high access in 1990 and also a high proportion of home ownership, single-family housing, or white racial makeup may point to a situation in which greater access is afforded blocks with a higher socioeconomic status.

For figure 6, “high” and “low” access scores and
TABLE 1. 1990 statistics for selected blocks (figure 5)

<table>
<thead>
<tr>
<th></th>
<th>Planned provision high; actual provision low (selected blocks)</th>
<th>Planned provision high; actual provision high (selected blocks):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median</td>
<td>Interquartile Range</td>
</tr>
<tr>
<td>Avg no. of rooms</td>
<td>5.0</td>
<td>5.0-6.0</td>
</tr>
<tr>
<td>Mean housing value</td>
<td>$50,000</td>
<td>$47,350-$58,100</td>
</tr>
<tr>
<td>Single-family units</td>
<td>16</td>
<td>13-22</td>
</tr>
<tr>
<td>Owner-occ. units</td>
<td>12</td>
<td>9-17</td>
</tr>
</tbody>
</table>

Socioeconomic characteristics are based on the median statistic. The map highlights blocks that have the following two simultaneous characteristics: a low gravity model access score in 1990, and low housing value in 1990. The number of blocks included in these two categories is not unexpected: 408 blocks (approximately one-fourth of the total number of blocks). But the question to be answered is whether or not those blocks show any spatial patterning. Planners should investigate why this area had low access, despite the fact that it is an area with below-average economic means (i.e. below-average housing value), and thus had demonstrated need. Further, a visual comparison with figure 4 reveals that the blocks selected in figure 6 correspond to areas of high Hispanic population. Again, questions about infrastructure, political prowess, and simple random variation are all valid. Equity maps like this one alert planners to areas that may not be acquiring access to resources to the degree in keeping with community goals and need-based standards of equity.

The equity mapping procedure presented above could be built upon in a number of ways. Input variables could be changed, for example, to produce comparisons of changes in distributional equity over time, or maps of quintile distributions related to socioeconomic attributes. Further, variation in the methodological components (the way distance is computed, for example) could be used to add analytical depth to the analysis, and to test the robustness of the initial results. Here, dynamically linked windows in a GIS format would be particularly useful.

In a less spatially-referenced procedure, one possible type of analysis is to compute and analyze the correlation coefficients between socioeconomic variables and the access measures. For example, 1970 socioeconomic variables could be correlated with measures on the plan, and compared with the correlation coefficients between 1990 access measures and 1990 socioeconomic data. Changes may indicate that the intention of the plan was not upheld, for example, if the directions of the relationships between income groups and access are different between the plan and 1990. Alternatively, scatterplots and other exploratory data analysis could be used to investigate the linearity of the relationship between access and socioeconomic data.
Formal Indicators of Spatial Association

Much of the analysis presented in the previous section relies on a visual assessment of spatial clustering in the data. The clusters of blocks appear to be significant; but, strictly speaking, there is always a chance that the clusters of blocks revealed in equity mapping are a result of random patterning. This is particularly a danger when broad categories like “above the median” are used to stratify the data.

There are, of course, statistical methods to discern whether or not observed spatial patterns and spatial clusters are statistically significant or random. One such method that is particularly useful in equity mapping is Local Indicators of Spatial Association (LISA). (See Anselin 1995.) This test for spatial association (known as spatial autocorrelation) is designed so that a null hypothesis of no spatial autocorrelation—i.e. a random spatial pattern—is rejected if large values are consistently surrounded by large values, small values are consistently surrounded by small values, or large values are surrounded by small values, and vice versa (Anselin 1995). The testing procedure is easily accomplished using SpaceStat software (Anselin 1992). For any variable, the LISA function in SpaceStat returns a z-value and associated probability for each block. Mapping the significant values reveals clusters of
blocks that are spatially autocorrelated in a more rigorous, statistical sense.

**Comparing the Characterization of Access**

Essentially, deriving a measurement standard for equity in resource distribution depends on the definition of equity being used, and how it is measured. If equity is predicated on expansion of choice for disadvantaged groups, measurement methods will focus on access to facilities by spatially distinct socioeconomic groups. Assuming that the location of these groups can be agreed upon—for example, from census data—the task for communities is to agree upon how to measure access.

A primary issue to be decided is: what characterization of access is most suitable? Largely, this boils down to a decision about how distance between the user and the facility should be characterized. In all measures used in this paper, the value of the facility to the user declines with distance. If a community wishes to emphasize the effect of distance as a deterrent, then the gravity model may be appropriate. Alternatively, a community may wish to compare access to facilities as an average of all distances to all facilities (travel cost measure), which treats the resources of a city as a complete package of public goods. If the goal is to assess how to minimize the inequality of nearest distance between origin and destination, then a mini-
mum distance measure may be applied. Finally, if the
goal is to maximize the number of people “covered,”
and if it is decided that beyond a given radius, users
acquire no benefit, then a covering approach may be
warranted.

A useful way to assess these different characteriza-
tions of access is to compare the mapped distribution
of each type of measure. Figures 7 and 8 give visual
insight into the kinds of variation. Figure 7 shows a
distribution of travel cost quartiles; the darker shaded
blocks are those with a lower travel “cost.” Predictably,
the central portion of the city has, on average, more
access to park facilities as a whole. Thus if a community
views the distribution of park facilities as a total
“package” of resources and compares average distance
to all parks, the peripheral areas of the city clearly end
up behind. This situation may not be inconsistent
with need-based equity goals if disadvantaged groups
are located in the central portion of the city.

Comparing figure 7 with figure 8 reveals how the
spatial pattern of access changes substantially if access
is measured differently. Figure 8 shows two distribu-
tions that are markedly different from the quartile dis-
tribution of travel cost. For both the minimum
distance and covering model distributions, higher
scores (darker shaded blocks) correspond with higher
access. The covering model map reveals that high ac-
cess is somewhat polarized into the west and north-
eastern portions of the city, whereas the distribution
of access scores defined as minimum distance to the
nearest park presents a more variegated pattern. In the
latter case, high scores (i.e., high minimum distances)
identify those blocks that have fallen “between the
cracks” in their proximity to parks. The main conclu-
sion to be drawn is that a characterization of access to
parks that differentiates blocks with “high access” and
those with “low access” can vary significantly, de-
pending on how access is defined.

Conclusion
Equity mapping is a useful visualization tool. In
an interactive GIS format, the procedure allows plan-
ers to gauge the degree of equity associated with any
particular geographic arrangement of public facili-
ties. The process of building equity maps should be a
standard procedure in any local planning office. Any
locality that has the basic components—locational in-
formation on public facilities, census data, a standard
GIS package, and a statistical package—can explore spatial equity issues.

The process of equity mapping proposed in this paper proceeds as follows. First, the analyst must choose among a number of methodological alternatives: the type of facility used (or a "package" of public facilities); the attributes of the population to be included (i.e., how need is to be characterized); the type of accessibility measurement to be used (one model, or more than one for comparative purposes); the distance measurement to be used (for example, straight-line or network-based); and the parameters of the access measures (covering radii, distance decay parameter, etc.). The analyst may also decide to increase the complexity of any given measure by adding additional components to it (for example, by adding a demand constraint).

Once the accessibility measures have been calculated, the second step is to enter the locational and attribute data into a GIS for mapping and analysis. Attributes for facilities (either planned, existing, or both) as well as for population units (for example, census blocks) are included. If those are not available in the GIS, a statistical package must be selected. Finally, the analysis is performed, consisting of spatial univariate, bivariate, or multivariate analysis, and the mapped distribution of data and the spatial patterns are reviewed in order to assess the spatial equity of facility distribution.

Essentially, the construction of equity maps is exploratory spatial data analysis. Relationships are discovered and assessed, and data inputs are reformulated to investigate, in an interactive way, existing and/or planned equity patterns. As with any seemingly simple method, the method does not reveal all the complexities involved. Admittedly, it is no easy matter to demarcate clearly between "bias" and "no bias" in distributions, particularly since tests of significance are not readily applied.

One must also consider the interpretation that very little "bias" exists. When the equity of plans is assessed in terms of how they are implemented, for example, observed patterns and relationships may reflect no more than the inability of plans to anticipate sociodemographic change. Distributions may reflect no more than the fact that the placement of park facilities is not based on the distribution of socioeconomic data. Yet even if distributional patterns reflect only an ad hoc approach to facility planning, the ability to delve into the relationship between access and socioeconomic characteristics is no less useful.

No doubt equity mapping will be criticized on the basis of methodology. The models of accessibility used in the construction of equity maps can be almost infinitely refined in the attempt to acquire more precise measurement. The use of equity maps will be troublesome to those who are more comfortable with a perceptual-behavioral paradigm when assessing issues such as equity in urban environments. Some will see the necessity of incorporating the quality of the facility or the service in the assessment. Smaller spatial zones, sophisticated measures of personal mobility, and greater detail on resident age structure and use preferences have all been called for (Pacione 1988). It is not clear, however, whether the increased costs for data gathering and computation may outweigh the unsubstantiated gain in precision. The real benefit of the approach outlined in this paper is that it is a technique that is readily available to local planners.

Perhaps more damaging to the notion of equity mapping is the inherent difficulty of differentiating among varying levels of need: how are the various categories of advantaged versus disadvantaged groups to be defined? The approach advocated in this paper takes as its philosophical basis a "moral imperative"; in the tradition of Kant, Hobbes, Rousseau, Hegel and Marx, a unitary public interest is identified (Weaver et al. 1985). Yet, even if that elusive notion can be identified, planners will have to grapple with defining what range of territorial variation is acceptable: to what extent is the community willing to redistribute public welfare and offset the inequities imposed by a free-market economy?

In any case, as stated at the outset, the complexities involved do not undermine the legitimacy of the endeavor. The method demonstrated in this paper should be viewed as a framework rather than a rulebook for the investigation of spatial equity. In this light, the goals of equity mapping are fairly basic: the production of equity maps serves to promote, through visualization, a sociological understanding of the relationship between distribution and need. Although this method does not address the underlying sociopolitical processes that determine who benefits and who pays for public resources, the mapping of spatial opportunity in relation to population profile establishes an essential, and as yet overlooked, preliminary basis for inquiry.

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NOTES

1. This statement is particularly controversial when planning is equated with regulation (as discussed by Richardson and Gordon (1993)). The allocation of public facilities is no different, and represents one arena in which planners are especially needed to compensate for market failure (e.g., in the provision of public facilities like parks; see Banerjee (1993)).

2. Policies—as reflected in comprehensive plans—imply theories, whether explicitly stated or not. Similarly, the distribution of public facilities such as parks is based on a particular, perhaps unstated service distribution theory that implies a certain standard. To discover what the implicit theories and standards that operate in comprehensive plans are is a task similar to deconstructing the discourse of planning. (See Moore-Milroy 1989.)

3. As with most empirical endeavors, the specific methodology used is not infallible. A few of the difficulties associated with the building of equity maps are: (1) ecological fallacymodifiable areal unit problem, which occurs when characteristics of aggregate data are also assumed to be present in the individual data; (2) temporal lag problem, which results from the fact that the relationship between facility distribution and population distribution (which determines the distribution of needs) is dynamic; and (3) the problem of defining accessibility, which can be very complex in its definition and measurement.

4. Any appropriate standard could be used. For figures 2 and 3, 0.0025 acres per person was the standard used, based on DeChiara and Koppelman’s Urban Planning and Design Criteria (1982).

5. Of course, the normality of the data would have to be investigated, and the unique methodological problems that result from performing bivariate correlation analysis using spatial data (Haining 1991) would have to be addressed. In the absence of data normality, the relative magnitude and the signs of the coefficients (positive or negative) could still be of value.

REFERENCES


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