EVALUATING NEIGHBORHOOD ACCESSIBILITY: ISSUES AND METHODS USING GEOGRAPHIC INFORMATION SYSTEMS

by

Susan L. Handy

Kelly Clifton

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Southwest Region University Transportation Center
Center for Transportation Research
The University of Texas at Austin
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16. Abstract

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The goals of the project described in this report were to identify the factors that contribute to accessibility at the neighborhood level and to explore the variety of ways that planners can evaluate neighborhood accessibility using existing data sources and the capabilities of geographic information systems (GIS). Rather than developing a single measure of accessibility, we set out to design and build a neighborhood accessibility database that would allow planners to assess a wide range of accessibility factors and identify specific kinds of deficiencies in either land use or transportation systems.

Despite limitations in both data availability and GIS capabilities, several useful and insightful measures of neighborhood accessibility in terms of proximity to retail and services and the simple and practical database can be calculated. These measures, calculated for seven neighborhoods in Austin, TX enabled a comparison of accessibility between different kinds of neighborhoods that highlighted potential deficiencies and inequities. The development of a database to monitor and assess neighborhood accessibility is the first step towards developing policies that will enhance accessibility and guarantee an adequate range of choice.

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ABSTRACT

Several different trends in the 1990s have led to increased efforts to improve the alternatives to driving. In response, planning agencies have been taking a new look at both transportation and land use policies in an effort to enhance transportation choices. Their efforts have been hampered by a lack of practical planning tools. What's needed are practical measures of accessibility that can be used to evaluate the proximity to and adequacy of activities and the availability of alternative modes in neighborhoods throughout the city.

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EXECUTIVE SUMMARY

Several different trends in the 1990s have led to increased efforts to improve the alternatives to driving. In response, planning agencies have been taking a new look at both transportation and land use policies in an effort to enhance transportation choices. Their efforts have been hampered, however, by a dearth of applicable planning tools, particularly measures or indicators they can use to evaluate the adequacy of current policies or the impacts of proposed policies at the neighborhood level. Planners are beginning to turn to accessibility measures to fill this need. As generally defined, accessibility reflects the ease of reaching needed or desired activities and thus reflects characteristics of both the land use system (where activities are located) and the transportation system (how the locations of activities are linked). Despite an extensive academic literature, examples of the actual use of accessibility measures in planning are relatively scarce, and the literature offers few approaches that adequately assess accessibility at the neighborhood level for different modes of travel. What's needed are practical measures of accessibility that can be used to evaluate the proximity to and adequacy of activities and the availability of alternative modes in neighborhoods throughout the city.

The goals of the project described here were twofold: first, to identify the factors that contribute to accessibility at the neighborhood level, and second, to explore the variety of ways that planners can evaluate neighborhood accessibility using existing data sources and the capabilities of geographic information systems (GIS). Rather than developing a single measure of accessibility, we set out to design and build a neighborhood accessibility database that would allow planners to assess a wide range of accessibility factors and identify specific kinds of deficiencies in either land use or transportation systems.

The first step in designing a neighborhood accessibility database was to identify the range of factors that contribute to accessibility for residents of a neighborhood. Although few studies address this need directly, we found a number of studies which provide insights into the factors that matter to residents and a smaller number which provide ways of measuring these factors. Activity factors include those that relate to the activity itself, such as the size of the activity or the quality of the products or services provided, and those that relate to the design of the site where the activity is located, such as the density and mix of activities found at the site. Transportation factors can be categorized as impedance factors (e.g. distance, time, cost), level-of-service factors (e.g. crowding, directness of route, information availability), terminal factors (e.g. parking availability, intermodal connections, terminal design), and comfort factors (e.g. traffic speed, lighting, weather, scenery). The set of factors and their relative importance is somewhat different for each mode. For both activity and transportation factors, the research suggests that qualitative and subjective factors are important enough to residents that planners must consider them.

Practical data limitations hinder the ability of planners to evaluate these neighborhood accessibility factors on a city-wide basis. Usually, data on qualitative and subjective factors are not readily available; these factors are hard to assess and the accuracy and stability of the observations are often questionable. Available land use data include data on residents from the Census of Population and Housing down to the block level and data on employment from Metropolitan Planning Organizations at a census tract or traffic analysis zone level. In addition, telephone directory listings in electronic format are available commercially and provide the name of the business, its Standard Industrial Classification, and its street address with geocoding. Although these databases have important limitations, the availability of disaggregate business data for an entire urban area permits a detailed analysis at both the local and regional level. Available data on transportation factors are usually limited to automobile and transit travel distances, times, and costs. Data on infrastructure for pedestrians and bicycles are not generally available, although the situation seems to be changing.

The spatial nature of both land use patterns and transportation networks lends itself to evaluation using a geographic information system. A GIS has several built-in capabilities that enable the analysis of a variety of accessibility factors. The buffering capabilities of GIS allow for a simple analysis of proximity to retail and services at several distances from the neighborhood. A number of useful accessibility measures can be readily calculated from the available land use data using this buffering capability. We defined the retail *intensity* as the total number of all retail establishments that occur within the neighborhood boundaries. We defined the *diversity* of development as the number of different types of establishments, as defined by SIC codes, that occur within a specified area. Finally, we defined retail *choice* as the number of establishments of a particular type that occurs in the neighborhood. All of these measures can be normalized by population or land area to facilitate comparisons between neighborhoods. In addition, *location quotients*, a technique borrowed from the field of regional economics, can be calculated that compare the share of local businesses that a particular type of business represents in the neighborhood to the share for the city or region as a whole. This measure can be used to show a relatively high concentration of activities in a certain area, or the converse, a relative lack of activities

These measures may provide a useful and insightful analysis of neighborhood accessibility in terms of proximity to retail and services. However, they do not reflect the structure or characteristics of the transportation system, particularly for transportation modes other than driving, and they focus on the entire neighborhood as the unit of analysis. These limitations reflect limitations in both data availability and the structure of GIS. Several recent research projects demonstrate some of the ways that GIS can be used to evaluate accessibility but also reflect the limitations of current GIS technology and data sources. In all these examples, researchers point to the poser of visualization as an important benefit of the use of GIS for accessibility analysis.

To explore the usefulness of the alternative measures of neighborhood accessibility, we chose as case studies seven neighborhoods in Austin that vary in their physical form, era of development, location within the city, and socio-economic characteristics. For the seven neighborhoods we calculated the intensity, diversity, and choice measures, as well as the location quotients, for business types deemed most important to neighborhood access. These measures proved useful in illustrating differences in accessibility that occur in neighborhood development patterns. Neighborhoods built in the 1970s and 1980s were shown to provide much lower levels of accessibility than neighborhoods built before WWII or even in the 1950s and 1960s. This finding is due at least partly to the location of these neighborhoods at the fringe of the metropolitan area. In addition the measures pointed to deficiencies in lower-income neighborhoods, not so much in terms of the numbers of establishments but rather in the types of establishments found there.

Although the available data and the capabilities of GIS fall short of providing planners with a full assessment of the factors that influence neighborhood accessibility, the simple analysis that is currently possible still yields useful information and helps to identify important differences in accessibility between neighborhoods. Even with limited data and limited GIS capabilities, it is possible to generate useful measures of neighborhood accessibility. Fortunately, both the data available to planning departments and the facility of planning staff with GIS are improving. Planners have an interesting opportunity to help the process along by making data collection itself an important part of the planning process - to use data collection as a way to facilitate public involvement and build technical capacity within neighborhoods as well as to build a city-wide database. Planners can also use the mapping capabilities of GIS to facilitate input from the neighborhood by helping residents to visualize and understand the implications of the data. Providing the neighborhood planning team with direct access to a GIS and sufficient training to use it effectively would be even better – and may not be as costly or impractical as one might think, as demonstrated by a growing number of examples. The development of a database to monitor and assess neighborhood accessibility is the first step towards developing policies that will enhance accessibility and guarantee an adequate range of choice - for both activities and the means to reach them - for all.

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CHAPTER 1. INTRODUCTION

Several different trends in the 1990s have led to increased efforts to improve the alternatives to driving. Federal transportation policy, as shaped by the Intermodal Surface Transportation Efficiency Act of 1991 and the Transportation Equity Act for the 21st Century of 1998, now emphasizes transit as well as walking and biking out of concern for both the environment and equity of service. The New Urbanism movement has focused attention on how the design of neighborhoods encourages or discourages walking, among other things, and has given weight the idea that land use regulations are also an important element of a transportation program. In addition, the relative lack of services in lower-income neighborhoods, where residents have more limited options for transportation, has been the target of renewed attention in recent years. In response, planning agencies have been taking a new look at both transportation and land use policies in an effort to enhance transportation choices. Their efforts have been hampered, however, by a dearth of applicable planning tools, particularly measures or indicators they can use to evaluate the adequacy of current policies or the impacts of proposed policies at the neighborhood level.

Planners are beginning to turn to accessibility measures to fill this need. As generally defined, accessibility reflects the ease of reaching needed or desired activities and thus reflects characteristics of both the land use system (where activities are located) and the transportation system (how the locations of activities are linked). An extensive academic literature on accessibility measures produced over several decades suggests many ways to define and measure accessibility, though examples of the actual use of accessibility measures in planning are relatively scarce. In addition, the literature offers few approaches that adequately assess accessibility at the neighborhood level for different modes of travel. What's needed are practical measures of accessibility that can be used to evaluate the proximity to and adequacy of activities and the availability of alternative modes in neighborhoods throughout the city.

The development of such measures presents interesting challenges. While traditional measures of accessibility focus on the distance to and size of potential destinations, for example, other characteristics of the local environment may have an important impact on travel options, particularly modes like walking and biking that also depend on how comfortable and safe the route feels. Traditional measures often assume that all residents care equally about the same factors and the same activities, when in fact preferences and needs vary from household to household. Of course, incorporating these qualities into an assessment of accessibility would require data that are not readily available nor easy to collect, a real obstacle to developing practical accessibility measures. Planners may find some help, however, in geographic information systems (GIS), which offer a unique tool for managing and analyzing data on the variety of land use and transportation characteristics that contribute to neighborhood accessibility.

The goals of the project described here were thus twofold: first, to identify the factors that contribute to accessibility at the neighborhood level, and second, to explore the variety of ways that planners can evaluate accessibility using existing data sources and the capabilities of geographic information systems (GIS). Rather than developing a single measure of accessibility, we set out to design and build a neighborhood accessibility database that would allow planners to assess a wide range of accessibility factors and identify specific kinds of deficiencies in either land use or transportation systems. Although we found the available data on characteristics of alternative modes of transportation and the capabilities of GIS to analyze transportation linkages more limited than we'd hoped, the simple and practical database we were able to construct for Austin, TX enabled a comparison of accessibility between different kinds of neighborhoods that highlighted potential deficiencies and inequities. Our hope is that this work will prove useful in the growing number of neighborhood planning programs found in Austin and throughout the country.

In Chapter 2, we provide a short review of the literature on accessibility measures and summarize existing research that identifies the range of factors that contribute to neighborhood accessibility. Chapters 3 and 4 include assessments of the kinds of land use and transportation data commonly available to planning departments and of the capabilities of GIS to help planners make sense of the data. In Chapter 5 we present an example of how this approach to evaluating neighborhood accessibility can highlight deficiencies and inequities using a sample of neighborhoods from Austin, TX. Finally, in Chapter 6 we consider possible improvements to the approach presented here that might be possible with additional data collection and more sophisticated analysis and discuss the role of GIS and accessibility measures in the neighborhood planning process.

CHAPTER 2. MEASURING ACCESSIBILITY

Accessibility is an important concept for urban planners in that it reflects the possibilities for activities, such as work or shopping, available to residents of a neighborhood or a city or a metropolitan area. Accessibility is determined by attributes of both the activity patterns and the transportation system in the area. The spatial distribution of activities, as determined by land development patterns, and their qualities and attributes are important components of accessibility, as are the qualities and attributes of the transportation system that links these activities, such as travel time and monetary costs by mode. Although most researchers agree on this general definition of the concept of accessibility, they have developed a wide variety of ways to measure it.

The literature on accessibility measures has a long history. Most measures can be classified as one of three basic types (Handy and Niemeier 1996). Cumulative opportunities measures are the simplest type. These measures count the number of opportunities reached within a given distance or travel time and give an indication of the range of choice available to residents. Gravity-based measures are derived from the denominator of the gravity model used to predict trip distribution; these measures weight the amount of activity at different destinations by the cost (or time or distance) to get there. The third type of measure is based on random utility theory, in which the probability of an individual making a particular choice depends on the utility of that choice relative to the utility of all choices; the accessibility measure comes from the denominator of the model and reflects the total utility of all choices. All three types of measures require that the activities and the transportation system be characterized in some way. In general, the three approaches offer different trade-offs between the simplicity and ease of comprehension of the measure and the sophistication with which the activities and transportation system are characterized. The more sophisticated measures also require the more sophisticated data.

Whatever the form of the measure, the key is to measure accessibility in terms that matter to people in their assessment of the options available to them (Handy and Niemeier 1996). For the activity component of accessibility, this means knowing something about what activities and what characteristics of different activities matter to people. A neighborhood resident might value proximity to a supermarket but not care about being near a motel, for example, and he might care about the atmosphere of the supermarket as much as the relative prices of the goods sold there. For the transportation component of accessibility, this means knowing something about what characteristics of different modes of travel matter to people. A resident may be most concerned about the time it takes to get to a destination using different modes, or may focus more on cost.

In developing a practical technique for assessing neighborhood accessibility, then, a number of questions must be addressed. First, what factors tend to matter most to residents? Clearly it is impossible to measure, let alone know, every factor that matters to every resident. Fortunately, a number of studies help to identify the factors that seem to matter most to most residents. We compile a list of these factors below. Second, what kind of data are available or can be collected about these factors? The data commonly used by planning departments miss many of the factors important to neighborhood accessibility and may not be available in a useful format if they are available at all. Some factors are reasonably objective and can be easily measured, while others involve significant subjectivity and are not so easily quantified. We explore these issues in Chapter 3.

Third, how can planners make sense of the available data on neighborhood accessibility factors? Traditional accessibility measures can, depending on their structure, specification, and calibration, combine a number of important factors into a single, all-encompassing measure of accessibility. This approach, however, may be neither practical nor desirable for planning purposes. The more complex the measure, the more data and the more analysis skill required, limiting the ability of most planning departments to develop such measures. The development of utility-based measures, for example, is probably beyond the capability of most departments. In addition, much important information is lost when the data are collapsed into a single or even a few measures. Traditional measures of accessibility may help planners identify neighborhoods where accessibility is relatively high or relatively low, but they do not, on their own, point to the specific factors contributing to high or low accessibility for residents. As an alternative, we explore the practicality and effectiveness of using GIS to manage and analyze a database of neighborhood accessibility factors. This effort is described in Chapters 4 and 5.

Finally, the use of the neighborhood as the spatial unit of analysis presents both opportunities and challenges. Analysis at the neighborhood level allows for a more detailed examination of the qualitative characteristics of the local environment than would an analysis at a larger geographic level. However, if neighborhoods are defined by their natural boundaries (usually major arterials or open space), their areas and populations may vary considerably. Thus, some normalization by area or population may be necessary in order to compare accessibility between neighborhoods. In addition, accessibility may vary considerably within a neighborhood depending on the distribution of retail and services relative to the distribution of population within and among adjacent neighborhoods. Thus, it is important to also evaluate accessibility from different points within the neighborhood. This evaluation requires a more sophisticated analysis, including some sampling of points within the neighborhood and a more accurate estimate of distances between points. These issues are highlighted in the example presented in Chapter 5.

The first step in designing a neighborhood accessibility database is to identify the range of factors that contribute to accessibility for residents of a neighborhood. Although few studies address this need directly, we found a number of studies which provide insights into the factors that matter to residents and a smaller number which provide ways of measuring these factors. We found more research that spoke to transportation factors than to activity factors, but in both cases the research suggests that qualitative and subjective factors are important enough to residents that planners must consider them.

ACTIVITY FACTORS

The most basic characterization of activity is that a particular type of activity can be found at a particular location. Cumulative opportunities measures, for example, typically reflect a simple tally of locations of a particular type of activity. Another common approach is to account for the relative amount of activity at each location, usually measured in terms of the number of employees or sometimes the square footage of building found at each location. This approach is commonly used in both gravity measures and utility measures of accessibility. But beyond the existence of an activity and the amount of an activity at a particular location, what factors influence the attractiveness of a particular destination to residents?

Our previous research has identified several specific characteristics that residents consider in evaluating the activities in and around their neighborhood; these characteristics range from mostly objective to highly subjective (Handy et al. 1998; Handy and Clifton forthcoming). The more objective factors for an activity such as grocery shopping include size of store, prices, ease of parking, and range of product selection. More subjective factors include quality of products, crowds, length of check-out lines. Highly subjective factors like atmosphere also matter. The relative importance of such factors is difficult to assess, however. Not only does the importance of these factors vary by individual, but it may vary at different times for each individual: residents may use different criteria in evaluating stores for major food shopping than for a trip for a gallon of milk, for example.

Recker and Kostyniuk (1978) also studied factors that influence destination choice for grocery shopping trips in urban areas. Their study included a survey of respondents' perceptions of grocery stores they frequented on a variety of different attributes. Using factor analysis, they reduced these attributes into four factors: quality (determined by reasonable prices, variety of items, meat quality, produce quality, selection of goods, and has items other stores don't), accessibility (determined by ease of getting home from store, to store from work, and to store from home), convenience (determined by parking facilities, proximity to other shops, hours of operation, ease of finding items in store, and crowding in store), and service (acceptance of credit cards, check cashing, ease of returning goods). In the destination choice models estimated, only the service factor proved insignificant.

Research in the field of retailing, of course, provides additional insights into factors that influence the customer's choice of a particular establishment. A 1980 study by Nevin and Houston, for example, looked at the role of image in the attractiveness of urban shopping areas. Besides factors such as the quality of stores, the variety of stores, product quality and selection, and general price level, they found that the availability of lunch/refreshments, the adequacy of comfort areas, the friendliness of the atmosphere, the helpfulness of store personnel, and whether the center was an easy place to take children also contributed to the attractiveness of a shopping area.

These studies suggest a list of factors that contribute to the attractiveness of a particular activity site. These factors can be grouped as relating to the activity itself or relating to the design of the site (Table 2-1). This list is by no means exhaustive, but it gives a sense of the wide range of factors that contribute to attractiveness. It is also important to remember that the relative importance of these factors will vary depending on the type of activity.

TABLE 2-1. ACTIVITY FACTORS

Factors Related to Activity Itself:
- size and scale
- quality of products/services
- variety of products/services
- price of products/services
- hours of operation
- crowds/lines
- interior design
- atmosphere
- ownership (local vs. chain)
- customer recognition

Factors Related to Site Design:
- mix of activities at site
- density of activities at site
- parking facilities
- atmosphere
- landscape design

What activities to include in an assessment of neighborhood accessibility is also an important question. Most examples of accessibility measures in the literature use total retail and service employment, without further differentiation of activity types. Some studies focus on specific kinds of activities, such as grocery shopping (Handy and Neimeier 1996) or health care services (Wachs and Kumagai 1973). Our previous study gives some indication of the local businesses most frequently used by residents of six Austin neighborhoods. Supermarkets and grocery stores topped the list, followed by drug stores, restaurants, discount stores, convenience stores, video stores, Laundromats or cleaners, and bakeries (Handy, et al. 1998). This list can serve as a guide to activities to include in an assessment of neighborhood accessibility. What it leaves out, however, are possible high-priority activities not located in or near these six neighborhoods.

TRANSPORTATION FACTORS

Just as important as the activities found in and around the neighborhood are the options residents have for getting there. Distance and time are used most often as measures of impedance in accessibility functions and represent the burden required to travel to a particular destination - an important factor but not the only one. While distance and time can be important considerations in the decision to drive, walk, bike, or ride transit, additional factors contribute to the varying degrees of accessibility offered by different modes of travel in different neighborhoods. Mode choice models and level-of-service measures as well as exploratory studies suggest a long list of transportation factors that contribute to neighborhood accessibility for different modes (Table 2-2). These factors can be categorized as impedance factors, level-of-service factors, terminal factors, and comfort factors.

Accessibility factors for drivers are, perhaps, the most straightforward. Mode choice models consistently show that travel time, or sometimes a generalized travel cost including travel time and monetary costs, is the most significant factor to drivers. Other factors that influence the travel time or cost, including traffic volumes, signalization, directness of route, and continuity of route, may also be important. Drivers may consider the availability and cost of parking at the destination. Comfort factors may also play an important role for some drivers in their perception of accessibility: poor lighting, bad weather, excessively high or low traffic speeds, high volumes of traffic, unappealing scenery, inadequate signage, or poor pavement condition may contribute to a negative perception of accessibility. The importance of these perceptual factors is mostly undocumented. Work by Ullrich (1991), however, shows that the kind of chaotic visual environments found along many (if not most) arterials in metropolitan areas significantly increases levels of stress for drivers.

TABLE 2-2. TRANSPORTATION FACTORS BY MODE

	Automobile	Transit	Walking	Bicycling
Impedance Factors				
distance	X	X	X	X
in-vehicle time	X	X		
out-of-vehicle time	X	X	X	X
cost	X	X		
topography			X	X
Level of Service Factors				
volumes/crowding	X	X	X	X
signalization	X	X	X	X
service frequency		X		
hours of operation		X		
directness of route	X	X	X	X
continuity of route	X	X	X	X
information availability		X		
signage	X	X	X	X
facility widths	X		X	X
vehicle design	X	X		X
shelter		X	X	X
benches		X	X	
Terminal Factors				
parking availability	X	X		X
parking cost	X	X		
terminal locations		X		
intermodal connections		X	X	X
terminal design	X	X	X	X
Comfort Factors				
traffic speed	X	X	X	X
traffic volumes	X	X	X	X
pavement condition	X	X	X	X
lighting	X	X	X	X
weather	X	X	X	X
shade		X	X	X
scenery	X	X	X	X
crime/police presence		X	X	X
cleanliness		X	X	X
conflicts with other modes	X	X	X	X
other users	X	X	X	X

Mode choice models show that travel time is the most significant factor in the decision to use transit as well. However, most models also show that transit users differentiate between in-vehicle and out-of-vehicle time, assigning significantly greater cost to the latter. This finding reflects the exposure of the transit user to the elements as well as to the uncertainty of transit service as he waits for a transit vehicle. As a result, amenities such as benches and shelters are important to transit users, as are factors that influence how safe transit users feel while waiting, including lighting, the speed and volume of passing traffic, crime levels in the area, etc. A study of customer satisfaction among riders of the Bay Area Rapid Transit (BART) system (Weinstein 2000), for example, used factor analysis to group over forty attributes of the system into eight factors influencing satisfaction, listed in order of relative importance: service and information timeliness, station entry and exit (including length of lines, reliability of fare gates, availability of escalators and elevators, etc.), train cleanliness and comfort (determined by noise levels, graffiti, cleanliness of windows, temperature, seat comfort, etc.), station cleanliness, police presence (in stations, parking lots, and on trains), policy enforcement (such as no smoking, eating, or drinking), and parking (car and bicycle parking plus lighting).

Although pedestrians also are sensitive to travel time and are limited in how far they can travel by the slow pace of walking, they are also highly sensitive to the character and quality of the environment through which they walk. Our previous study showed that perceptions of safety, shade, and the presence of other people were important determinants of the frequency with which residents walked in the neighborhood (Handy, et al. 1998). Several recent efforts to evaluate the pedestrian environment also point to important accessibility factors. In the LUTRAQ studies, a Pedestrian Environmental Factor (PEF) was calculated from four factors: ease of street crossing, sidewalk continuity, local street connectivity, and topography (1000 Friends of Oregon 1993). In Fort Collins, CO, a pedestrian level-of-service measure is used in evaluating the traffic impacts of new development. This measure incorporates the directness of street layout, the continuity of sidewalks, the width of street crossings, visual interest and amenities, and security/safety evaluations (Moe and Reavis, undated). The City of Gainesville, FL, developed a pedestrian level-of-service measure that included the provision of a pedestrian facility (characterized by continuity, width, parallel alternatives), conflicts (driveways and side streets, pedestrian signal delay, crossing width, speed limits, presence of medians), amenities (buffers, benches, lighting, shade trees), motor vehicle level-of-service (to reflect volumes of traffic), maintenance, and transportation demand management or multi-modal policies (Dixon 1995). Sarkar (1993) used a pedestrian level of service measure based on safety, security, comfort and convenience, continuity, system coherence, and attractiveness to evaluate the street environment in European cities. Pedestrian level-of-service is also influenced by the degree to which sidewalks and curb ramps meet the requirements of the Americans with Disabilities Act. Sidewalk characteristics such as driveway crossings, cross slopes, small changes in level (including irregularities), clearance widths, and protruding objects determine the accessibility of sidewalks to persons with disabilities (Axelson, et al. 1999) – and to parents with strollers, kids on skateboards or scooters or bicycles, and pedestrians in general.

Bicycle riders are influenced by a mostly parallel set of factors. The National Bicycling and Walking Study included an assessment of the reasons why bicycling is not being used more extensively (FHWA 1992). In reviewing a number of surveys on bicycle use, this study found that primary deterrents to cycling included traffic safety concerns, adverse weather, inadequate parking, and road conditions, and that secondary deterrents included fear of crime, lack of bicycle routes, inconsiderate drivers, and inability to bring bicycles on the bus. The FHWA has, more recently, developed a "bicycle compatibility index" to evaluate the appropriateness of a roadway for bicycle use. This index includes the presence of a bicycle lane, the width of the lane, the width of the curb lane, traffic volume in the curb lane and other lanes, speed of traffic, the presence of a parking lane and its occupancy, truck volumes, parking turnover, and right-turn volumes (FHWA 1999). The City of Gainesville also developed a bicycle level-of-service measure, similar to its pedestrian measure but with slightly different definitions of each factor (Dixon 1995).

CHAPTER 3. DATA NEEDS AND ISSUES

Practical data limitations hinder the ability of planners to evaluate these neighborhood accessibility factors on a city-wide basis. While some relevant data may be available, complete information in formats compatible with computer applications often is not. Usually, data on qualitative and subjective factors are not readily available; these factors are hard to assess and the accuracy and stability of the observations are often questionable. Gathering detailed information about activity systems and transportation systems, let alone residents' perceptions of them, would require a time-consuming and costly data collection effort. Planners must weigh the costs of collecting such data with the potential benefits.

LAND USE DATA

At a minimum, an accessibility analysis requires information about what kinds of activities exist and where they are located. The availability of land use data and its level of detail often vary by local planning department. Data about residents are the easiest to find. The Bureau of the Census provides aggregate socio-economic data down to the census tract, block group, and even block level; however, since the Census is only conducted every ten years, it may not reflect recent changes on the neighborhood level. Some jurisdictions may have updates of the Census data for population and, more rarely, socio-economic characteristics.

Data about employment are more difficult to find. Most Metropolitan Planning Organizations and some cities have developed databases of employment by type by area (census tract or traffic analysis zone), but the quality of such data is notoriously poor and the categories of employment are usually quite broad. Data on floor space by type of commercial or industrial use can sometimes be extracted from the databases of local tax assessors, and zoning classifications are also sometimes used as an indication of land use. However, it is often difficult to find accurate and specific information about current land uses in electronic format, and collecting detailed information through field work can be laborious and time consuming. In most cases, data on the amount of several general categories of activities at the zone or tract level are available, if nothing more.

Telephone directory listings for both businesses and residences provide more specific data on what land uses are located where and are readily available in electronic format. For this study, we used the Select Deluxe CD-ROM for the year 1996. These data include business or residential name, address, phone number, and geographic coordinates in latitude and longitude. Business listings also include approximations of the appropriate Standard Industrial Classification (SIC) codes to the four-digit level.

The use of telephone listings as a source for land use data offers several advantages. First, the data are readily available and relatively inexpensive. The CD-ROM can be purchased at many computer software retail stores, and data for the entire United States cost less than $150 as of this writing. Second, the SIC approximation allows for easy classification of business types and thus permits disaggregate analysis on specific industries or services. Third, the addresses for business and residential listings are already geocoded and can be easily imported in to GIS software. Last, the availability of disaggregate data for an entire urban area permits a detailed analysis at both the local and regional level.

However, using these data for accessibility analysis also has its drawbacks. First, establishments and households with multiple telephones are over-represented in the database as are households where each person using a phone number is listed in the directory, and those businesses and residences without a phone at the time of publication of the directory are missing from the data set. Second, the SIC codes provided in the data are only approximations based upon the category under which the business is listed within the yellow pages. In addition, businesses turnover with some frequency so that the most current data available may no longer be accurate, and those listings that do not include an address in the telephone directory will be omitted. Finally, although these data provide detailed information about the location and type of establishment, other land use characteristics cannot be obtained from this data set; no information about the size, quality, or site design of the businesses are included.

TRANSPORTATION DATA

The availability and detail of transportation information also varies widely by planning department. Transportation data often describe average characteristics of the system at the zone, city or regional level and may mask many of the variations that occur within the neighborhood. Usually, detailed data for modes other than driving are not readily available.

Network files can be obtained from the Bureau of the Census in the TIGER/Line files. These files may require some modification to capture changes made in the road network since publication and ensure the necessary level of detail. Enhanced and updated network files can be obtained from private vendors and sometimes from MPOs or other local agencies. These files allow for distance calculations between points on the network, although travel times are usually more important to residents. Estimating the travel times between two points requires estimations of the average travel speeds for each link in the network, which for drivers is dependent upon traffic volumes. Data on automobile travel times are available from regional transportation planning models usually maintained by MPOs. These data can be problematic, however: they are often rough approximations, not available for most local roads in the network, out of date, rarely reflect temporal variations, and reflect zone-to-zone rather than point-to-point times. As an alternative, speeds limits can be used to estimate travel time, but speed limit data are often still not available in GIS format. The problem of compiling the necessary transportation data is complicated by the lack of coordination between various government agencies responsible for data on different transportation factors.

Data for alternate modes is often difficult to locate. For transit, data about the location of transit stops, routes, capacity and schedules are usually available but may not be in electronic format. Accurate information about the presence of benches, shelters, and lighting, crime and safety statistics, and intermodal access is less often available. Collecting this type of detailed information usually requires fieldwork**.** For example, as of this writing, Capital Metro, the transit authority in Austin, TX, has data on the locations of transit stops in electronic format that can easily be incorporated into a GIS analysis. However, this data contains no additional information about the stops, such as presence of bus shelters, that might be valuable in an accessibility analysis. Ridership information has been available in electronic format by route and stop, but bus routes themselves have been put into electronic format only recently.

Data on infrastructure for pedestrians and bicycling are not generally available, although this situation seems to be changing. Some cities may have an inventory of sidewalks but such data seem rarely to be in electronic form. In the mid-1990s, the City of Portland completed a city-wide sidewalk inventory that required considerable time and labor. In 1995, students in the Neighborhood Transportation Planning class at the University of Texas completed a sidewalk inventory for one neighborhood in Austin that included not only the mapping of where sidewalks were found within the neighborhood but also an assessment of the condition and characteristics of the sidewalks. This data collection effort took approximately ten people and two solid days of work to complete. Data on other factors that influence the quality of the walking and biking experience, such as tree canopy, can sometimes be extracted from aerial photos. Data on more qualitative factors, such as the quality of the scenery and the presence of interesting houses or gardens to look at, can only be evaluated through field work and the development of criteria by which to judge such factors. The LUTRAQ study used such a system to evaluate less qualitative factors such as topography and the interconnectedness of the street network (1000 Friends of Oregon).

The changing attitudes about alternate modes and the availability of federal funding for transit, bicycling, and pedestrian projects have influenced some planning agencies to focus more attention on the deficits in data related to these modes. In Austin, TX, an extensive data collection effort was initiated to gather information about the street conditions and physical characteristics along existing and proposed bike routes and their adjacent streets. Data about traffic volumes and speeds, pavement conditions, street and lane widths, presence and continuity of bike lanes, number of stop signs and traffic signals along the route, and other objective criteria were compiled. Based on this information, the street segments were then ranked for bicycle friendliness and published on the bicycle route maps for distribution to the public. This model, when applied to all modes, represents a first step towards building a database of accessibility factors for use in both neighborhood and city-wide analysis.

CHAPTER 4. GIS ANALYSIS CAPABILITIES

The spatial nature of both land use patterns and transportation networks lends itself to evaluation using a geographic information system. With the increasing availability of spatial data and desktop GIS software packages, planners have acquired new analytical tools to evaluate needs and assess the benefits of policy alternatives. A GIS has several built-in capabilities that enable the analysis of a variety of accessibility factors. However, we found that while GIS has sufficient capabilities to evaluate the land use component of accessibility, our ability to analyze transportation linkages with GIS was limited in important ways. At the same time, several innovative applications of GIS to planning problems in recent research projects suggest that the full potential of GIS has yet to be reached.

POSSIBILITIES

The buffering capabilities of GIS allow for a simple analysis of proximity to retail and services at several distances from the neighborhood. For example, in a disaggregate analysis of travel behavior, Crane and Crepeau (1998) employed this buffering capability to incorporate neighborhood street design characteristics directly surrounding each household in the study. However, the use of straight-line distances in most buffering applications masks differences in network structure that might mean significant differences in distance and time, an issue discussed in the next section.

A number of useful accessibility measures can be readily calculated from the available land use data using this buffering capability. We defined the retail *intensity* as the total number of all retail establishments that occur within the neighborhood boundaries (or within some fixed distance beyond the boundary). This measure reflects the overall amount of commercial development within a neighborhood, although data on the size of different businesses are not available. We defined the *diversity* of development as the number of different types of establishments, as defined by SIC codes, that occur within a specified area. Finally, we defined retail *choice* as the number of establishment of a particular type that occurs in the neighborhood; for example, the number of grocery stores or pharmacies. All of these measures can also be normalized by population or land area to facilitate comparisons between neighborhoods.

A simple example can illustrate the different information about a neighborhood each measure conveys. Say that two neighborhoods have a similar *intensity* of development, each with 20 establishments within a reasonable walking distance. However, Neighborhood A has relatively lower retail *diversity* (with 3 different types of establishments: grocery stores, bakeries, and restaurants) when compared to Neighborhood B (with 8 different types of establishments: grocery stores, bakeries, laundries/dry cleaners, pharmacies, restaurants, banks, clothiers, and liquor stores). On the other hand, the measures show that Neighborhood A has much more *choice* in certain establishments as there are over 10 bakeries to choose from within walking distance compared to only 3 bakeries in Neighborhood B.

The land use data and buffering capabilities may also be used to show a relatively high concentration of activities in a certain area – or the converse, a relative lack of activities. The concept of a location quotient, widely used in the analysis of regional economies, is useful here. A location quotient in the context of neighborhood accessibility compares the share of local businesses that a particular type of business represents in the neighborhood to the share for the city or region as a whole. A location quotient greater than one indicates a higher concentration of an activity in the neighborhood than occurs in the region as a whole; a value less than one indicates less concentration. If, for example, in Neighborhood B in the above example, liquor stores make up 10% of all establishments, whereas liquor stores make up 2% of all establishments city-wide, the location quotient would be 5.0 for liquor stores for the neighborhood. This would suggest an over concentration of liquor stores in this neighborhood and could reflect greater demand on the part of local residents for liquor or the use of local liquor stores by residents from elsewhere in the city. In general, location quotients of less than one for important businesses or services would be of concern for a neighborhood, but location quotients greater than one for businesses that have negative impacts on a neighborhood (such as increasing traffic or encouraging alcoholism) would also be of concern.

LIMITATIONS

These measures may provide a useful and insightful analysis of neighborhood accessibility in terms of proximity to retail and services. However, they do not reflect the structure or characteristics of the transportation system, particularly for transportation modes other than driving, and they focus on the entire neighborhood as the unit of analysis. While these limitations are due partly to data limitations, they are also related to the structure of GIS. One important feature of desktop GIS packages is the display of different types of data in different layers. For example, point data such as residential locations or business establishments may be displayed in one layer while linear data such as street networks are displayed in another. This feature, which facilitates other types of spatial analysis and is a valuable tool for illustrating the combined effects of many different data types, can limit the ability to easily perform some operations that are useful for transportation applications.

In particular, in analyzing accessibility at the neighborhood level, it is desirable to calculate network point-to-point distances between households and the business establishments in an area. ArcView is one commercially available package that permits easy computation of the network distance between two points, a household location and the nearest grocery store, for example. Calculating the average straight-line distance between one household and all of the possible commercial establishments is also computationally tractable. However, the ideal neighborhood analysis would use point-to-point network distances (or better yet, travel times by mode) for all possible combinations of origins and destinations or at least a sufficiently large sample of origins. As of this writing, this function cannot be performed using the standard user interfaces and requires customized script to perform. Luckily, such scripts are increasingly available via the Internet, which is proving to be a valuable source of add-on capability for many GIS platforms.

This limitation leads to important limitations on accessibility measures. For example, a potentially useful accessibility measure is the distance to the nearest destination of a certain type; the distance to the closest medical facility may be one indicator of a neighborhood's access to health care, for example. GIS packages can easily determine which location of a particular type of establishment is closest to a given household but cannot readily make this determination for an entire neighborhood. This problem could be resolved, in part, by using neighborhood centroids to represent the aggregation of individual households. However, much of the value of performing an analysis on a neighborhood level would be lost, the variations in accessibility within neighborhoods would be masked with aggregation, and the accuracy of the point-to-point network distance calculations using centroids is questionable.

Transportation modeling programs, on the other hand, are ideally suited to estimating a from-to matrix of network travel times or distances. Most Metropolitan Planning Organizations and some cities maintain their own transportation models for forecasting travel demand and evaluating proposed transportation investments. Typically, these models operate on a zone system, so that travel times between zones are estimated. Because zones are usually the size of a census tract or so, the travel times estimated for these models are too coarse for the purposes of evaluating neighborhood accessibility. However, if a more detailed network, incorporating local and collector streets and designating each potential destination as a node in the network, is used, then these programs can be used to easily estimate a matrix of point-to-point distances or times. Our previous studies used the TRANPLAN package to estimate network travel times from households in our travel surveys to various retail destinations in and around the neighborhood (Handy 1996b; Handy et al. 1997). This approach enabled a household-level assessment of accessibility and an analysis of variations in accessibility within the neighborhood.

An alternative approach to the use of point-to-point distances is to map the portions of the network within a specified distance of a specified location, or what we termed "coverage." This analysis is relatively straightforward using the network capabilities of GIS. The results can then be presented in graphic format or can be converted into numeric form as the length of the streets within the specified distance of the destination as a percentage of the total length of the street network within the neighborhood. If residences are evenly distributed throughout the street network, then this measure gives a reasonable approximation of the share residents within the specified distance of the destination. The advantage of this measure over the intensity, diversity, and choice measures defined above is that it reflects the structure of the street network within the neighborhood and provides a more refined assessment of accessibility to nearby destinations.

EXAMPLES

Several recent research projects demonstrate some of the ways that GIS can be used to evaluate accessibility but also reflect the limitations of current GIS technology and data sources. In all these examples, researchers point to the power of visualization as an important benefit of the use of GIS for accessibility analysis.

Talen (1998) used GIS to evaluate the distribution of public facilities, such as parks, in terms of the match between the facilities provided and the needs of residents and in terms of the equity of the distribution across socio-economic groups. Four different measures of access from census blocks to parks were calculated: "gravity model," with parks weighted by size and separation distance between origin and each park destination; "minimizing travel cost," determined by the straight-line distance between each origin and each park destination; "covering objectives," measuring the number of parks located within a critical distance (essentially a cumulative opportunities measure); and "minimum distance" between each origin and the nearest park. Her "equity mapping" approach involved mapping the distribution of accessibility measures and the distribution of socio-economic data in order to evaluate spatial variation and characterize spatial association; statistical tests of spatial autocorrelation between accessibility and socio-economic characteristics were discussed but not presented. This study demonstrates the power of GIS as a tool for evaluating accessibility across an urban area and for evaluating the impact of public facilities plans on the equity of accessibility patterns. As Talen points out, the analysis can be refined through more precise measurement of accessibility, including an assessment of the quality of the facility or service, the use of origin zones smaller than census blocks, and more sophisticated measures of transportation. However, the increased costs of data collection and analysis may outweigh any benefits from increased precision: "The real benefit of the approach outlined in this paper is that it is a technique that is readily available to local planners."

A study by Grengs (2000) underway at Cornell University uses GIS to evaluate accessibility of inner-city neighborhoods to supermarkets. His initial approach was to use a buffer of a given distance around a busline that serves a supermarket and then to analyze the portion of each traffic analysis zone within the buffer area. Assuming that population and households are uniformly distributed throughout the zone, the area within the buffer can then be translated into the share of population within the buffer and, in particular, the share of carless households within the buffer. Grengs points to several limitations of this analysis. First, the analysis would ideally account for the affordability and quality of products offered by each supermarket. Second, the buffers were drawn around bus lines, rather than bus stops, given limitations of the data. Third, only transit trips possible without transfers were considered. Fourth, the approach estimates equal accessibility for households with and without cars. Nevertheless, an application of the analysis approach to Syracuse, NY points to (probably underestimated) disparities in accessibility to supermarkets for low-income and African-American households.

The British government's Planning Policy Guidance 13, which encourages development plans that promote development at locations accessible by modes other than the car and that improve access by non-car modes, has led to the creation of at least two models that evaluate accessibility using GIS. One project evaluated both the accessibility of a particular residential location to public transit ("local accessibility") and the accessibility of locations to specific destinations using public transit ("network accessibility") (Hillman and Pool 1997). Local accessibility was calculated as a combination of the walk time to a transit stop and the average wait time for service at that stop. For each residential location, access to all possible stops was evaluated and combined into one measure. Network accessibility was calculated by defining a set of destinations (such as schools or shopping centers) and identifying the transit routes that link the residential zone to the selected destinations. The total travel time, including walking to the stop, waiting at the stop, riding on the transit vehicle, any waiting for a transfer, and walking to the destination. An integrated system consisting of a GIS and public transit planning software was used to compile an extensive database on land uses, transit system characteristics, and population characteristics and to calculate accessibility measures. Applications for this tool include: the evaluation of proposed service changes in the transit system, the identification of areas of need based on accessibility levels and the distribution of specific population segments, and the assessment of public or private development proposals. But the fact that the required data on public transit systems are not always readily available has been an obstacle to the more widespread use of this tool.

A second U.K. project focused selected destinations and the determination of the number of residents within various travel times of a destination by each transportation mode (Hardcastle and Cleeve 1995). Although data on land uses and road networks were readily available for this model, estimates of travel times by mode were relatively crude, depending on assumptions about the match between the pedestrian network and the road network, for example, and about average travel speeds by mode. The developers of this model suggest taking into account pedestrian paths and bicycle trails, topography, bicycle parking, and other transportation factors. Suggested applications included the development of accessibility profiles for an area, evaluation of the potential of alternative locations for parking facilities, analysis of the match between travel patterns and transportation facilities and services, and assessment of road network needs over time.

CHAPTER 5. AUSTIN EXAMPLE

To explore the usefulness of the alternative measures of neighborhood accessibility defined in Chapter 4, we chose as case studies six neighborhoods in Austin from our earlier study (Handy, et al. 1997) and added an additional neighborhood for comparison. The neighborhoods vary in their physical form, era of development, location within the city, and socio-economic characteristics. These variations allow for comparisons across neighborhoods and the testing of assumptions about how accessibility varies in different types of neighborhoods.

The physical form of a neighborhood is generally related to its era of development. Pre-W.W.II neighborhoods are usually different from those developed later in a variety of ways: rectilinear street grids, narrower streets, a greater mix of housing styles and sizes, occasionally neighborhood stores. Neighborhoods were classified as "traditional" (pre-W.W.II), "early-modern" (post-W.W.II to 1960s), and "late-modern" (1960s to present). We assumed that traditional neighborhoods would have greater intensity and diversity of retail and service destinations within a short distance, but that these differences would tend to wash out at greater distances from the neighborhood. Location of the neighborhood relative to the center of Austin is also important because of its potential influence on accessibility. A more central location, we assumed, would mean better accessibility in terms of intensity, diversity, and choice beyond the neighborhood than a location at the fringe of the city. Finally, the socio-economic characteristics of a neighborhood may influence the numbers and types of businesses found there; for example, some businesses may shun lower-income neighborhoods that offer little profit potential, but upper-income neighborhoods may have more success in keeping unwanted away from the neighborhood.

In the earlier study, one pair of each type of neighborhoods was selected, with one neighborhood from each pair located north of Town Lake (which bi-sects the city just south of downtown) and the other south but both located similar distances from downtown (Table 5-1). These three pairs allow for a testing of differences between types of neighborhoods as well as an analysis of variation between neighborhoods of the same type. For the current study, the Cesar Chavez neighborhood was also included. The physical form of this neighborhood, located just to the east of downtown and north of Town Lake, is similar to that of the other traditional neighborhoods, but the residents of this neighborhood are more ethnically diverse and have a lower average income than residents of the other six neighborhoods. These differences enable some comparison of neighborhood accessibility across socio-economic characteristics.

TABLE 5-1. NEIGHBORHOOD CHARACTERISTICS

	Nbhd Type	Nbhd Location	Square Miles	1990 Popu-lation	1990 Median Income
Old West Austin	Traditional	Central North	0.75	4,311	$ 21,910
Travis Heights	Traditional	Central South	0.99	5,666	$ 24,551
Cherrywood	Early Modern	Central North	0.50	4,137	$ 28,206
Zilker	Early Modern	Central South	0.82	4,741	$ 25,359
Wells Branch	Late Modern	Fringe North	0.64	5,005	$ 38,862
Tanglewood	Late Modern	Fringe South	1.00	5,650	$ 34,873
Cesar Chavez	Traditional	Central North	0.76	3,958	$ 13,272

INTENSITY, DIVERSITY, AND CHOICE

For the seven neighborhoods, we calculated the intensity, diversity, and choice measures described in the previous chapter. In these calculations, three issues emerged: what land uses should be included, what buffering distances should be used, and what normalization - population or area - if any, should be used? On the first issue, we used SIC codes to extract retail and service establishments deemed most important to neighborhood access from the Select Deluxe database. We included all establishments classified as retail trade (SIC codes 5200 to 5999) plus establishments from various other selected categories, as listed in Table 5-2. We excluded legal and medical services from this analysis because of the large number of individual listings for private practitioners in both fields; a separate analysis for these important activities could be insightful.

TABLE 5-2. LAND USES ARE REPRESENTED BY SIC CODES

SIC Code	Description
5200 - 5999	Retail Trade: establishments engaged in selling merchandise for personal or household consumption and rendering services incidental to the sale of the goods
6021 - 6062	Commercial Banks, Savings Institutions, and Credit Unions
7211 - 7219	Laundry, Cleaning, and Garment Services
7231 - 7241	Beauty and Barber Shops
7251	Shoe Repair Shops
7299	Miscellaneous Personal Services
7832	Motion Picture Services
7841	Video Tape Rental
7933	Bowling Centers
7991 - 7999	Amusement and Recreation Services
8231	Libraries
8351	Child Day Care Services
8412 - 8422	Museums, Art Galleries, Botanical Gardens

Source: Standard Industrial Classification Manual 1987. Washington, DC: Executive Office of the President, Office of Management and Government, 1987.

On the second issue, we selected several different buffering distances in order to evaluate the sensitivity of the results to the distance chosen. We calculated each measure for establishments within the boundaries of the neighborhood and within distances of 1/4 mile, 1/2 mile, one mile, and two miles from the neighborhood boundaries. These distances reflect the potential for walking and biking as well as short automobile trips. Shorter distances should emphasize development patterns within the neighborhood itself, while longer distances should emphasize development patterns in the areas surrounding the neighborhood and thus the location of the neighborhood within the region.

On the third issue, we calculated raw measures as well as measures normalized by population and by land area in order to test the sensitivity of the results to the normalization method used. None of the three versions seems to have an inherent advantage over the others. Rather, each version offers a slightly different interpretation and may be appropriate in different situations. The raw numbers, for example, give an indication of the actual numbers of establishments or types of establishments available to residents and thus may be the version that most directly evaluates accessibility from the residents' perspective. Normalized by land area (measured in square miles), the measures account for relative distances from points within the neighborhood to surrounding destinations, at least in a crude sort of way, and may be more closely associated with travel patterns than the other measures are. Normalized by population, the measures speak more directly to equity in terms of the relative amount of retail or service activity per person in a neighborhood and illustrate how uniformly establishments of a particular type are distributed across a metropolitan area.

Intensity

The measures of intensity of retail and service development give an indication of the overall accessibility for residents of the neighborhoods. The total number of establishments within the neighborhood and various distances from the neighborhood suggest that residents of Old West Austin have considerably higher accessibility than residents of the other neighborhoods, while the two late-modern neighborhoods, Wells Branch and Tanglewood, have considerably lower accessibility (Table 5-3). At a distance of 1/4 miles, the rank ordering of the neighborhoods changes somewhat, with Zilker now showing the highest level of accessibility. At greater distances, the location relative to downtown begins to impact the rankings; this impact is seen at 1/2 mile for Cesar Chavez, 1 mile for Old West Austin and Travis Heights, and 2 miles for Zilker. At all distances, the late-modern neighborhoods, located at the fringe of the city, show the lowest levels of accessibility.

TABLE 5-3. NEIGHBORHOOD COMMERCIAL DEVELOPMENT INTENSITY

	Commercial Establishments Within…				
	Nbhd	1/4 mile	1/2 mile	1 mile	2 miles
Old West Austin	146 (1)	256 (2)	356 (2)	2196 (1)	3172 (3)
Travis Heights	72 (3)	174 (4)	317 (3)	2153 (2)	3157 (4)
Cherrywood	49 (5)	147 (5)	236 (5)	448 (5)	3455 (1)
Zilker	91 (2)	273 (1)	307 (4)	1050 (4)	3421 (2)
Wells Branch	25 (6)	49 (6)	87 (6)	108 (6)	180 (7)
Tanglewood	9 (7)	46 (7)	67 (7)	93 (7)	255 (6)
Cesar Chavez	68 (4)	193 (3)	1681 (1)	2089 (3)	3086 (5)

Rank shown in parentheses.

Normalizing the intensity measures by the size of the neighborhood in terms of square miles or population also impacts the rankings, although the general patterns seen with the raw measures still hold. When the number of commercial establishments is normalized by square miles of the neighborhood (Table 5-4), Travis Heights drops in the rankings and Cherrywood jumps in the rankings for most buffer distances. This result reflects the fact that Cherrywood is the smallest neighborhood and Travis Heights one of the largest neighborhoods in terms of land area. But as was the case for the raw measures, the late-modern neighborhoods stay at the bottom of the rankings, and the effect of location relative to downtown can be seen as the buffer distance increases. When the number of commercial establishments is normalized by the population of the neighborhood (Table 5-5), Cesar Chavez ranks somewhat higher than on the raw measures and Travis Heights ranks somewhat lower, reflecting the relatively low population in Cesar Chavez and the relatively high population in Travis Heights. Again, the late-modern neighborhoods consistently rank lowest.

TABLE 5-4. NEIGHBORHOOD COMMERCIAL INTENSITY - NORMALIZED BY AREA

	Commercial Establishments per Square Mile Within…									
	Nbhd		1/4 mile		1/2 mile		1 mile		2 miles	
Old West Austin	195	(1)	341	(1)	475	(2)	2928	(1)	4229	(1)
Travis Heights	73	(5)	176	(5)	320	(5)	2175	(3)	3189	(3)
Cherrywood	98	(3)	294	(3)	472	(3)	896	(5)	6910	(5)
Zilker	111	(2)	329	(2)	374	(4)	1280	(4)	4172	(4)
Wells Branch	39	(6)	77	(6)	136	(6)	169	(6)	281	(6)
Tanglewood	9	(7)	46	(7)	67	(7)	93	(7)	255	(7)
Cesar Chavez	89	(4)	254	(4)	2212	(1)	2749	(2)	4061	(2)

Rank shown in parentheses.

Diversity

The measures of diversity are calculated as the number of different types of establishments (as defined by SIC code) rather than the number of establishments. The rankings for the raw diversity measures are similar to those for intensity - not surprising, since the number of different types of establishments is likely to increase as the total number of establishments increases (Table 5-6). Across the different buffering distances, Old West Austin ranks somewhat lower on diversity than intensity, while Travis Heights ranks somewhat higher. This result suggests that while Old West Austin had a relatively high number of establishments, they are

TABLE 5-5. NEIGHBORHOOD COMMERCIAL INTENSITY - NORMALIZED BY POPULATION

	Commercial Establishments per 1,000 Residents Within…									
	Nbhd		1/4 mile		1/2 mile		1 mile		2 miles	
Old West Austin	34	(1)	59	(1)	83	(2)	509	(2)	736	(3)
Travis Heights	13	(4)	31	(5)	56	(5)	380	(3)	557	(5)
Cherrywood	12	(5)	36	(4)	57	(4)	108	(5)	835	(1)
Zilker	19	(2)	58	(2)	65	(3)	221	(4)	722	(4)
Wells Branch	5	(6)	10	(6)	17	(6)	22	(6)	36	(7)
Tanglewood	2	(7)	8	(7)	12	(7)	16	(7)	45	(6)
Cesar Chavez	17	(3)	49	(3)	425	(1)	528	(1)	780	(2)

Rank shown in parentheses.

TABLE 5-6. NEIGHBORHOOD COMMERCIAL DIVERSITY

	Number of Establishment Types Within…									
	Nbhd		1/4 mile		1/2 mile		1 mile		2 miles	
Old West Austin	40	(1)	46	(3)	48	(2)	77	(3)	78	(5)
Travis Heights	32	(2)	48	(2)	57	(3)	79	(1)	79	(3)
Cherrywood	22	(5)	39	(4)	46	(5)	59	(5)	81	(1)
Zilker	32	(2)	49	(1)	50	(4)	69	(4)	79	(3)
Wells Branch	15	(6)	22	(6)	32	(6)	36	(6)	45	(6)
Tanglewood	6	(7)	22	(6)	29	(7)	32	(7)	53	(7)
Cesar Chavez	25	(4)	39	(4)	77	(1)	78	(2)	80	(2)

Rank shown in parentheses.

distributed across relatively fewer different types. Residents of this neighborhood may thus have fewer of their retail and service needs met nearby. On the other hand, they should have more establishments to choose from within each establishment type, as shown below. The late-modern neighborhoods, which consistently ranked lowest on intensity, also consistently rank lowest on diversity. The normalization options produce the same effects as they did for the intensity measures (Tables 5-7 and 5-8): the largest neighborhoods in terms of land area or population drop in the rankings while the smallest ones jump, at least when the raw measures are relatively close to begin with.

TABLE 5-7. NEIGHBORHOOD COMMERCIAL DIVERSITY - NORMALIZED BY AREA

	Number of Establishment Types per Square Mile within…									
	Nbhd		1/4 mile		1/2 mile		1 mile		2 miles	
Old West Austin	53	(1)	61	(2)	64	(3)	103	(2)	104	(3)
Travis Heights	32	(5)	48	(5)	58	(5)	80	(5)	80	(5)
Cherrywood	44	(2)	78	(1)	92	(2)	118	(1)	162	(1)
Zilker	39	(3)	60	(3)	61	(4)	84	(4)	96	(4)
Wells Branch	23	(6)	34	(6)	50	(6)	56	(6)	70	(6)
Tanglewood	6	(7)	22	(7)	29	(7)	32	(7)	53	(7)
Cesar Chavez	33	(4)	51	(4)	101	(1)	103	(2)	105	(2)

Rank shown in parentheses.

Choice

Choice measures illustrate the number of options a resident has when selecting a particular type of establishment, as shown in Table 5-9 for five types of establishments: food stores, restaurants, child care services, liquor stores, and pharmacies. Several patterns can be seen in this table. First, residents have many more choices for some types of establishments

TABLE 5-8. NEIGHBORHOOD COMMERCIAL DIVERSITY - NORMALIZED BY POPULATION

	Number of Establishment Types per 1000 Residents within…									
	Nbhd		1/4 mile		1/2 mile		1 mile		2 miles	
Old West Austin	9.3	(1)	10.7	(1)	11.1	(1)	17.9	(1)	18.1	(2)
Travis Heights	5.6	(3)	8.5	(4)	10.1	(4)	13.9	(4)	13.9	(4)
Cherrywood	5.3	(4)	9.4	(3)	11.1	(1)	14.3	(3)	19.6	(1)
Zilker	6.7	(2)	10.3	(2)	10.5	(3)	14.6	(2)	16.7	(3)
Wells Branch	3.0	(6)	4.4	(6)	6.4	(6)	7.2	(6)	9.0	(7)
Tanglewood	1.1	(7)	3.9	(7)	5.1	(7)	5.7	(7)	9.4	(6)
Cesar Chavez	3.8	(5)	5.6	(5)	8.1	(5)	9.1	(5)	11.4	(5)

Rank shown in parentheses.

than others; choices for eating places are especially abundant. Second, the neighborhoods that ranked high on intensity measures also tend to rank high on choice measures, although high rankings on diversity measures tend to mean lower rankings on choice measures. If a neighborhood has enough development - high intensity, that is - it may offer relatively high levels of diversity and choice, however, as is the case in Old West Austin. The late-modern neighborhoods, not surprisingly, also rank lowest on choice measures. The effect of buffering distance on choice measures is similar to its effect on intensity and diversity measures: as distance increases, the measure increasingly reflects the location of the neighborhood relative to downtown. The effect of the normalization options on choice measures is also similar to its effect on intensity and diversity measures; because of the complexity of the comparisons, the tables for the normalized measures have been omitted here.

The importance of evaluating access to specific uses becomes clear in looking at the results for Cesar Chavez, which ranked fourth on intensity and diversity measures for short distances but is ranked lowest on choice for grocery stores, arguably the most basic retail need.

TABLE 5-9. NEIGHBORHOOD COMMERCIAL CHOICE - BASIC TYPES

	Number of Establishments by Type…				
	Grocery Stores	Eating Places	Child care	Liquor Stores	Drug Stores
Within Neighborhood:					
Old West Austin	5	16	3	2	2
Travis Heights	4	15	4	2	1
Cherrywood	5	3	3	0	0
Zilker	6	10	2	0	0
Wells Branch	2	6	2	0	0
Tanglewood	3	2	1	0	0
Cesar Chavez	2	7	4	0	0
Within 1/4 Mile:					
Old West Austin	7	32	5	5	3
Travis Heights	10	42	6	2	1
Cherrywood	5	3	3	0	0
Zilker	11	46	4	1	2
Wells Branch	3	11	3	0	0
Tanglewood	5	9	2	2	0
Cesar Chavez	8	31	6	3	3
Within 1/2 Mile:					
Old West Austin	8	44	8	7	3
Travis Heights	19	70	8	4	1
Cherrywood	23	48	8	3	0
Zilker	14	50	8	1	2
Wells Branch	4	15	5	1	0
Tanglewood	5	11	4	3	1
Cesar Chavez	41	197	27	12	22
Within 1 Mile:					
Old West Austin	43	312	29	19	28
Travis Heights	69	312	34	21	21
Cherrywood	34	80	15	5	2
Zilker	35	160	21	8	4
Wells Branch	6	17	5	1	0
Tanglewood	7	13	6	3	1
Cesar Chavez	58	287	32	22	26
Within 2 Miles:					
Old West Austin	90	467	59	32	42
Travis Heights	14	487	62	37	34
Cherrywood	136	503	91	36	46
Zilker	100	492	79	30	37
Wells Branch	11	34	8	5	0
Tanglewood	22	36	17	6	2
Cesar Chavez	127	490	57	31	33

A look at the three types of establishments with the highest number of establishments within the various buffer distances for each neighborhood (Table 5-10) also suggests problems for Cesar Chavez: within the neighborhood, drinking places tops the list with eleven establishments, followed by used auto lots with nine establishments. In this case, having many choices is probably not such a good thing for residents of the neighborhood.

TABLE 5-10. NEIGHBORHOOD COMMERCIAL CHOICE - MOST FREQUENT ESTABLISHMENT TYPES

	Numbers of Establishments by Type per Square Mile within…									
	Nbhd		1/4 mile		1/2 mile		1 mile		2 miles	
Old West Austin	Beauty shops	23	Eating places	43	Beauty shops	63	Eating places	416	Eating places	623
	Eating places	21	Beauty shops	32	Eating places	59	Misc pers svc	197	Misc pers svc	264
	Resale	15	Misc pers svc	24	Misc pers svc	33	Computer	152	Beauty shops	259
Travis Heights	Eating places	15	Eating places	42	Eating places	71	Eating places	315	Eating places	492
	Resale	6	Resale	16	Grocery stores	19	Misc pers svc	121	Beauty shops	165
	Grocery stores	4	Grocery stores	10	Resale	18	Computer	106	Misc pers svc	164
Zilker	Eating places	12	Eating places	56	Eating places	61	Eating places	195	Eating places	600
	Resale	12	Beauty shops	34	Beauty shops	37	Beauty shops	117	Misc pers svc	274
	Beauty shops	10	Auto/home sup	23	Auto/home sup	24	Misc pers svc	56	Beauty shops	252
Cherry-Wood	Florists	16	Eating places	54	Eating places	96	Eating places	160	Eating places	1006
	Computer	12	Grocery Stores	26	Grocery Stores	46	Beauty Shops	72	Beauty Shops	388
	Grocery stores	10	Florists	20	Beauty shops	36	Grocery stores	68	Misc pers svc	360
Tangle-wood	Grocery stores	3	Eating places	9	Eating places	11	Eating places	13	Eating places	36
	Eating places	2	Grocery stores	5	Grocery stores	5	Misc. retail	10	Beauty shops	23
	Upholstery	1	Auto/home sup	4	Auto/home sup	4	Grocery stores	7	Grocery stores	22
Wells Branch	Eating places	9	Eating places	17	Eating places	23	Eating places	27	Eating places	53
	Grocery stores	3	Used Auto	8	Building matls	11	Used Auto	19	Misc food store:	19
	Florists	3	Drycleaning	6	Used Auto	11	Building matls	13	Used Auto	19
Cesar Chavez	Drinking places	14	Drinking places	49	Eating places	259	Eating places	378	Eating places	645
	Used auto	12	Eating places	41	Misc pers svc	155	Misc pers svc	171	Beauty shops	222
	Eating places	9	Used Auto	13	Computer	114	Computer	136	Misc pers svc	218

Discussion

These measures are useful in illustrating differences in accessibility that occur in neighborhood development patterns. In particular, late-modern neighborhoods were shown to provide much lower levels of accessibility on all three measures than traditional or early-modern neighborhoods. Not only do these neighborhoods have a limited number of establishments within their boundaries or even within a quarter mile of their boundaries, their location at the fringe of the metropolitan area means that they have substantially fewer establishments within even two miles of the neighborhood than do the centrally-located neighborhoods. In addition, the measures point to deficiencies in accessibility in lower-income neighborhoods, not so much in terms of the numbers of establishment but rather in the types of establishments found there.

However, planners must use this approach to measuring accessibility carefully. The choice of buffer distance was found to have a significant impact on the results of the analysis. While comparing the results for several different buffer distances can be cumbersome (as this report shows), using just one buffer distance might be misleading. Depending on the purpose of the analysis, the use of one short distance and one longer distance might provide the most meaningful results. The choice of normalization option was found to have a less significant impact on the overall results of the analysis. However, the results did change significantly for neighborhoods that were much larger or much smaller than the others. Each approach has a somewhat different interpretation.

This example also helps to illustrate the limitations of these accessibility measures. Most obviously, they reflect land use patterns but completely ignore characteristics of the transportation system such as network distances, travel times, or the availability of alternative modes. These measures also say nothing about the size or characteristics of the establishments, important factors in determining how well these establishments meet the needs and preferences of residents.

LOCATION QUOTIENTS

Location quotients, as described in Chapter 4, compare the share of establishments of a certain type within a neighborhood to the share of establishments of this type for the city overall. A value greater than one indicates that the neighborhood has a greater share of establishments of that type than the city as a whole and may thus be over served; a value less than one indicates that the neighborhood may be under served. The location quotients for grocery stores, eating places, and drinking places found within the boundaries of the seven neighborhoods, as shown in Table 5-11, reveal some interesting differences between the neighborhoods but also suggest some of the limitations of the land use data.

TABLE 5-11. NEIGHBORHOOD LOCATION QUOTIENTS - SELECTED TYPES

	Share of Establishments…			Location Quotient*…		
	Grocery Stores	Eating Places	Drinking Places	Grocery Stores	Eating Places	Drinking Places
Total City	15.1%	5.2%	1.7%	-	-	-
Old West Austin	3.4%	11.0%	0.0%	0.2	2.1	0.0
Travis Heights	5.6%	20.8%	2.8%	0.4	4.0	1.6
Cherrywood	10.2%	6.1%	0.0%	0.7	1.2	0.0
Zilker	6.6%	11.0%	1.1%	0.4	2.1	0.6
Wells Branch	8.0%	24.0%	4.0%	0.5	4.6	2.3
Tanglewood	33.3%	22.2%	0.0%	2.2	4.2	0.0
Cesar Chavez	2.9%	10.3%	16.2%	0.2	2.0	9.3

* Share of neighborhood establishments/share of city establishments

First, all of the neighborhoods except for Tanglewood appear to be under served relative to the regional overall in grocery stores. This result may be driven by two factors: one, that neighborhoods are also served by grocery stores beyond their boundaries, and two, that many of the establishments included in this category are combined convenience store - gas stations, a significant portion of which are located along highways and away from neighborhood areas. Second, all of the neighborhoods appear to be over served in eating places. This result is surprising but may reflect a locational pattern of restaurants that favors neighborhood areas. The results for grocery stores and eating places suggest that a more useful approach might be to calculate location quotients relative to a neighborhood average rather than to the city overall. In contrast, the location quotients for drinking places reveal large differences between the neighborhoods, with four having a lower share of drinking places than the city overall and three having a greater share. Most notably, the Cesar Chavez neighborhood has over nine times the share of drinking establishments as the city overall. In this case, the location quotient has highlighted a potentially serious issue for the neighborhood.

COVERAGE

Coverage was defined as the percent of the neighborhood street network within a specified distance from a specified establishment. If households are relatively evenly distributed throughout the street network, this measure gives a reasonable approximation of the percent of households within that distance of that establishment, where distances are measured along the actual street network and not simply by straight lines. For this analysis, we focused on grocery store category but extracted convenience stores and supermarkets from this category (based on the names of the establishments as listed in the database and our knowledge of the establishments in these neighborhoods). The results can be presented either graphically (Figure 1) or numerically (Table 5-12).

Although the rankings of the neighborhoods are similar to those for the simple counts of grocery stores within various buffer distances from the neighborhood (Table 5-9; note that "grocery store" in this table includes convenience stores and supermarkets), the coverage measures give an indication of how equitably served the residents within each neighborhood are. In general, the late-modern neighborhoods have the lowest share of street network (and thus, probably, residents) within a quarter mile or mile of a convenience store, grocery store, or supermarket. In fact, none of the street network within Wells Branch is within a mile of a grocery store or supermarket, and only 28 percent of the street network in Tanglewood is within a mile of a supermarket. The coverage for Zilker is also relatively low, perhaps because of the concentration of commercial establishments along one side of the neighborhood, rather than on multiple sides as in many of the other neighborhoods. Coverage levels reflect both the number of establishments and their distribution in and around the neighborhood.

TABLE 5-12. NEIGHBORHOOD COVERAGE - SELECTED TYPES

	Percent of Street Network Within 1/4 Mile of…			Percent of Street Network Within 1 Mile of…		
	Conv. Store	Grocery Store	Super-market	Conv. Store	Grocery Store	Super-market
Old West Austin	19%	27%	7%	100%	100%	79%
Travis Heights	23%	8%	4%	100%	100%	62%
Cherrywood	37%	8%	6%	100%	100%	100%
Zilker	10%	19%	4%	84%	87%	39%
Wells Branch	18%	0%	0%	91%	0%	0%
Tanglewood	9%	4%	1%	75%	45%	28%
Cesar Chavez	22%	26%	0%	100%	100%	75%

Figure 5-1. Supermarket coverage for Cesar Chavez Neighborhood: street network within 1 mile of supermarket

CHAPTER 6. CONCLUSIONS

Although the available data and the capabilities of GIS fall short of providing planners with a full assessment of the factors that influence neighborhood accessibility, the simple analysis that is currently possible still yields useful information and helps to identify important differences in accessibility between neighborhoods. Even with limited data and limited GIS capabilities, it is possible to generate useful measures of neighborhood accessibility. Fortunately, both the data available to planning departments and the facility of planning staff with GIS are improving. But what options do planning departments have to help the process along?

One way is to invest a lot of money. Developing a comprehensive neighborhood accessibility database would require a significant commitment of resources on the part of a planning department. First, the collection of data beyond the very basic data likely to be available to the department requires extensive field work. Once such data have been collected, the database must also be maintained and periodically updated. Second, the purchase and operation of a GIS itself demands significant resources. These systems are not cheap, nor are they especially easy to use, so that additional staff training may be required. Many planning departments now have a GIS as well as trained staff, but capabilities may vary significantly from city to city.

Another way is to make data collection itself an important part of the planning process - to use data collection as a way to facilitate public involvement and build technical capacity within neighborhoods. In Austin's neighborhood planning program, for example, residents and other local stakeholders are responsible for developing their own plan for the neighborhood, with guidance and some assistance from city staff. An early task is to compile data about existing conditions in the neighborhood, such as inventories of existing land uses and infrastructure and an assessment of the condition of infrastructure. In addition, the planning team is required to conduct surveys of residents as to their concerns and priorities. This approach has many benefits. Such data collection efforts are labor intensive and thus gets many volunteers from the neighborhood involved. Those who do participate will learn what kinds of information are useful for planning purposes and what kinds of techniques are effective in collecting that information. Participants are likely to understand and appreciate the results more than if city staff simply presented the results to them. These data can also be incorporated into a city-wide database.

Neighborhood planning teams will probably have to rely on city staff for anything beyond basic analysis of the data, particularly GIS analysis. The mapping capabilities of GIS, however, may also help to facilitate input from the neighborhood by helping residents to visualize and understand the implications of the data. Some of the examples presented in Chapter 4 demonstrate ways that GIS-based accessibility measures can be used to assess transportation and land use needs and to evaluate proposed plans and policies. If structured as an interactive process involving staff and neighborhood residents, these analyses could prove especially fruitful.

Providing the neighborhood planning team with direct access to a GIS and sufficient training to use it effectively would be even better – and may not be as costly or impractical as one might think, as demonstrated by a growing number of examples. In 1993, a group of graduate students at the University of Wisconsin-Milwaukee developed a process for training neighborhood residents to use GIS to analyze a publicly-accessible database of property characteristics, including ownership, zoning, land use, assessed value, and other useful information (Myers 1994). One step in the process included a walk through the neighborhood to collect information about the condition of properties in the neighborhood. The project succeeded in providing neighborhood residents with the capability to use GIS to analyze and address a variety of problems in the neighborhood. In Philadelphia, the city has allocated funds to Community Development Corporations (CDCs) for GIS hardware, software, and training so that the CDCs can better illustrate the quality and character of the environment of the neighborhood (Casey and Pederson 2000). Such examples hint at the power of GIS not only as a planning tool but also as a public involvement technique.

Whatever approach is taken, investment of the necessary resources on the part of the city should be justified easily. Providing adequate accessibility to services, jobs, public facilities, and other activities is an important planning function but one that most planning departments have not sufficiently fulfilled. The development of a database to monitor and assess neighborhood accessibility is the first step towards developing policies that will enhance accessibility and guarantee an adequate range of choice - for both destinations and the means to reach them - for all.

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