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REPORT 60

TRANSIT COOPERATIVE RESEARCH PROGRAM

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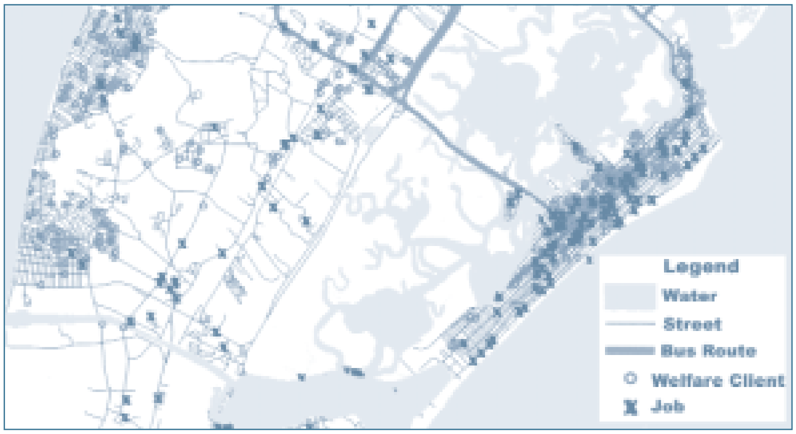
Using Geographic Information Systems for Welfare to Work Transportation Planning and Service Delivery
A Handbook



TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP REPORT 60

Using Geographic Information Systems for Welfare to Work Transportation Planning and Service Delivery

MULTISYSTEMS, INC.
Cambridge, MA
with
APPLIED GEOGRAPHICS, INC.
Boston, MA

SUBJECT AREAS
Planning and Administration
Public Transit

Research Sponsored by the Federal Transit Administration in Cooperation with the Transit Development Corporation

TRANSPORTATION RESEARCH BOARD — NATIONAL RESEARCH COUNCIL

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), *Transportation 2000*, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA; the National Academies, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

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NOTICE

The project that is the subject of this report was a part of the Transit Cooperative Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the project concerned is appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, the Transit Development Corporation, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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FOREWORD

By Staff
Transportation Research Board

This handbook will be of interest to transportation planners, human service agencies, transportation providers, and others concerned with using Geographic Information Systems (GIS) to support welfare to work transportation planning and service delivery. The handbook is intended to facilitate GIS as a tool among organizations responsible for planning or providing transportation services in response to welfare reform, including trip itinerary planning. The handbook includes guidance on how agencies can either implement GIS or enhance their current GIS applications for this purpose. Accompanying this handbook is a CD-ROM containing case study descriptions and color illustrations of GIS applications for transit planning and welfare to work purposes. The material contained on the CD-ROM also can be found on the TCRP web site as *Web Document 14*. The handbook, CD-ROM, and *TCRP Web Document 14* are appropriate for use by those professionals with no or little GIS experience and by those who have implemented GIS for welfare to work purposes and wish to take their systems to a higher level.

It is well understood that welfare recipients seeking to enter the workforce face tremendous mobility challenges. Dispersed employment locations, child-care transportation needs, varied work schedules, and lengthy travel times all contribute to these mobility challenges. In addition, many welfare and "working poor" families do not have access to a car and are headed by single parents posed with complex trip-making patterns. Transit, welfare, social service, and other agencies are assessing the magnitude of these challenges throughout the country in response to welfare to work initiatives. Geographic Information Systems can be a powerful tool for understanding the specific dimensions of such mobility problems. The spatial analysis provided by GIS, together with its ability to visually display results, is being used by caseworkers, employment counselors, and employers to formulate transportation solutions and help welfare recipients find and reach suitable jobs and child-care facilities.

Under TCRP Project H-20, research was undertaken by Multisystems, Inc., to better understand current practices in welfare to work transportation planning and service delivery and to develop a handbook with recommended model approaches for applying GIS to this purpose. The researchers provide guidance on using GIS to determine (a) the relative proximity of recipients and employers to transit services; (b) travel time and distances associated with mobility needs; and (c) any obvious gaps in transit service.

To achieve the objectives of TCRP Project H-20, the researchers first reviewed current practices of transportation and human service agencies using GIS to respond to the mobility needs of current and former welfare recipients and then documented examples of useful practices. The researchers summarized and assessed current practices in terms of their potential for replication in other locations and by other entities in welfare to work planning. In addition, the researchers prepared recommendations on model approaches for using GIS for welfare to work transportation planning and service delivery. For each model approach, the following considerations are included: (a) a description of what GIS software capabilities and techniques are used in the applications; (b) a description of what data resources are needed by the applications and their likely sources; (c) the level of effort and GIS knowledge required; and (d) the expected outcomes of the analysis. The most basic sets of data for spatial analysis of access to jobs include:

- Digital maps of the transportation system, including transit services;
- Locations of welfare recipients who need to find work; and
- Locations of potential employers.

Analysis options also include the locations of child-care centers, schools, job training centers, community-based organizations, and other critical service providers.

On the basis of the researchers' assessment, a handbook providing guidance for the implementation of GIS to support welfare to work transportation planning and systems delivery was prepared. Accompanying this handbook is a CD-ROM that details case descriptions developed during the researchers' study of GIS applications for transit planning and welfare to work purposes. The CD-ROM also provides color graphics and an image viewer to allow the reader to view and print more detailed GIS illustrations than were possible to include in the printed handbook. The material contained on the CD-ROM also is located on the TCRP web site as *Web Document 14*.

Together with *Web Document 14*—a full-text version of this handbook can be found in portable document format (PDF) on the TCRP web site at:
www4.national-academies.org/trb/crp.nsf

CONTENTS

USING GEOGRAPHIC INFORMATION SYSTEMS FOR WELFARE TO WORK TRANSPORTATION PLANNING AND SERVICE DELIVERY

SUMMARY

In response to federal welfare reform legislation passed in 1996, states and local governments are now in the process of implementing welfare to work programs. The goal of these programs is to assist recipients of public assistance in finding gainful employment. Expanded support services, including job training, job search assistance, and child care are being developed to enable recipients to become employed and to keep these newfound jobs. Getting recipients and their dependents to and from support services and ultimately to the jobs obtained is a crucial part of these welfare to work programs and efforts.

The transportation challenges of moving individuals from welfare to work are daunting. Nationally, jobs are migrating to the suburbs, whereas the majority of welfare recipients live in cities or rural areas. Detroit, for example, lost 100,000 jobs in the 1980s, while 250,000 jobs were added in suburban communities. Compounding the problem is the fact that, on average, only 6 percent of welfare recipients have cars. The problem is particularly acute in rural areas. One in four families receiving public assistance lives in rural areas, and, according to the National Association of Counties, welfare clients in rural counties may need to commute up to 200 miles a day. Yet more than 40 percent of the nation's rural counties have no public transit whatsoever. Even in cities, where transit is generally more available, job access is hardly guaranteed. In Boston, for example, it is estimated that 99 percent of welfare recipients live within one-half mile of transit service, while only 43 percent of the area's jobs have equally convenient access.

The urgent need to address these challenges has led to new roles for social service agencies and new collaborations between social service providers, transportation providers, and transportation planners. Shifting the emphasis from benefits to employment has changed the entire welfare environment. Welfare offices have found themselves responsible for providing their clients with the range of services designed to help them find and keep jobs. These supporting services may include training in work and so-called "life" skills, job placement, child care, and, of course, transportation. The need for social service case workers to function as mobility managers has led to new partnerships between social service and transportation providers. Some states, such as New Jersey and Virginia, have facilitated this process by mandating a local coordinated planning process: localities must prepare a written transportation plan in order to

receive state assistance. Others have set up state coordinating committees; Oklahoma's Transportation Task Force, for example, includes representatives from the state Department of Transportation, Department of Health and Human Services, and Department of Commerce, among others.

Because welfare recipients are not always located near employment opportunities—and most do not have access to an automobile—transit has become a critical link in the welfare to work process. Unfortunately, this new transit market is not an easy one to serve for a number of reasons, summarized below:

- **Spatial mismatch.** Welfare recipients tend to live in central cities and rural communities, while recent job growth has been concentrated in the suburbs. At best, this spatial mismatch requires long commuting trips that may involve multiple transfers. At worst, jobs (or employees) are located in areas without any transit service at all.
- **Temporal mismatch.** Many welfare recipients are expected to find employment in the retail, service, and health-care industries. These jobs frequently have evening and weekend shifts, which are not well served by traditional transit schedules.
- **Multiple destinations.** The typical welfare recipient is a single mother with young children whose work trip may need to include stops at one or more schools or child-care facilities.
- **Changing needs.** As welfare recipients progress from training programs to permanent employment, their transportation needs are likely to change over time.

USE OF GEOGRAPHIC INFORMATION SYSTEMS SOFTWARE

Geographic Information Systems (GIS) software, which can link electronic databases with computer-mapping capabilities to graphically display information, has become less expensive and more user-friendly and is being used more widely in transportation planning and human service program planning. It has become one of the tools being used to assist in implementing welfare to work programs. GIS software has been used to assist with welfare to work transportation in several ways, including:

- Policy development,
- Service planning,
- Trip planning, and
- Program evaluation.

In the area of transportation *policy development and general service planning*, GIS has been used to:

- **Illustrate spatial mismatches.** By mapping the locations of welfare recipient and employment opportunities, a number of communities have been able to better understand the potential transportation issues involved in getting individuals to jobs. This simple depiction was used successfully in many areas as welfare reform legislation was being prepared to demonstrate the importance of transportation. Available fixed-route bus and rail services are often displayed as well in order to determine the potential role of transit in serving recipient travel needs. Some communities have also mapped child-care programs, work training, and other important support services to understand the transportation issues not only for work but for these other activities as well.

- **Present information about welfare recipients and jobs.** Detailed information about jobs, support services, and recipient needs can also be collected and displayed. Recipient information might include the availability of private transportation or the need for child-care services. Job information could include hours, wage rate, and type of work. Support service information might include age restrictions at child-care centers, service hours, the availability of ridesharing at an employment site, or the availability of transportation at a child-care program. Specific needs can then be matched with appropriate services. For example, only recipients who are transit dependent can be mapped. Or, different symbols can be used to map day-care centers that provide transportation and those that do not.
- **Locate areas of transit need.** Basic GIS features can be used to identify and highlight areas of transit need. The illustration of spatial mismatches and areas with high concentrations of welfare recipients and transit-dependent populations or high numbers of entry-level jobs can lead to the identification of specific areas as in need of transit service. Communities have used this type of GIS analysis to support broad-based transit improvements that can serve the needs of welfare recipients, the working poor, seniors, and other transit-dependent populations.
- **Present transit level of service information.** By combining the location of transit services with databases that contain level of service information, more detailed analysis of the adequacy of existing services can be conducted. Work shifts and support service program hours can be compared with transit operating hours to determine if weekend and evening travel needs can be met. Fares and headways can also be considered in order to determine if transit is a feasible alternative for individuals.
- **Illustrate the extent of access to transit service.** GIS software allows areas or "bands" to be defined at a fixed distance around a given point or line. Once these areas are created, the number of recipients, jobs, or support services in these areas can be counted. Many communities have used these features to determine how many recipients or jobs are within a reasonable distance of transit services. This type of analysis can assist in policy development by identifying the potential of transit services to meet access to jobs needs. Possible changes to the current design of the transit system can also be identified. In New Jersey, for example, the mapping of transit services, Work First New Jersey participants, jobs, and support services showed that in several counties over 90 percent of jobs, participants, and support services were within one-quarter mile of existing fixed-route services. This helped to stress the importance of transit and led to the creation of the "Work Pass" program in these areas. In other rural and suburban counties, the analysis emphasized the need for nontraditional transit solutions and the importance of more demand responsive services, ridesharing programs, and private automobile support efforts.
- **Analyze transportation service changes.** GIS has been used extensively to assist in the design of new transit services. As areas of need are identified, new routes or service areas can be depicted and the impact of these new services can be assessed. Several different service alignments might be mapped to determine which serves the greatest number of target sites. This type of "what if" analysis can help in the selection of the best new service option.

GIS can also be used to assist in *trip planning and service delivery*. Customized GIS-based software products are being developed that allow job counselors, transportation brokerage agencies, and even welfare recipients to access information about job and support service locations and transit availability. For example, the Southern California Council of Governments undertook a collaborative effort with local transit agencies and human service agencies to develop a trip planner that can provide information about transit options for a given origin and destination. To select the best transit option for the individual, users can specify whether they would prefer a short walking distance, no transfers, or the shortest overall travel time. Detailed directions for accessing and using transit are provided. The trip planner is on the Internet, which allows it to be accessed and used by a number of local agencies as well as by individuals. Other GIS trip-planning products are also available commercially. Some, such as the trip planner used in Orlando, Florida, provides ridesharing as well as transit options. Simple trip planners, built on low-cost GIS platforms have also been developed. The Bergen County (New Jersey) Department of Planning and Economic Development created a trip-planning program that can display transit routes that serve selected origins and destinations. In a number of locations, "one-stop" centers have been established which provide temporary assistance for needy families (TANF) participants with a variety of services, including job search support, child care, and transportation. GIS-based trip planning software can be an important tool for evaluating job and transportation options at these neighborhood centers.

In addition to mapping current circumstances, GIS can be used to track and display outcomes in order to *evaluate the effectiveness of policies and programs*. Databases can be created, for example, which show actual job placements and transportation options utilized. Similarly, potential job opportunities that were not pursued because of transportation difficulties can be tracked and displayed.

CREATING A GIS TO SUPPORT WELFARE TO WORK EFFORTS

As the above examples of GIS use might suggest, the types of data and levels of effort needed to create these applications will vary. Table S-1 shows the various types of information that are typically collected for welfare to work GIS applications. As shown, the basic data elements include information about recipient, employment, support services, and transit. Basic background geographic data are also needed for creating maps and displays. Census demographic information is also often used to supplement recipient information and show areas with high transit dependency and need. For each of these basic data elements, a variety of attribute information might also be helpful for depicting needs and the adequacy of available services.

The level of effort and skill needed to develop a welfare to work transportation GIS application will also vary based on the GIS features used as well as the amount and types of data that must be collected, reviewed, organized, maintained, and updated.

GIS applications for one-time mapping of basic recipient, job, and transit information can be relatively straightforward. Data do not need to be continuously updated and maintained. Basic GIS software skills also are often sufficient to create the desired maps and displays. Even with the simplest of applications, though, there are a number of "helpful hints" that can make the job easier and more productive. These include:

- **Select the right data to display.** This is particularly important when depicting employment opportunities. The locations of existing employers might show where current jobs are, but not where appropriate job opportunities exist. Similarly, it might be more useful to show the types of jobs for which recipients are likely to be considered. It may be more useful to show actual job openings or to highlight employers who have been working with local agencies and have been active in hiring recipients in the past.

TABLE S-1 Welfare to work GIS data

Data Element	Types of Data and Possible Attribute Data
Background Geographic Information	Political boundaries, roads, census statistical boundaries, traffic analysis zones
Demographic Information	Population, poverty status, low-income households, automobile-less households, other transit-dependent populations
Recipient Locations	Child-care needs (number and ages of children). Time on assistance or time expected off assistance. Automobile availability and driving status
Employer/Employment Information	Employers by type and size Job openings at employer locations Types of jobs/job openings Employers who have hired recipients Total number of jobs in an area Recent or projected job growth
Child-Care Service Locations	Ages of children served Hours of operation Costs Funding sources accepted Availability of center-provided transportation
Other Key Support Service Locations	Welfare service offices, work training sites, colleges and universities, etc. Hours of operation
Current Transportation Services	Fixed-route bus and rail Paratransit and demand responsive services Ridesharing services Public and private services Level of service information (days and hours, headways, fares, eligibility requirements, special features, schedules, service performance information)

- **Get complete location information.** Before information can be mapped, it must be "geocoded" (assigned "x" and "y" coordinates). For information to be successfully geocoded, it is helpful to have specific and unique address information. Typically, this includes a complete street address, city/town name, and postal zip code. Collecting this information up front can greatly reduce the time that might be needed to "clean-up" and accurately map the data.
- **Consider recipient confidentiality.** A major issue in obtaining and using recipient information is protecting the identity and confidentiality of these individuals. Many welfare agencies may be reluctant to release information unless it can be

adequately "masked" or aggregated. Recipient names may be removed from the database provided. Exact street addresses may also be replaced with "ZIP+4" or other proximity information. If exact address information is provided, it might be on the condition that it be displayed as aggregate information in a defined area.

- **Consider available sources of information.** Before new databases are created, consider existing sources of the information needed. State or local agencies often have information about recipients, support services, and transit. Local transit or planning agencies may have already developed a GIS database of local transit services. At the federal level, the Federal Transit Administration (FTA) has funded the development of a GIS database of all federally funded public transit systems. Employment or placement agencies might have the most appropriate information about job opportunities.
- **Consider available support.** A number of states and communities have successfully worked with local agencies and organizations to develop maps and displays. In some cases, colleges and universities have provided valuable assistance. Many regional planning agencies also have GIS capabilities and can be of assistance.

More complex data and organizational issues will need to be considered if GIS efforts are ongoing. This will be the case if mapped information needs to be periodically updated and recreated. This will also be the case for trip planning applications, which require the latest information about transit and other services. Some considerations in developing an ongoing GIS effort include:

- **Develop mechanisms and relationships for updating data.** As the data table above suggests, there may be many different sources of data needed for welfare to work applications. State welfare agencies will keep recipient information. Other state agencies may have child-care and support service data. The local transit agency or transit planning organization should have transit service information. Each of these agencies will need to provide updated information as needed. Ideally, each agency will maintain the type of location and attribute data needed and could geocode this information before it is provided.
- **Designate GIS staff at each agency.** Where multiple agencies and organizations are involved in a GIS effort, a staff person at each agency should be designated as a point of contact and as the person responsible for ensuring that needed information is collected and updated.
- **Develop standards for data development.** To ensure that data can be shared effectively, common standards may need to be developed. This might include developing standards for common projections that are used in developing spatial data.

More complex GIS applications will also require careful thinking about internal agency data management functions and responsibilities. It may be necessary to dedicate staff to system administration, database management, application development, and support. At the same time, it may be important to enable other staff within the organization to have access to GIS information to facilitate planning and program development efforts.

Collaborative efforts between transit and human service agencies might also be considered in order to ensure that accurate and relevant data are available to all agencies involved in welfare reform efforts. One agency or organization in this collaborative effort might be selected to serve as a central depository of information. This organization could be responsible for collecting data from participating agencies, checking data for completeness and accuracy, and geocoding data (if participating agencies are unable to do this). The information could then be available to all organizations for transportation planning or broader program development.

Users should be aware that GIS information and resources may already be available to them through other parts of their agencies. GIS is increasingly becoming an important component of Information Technology (IT) departments. It may be possible to integrate GIS with other IT applications and customize GIS to support specific programs or projects. Given the stringent budgetary requirements, which many government agencies must consider, an integrated approach may be particularly attractive so as to take advantage of existing staff expertise and existing software and hardware facilities.

In the long run, state agencies and transit agencies should continue to consider ways to incorporate geographic information into their broader information systems. As transit routes are periodically changed and service information is updated, efforts should be made to update GIS files at the same time. Similarly, state agencies involved in welfare reform should consider adding coordinate information to any databases that include location information (recipient addresses or support service sites). This will help ensure that data needed for GIS efforts are available. A wide range of service and program data in a GIS will, in turn, enhance planning, service delivery, and evaluation efforts.

CHAPTER 1

INTRODUCTION

This handbook was developed to assist transportation planners, human service agencies, and transportation providers in developing geographic information systems (GIS) to support welfare to work transportation planning and service delivery. Examples of maps and visual displays that can assist in identifying and addressing transportation issues are included. Guidance on creating an information system with the cooperation of all agencies involved in welfare reform efforts is provided.

ORGANIZATION OF THIS HANDBOOK

Chapter 2 provides a brief description of welfare reform legislation and important background information about the population being served. Information about the current mobility and transportation needs of welfare recipients is highlighted and some of the unique and challenging issues in developing welfare to work transportation services are described.

An overview of GIS is provided in Chapter 3. The components of a complete information system are noted. Some of the basic functions that can be performed by GIS software are described. Sources of information for a more detailed discussion of GIS are also provided.

Chapter 4 provides guidance on getting started in the development of a GIS for welfare to work transportation planning and service delivery. Some key issues to consider when purchasing GIS software are noted. Hardware considerations are also discussed. Interagency cooperation and coordination, a critical issue in developing a comprehensive and consistent information system, are described. Some successful examples of interagency and state-level coordination are presented. Guidance on internal staffing and organization of a GIS effort are also noted. Alternatives for developing outside technical assistance and support are also provided.

At the heart of any GIS effort is the collection and maintenance of a complete and accurate set of data on individuals being served, employment opportunities, day-care and support services, and current transportation services. In addition, background geographic information is needed to make the creation of maps and displays possible. Chapter 5 provides a detailed review of each type of data needed for a welfare to work transportation GIS. Possible sources of information are identified. Important related data attributes, which can be useful in analyzing transportation needs, are described. Guidance is also provided on data updating and maintenance needs.

Chapter 6 then provides several examples of maps and displays that can be developed to assist with welfare to work transportation issues. Model GIS applications that support welfare to work policy development, transportation service planning, trip planning, and evaluation are included. These examples were developed largely from research on current exemplary GIS applications across the country. The types of data and the level of expertise needed to create each application are indicated.

Included as appendixes to this handbook are a listing of terms and definitions, sources of information on GIS products, data sources, and contacts for further information about trip-planning applications and software. A list of agencies that have had experience developing welfare to work transportation GIS applications is also provided.

In addition to this handbook, case study descriptions and color illustrations of GIS applications for transit planning and welfare to work purposes can be found on the accompanying CD-ROM. In addition, the material on the CD-ROM can be found on the TCRP web site as *Web Document 14*. The handbook, CD-ROM, and *TCRP Web Document 14* are appropriate for use by those professionals with no or little GIS experience and by those who have implemented GIS for welfare to work purposes and wish to take their systems to a higher level.

CHAPTER 2

WELFARE REFORM AND THE WELFARE TO WORK TRANSPORTATION CHALLENGE

OVERVIEW OF WELFARE REFORM

In 1996, federal welfare reform legislation created a new emphasis on moving individuals from welfare to work. The Personal Responsibility and Work Opportunity Reconciliation Act replaced the Aid for Families with Dependent Children (AFDC) program with block grant funding and mandatory work requirements. The new welfare program, known as Temporary Assistance for Needy Families (TANF), imposed a 5-year lifetime limit on welfare benefits and a 2-year deadline for placing most recipients in jobs, job training, or vocational education programs. At the same time, states were required to prepare TANF plans and to track their progress in meeting the legislation's goals.

The urgent need to address these challenges has led to new collaborations between social service and transportation planners and providers at the state and local levels. Suddenly, welfare offices have found themselves responsible for providing their clients with the range of services designed to help them find and keep jobs. These supporting services may include training in work and so-called "life" skills, job placement, child care, and, of course, transportation. At a minimum, most states have set up interdisciplinary coordinating committees to develop the required statewide TANF plans. Oklahoma's Transportation Task Force, for example, includes representatives from the state Department of Transportation, Department of Health and Human Services, and Department of Commerce, among others. Other states have taken a more active role. New Jersey and Virginia, for example, have mandated a local coordinated planning process: counties must prepare a written transportation plan in order to receive state assistance.

PROFILE OF WELFARE RECIPIENTS

Welfare clients are overwhelmingly single women with children.[1] According to the U.S. Department of Labor, only 13 percent of welfare mothers are married, with husbands present in the household; nearly half (48 percent) never married and others are widowed, divorced, or separated.[2] Most of these women have only one or two children (the average is 1.9), consistent with patterns in the general public, but these children tend to be young. About 44 percent of children in welfare families are 5 years old or younger, and nearly 38 percent are between 6 and 12 years old. The average age of children receiving welfare benefits is 7.6 years. The majority of parents in welfare families are in their twenties (42 percent) or thirties (35 percent). Only 6 percent are teenagers. Finally, welfare families are diverse. About 37 percent are African American, 36 percent are white, and 21 percent Hispanic. Figure 2.1 graphically portrays these demographic characteristics.

Fewer than one-half of welfare recipients (42 percent) have never completed high school. The rest have, at a minimum, a high school degree or GED; 16 percent of welfare recipients have at least some college experience.[3] Finally, while almost two out of three welfare mothers (61 percent) report prior work experience, many have worked only in low-wage, low-skill jobs.[4] For example, the Institute for Women's Policy Research reported that 37 percent of AFDC mothers worked as maids, cashiers, nursing aides, child-care workers, and waitresses. Most of these jobs were in low-paying service industries, including restaurants, bars, nursing homes, private households, hotels and motels, department stores, hospitals, and temporary help firms; these industries employed 40 percent of welfare mothers, compared with 19 percent of all women.[5]

Welfare recipients overwhelmingly live in the nation's metropolitan areas, but not necessarily the center cities. Among individuals receiving AFDC or General Assistance in 1992, 48 percent lived in central cities, 28 percent in suburbs, and 24 percent in rural areas.[6] Looking only at women with children, the pattern is slightly different. In 1993, the Census Bureau looked at the characteristics of women of childbearing age (defined as 15–44 years) receiving AFDC benefits.

[1] These descriptions are based on characteristics of participants in the AFDC program; it is assumed that TANF recipients have similar characteristics.

[2] Unless otherwise noted, all data are based on statistics presented by the U.S. Department of Labor in "About Welfare—Myths, Facts, Challenges and Solutions." February 1998.

[3] Tabulations of 1995 AFDC Quality Control Survey Data. Prepared by Demetra Nightingale, The Urban Institute, DOL Contract F-5532-5-00-80-30.

[4] U.S. Department of Labor. "About Welfare—Myths, Facts, Challenges and Solutions." February 1998.

[5] Institute for Women's Policy Research. "Welfare to Work: The Job Opportunities of ADFC Recipients." [Online] Available: http://www.iwpr.org/wtwrib.html.

[6] U.S. Census Bureau. Dynamics of Economic Well-Being: Program Participation, 1991 to 1993. [Online] Available: http://www.census.gov/hhes/progpart/dewb9193/pp91t1.html.

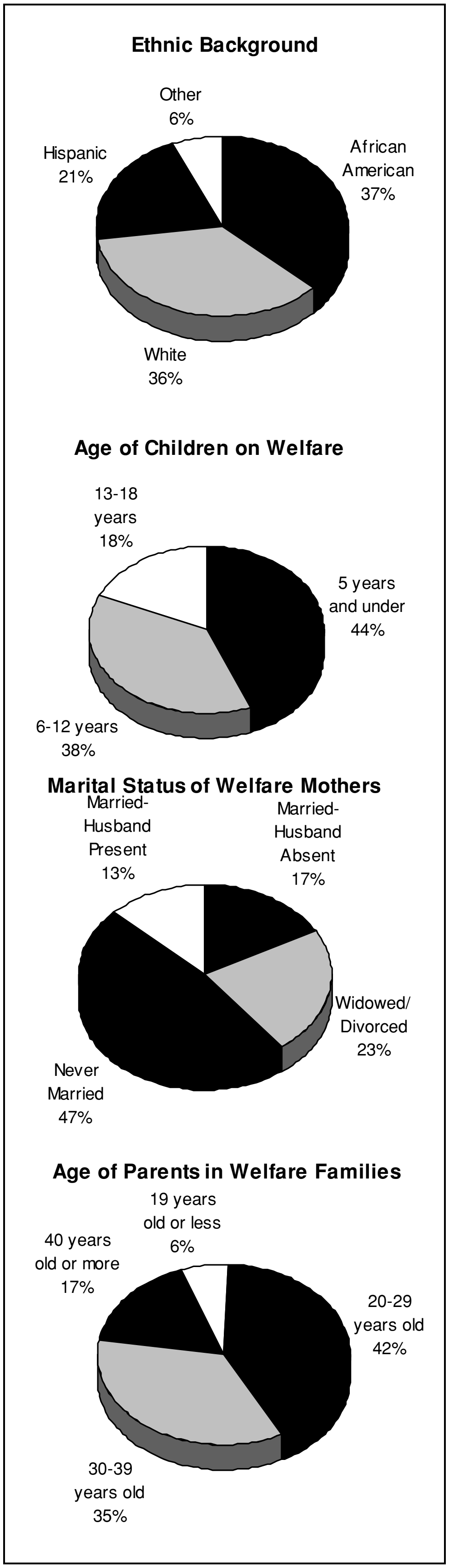

Figure 2.1. Examples of demographic characteristics.

Among these women, who make up the majority of people on welfare, 56 percent lived in center cities, 25 percent in suburbs, and 19 percent in rural areas.[7]

WELFARE TO WORK TRANSPORTATION CHALLENGES

The transportation challenges of moving individuals from welfare to work are daunting. Nationally, jobs are migrating to the suburbs, whereas the majority of welfare recipients live in cities or rural areas. Detroit, for example, lost 100,000 jobs in the 1980s, while 250,000 jobs were added in suburban communities. Compounding the problem is the fact that most welfare recipients do not have cars. The problem is particularly acute in rural areas. One in four families receiving public assistance lives in rural areas and, according to the National Association of Counties, welfare clients in rural counties may need to commute up to 200 miles a day. Yet more than 40 percent of the nation's rural counties have no public transit whatsoever. Even in cities, where transit is generally more available, job access is hardly guaranteed. In Boston, for example, it is estimated that 99 percent of welfare recipients live within one-half mile of transit service, while only 43 percent of the area's jobs have equally convenient access.

Because welfare recipients are not always located near employment opportunities—and most do not have access to an automobile—transit has become a critical link in the welfare to work process. Unfortunately, this new transit market is not an easy one to serve for a number of reasons, summarized below:

- Spatial mismatch. Welfare recipients tend to live in central cities and rural communities, while recent job growth has been concentrated in the suburbs. At best, this spatial mismatch requires long commuting trips that may involve multiple transfers. At worst, jobs (or employees) are located in areas without any transit service at all.
- Temporal mismatch. Many welfare recipients are likely to find employment in the retail, service, and health-care industries. These jobs frequently have evening and weekend shifts, which are not well served by traditional transit schedules.
- Child-care transportation. The typical welfare recipient is a single mother with young children whose work trip may need to include stops at one or more schools or child-care facilities.
- Language barriers. Some welfare recipients have limited English language speaking or reading skills, which may make it difficult to obtain information about transportation services.
- Changing needs. As TANF participants progress from training programs to permanent employment, their transportation needs are likely to change over time.

[7] Bureau of the Census. "Mothers Who Receive AFDC Payments—Fertility and Socioeconomic Characteristics." Statistical Brief 95-2. March 1995.

Transportation services for this population typically combine elements of traditional fixed-route services, flexible alternatives, service coordination, information services, and automobile-ownership programs. Strategies in place today include the following:

- In Chicago, subscription routes operate between an inner-city residential neighborhood and suburban job sites.
- In Louisville, Kentucky, the transit authority introduced a late-night subscription van to serve second- and third-shift workers.
- In Burlington, Vermont, the Good News Garage refurbishes donated automobiles and makes them available to welfare recipients.
- In Southern California, commuters can access a GIS-based transit trip planner over the Internet.
- In rural South Carolina, a flexible route was tailored to serve the transportation needs of TANF recipients and Medicaid clients.
- In Pinellas County, Florida, the metropolitan planning organization coordinates the provision of various transportation services to welfare clients.
- In Hartford, Connecticut, evening bus schedules were adjusted to accommodate work shifts at the local shopping mall.
- In Seattle, a three-way partnership among the transit agency, a municipality, and a major employer has sponsored a vanpool program.
- In Maryland, welfare clients are operating their own vans to provide transportation service to others.

Although strategies like these were developed in direct response to the transportation needs of individuals moving from welfare to work, they may serve other community transportation needs, as well. Given recent changes in the job market—including the growth of suburban employment, service industries, and the "24/7" culture—many transportation strategies designed for welfare recipients can easily serve other commuters as well. Reverse commuting, in particular, reflects changes in land use and economics that affect individuals beyond welfare recipients.

A number of funding sources are available to support these and other programs. At the federal level, both the U.S. Department of Labor (DOL) and the Federal Transit Administration (FTA) have introduced funding for welfare-related programs. The DOL Welfare to Work program, which includes formula funding and competitive grants, supports a wide range of activities, including transportation; the program focuses on welfare recipients who are likely to have the most difficulty finding and retaining employment. The FTA Jobs Access and Reverse Commute program, which was authorized in the Transportation Equity Act for the 21st Century (or TEA-21), is funding transportation projects that were developed through a coordinated human services/public transit planning process. Many states are using DOL formula funds, along with their allocation of federal TANF funds, to support welfare-related transportation efforts as well. Other funding sources include employer contributions, private foundations, and donations from community- and faith-based organizations. Using these resources, many states and urbanized areas are taking steps to make sure their FTA-funded transit services are able to meet welfare-related and new worker transportation needs.

CHAPTER 3

OVERVIEW OF GEOGRAPHIC INFORMATION SYSTEMS

This chapter provides a basic overview of geographic information systems (GIS). The following sections describe what GIS is and how GIS can assist in analyzing and addressing welfare to work issues. A basic understanding of the types of GIS databases and GIS functions is also provided.

WHAT IS GIS?

GIS is often thought of as computerized, automated mapping. While computerized mapping is one of the significant benefits of implementing a GIS, a GIS is much more. It is an information system that contains spatial data. Spatial data describe the position of a feature on the surface of the earth. Spatial data for a particular geographic feature consist of one or more sets of "x" and "y" (and sometimes "z") coordinates (longitude and latitude, for example). Because information on the location of each feature is incorporated into the data, a GIS is able to (1) illustrate on a map the spatial relationships between features and (2) perform analyses based on spatial relationships (e.g., adjacency, proximity, paths, and clustering).[8]

The often-quoted definition of GIS is one initially written by Dueker and Kjerne as follows.

> "Geographic Information System—A system of hardware, software, data, people, organizations, and institutional arrangements for collecting, storing, analyzing, and disseminating information about areas of the earth."[9]

Many other definitions can be found in the literature. Variations on the definition evolve out of the specific needs of the applications. The distinction between GIS and other information systems (for example, service-planning systems and trip-planning systems, database management systems, customer information systems, address-matching systems, query and display systems, and routing and permitting systems) is becoming blurred as each of these systems incorporate more and more locational data and algorithms.

Perhaps the best way to grasp the meaning of GIS is to describe the types of problems a GIS is designed to solve. In general, a GIS is developed because a user needs information about the location of something in relation to something else. So, for example, a GIS might be used to show the location of welfare recipients relative to the location of transit stations or bus stops. A user could calculate the walk distance to the nearest bus stop for a given recipient. Transportation agencies might use such a system to identify recipients who are outside the transit system service area. Welfare recipients might use such a system to identify the nearest bus stop.

A GIS for transportation contains more information than just the location of features relative to each other. A transportation GIS is capable of producing routes or paths across the lines that represent the roadways and rail lines, allowing the user to find the shortest route from the recipient's residence to the place of work. Sophisticated GIS systems can identify the shortest route across multiple modes (for example, walk, bus, rail). Some such systems can even estimate travel times.

APPLICABILITY OF GIS TO WELFARE TO WORK TRANSPORTATION PLANNING AND SERVICE DELIVERY

The adaptation of GIS for use in transportation planning was a natural outgrowth of computation-intensive travel modeling activities. Since the 1960s, travel modelers have been working with spatial data and distances between locations without the benefit of graphic displays or maps. Travel models rely heavily on the calculation of travel time, as a product of distance and speed. They also rely on the proximity of origins (e.g., home) to destinations (e.g., work place). Spatial algorithms have also long been used in transit service planning, particularly in ridesharing applications, scheduling, and route planning. GIS can be used to buffer proposed transit stations in order to estimate the number of potential users of the transit system. It can also be used to find the fastest route between two points and to determine where the transit market is located. These transportation planning and service delivery activities are undergoing extensive changes in implementation because of the availability of GIS functionality.

In the same way that these generic transportation activities are benefiting from GIS, welfare to work programs are also benefiting from GIS functionality. There are two GIS

[8] Note that these topological relationships can be, and have been, calculated outside of a GIS. However, the algorithms developed for implementation of these topological relationships have been vastly improved through the use of GIS systems and the structuring of data that arose out of GIS development.

[9] Dueker, K.J. and Kjerne, D., "Multipurpose Cadastre: Terms and Definitions." Annual Convention of ACSM-ASPRS, Proceedings, Vol. 5 (1989), pp. 94–103.

functions that are providing insight into the welfare to work problem: proximity and routing. There are also two activities within a transit agency that can make use of these GIS functions: service planning and trip planning. Typically, proximity calculations are used for service planning, while routing algorithms are used for trip planning. So, for example, the GIS's ability to determine the proximity of welfare recipients to places of employment provides a transit agency with information that can be used to analyze and modify service in order to more effectively serve the recipients and employers. The ability that a GIS has to calculate shortest paths can assist the welfare case worker to identify the best way for a recipient to get to potential jobs.

While there are many aspects of the welfare to work problem that cannot be addressed with transportation-specific planning activities, many transportation aspects of the problem can be addressed. For example, transit agencies could identify the areas with high concentrations of welfare recipients and areas with high concentrations of jobs available for recipients. This information can be used to design new services to serve the population leaving the welfare roles. As another example, transportation agencies could provide incentives for businesses with a large number of appropriate job openings to locate in close proximity to transit facilities that serve the recipients' home locations.

It is important to recognize that spatial analysis addresses only part of the welfare to work transportation challenge. As described in Chapter 2, temporal functions are also critically important to the successful delivery of service to welfare recipients. Welfare recipients may live near public transit routes, but buses may not run at the times when jobs are available. The integration of a temporal dimension to the state of the practice of GIS is currently a topic of extensive study and development. It will most certainly become an important aspect of the future uses of GIS for welfare to work applications.

TYPES OF DATABASES

GIS uses two types of data: feature data and attribute data. *Feature* data, which are required for any GIS application, include all the information that describes the location, size, and shape of a particular geographic feature. A database includes all of the features of a particular type; for example, streets, census tracts, employer locations, and bus routes would each be a separate database. Each database must generally be one of three basic types: points, lines, or areas (areas are sometimes called polygons).[10] The feature data include an ID for each feature (i.e., for each segment of a road or for each bus stop) and the coordinates for describing the location of that feature. Each type of feature database is described in more detail below.

In addition to the feature data, a GIS is most useful when there are *attribute* data. Attribute data are data that are linked to the features by the ID mentioned above. Attribute data are basically any data about the related feature that describe the feature beyond the basic size, shape, and location feature data. Attribute data that may be used in welfare to work applications are also described below.

Feature Data

The three most common types of GIS feature data are points, lines, and areas (or polygons). Figure 3.1 illustrates

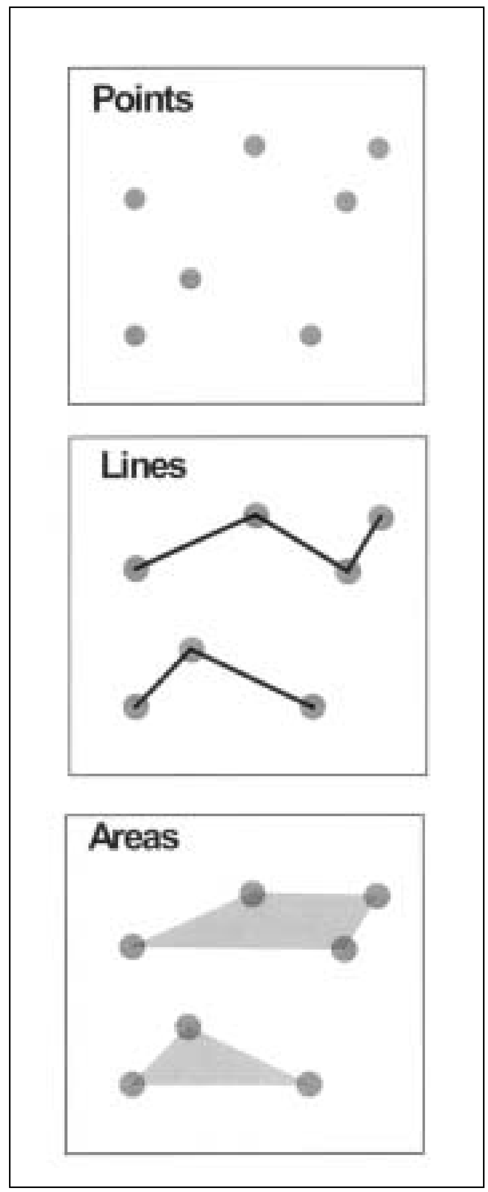

Figure 3.1. Types of GIS features.

[10] There are other complex feature types, such as regions and routes, that are used for specific applications. These features are not described here.

these feature types. Lines are constructed out of a series of points, and areas are constructed out of a series of lines. Each feature type is described as follows.

Point Databases

A point feature type is the simplest, requiring only a single set of coordinates to describe its location. Points can be used to describe the location of many different objects, depending on the scale at which the geographic data are recorded and displayed. For example, at a statewide mapping scale of 1 : 100,000 or even 1 : 24,000, points can be used to indicate the location of airports or inter-city train stations. However, at larger scales, a single point used to identify the location of the airport property might be misleading because the area the airport covers might be much larger than the size of the point symbol. Similarly, using a single point to describe a transit station or place of employment can be misleading at scales of 1 : 100 or larger.

The features which one might want to identify with points, for trip-planning purposes, include the location of recipients, bus stops, rail stations, child-care services, other support services, potential employers, and various landmarks required for giving the user context for location on the map. Service planning can often be conducted using data displayed at a smaller scale, since service planning requires the identification of market areas and not specific addresses. One might want to encode transfer stations as points for service planning. In addition, the locations of bus stops and intermediary train stations might be useful for identifying points of embarkation and disembarkation.

Line Databases

Line features require at least two points and may include a large number of intermediate points, depending on the limitations of the software. Typically lines are defined by two nodes, the start node and the ending node. Nodes are simply points that are used to identify the beginning and ending of a line and, therefore, lines may not necessarily be straight. Line databases typically include information about direction of the line (from node and to node), about which polygon lies on each side of the line, and information as to the ID of the line which immediately proceeds it and the ID of the line which immediately follows. This is the data structure that allows the GIS to calculate shortest paths and/or routes.

Line databases can be used to describe a wide variety of features including roadways, rail lines, geopolitical boundaries, and rivers. The incorporation and display of line features will also depend on scale. For example, on a map of a geographical region, one would not want to display all the local roads because they would be too close together to distinguish and would look like a large mass of ink. At service-planning scales, it may not be necessary to use all local roads. At trip-planning scales, one might want to include bus and rail transit lines, all roads (including local streets), geopolitical boundaries, and other line features which help a person identify where he/she is in relation to the transit line (i.e., rivers, transmission lines, abandoned rail lines, and fences).

Area Databases

Area or polygon databases represent geographic areas that are assumed to represent an even distribution of data items across the geographic area. For example, a soils map will include polygons for each geographic area that is more or less the same soil type. Similarly, census tracts, block groups and blocks are thought to be generally homogenous.[11] As with points and lines, the decision to use areas to represent features depends on the scale that is used. For example, an airport may be displayed as a point in larger scale maps while on smaller scale maps a point would totally misrepresent the size and location of the airport. Areas are made up of lines and may differ substantially in how they are represented depending upon the software that is employed. For example, some GIS software represents each polygon as a separate feature, requiring that the border between two polygons be digitized twice, once for each polygon. Other software products will identify places where two polygons share a border and attempt to generate a single line that is shared by the adjacent polygons. The choice of methods for building a polygon database can have a substantial effect on the types of analysis the user can employ. If the GIS maintains a separate line for shared borders of adjacent polygons, then it may be impossible to identify the polygons which are immediately adjacent or to identify which polygons lie on each side of a given line.

Polygon features are more likely to be used in service planning rather than trip planning. Some of the area databases which one might want to use in addressing welfare to work issues include neighborhood boundaries; town boundaries; paratransit service areas; ridesharing program service areas; and, in the event that the transit agency employs a zone-based fare, the boundaries of the fare zones.

Attribute Data

Attributes are the data items that describe the characteristics of the features. For example the points representing the potential employers might have attributes which describe the business, such as company name, number of open positions, product or service provided, address, and contact person's name and phone number. Attributes of transit route lines might include times of operation, average headway, and common name of the route. Examples of attributes of an area

[11] The validity of this assumption is unproven and considered by some to be debatable.

database are shown in Figure 3.2. For each zone shown in this map, the zoning for that area (business, residential, etc.) as well as the total population of the zone is included in an attached attribute file. Another example of attributes for welfare to work applications might be the number of welfare recipients in a given neighborhood or area.

Attributes describe the characteristics of a feature and can be used in database queries to select and categorize features for map display or analysis.

GIS FUNCTIONS

Because the GIS contains location data, the user is able to perform spatial analyses using GIS functions. Several basic GIS functions are described below.

Layering

One of the most valuable functions that a GIS provides is the ability to layer many types of spatial data and evaluate the resulting information. Layering is used to combine two or more spatially located data sources to produce new information that is the spatial integration of the two. Figure 3.3 provides an example of layering. In this example, the location of welfare recipients is overlaid on zones, the total population of each zone, and the street network. The number of recipients in each zone is then calculated. Another example might be to overlay polygons representing transit fare zones with a point layer representing potential employers to identify the cost of commuting by employer. In welfare to work applications, many planners overlay the residential locations of welfare recipients and the transit market served by existing bus and train lines to determine if existing service is within reach of the potential new users.

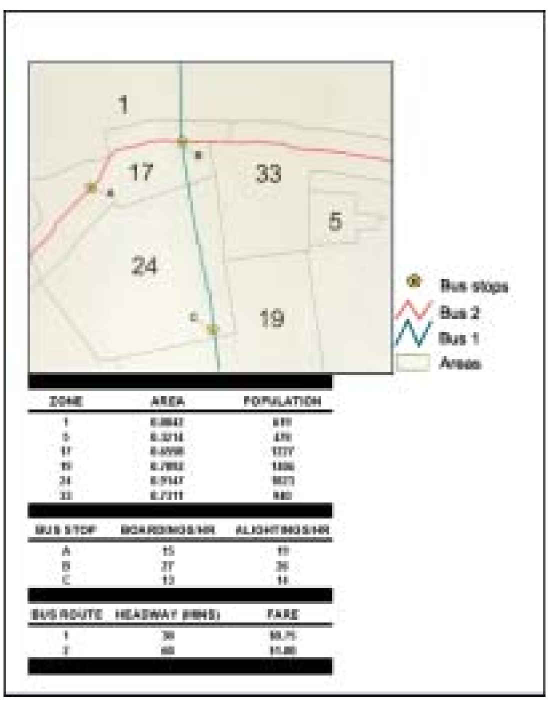

Figure 3.2. Examples of attribute data.

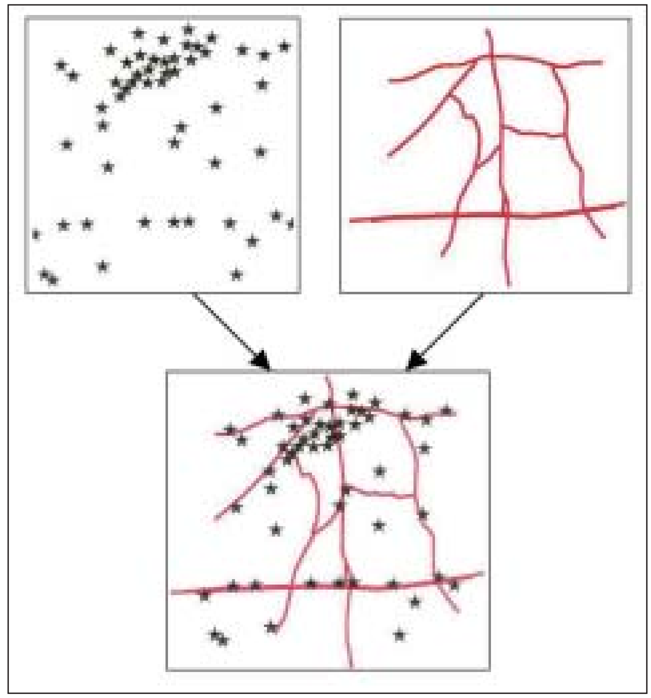

Figure 3.3. Example of layering.

Typically, layering refers to the visual display of multiple layers. The actual combination of multiple layers is discussed under the section "Overlaying."

Thematic Mapping

Figure 3.4 provides an example of thematic mapping. In addition to the power of spatial analysis, GIS provides a powerful visual analysis of geographic data. Simply showing the data in a geographic format will provide insight into the data that statistical analysis cannot provide.

Thematic mapping generally refers to using colors and symbols to visualize the characteristics of features as described by attribute data. A map showing color-coded census tracts to represent the number of employers per tract is a thematic map. Similarly, a map of bus routes can be color coded to indicate the different headways of each route.

Selection Subsets

Because GIS integrates data with locations, it is possible to use the GIS to identify features that meet specific criteria. These criteria may be related to size or location (i.e.,

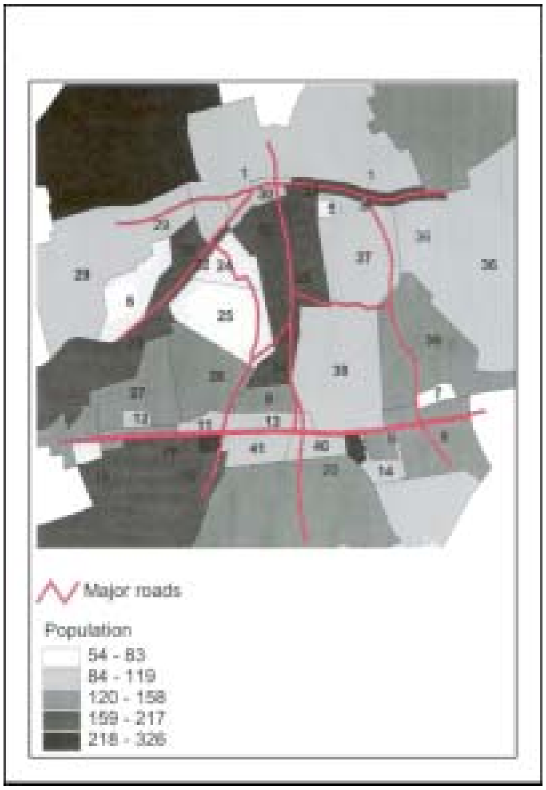

Figure 3.4. Example of thematic mapping.

proximity or distance[12]) or may be based on attribute data. For example, the user can select all day-care centers within a quarter mile of a transit station. The GIS then calculates the distance from the station and identifies all day-care centers within that distance. The selected set can be copied into a new database, used in a calculation, and/or displayed in a highlighted color on a display or map. The user could then use attribute data to select, from those day-care centers within the quarter-mile distance, those that are licensed for infant care.

Most GISs also allow for selection by interacting with the map. For example, a user might draw a polygon around a general neighborhood and have the GIS select all the welfare recipients within that area. The user can select one or more features by pointing the mouse at them. The result of this type of selection is not only the highlighting of the feature on the map, but also a selection of the data records from the linked database. It is the interaction between the map display and the underlying database that makes GIS a powerful tool.

Banding (Buffering)

Banding or buffering refers to a capability to identify the geographic area that is within a given distance of a feature, such as a bus stop or a route. In Figure 3.5, buffers are created around bus stops. Recipients living within and outside these buffer areas are thematically shown. Most GIS packages are capable of generating a buffer of a specified distance. Banding is frequently used by transit planners and operators to identify the households or businesses that are within the transit market area. This is the technique used to determine if a welfare recipient has access to transit, and whether or not a place of business can be served by transit. Other ways in which banding can be used to assist in the welfare to work programs might be to band the home and work locations to identify any day care facilities within a reasonable distance.

Once a buffer has been calculated for a feature, a new layer can be created which contains the buffer, or buffers, as polygons. This new layer can be used in layering and thematic mapping as described above.

It is important to notice the difference between banding and determining the network travel time or distance from a station. Bands do not take into account the environmental impediments to a patron's access to the station or stop. For example, households separated from a transit station by a limited access highway, a river, or a railroad track may be within a quarter-mile buffer of the station but not have access to the station. The same problem exists with regard to generation of a band around a transit alignment. Potential patrons may be

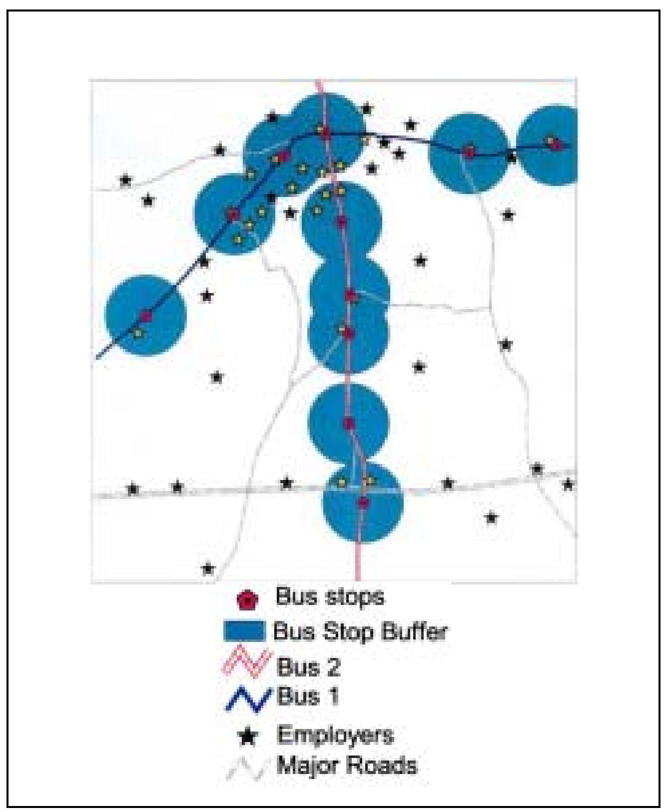

Figure 3.5. Buffering of bus stops and employers.

[12] Distance calculations can be either linear or actual walking distances. For general planning purposes, linear distances are often used. For trip planners, walking distance is important. Many GIS software systems can calculate shortest path walking distances.

within a quarter mile of the route but not within a reasonable distance of the station. There are GIS algorithms designed to calculate the distance from a point to a station. These algorithms are often used in trip-planning applications.

Overlaying

Overlaying is a generic term for functions that either generate a new layer from the combination of two or more separate layers, or that transfer the attributes of one layer to another. Overlay processing is similar to layering, but overlaying requires the actual generation of new features or new data, whereas layering implies that layers are simply displayed together for a visual analysis. Layering is discussed above.

Polygon Overlay

The user might overlay two area layers in order to remove features from one of the layers. For example, one might remove all of the features that fall within a quarter mile of a bus stop, and, create a new layer containing only those areas beyond a quarter mile of a bus stop. This intersecting activity is illustrated in Figure 3.6.

Two area layers may also be overlayed in order to estimate new attribute data in one layer based on the attribute data in another layer. For example, an area layer of bands around a bus route could be overlayed on census tract data containing counts of welfare recipients as attribute data in order to estimate the number of recipients within walking distance of the bus route.

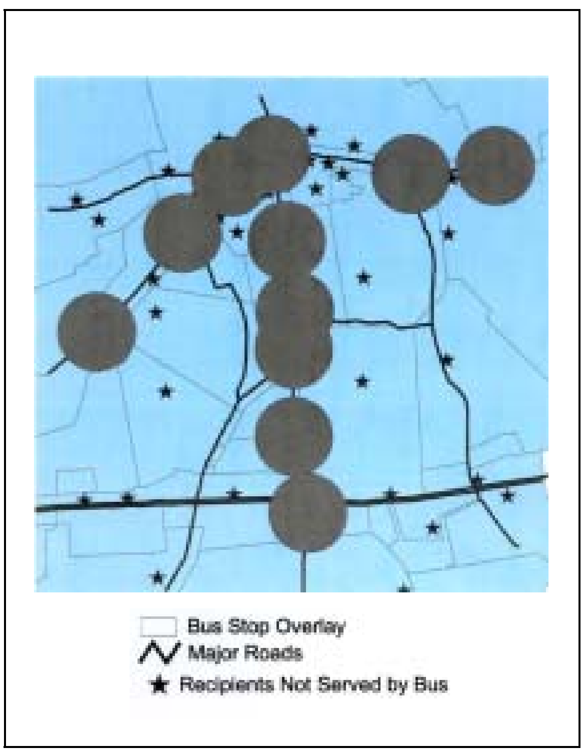

Figure 3.6. Polygon overlay.

Caution is recommended in using overlay processing to avoid convoluting polygon attribute data. If a polygon layer (such as a census tract layer) is subdivided by another polygon layer, (for example the quarter-mile radius around a bus stop) the attributes of the resulting two census polygons must be allocated to each of the two new polygons. For example, if a census tract containing 2,000 residents is divided exactly in half by the overlay of the bus stop buffer, it does not necessarily follow that exactly half of the population should be allocated to each new polygon. It may be the case that the vast majority of the population resides primarily in one-half of the original tract. There are many methods for reallocation that can be considered. Each attribute may have different methods for reallocation.

Point in Polygon Overlay

Like polygon overlay, points can be overlayed on polygons. Point in polygon functions do not generate new layers with new features, but rather result in attaching attributes from a polygon onto the attributes table of the points. For example, the welfare recipient point layer may be overlayed with the quarter-mile polygons around bus stops. A new attribute of the welfare recipient point table would then be assigned the number of the bus stop represented by the polygon. This point in polygon overlay, illustrated in Figure 3.5, uses both point in polygon as well as buffering.

Line in Polygon Overlay

Lines can also be overlayed on polygons. Line in polygon functions also do not generate new layers with new features, but rather result in attaching attributes from a polygon onto the attributes table of the lines. Line in polygon processing can be performed in three ways: (1) to identify all lines that are completely within a polygon, (2) to identify all lines that are completely or partially inside a polygon, and (3) identify all lines that cross the boundary of a polygon. The welfare to work applications are concerned with the second function. This can be used to identify transit routes that are partially or completely within an area of high numbers of employers.

Geocoding

As detailed in Chapter 5 of this handbook, some of the obvious pieces of information that are required for a welfare to work application are the locations of the recipients, the locations of potential employers, and the locations of support services. These locations are usually easily available in the form of addresses. Most mainstream GISs are capable of approximating the longitudes and latitudes of a given address if they are populated with the appropriate address range information. Address range data are typically provided as a part of the GIS roadway line features.

Origin-Destination Links/Desire Lines (Flows)

As noted in Section 3.2, transportation planners have been integrating spatial data with transportation models since before the popularization of GIS. One of the important ways that spatial data were integrated into travel modeling was to calculate distances between origins and destinations in the study area. Typically the study area is divided into analysis zones. The travel times and distances from each of these zones to every other zone is used to calculate and calibrate models. Understanding the relationship of travel between zones is very difficult unless there is an easy way to describe them. Early attempts to describe the travel between these zones involved drawing lines (referred to as desire lines) from one zone to all other zones to which people will travel. Variation of the band width of the straight line reflects the number of trips destined to each other zone.

Automated mapping programs made the generation of desire line maps feasible. More recent advances in GIS software make it possible to design an interactive system for studying the demand for travel between zones. With the GIS, a user can select a zone as the origin zone and request the GIS to thematically display all the destination zones for trips originating in the origin zone, thematically coding them to indicate volume of travel. The user can also look at the distribution of trips destined to the selected zone. This kind of analysis uses GIS to aid the modeler in both calibrating trip tables and networks as well as evaluating the results of a model run.

For welfare to work transportation planning, the evaluation of origin-destination data can be used to illustrate major work trip flows between areas or regions. It may also be used to identify pairs of recipients and employers that may constitute enough volume to warrant some type of service. This might be a bus route in the extremely high volume pairs of zones, or it might be a vanpool or shuttle bus service.

Distance and Shortest Path Functions

One of the most basic functions that a GIS provides is the ability to measure distance. Most GIS products provide a utility to select two or more points and calculate the distance between them. A user might want to use this function to estimate the distance a recipient will need to walk on each end of a trip. Shortest path functions are more complex and involve measuring distances over a network made up of one or more line databases. They are used to estimate the total distance, time, and/or cost of a trip to work, including walk distance. By measuring distance along the route and because the GIS contains information about the mode or type of travel (bus, walk, drive, etc.), the GIS will also have the ability to calculate travel times for recipients.

CHAPTER 4

GIS START-UP CONSIDERATIONS

Desktop GIS has become less expensive, more feature oriented, and more user friendly over time. In addition, many vendors are providing substantial data along with the software. In the near future, we may see the interchangeability of data as well, making the choice of software less and less a function of compatibility of data. The following sections discuss some of the issues you will face in setting up your GIS.

SELECTING THE RIGHT SOFTWARE

The authors make no recommendation on which specific software package should be purchased and used for welfare to work applications.* Advances in the GIS software industry are developing so rapidly that the products selected by an organization at the beginning of the implementation may be outdated before the implementation is completed. Such a dynamic environment benefits the consumer by making new and effective features available at increasingly reasonable costs. But it is also frustrating to constantly upgrade software. However, the intensely competitive environment for GIS software vendors assures users that effective features available today in one package are likely to be made available in all other comparable products within a short time frame. Consequently, as long as users select a GIS package from among the major suppliers, they need not be overly concerned about choosing the "wrong" software package. However, factors such as flexibility for customization, network-based software (versus a desktop solution), and the popularity of various packages should be considered. A summary of the major software products can be found in Appendix B.

For the basic display and query of the locations of recipients and places of employment, most commercially available software packages will be adequate. However, if the user wants to perform trip planning and service planning, transportation-planning functions are required. Transportation-planning functions are not commonly included in all packages, but are included in the three major [products]13: TransCAD, ArcInfo (and ArcView), and GeoMedia. Furthermore, TransCAD and GeoMedia are capable of reading file formats of their competitors, and ESRI (maker of ArcInfo and ArcView) is likely to follow suit in the future. Therefore, compatibility with databases developed by other departments is quickly becoming a non-issue.

TransCAD, from Caliper Corporation, tightly integrates a wide array of transportation planning functions, particularly transit analysis functions, with GIS functions. Planning functions such as routing a trip are already available and packaged with the TransCAD package.

If compared with other major desktop packages, TransCAD will appear considerably more expensive (approximately $10,000 vs. $1,000–$1,500). However, it is important to recognize that many of the data development and analysis capabilities of TransCAD are not available in the other desktop packages without investing in additional expensive add-ons and non-desktop products.

ArcView is the second major desktop GIS vendor. The base ArcView price is approximately $1,100, but each additional module adds another $1,000–$1,500. Modules such as ArcLogistics, Network Analyst, and ArcRoute can be added to ArcView for routing or trip planing functions. With these added modules, the user will have all the tools needed to develop trip planning and service planning. However, trip planning and service planning will need to be specifically developed.

The ease of use of ArcView is an appealing feature; however, ArcView is not an ideal platform for some of the more complex data development and feature editing functions. Transportation functions, such as building routes, require the use of ArcInfo, the larger, more expensive non-desktop GIS software. ArcInfo may be required for initial setup of the system and for periodic update and maintenance of the data. The ArcInfo software is considerably more expensive and requires a large investment in specialized training. In many cases, public agencies may rely on a sister agency or a consortium to provide the data clearinghouse for data for the region. In such an arrangement, the planning agency may feel comfortable with an ArcView-only choice.

The third major vendor of desktop GIS software is Intergraph with its GeoMedia product. Like the ESRI products, Intergraph relies on its larger, more expensive product, MGE, for major data development and maintenance, while marketing GeoMedia as an inexpensive, easy-to-use desktop

*Note: The Transportation Research Board, the National Research Council, the Federal Transit Administration (sponsor of the Transit Cooperative Research Program), and the Transit Development Corporation do not endorse products or manufacturers. Trade or manufacturers names appear herein solely because they are considered essential to the clarity and completeness of the project reporting.

[13] MapInfo is generally considered to be one of the major GIS products available on the market. It does not, however, provide any network analysis functions that are required for trip planning and/or service planning. Future enhancements to add routing capabilities are planned.

platform for applications. An important feature of GeoMedia is its ability to read and display data from most major GIS and database products, without conversion. Also, like ArcView, GeoMedia requires an additional add-on product, GeoMedia Network, for implementation of transportation functions for routing, trip planning, and service planning.

Regardless of the software product chosen, a program for use in addressing welfare to work issues will require additional programming to implement the specific application. All of the major products can be customized for specific applications.

Another option that is becoming available is the ability to develop the trip-planning or service-planning application in a web-based software product. Both ESRI and Intergraph offer Internet server products. This approach will require more intensive programming and will limit the functionality to only what is programmed. However, because it is web-enabled, it requires only a server license. Individual licenses for the GIS software do not need to be installed on each computer running the welfare to work applications.

HARDWARE NEEDS

As hardware power increases and hardware prices decrease, hardware selection is becoming easier. Most GIS software and applications will run well on the state-of-the-practice hardware. However, if the user is intending to run the application on old existing hardware, some consideration must be given to determining the lower limit to hardware configuration.

If the user chooses to implement an Internet solution, then the hardware configuration must include an adequate computer to be used as the server and sufficient speed on the communications hardware to support access.

An Internet solution may still reduce the overall hardware investment required, because more inexpensive workstations can be purchased. An Internet solution can also have advantages other than hardware costs, such as eliminating the need to distribute updated data to multiple sites.

Because GIS software and the necessary hardware are developing so rapidly, it is difficult to make any specific recommendations for minimum hardware requirements. Such minimum requirements would be quickly outdated. It is recommended that guidance from the specific GIS vendors be followed when making hardware investments.

GIS PROGRAM STAFF

The simplest GIS installation can be a single PC installed with a basic desktop GIS package and free data from federal and state agencies. In this configuration, users would work with consultants or service providers to specify and develop applications specific to their needs. An organization could have as few as one GIS user with basic training in the use of the GIS software and the specific application provided. This configuration would require periodic maintenance of data to be provided by an outside vendor. Extensive dedicated staff with substantial training would not be required.

The most comprehensive GIS program will involve a more sophisticated GIS software package, to allow for data update and maintenance and applications development. Typically, the most comprehensive GIS installation consists of an integrated network with a client server configuration. There would be a variety of GIS users and staff. This comprehensive configuration would require at a minimum a system administrator, a data manager, and an applications developer. Depending on the size of the installation, there could be many systems analysts and programmers working on applications, assisting users with training, and updating and maintaining the database. Usually these larger GIS installations supplement their GIS software with a third-party database management software package integrated with the GIS software.

Because GIS is operating in a very dynamic environment, with changes in software and hardware capabilities and increasing awareness of GIS in the workplace, organizations typically will start with a small GIS installation and develop the staff expertise over time and as the number of applications and users grow.

Making a Commitment to GIS

The successful GIS installation requires that the organization make a commitment to the development of GIS data and applications. Without a commitment to GIS, an organization can install a basic desktop application, such as a trip planner, and never use the GIS beyond the specific application. However, in order to gain the full advantage of the purchase of hardware, software, data, and applications development, an organization should plan for and implement a staffed, fully functioning GIS program.

Most successful installations begin with a needs assessment and implementation plan. The needs assessment process involves working with all departments and agencies that have an interest in using GIS to define their needs and assess the availability of data and applications. An implementation plan will be a fiscally constrained guide to the staged implementation of hardware, software, data, applications, and staff.

The needs assessment process not only results in an understanding of what is needed but also serves as a vehicle for building a commitment to GIS among the various departments. As applications are discussed, the participants in the needs assessment begin to see the value to themselves of the GIS. It is important to foster this commitment throughout the implementation process. One way to support this commitment is to plan for early installation of significant applications, allowing the organization to reap some of the benefits of the GIS installation early. Demonstrations and pilot studies are other tools that can be used to build an organization's commitment.

Dedicated Staff

As noted above, GIS staffing needs will vary widely depending on the size of the system installed. In the most basic installation, dedicated GIS staff are not required. However, without dedicated GIS staff, the organization will need to rely on outside vendors for periodic data updates, applications enhancements, and servicing.

In the larger installations, it may be necessary to dedicate full-time staff to system administration, database management, applications development, and support.

It may be possible to integrate GIS with another part of the organization. For example, GIS functions may be integrated within an information technology (IT) department or within a planning department. The IT department may even have experience working with a network-based GIS. For example, another department may have collected detailed road and employment information and may be using a network-based system to access these data. Users interested in creating a welfare-related application may be able to tap into the existing information, arrange for additional welfare-related data to be structured and stored, and, with the help of existing staff, complete the project using an existing network-based (rather than to a desktop) solution. If an existing network-based GIS option exists, it would be worth considering it before a desktop GIS is selected.

Internal Structure

Regardless of the size and organization of the GIS, it is important to allow users the opportunity to explore the capabilities of GIS at all levels of expertise. GIS is still somewhat new as a tool and requires the users to think differently about how they accomplish their objectives. Sometimes staff will discover more effective ways of accomplishing a task by using GIS rather than older methods.

A rigid internal structure is one in which all data are restricted and GIS functionality is limited to specifically developed programs. Users are unable to access the variety of features that each software package makes available and are prohibited from making copies of the data for experimentation. A flexible system will require safeguards against corrupting data and software, but will allow users at all levels of sophistication to copy data or engage in ad hoc experimentation.

A successful integration of GIS into an organization will involve the full integration of the maintenance of GIS features data (for example, locations of bus stops) with other data collection and maintenance activities.

Where to Get Assistance

There are many sources of information about the uses of and implementation of GIS at all levels of expertise. Because GIS is a computer-based technology, most of the resources for assistance make use of computer-based information dissemination and can be found on the Internet.

Many states have developed centralized GIS organizations, targeted at sharing data across towns, regions, and agencies and providing a resource to assist state organizations in effective use of GIS. In addition, at the federal level, there are organizations primarily focused on standards and data development. These organizations also provide information that is useful in evaluating and implementing a GIS.

A substantial number of professional organizations are also providing information about GIS. Many of these organizations sponsor monthly meetings for an exchange of information about GIS. In addition, some of them sponsor conferences aimed at supporting GIS users at all levels of expertise.

Academic GIS programs have evolved in many colleges and universities across the country and provide an important source of training as well as system applications. Finally, GIS software vendors and consultants are experienced at performing needs assessments and can provide information about the capabilities of the various GIS systems.

GETTING BASELINE DATA

It is likely that the biggest expense in setting up your GIS will be local data development and maintenance.

Many GIS vendors are making a substantial amount of baseline data available with the software, such as large-scale data sets of roads, waterways, state and county boundaries, and point locations for cities and towns.

More and more baseline data are becoming available through federal and state GIS programs. For example, the Federal Transit Administration (FTA) GIS database, compiled by the Geographics Lab at Bridgewater State College, contains geographic features data for all the transit routes in the country's 550 transit properties. The data are free and downloadable from the Geographics Lab Web site at http://geolab.bridgew.edu/home. In addition, other nationwide transportation data, including highways, airports, navigable waterways, intermodal sites, and rail lines, can be downloaded from the Bureau of Transportation Statistics (BTS) web site at http://www.bts.gov/gis/ntatlas/networks.html. These data are available in ASCII text file formats and can be translated to other popular GIS software formats using the BTS Viewer program, also available for download from the BTS web site.

Regardless of the amount of freely available data, an organization implementing a welfare to work application will find that additional local data, both features and attributes, will need to be incorporated into the application. Such data might include geocoded locations of employers, new streets built since the most recent street database, forecasted travel times, and childcare resources. The gathering and structuring of these data should be planned with an understanding of the database maintenance issues. Chapter 5 provides information about the common types of data required to develop GIS for welfare to work transportation planning and service delivery applications.

Maintaining Data Integrity

One of the most difficult aspects of implementing and operating a GIS is maintaining currency and accuracy of the data—both features and attributes. Just as the world around us is constantly changing, the data, which describe the world, must change. New roads are built, rivers flood and change shape, towns annex property and change their limits, welfare recipients and employers move, and transit lines change to reflect the changing demographics of a city. Additionally, attribute data change. Headways on bus lines change; employers change their product line and, therefore, have different labor needs; and welfare recipients' children grow older and require different schooling and day-care options.

In this dynamic environment, it is important that a GIS is maintained with good version control, metadata, and verification. For example, you do not want the transit service provider changing the route of a bus on one version of the data while the scheduler is changing headways on another version of the data.

In many areas of the country, local, regional, and state GIS users are coordinating their efforts and orchestrating shared data and data management. This approach is ideal because it allows the knowledgeable users to update their own data. At the same time, the user can depend on other participants to maintain the currency and integrity of the data that they contribute.

In the absence of this cooperative environment, an agency should develop a procedure for updating data to ensure that users are working with the most recent accurate data.

INTERAGENCY COOPERATION

As described in Chapter 5, setting up welfare to work GIS will involve getting and maintaining data from a variety of agencies. Information about existing transportation services will need to be obtained from transit providers or planning agencies. Information about welfare recipients will need to be obtained from state or county welfare agencies. Employer/employment information, child-care, and other support service information will also need to be gathered from other sources. Maintaining accurate and up-to-date information from all of these sources can be a daunting task. The task of data collection and maintenance can be made easier if the GIS system is developed in a cooperative way by all agencies that are likely to benefit from the effort.

Interagency coordination can also be useful in developing standards for data development. This might include developing standards for common projections that are used in developing spatial data. Interagency coordination can also ensure that all agencies involved in implementing welfare reform initiatives benefit from the GIS applications and data that are eventually developed. Information can be used not only for transportation planning and service delivery, but for job placement, identification of needed support services, recruitment by employers, or in decisions about where best to locate services or jobs.

Following are some examples of this type of interagency cooperation.

Interagency GIS Efforts in New Jersey

In 1997, the New Jersey DOT and the New Jersey Department of Human Services co-sponsored a Transportation Summit for human service professionals, transportation professionals, and workforce/economic development professionals. Work begun at the summit continued as a statewide effort to develop coordinated transportation plans for each county; the aim was to remove barriers that prevent welfare clients from getting jobs by recognizing the interrelationship of transit service and various support services. GIS databases of transit and supporting services such as day-care, shopping, banking, and employment locations, as well as other demographic characteristics, were used extensively throughout the design of all countywide transportation plans. Because the plans were created as part of a coordinated statewide effort, all of the GIS databases that were collected from various state, county, and local agencies were maintained in one central location. At project completion, all the databases were turned over to a central GIS contact person at New Jersey Transit, which now, on request, provides these GIS data and maps to various state and county agencies. NJ Transit continues to add additional geographic databases to the state's geographic "library."

Southern California Association of Governments

The TranStar trip planner is used throughout the Southern California area and is operated under the management of the Southern California Association of Governments (SCAG). In Los Angeles, TranStar is used by five transit agencies, over 80 employers with rideshare programs, and a growing number of welfare to work centers to produce real-time transit itineraries. SCAG's rideshare services include telephone ridematching that includes transit itineraries. The Internet services currently account for 2,500 user accesses per day.

As with any system that incorporates data received from multiple agencies, data entry, standardization, and ongoing file maintenance can be a challenge. In the Los Angeles service area, several carriers enter and maintain their own route, schedule, and fare data, but the majority of transit-related data are entered, maintained, and quality-assured by SCAG. TranStar supports online, real-time entry of transit data, placing it into production immediately upon certification of its correctness. Data can also be loaded for multiple route patterns in batch mode.

SCAG maintains the geographic databases as well as a group of technical support staff to train users of TranStar. SCAG also maintains the computer operating environment for TranStar in-house and performs software upgrades, data backups, systems administration, etc. Chapter 8 further discusses the different levels of GIS-based trip planners. For more information on the TranStar trip planner, see Chapter 8 and Appendix D.

Statewide GIS Development in New York

Partnerships are needed to share in the creation and coordinated use of GIS data sets between governments and private entities at all levels. To achieve this purpose, the State of New York has implemented an NYS GIS Coordination Program, an innovative model for data sharing and partnerships.[14] The program helped address some of the issues pertinent to a GIS coordination effort, such as:

- Lack of awareness of existing data sets;
- Lack of or inadequate metadata;
- Lack of uniform policies on access, cost recovery, revenue generation, and pricing;
- Lack of uniform policies on data ownership, maintenance, and liability; and
- Lack of incentives, tools, and guidelines for sharing.

Furthermore, the New York State GIS Clearinghouse was created and established on the World Wide Web (http://www.nysl.nysed.gov/gis/) by the New York State Library. It includes a metadata repository describing GIS data sets held by many different organizations as well as information about how to obtain the data. It also has extensive information about New York's GIS Data Sharing Coordination Program, information on and links to GIS education and training opportunities, other state and federal GIS resources, GIS user groups throughout New York, and GIS-related listservs. In addition, members of the Cooperative can have direct access to selected data sets from the Department of Transportation (DOT), the Office of Real Property Services (ORPS), and the Adirondack Park Agency (APA). Recently, Cornell University created a linked companion data repository to house information from a variety of agencies too small to set up their own repositories.

[14] Source: GIS Coordinating in NY State: Center for Technology in Government, October 1998.

CHAPTER 5

TYPES OF DATA NEEDED FOR WELFARE TO WORK GIS APPLICATIONS

In order to undertake GIS-based transportation service planning or service delivery, information about current transportation systems, recipients, job opportunities, and other key services must first be obtained and mapped. Some basic geographic databases about the area to be served will also be required. Demographic information about the service area also might be useful. Most GIS-based planning and service delivery applications use some combination of the following types of data:

- Census geographic and demographic information,
- Recipient locations and needs information,
- Employer or employment data,
- Information about current transportation services,
- Child-care service information, and
- Other key support service information.

The first part of this chapter provides information about each of these types of data. Typical sources of this information are identified. Issues that arise in mapping each type of data are discussed. Data maintenance considerations are also presented.

In many planning and service delivery applications, it is also necessary to develop new databases that combine basic geographic or attribute information. Several of the more common "unique geographic databases" and how they are developed are presented.

Finally, important issues in visually displaying multiple types of data are discussed.

CENSUS DATA

The U. S. Bureau of the Census collects and maintains a wide variety of geographic files, such as streets, census blocks, census tracts, and various other geographic areas. The census also compiles a voluminous amount of demographic information for geographic areas across the nation, such as the percentage of low-income households for each census block group, the number of households receiving public assistance in a census tract, and the percentage of transit riders in a city (and hundreds of other variables/geographic levels). Because this census information is readily available and inexpensive, it is often the primary source of geographic and demographic information needed for GIS-based transportation planning and service delivery applications.

Planners often use the geographic databases available from the census as background layers on maps and sometimes edit or update the census geographic files to suit their particular planning needs. Planners and researchers can use census attribute data in a variety of ways and can easily combine the attribute data with geographic files by using GIS. Several of the data products provided by the U.S. Census, including Topologically Integrated Geographic Encoding and Referencing (TIGER)/Line files, Census Transportation Planning Package (CTPP) information, and demographic data, are described in this chapter. Some of the limitations of census data and future census products are discussed as well.

Census TIGER Files

The Census Bureau developed TIGER® files to support the Decennial Census and other mapping needs and sample survey programs. The TIGER/Line files are a digital database of line, landmark, and polygon features, such as roads, railroads, rivers, lakes, political boundaries, traffic analysis zones, census statistical boundaries, point landmarks such as schools and churches, and area landmarks such as parks and cemeteries covering the entire United States. The database contains information about these geographic features, such as their latitude and longitude, the address range for many street segments, and other related information. These files are digital data describing the geography; they are not pictures or maps.

The Census Bureau releases periodic extracts of these databases to the public; the most recent version available is TIGER/Line 1997. Information about ordering TIGER files is provided on the Census Bureau's Webpage at http://www.census.gov. An address and phone number for contacting the Census Bureau are also provided in Appendix C of this handbook.

Census Demographic Data

In addition to the geographic files, the Census Bureau sells Summary Tape Files (STF), which contain 1990 census statistical data, based on geographic area units of various size. These files are available both on tape and on CD-ROM.

Users may purchase these data and join statistical (attribute) data to the appropriate geographic features to create maps. This is possible because the Census creates summarized data at various geographic levels, such as states, counties, places, census tracts, block groups, and census blocks. This information is developed in accordance with Federal Information Processing Standards (FIPS) codes and Census Bureau codes so that data can be easily matched with geographic features. The "STF 3A" data are frequently used because they contain data for hundreds of demographic characteristics for geographic units as small as census block groups. Available information that is helpful in welfare to work transportation planning and service delivery includes the following:

- Population,
- Poverty status,
- Low-income households,
- Households with no automobiles,
- Households and persons receiving public assistance income, and
- Persons with mobility limitations.

Also available from the Census Bureau is the STF 1B database, which contains data for geographic units as small as census blocks (which are smaller than the census block groups). However, since the Census Bureau is required by law not to disclose information about specific individuals, households, or housing units, STF 1B data are essentially restricted to block-level population statistics.

CTPP Data

The Census Transportation Planning Package (CTPP) is a set of special work-trip tabulations sponsored by the DOT in each state and designed to meet the data needs of transportation planners. This work-trip information can be helpful in analyzing welfare to work transportation needs. The CTPP is divided into two "Elements"—the Statewide Element and the Urban Element—and three "Parts." These are described below.

The Statewide Element of the CTPP contains data for standard census geographic areas like states, counties, and places (only those with 2,500 or more persons). An urban element data set has been created for each Metropolitan Planning Organization (MPO) across the country. The Urban Element of the CTPP contains data for custom geographic areas like traffic analysis zones (TAZs), study areas, and CTPP regions.[15]

The Statewide and the Urban Elements are composed of three parts. Part 1 (tabulations by place of residence) contains data for housing units, households, persons, and workers living in the region for various types of geographic units. The different types of geography are called summary levels. The counts are based on the sample, or long-form, data from the 1990 census and may, therefore differ from the 100 percent 1990 census counts. In Part 2 (tabulations by place of work), the CTPP provides data for workers who worked in the region. This means that residents of the region who worked outside it are excluded from Part 2. Conversely, non-region residents who worked inside the region are included in the Part 2 numbers. Since the universes for Part 1 and Part 2 are so different (residence-based versus workplace-based), the totals for one part will not equal those for the other. Part 3 (tabulations of residence area by work area) includes in its universe workers who lived or worked in the CTPP region. The tables in Part 3, however, are restricted to workers who did not work at home. Therefore, any at-residence or at-work summaries calculated from the commuter flow data in Part 3 will not equal the all worker counts in Part 1 (by place of residence) or Part 2 (by place of work). However, there are some tables in Part 1 and Part 2 (such as Table 1-31 and Table 2-8) that are also restricted to workers not working at home. The residence or work summaries for an area from Part 3 should equal the number of workers not working at home for that area as shown in these two tables.[16]

CTPP information is available on CD-ROM and can be ordered directly from the Bureau of Transportation Statistics (BTS) by calling (202) 366-DATA. This information is provided free of charge and is usually sent within a few days. Data can also be ordered online at the BTS website, http://www.bts.gov (the order form is under BTS Product Information and Services). CTPP data may be accessed through a program called TransVU, which is contained on the CD-ROM along with the CTPP data. Through TransVU, the user may download the appropriate databases and select the particular geography and tables required. The CD-ROM contains detailed documentation regarding the directory structure and data files.

Census 2000 will include a new set of CTPP tabulations. Users can expect many of the most frequently used tables from the 1990 CTPP to appear again in CTPP 2000. As was the case with the 1990 CTPP tables, one can expect a several-year delay before the CTPP 2000 tables will become available.

Using Census Data in GIS Applications

The U.S. Census provides data only; it does not provide mapping software. To make use of these data in transportation service planning or service delivery applications, a user must have mapping or GIS software that can import TIGER/Line and other data. With the appropriate software, a user can produce maps ranging in detail from a neighborhood street

[15] Some MPOs chose to use census tracts or block groups (BGs) instead of TAZs for their most detailed geographic level. The MPO has defined the county or counties (towns in New England) to be included in the package, and the resulting area is called a CTPP region. Each CTPP region has been assigned a unique code to identify it. Generally this is the MSA, CMSA, or PMSA code for the central area, or some variant of the metropolitan area code.

[16] U.S. Department of Transportation, Bureau of Transportation Statistics.

map to a map of the United States. To date, many local governments have used the TIGER data in applications requiring digital street maps. Software companies have created products for the personal computer that allow consumers to produce their own detailed maps.

Several of the GIS software vendors, such as Caliper (TransCAD), ESRI (ArcView), and MapInfo package census data in a convenient format—including both selected geographic units as well as associated attribute data—and include these data along with the GIS program software. This simplifies the process of combining census geographic data with attribute data, so that the user can more easily access the census databases.

Limitations of Census Data

Census TIGER/Line files have limitations. Although updates are issued every few years (i.e., 1990, 1992, 1994, 1995, 1997), the geographic data are not entirely accurate. Road features are often cited as being particularly problematic. Users should not assume the Census TIGER/Line files are completely accurate. Users should review all geographic layers, particularly road features, to assess the accuracy of their data before using GIS functions such as geocoding. The Bureau of the Census is well aware of the limitations of certain databases, and points out various anomalies in its *TIGER/Line Files Technical Documentation*.[17]

Level of Detail for TIGER/Line Files

The level of detail provided by the TIGER/Line files may or may not be sufficient, depending on the complexity and requirements of the application. Some applications may require very accurate, detailed information about the street network, such as the number of lanes, travel speeds, directionality, the existence of bus or HOV lanes, and the presence of sidewalks. Extremely accurate street networks may include separate lines for each lane or direction, rather than a single line representing an entire roadway. While most welfare to work applications do not require highly detailed (and costly) street files, the original Census TIGER/Line files still may have considerable omissions and errors. Corrections and additions may have to be made in-house or purchased from an outside vendor. Sources of improved street files are described in Appendix C and include Dynamap 2000, ETAK, Thomas Brothers, and Claritas.

Missing Information

TIGER/Line files are often missing streets. In a growing area, new developments and streets may not be included. In a redeveloping area, streets that have been removed may still appear in the TIGER/Line data. Even in stable areas, streets may be missing, mislabeled, or misaligned. While street names may be correct, address ranges (which are critical for accurate geocoding) may be completely missing or may not allow for geocoding in certain circumstances. For example, many addresses in Queens, New York, use dashes within particular addresses. Even more commonly, many areas of the country use multiple names for particular street segments (i.e., Route 1 may be also known locally as Main Street or North Main).

Cleaning Up Census Data

While TIGER/Line files are not perfect, GIS software allows users to edit road features and other geographic units to create cleaner, more accurate geography. Significant data cleaning, however, can be time consuming. For example, in a recent planning effort in rural Cape May County (New Jersey), it was reported that a full day was spent adding and modifying the local TIGER-based street networks to allow more advanced GIS functions (such as geocoding points and entering a bus route system). In very advanced GIS applications, such as trip planners, a very accurate street network is required for the program to function correctly. In larger urban areas, this may take weeks or months to complete.

It is up to the user to determine the level of accuracy required for the particular planning or service delivery application. Some factors that may define the level of clean up include:

- The complexity of the application;
- The time and budget resources available; and
- The determination of an acceptable "hit rate" (percentage of factors that can be located geographically).

Private companies also provide updated geographic files. For example, in a rural demonstration program completed in Chautauqua County, New York, a cleaned-up version of the TIGER files (Dynamap 2000) was purchased to improve address matching during the geocoding process. Improved census files are also sold by ETAK, Thomas Brothers, Claritas, and other companies.

Future Census Data

Census 2000 is underway to determine how many people reside in the United States, precisely where they reside and their demographic characteristics. In order to mail out questionnaires and control the collection and tabulation of Census 2000 data, the Census Bureau will identify all living quarters in the country and locate them with respect to the geographic areas for which census data are reported. The Bureau will accomplish this by creating a Master Address File (MAF) that identifies all living quarters and locates those

[17] TIGER/Line Census Files, 1990 Technical Documentation. U.S. Department of Commerce, Bureau of the Census. Washington, D.C., 1991.

addresses in its TIGER database. To ensure that the TIGER database is complete and correct, the Bureau works with other federal agencies; state, local, and tribal governments; and other public and private groups to update both its inventory of geographic features and its depiction of the boundaries, names, and attributes of the various geographic entities for which the bureau tabulates data. Furthermore, as a result of legislation enacted in 1994, the Census Bureau has for the first time been allowed to have local and tribal governments review the MAF.[18]

Census 2000 data are being disseminated mainly using a new data retrieval system called the American FactFinder, which will provide an interactive system that enables data users to access prepackaged data products, data documentation, and online help, as well as to build custom data products online and offline. The first version of American FactFinder was available for limited use in 1999. Census 2000 data products will be available beginning in January 2001. American FactFinder will be accessible to the widest possible array of users through the Internet, Intranet, and all available intermediaries, including the nearly 1,800 State Data Centers and affiliates, the 1,400 federal Depository Libraries, as well as universities and private organizations. The Census Bureau will also provide geographic data products for data users. The products planned for Census 2000 are maps in digital and hard copy form and TIGER extracts in digital form.[19]

Because of changes being made to the collection and dissemination of census materials, one can expect that persons using GIS to help plan for welfare to work in the 21st century will be able to access relevant census information more quickly and more easily.

WELFARE RECIPIENT DATA

Information about where welfare recipients live is a critical part of any welfare to work spatial analysis. Recipient locations are the origins of most trips to work. Some form of these data, whether it is an actual address or some aggregated form of data display, is needed to locate gaps in transportation services between residences and jobs. Addresses are also needed to successfully match recipients to jobs and to identify transportation alternatives.

State or county welfare departments are typically the main source of data about recipient locations. Generally, these state or county agencies maintain an electronic client list that is used to forward monthly benefits or other assistance. These files are often in common spreadsheet or database formats such as .xls (Excel), .txt (text), .csv (comma delimited text), and .dbf (dBase).

Ideally, the information shown in Table 5.1 should be extracted from any list of recipients. In addition to street address, it is important to have the city/town name and, most importantly, a zip code. This additional address information will help to locate the address in the geocoding process. For example, 10 Main St. might be a common address found in many cities and towns across the country. Having city/town and zipcode information will help ensure accurate address matches and will speed up the geocoding process. A unique ID number is often assigned so that once the addresses have been geocoded, the recipient names can be removed from any list provided by the welfare agency to planners and service providers.

Resolving Confidentiality Concerns

Obtaining welfare recipient data can often be difficult because it is confidential and not readily available for dissemination. Once requested, it may take a state or county welfare agency some time to determine what information it can release and how confidentiality issues will be resolved. Typically, confidentiality is maintained by either *masking* or by *aggregating* the recipient data.

Masking

Masking recipient information involves removing or obscuring personal, individual information while still retaining the information of value. For example, the names of recipients and exact street addresses would be removed and a unique recipient ID number used instead. Once geocoded, the information shown in Table 5.1 would be made available in its masked format as shown in Table 5.2. After the original client database was geocoded, two new columns were added (LONGITUDE and LATITUDE). These two fields maintained geographic coordinates important to locating that specific address on a map. The two specific fields in the original database (NAME and ADDRESS) were then removed.

Aggregating

Some states have required an even higher level of protection of recipient confidentiality. Because geocoding can locate an address with some precision, these states have expressed concerns that addresses (and recipients) might be able to be identified even if data are masked. This is a particular concern in rural areas where there is a greater distance between residences.

An example of aggregating recipient location information would be to geocode specific addresses and then perform a 'count' of the number of addresses that fall within a particular geographic area (e.g., census block groups). A data field can then be added to the block group geographic layer (e.g., COUNT). A thematic map based on the field COUNT can

[18] Ibid, pages 4–5.
[19] Ibid, pages 12–13.

TABLE 5.1 Sample welfare recipient address database

ID NUM	NAME	ADDRESS	CITY/ TOWN	STATE	ZIP CODE
1	Elaine Johnson	10 Main St	Bedford	NY	03293
34	Scott Brown	16 Roundhouse Ln	Freeport	NY	03467
6	Lauren Smith	7 Sassafrass Ave	Assabet	NY	03281
18	Jessica East	35 Oaknut Rd	Mansfield	NY	03699

then be created to look at the relative density of recipient residences in each block group. The thematic map can have different colors or patterns to represent higher or lower incidences of recipients.

In Massachusetts, the state Department of Transitional Assistance (DTA) aggregates recipient data by replacing name and specific address information with a ZIP+4 code. ZIP+4 data were developed by running the recipient address database through a U.S. Postal Service approved program (DTA used the Mailers + 4 program) that adds the appropriate 4-digit ZIP Code extension. This offsets address points approximately one block in urban areas and further distances in rural areas. DTA feels that ZIP+4 information allows planners to see where clusters of recipients reside with enough accuracy to plan bus routes or conduct similar analysis.

Determining the Level of Accuracy Needed

The level of accuracy needed for recipient data varies depending on the task you want to complete and the amount of time and effort you can allocate to creating and updating your welfare client databases. General planning applications tend to focus on an overview of where welfare recipients live relative to existing transit routes, job locations, child-care services, and so on. For this type of analysis, aggregating recipient locations to a less specific level (such as ZIP+4, or block group) might be appropriate. The geographic level you choose depends on the level of detail necessary to complete your analysis.

More specific address information is necessary for individual trip planning services. When a caseworker works with a transitioning individual, trying to find all possible job opportunities and transportation options available to the individual, it is critical to know the recipient's exact address. Higher-end trip planners also need to know the residence address in order to create a trip itinerary and routing options. Often, though, this exact address information is entered voluntarily by the recipient.

Important Recipient Attribute Information

It may also be useful to develop and maintain other information about welfare recipients besides place of residence. This information may be useful to caseworkers and transit service providers for identifying needed support services, identifying transportation options, or prioritizing needs. For example, it may be useful to consider adding the following information to the recipient database:

- *Length of time on assistance or time expected off assistance.* Knowing the deadline that the recipient faces in transitioning off of public assistance might help focus transportation service improvements where they are most urgently needed.
- *Auto availability or driver status.* Identifying locations where there are many recipients who do not own or operate autos can also help focus transit solutions. Knowing if recipients own or are able to operate an automobile might help identify if driving a personal vehicle or serving as a driver in a ridesharing arrangement is an alternative.
- *Number and ages of children/child-care needs.* This information will indicate if child-care transportation needs to be part of the support services offered. Knowing the ages of the recipient's children may help identify

TABLE 5.2 Sample "masked" recipient database after geocoding

ID NUM	LONGITUDE	LATITUDE	CITY/ TOWN	STATE	ZIP CODE
1	-75154990	42519211	Bedford	NY	03293
34	-74803455	42655872	Freeport	NY	03467
6	-75030919	42709018	Assabet	NY	03281
18	-74958544	42625503	Mansfield	NY	03699

appropriate child-care services. Instead of asking for detailed dependent information, recipients might simply be asked to indicate if child care and child-care transportation will be needed.

Using more detailed attribute information, thematic maps can be created. For example, one might help identify critical transit needs with the following:

- First create a thematic map based on the exact months that recipients will be required to be off public assistance.
- Next, create a map for just those recipients whose time off assistance will occur in the next few months.
- Next, from the group of recipients who will need to be placed in jobs in the near future, select those who do not own vehicles.

Thus, information about the number of recipients coming off assistance in the near future who do not own cars could be provided to the local transit agency. This information might also be shown overlaid on current transit routes to show the distances to and adequacy of existing service.

Maintaining Recipient Data

For ongoing transportation planning efforts, periodic updating of recipient information will be necessary. For service delivery applications (trip planners), regular and frequent updating of this information may be needed. If frequent updates are needed, this can be done each time the state agency reviews and updates recipient eligibility (the agency should be contacted to determine how frequently this occurs).

State and local welfare agencies typically update eligible recipient lists on a daily basis. Arrangements can then be made to download the latest recipient information. Depending on the arrangements made to protect recipient confidentiality, relevant data may need to first be extracted from the master recipient files before updated information is transmitted to transit planners or service providers. Masking or aggregating of the information may also need to be done at the state welfare agency level each time the latest information is released. This is typically done by a staff person at the state agency who is responsible for maintaining agency data. This person may need to have GIS skills if data are to be geocoded and aggregated before they are released. State and county welfare agencies should consider developing in-house GIS capabilities. Having this skill in house will not only benefit external planning activities for welfare to work, but will also enable internal planning and evaluation. For example, a state welfare agency could use maps of recipient locations and attributes to evaluate support service needs and to plan for new service office locations.

If the state welfare agency does not have the capability to modify and geocode recipient information and to update these files, an agreement might be negotiated with a transit planning agency or provider to designate staff to perform these functions. Designated external staff would obviously need to agree to maintain strict confidentiality of any master files provided. The person designated to update the database should determine the best approach: either removing the records that were taken off assistance and re-evaluating the other records for accuracy, or purging the database and re-geocoding the entire set. The latter has been shown to be more accurate and less intensive once a routine for geocoding is established. This approach also allows old data sets to be compared with new information to evaluate changes and trends.

EMPLOYMENT DATA

Information about jobs and job openings is another critical data element for welfare to work transportation planning and service delivery applications. An employment database needs to be collected or created and will vary depending on the particular application. The database may include, for example, total employment, current job openings, or projected job openings.

Employment versus Employer Data

Information about jobs and job openings can be depicted in various ways; it can be presented in terms of overall employment, total job positions with specific employers, or actual job openings. Typically, information presented on employers and total jobs is developed as a point database and may include:

- Type of employer, and
- Total jobs at each employer location.

Information about actual job openings would also be developed as a point database and might include:

- Number of job openings at an employer location,
- Employers who have hired welfare recipients in the past, and
- Companies planning to expand their labor force.

In contrast, overall employment information is typically associated with an area database and may include:

- Total number of jobs in an area,
- Recent or projected job growth in an area, and
- Percentage of jobs located near transit in an area.

While data about job growth (i.e., job growth expected at the factory or in the town) would be most useful in longer-term planning applications, a database of current job openings is most useful to current job seekers. Table 5.3 illustrates both an employment database based on areas (jurisdictions), and a job openings database of employers based on points

TABLE 5.3 Employment versus employer databases

Employment Database			
(Jobs in a County)			
City, Town or Village	**Employment**		
	1990	**2000**	**Change**
Lawrence Town	5,000	5,100	+100
Springfield Town	12,000	15,000	+3,000
Columbus City	18,500	18,000	-500
Richmond Village	200	210	+10
W. Spring Town	50	50	0

Employer Database		
(Job Openings in a City)		
Company	**Position**	**Salary**
Nana's Bakery	Baker	$10/hr
City High School	Janitor	$20,000
ABC and Assoc.	Engineer	?
WeeMart	Cashier	$8.50/hr
City Diner	Waiter	Tips

(companies). These data are constantly changing as people accept new jobs, leave existing jobs, and as companies move, expand their workforce, or lay off workers.

The following sections describe various sources of employment data and difficulties that may be encountered when preparing employment databases for geocoding.

Sources of Employer and Employment Data

There are various sources of employment data, ranging from job openings posted in the newspaper and on the Internet, to prepackaged census data, to extensive databases maintained by public and private organizations. Often a local planning organization, chamber of commerce, or transit agency might also maintain an employment database. Some of these data sources include the following.

Local Agency Information

Local sources are probably the best place to start when trying to compile employment and employer databases. Many MPOs, other planning agencies, transit agencies, chambers of commerce, labor departments, libraries, and other organizations may have compiled employment information for various purposes. Data from each particular source will probably vary widely in their timeliness, overall format and layout, accuracy, and general usefulness. These data may have to be reviewed, cross-referenced, and combined with other data depending on the level of accuracy and thoroughness required. The compilation of an accurate, useful employment or employer database can be a time-consuming, painstaking task.

ES-202

Information collected by the Covered Employment and Wages program of the Bureau of Labor Statistics, commonly referred to as ES-202 data, is collected and aggregated to countywide summaries by industry. Information about specific companies and data at specific addresses are not distributed. Therefore, ES-202 data are often not useful for specific welfare to work efforts, but may be used for more general planning efforts.

CTPP Data

The Census Transportation Planning Package (CTPP) contains work trip and other information and is divided into two "Elements" and three "Parts." CTPP data are described in detail earlier in this chapter. It should be noted that these data are from 1990 and now may not be useful in rapidly changing areas.

Polk Data

R.L Polk & Company was founded 127 years ago and is a premier provider of information to a wide variety of corporations. Polk collects employment data via a variety of means, including yellow pages and business white pages and the U.S. Securities and Exchange Commission. Polk staff report that 14 million telephone calls are made annually for verification of information. Polk data can be expensive, perhaps $50 per thousand records, plus diskette conversion, tax, and shipping charges. Additional fees are required to include longitude and latitude for each site.

Dun and Bradstreet

The Dun and Bradstreet (D&B) Million Dollar Database contains employment information on over 1,260,000 U.S. public and private businesses.[20] Information includes company address, contact, number of employees working at *each particular address*, Standard Industrial Classification (SIC) code system, sales volume, and other information. Employer data can be purchased directly from D&B, but data can be expensive. The data are gathered via several sources, including 2,500 D&B associates, as well as impartial third-party business and government sources.

Possible Additional Employment Data Attributes

Employment databases may contain various attributes, which differ widely depending on the needs of each specific application. For example, while an employment database used for a planning study may include the total number of persons employed in a particular zone or at each location, an agency responsible for placing welfare recipients in jobs would require an updated database of job openings. Depending on the application, these databases could include some information about the business and available job, such as the following:

- The contact person's name and telephone number,
- The work hours,
- The number of employees who work at that location,
- The number of job openings available,
- The type of jobs available and the experience required, and
- The pay rate and benefits.

In addition to the information listed above, welfare recipients may be particularly interested in the following attributes about the job:

- The availability of on-site child care,
- Whether a ridesharing program is in place,
- Whether the site is served by public transportation, and
- If the employer hired welfare recipients in the past.

This latter information might be important for a trip planning or job placement application.

Checking and Correcting Employment Data

Many planning professionals agree that one of the most difficult challenges to setting up and maintaining a welfare to work GIS application is the development and maintenance of an accurate employment database. Experience shows that, even when expensive data are purchased, some clean-up efforts are required. Private sources do not include all employers and regularly omit even some very large employers. Dun and Bradstreet provides pre-geocoded data, but they charge an additional fee. Alternatively, employment sites can be geocoded based on address, but even with very good address information, the underlying street network must be in good condition to result in a successful geocode ("hit") rate. Geocoding will be less than 100 percent due to a variety of factors, including unusual street addresses, incorrect addresses, and inaccurate or incomplete census TIGER files. Some employment sites will have to be located via a manual process. Once a useful employment database is created, it will have to be continuously updated and modified to maintain its usefulness.

To illustrate some of the issues that might be encountered when developing an accurate employment database, consider the example of data presented below in Table 5.4 (a database of employers located in the fictional town of Columbia, Massachusetts).

It is likely that users just beginning to assemble an employment database would start with a nongeocoded (without a preassigned latitude and longitude) database similar to that in Table 5.4. The initial data might not even be available electronically. Users would first need to assess the quality of employment data sources to determine if they are accurate enough to use. Modification of the data is almost always necessary before the data can be successfully geocoded. Employer lists often contain errors that need to be corrected before the geocoding process can take place. Users should be aware that since most employment databases are significantly larger than the one presented in Table 5.4, the clean-up effort can be significant.

The following examples refer to Table 5.4 to illustrate some of the more common corrections likely to be needed before attempting to geocode an employment database.

Addresses That Cannot Be Geocoded

GIS geocoding procedures require databases that contain accurate street addresses or intersection information. The

[20] [Online] Available: http://www.dnbmdd.com/

TABLE 5.4 Example of an employment database

Company	Address	City	ST	Zip	Number of Employees	NAICS Code
ABC Bookpress	Columbia Industrial Park	Columbia	MA	02101	500	51113
CMC Burn Unit	1 Clark Hl	Columbia	MA	02101	32	62191
Columbia Medical Center	1 Clark Hl	Columbia	MA	02101	250	622
David's Bakery	123 Main	Columbia	MA	02101	5	311811
Family Restaurant Corp.	P.O. Box 80	Columbia	MA	02101-0080	351	72231
Learning Books	Columbia Industrial Park	Columbia Heights	MA	02101	505	51113
Town Gym		Columbia	MA	02111	20	
Town of Columbia	100 High St.	Columbia	MA	02101	5000	921

employment database for the Town of Columbia has several address-related deficiencies such as the following:

- Town Gym has no address, so it will not geocode.
- Since the Family Restaurant Corporation is identified with a post office box, rather than a specific street address, it will not geocode.
- While Columbia Industrial Park may be the address of ABC Bookpress and Learning Books, it is not a specific street address or intersection and it will not geocode.
- Some GIS software systems may not recognize that "1 Clark Hl" is an abbreviation of "1 Clark Hill," so Columbia Medical Center and Burn Unit may not geocode.
- Despite the fact that David's Bakery seems to have a valid address (123 Main) the user may need to fine-tune the address for it to successfully geocode. Perhaps there is more than one "Main" located within the Town of Columbia. If this is the case, the user must determine whether the correct address is (for example): 123 Main Street; 123 Main Road; 123 North Main Street; or 123 South Main Street. Furthermore, the underlying census geography may have used an alternative name for that road segment altogether. For example, rather than "Main Street," the TIGER files may have utilized the name "State Hwy 101." If this was the case, the user will need to either change the address from "123 Main" to "123 State Hwy 101" or modify the TIGER address data in order for David's Bakery to successfully geocode.
- The table notes that Town Gym is located in Columbia, in zip code 02111. However, Columbia's zip code is 02101. Since there is no address for Town Gym in the database, the user must use a different source to determine the correct address for Town Gym and subsequently determine whether the zip code is correct.
- The table notes that Learning Books is located in Columbia Heights, which is actually a neighborhood located within the Town of Columbia. Since many GIS software systems depend on zip code information (rather than City or Town name) to geocode addresses, the use of a neighborhood name should not cause serious difficulties (assuming the correct zip code is used).

Inaccurate Employer Statistics

Employment databases often contain various attribute information, such as the number of employees working at each particular site. Users should be aware of how employment statistics have been presented in order to avoid serious errors in how the data are used. For example, Table 5.4 indicates that there are 5,000 employees working at 100 High Street, employed by the Town of Columbia. Upon further investigation, the user is likely to discover that while there are 5,000 employees working for the Town of Columbia, they are not all employed at the 100 High Street location. In fact, these 5,000 employees work all over the Town—in schools, the police department, fire department, city hall, and so on. Perhaps 100 High Street is the location of the Town's administrative building, the physical work site of only 20 of the town's employees.

Missing and Conflicting Data

It is wise to compare various sources of employment data as another accuracy check. For example, the user may have an information source indicating that 9,000 employees work in the Town of Columbia. However, Table 5.4 indicates that only 6,663 employees work within the Town. This should lead the user to question the accuracy of the source used to develop Table 5.4. The user should then seek additional employment sites to augment the list compiled in Table 5.4. It is likely that if the user is able to obtain multiple data sources, some data will conflict. The user will have to use judgment to determine how to combine the various data sources to create the most accurate database.

Duplicate Data

Table 5.4 indicates that 500 people work at ABC Bookpress and 505 people work at Learning Books (located at the same address). It is possible that these are the same employees (perhaps ABC Bookpress was purchased by Learning Books, or ABC Bookpress is the name of a subsidiary of Learning Books, etc). The user should compare similar data and investigate questionable entries to ensure that the database does not contain duplication. As another example, Table 5.4 indicates that 250 people work for the Columbia Medical Center and that 32 people work for the CMC Burn Unit—both are located at 1 Clark Hl. The user should determine whether the 32 CMC Burn Unit employees are also included in the 250 persons working for the Medical Center to avoid counting these 32 employees twice.

Classifying Employers by Type

As shown in Table 5.4, employment databases may contain information about the Standard Industrial Classification (SIC) Code or The North American Industry Classification System (NAICS), which classify establishments by type of economic activity. The NAICS is replacing the SIC system and was developed jointly by the United States, Canada, and Mexico to provide new comparability in statistics about business activity across North America.[21] Tables showing the correspondence between NAICS and SIC are available for downloading at the following website:

http://www.census.gov/epcd/www/naicstab.html.

By including SIC or NAICS codes in the database, the user can eventually highlight particular types of economic activity on a map. For example, the user can highlight those codes starting with "62," which represents employment related to health care and social assistance.

Maintaining Employment Data

A current, comprehensive database of existing employment opportunities is difficult to maintain, but updates are important. For planning and policy purposes, only periodic updates may be needed, at the time that a planning analysis is undertaken. For trip planning applications, however, a current, accurate employment database is probably required. Private sources of employment data, as described previously, will typically update data. Updated data can then be purchased, but this can be costly.

There have been some statewide efforts to create centralized public job banks. Two examples are the Michigan "Talent Bank" and the New Jersey Department of Labor (NJDOL).

- The Michigan Talent Bank/Job Bank is an Internet online service for use by both job seekers and employers statewide. Job seekers no longer register at each office where they are interested in working; they identify in one statewide system all of the counties in which they wish to work. Employers will be able to access the Michigan Talent Bank/Job Bank directly to access resumes of potential job candidates and contact those candidates who meet their qualifications for more information and/or job interviews. The Michigan Talent /Job Bank is located at: http://www.michworks.org
- The NJDOL's web page includes an employment directory for each county listing the names and addresses for the employers covered under the state's Unemployment Insurance Program. The user can search the website to obtain all the employment locations in each county that are classified under each particular category (i.e., grocery store, automotive repair shop, etc.). The number of employees working at particular locations is not included, but is available at the New Jersey State Data Center for particular employers. Selected data downloaded from the web page can be appended with the number of employees to create a more useful database. The NJDOL's web page is located at: http://www.wnjpin.state.nj.us.

In other states, appropriate departments of commerce, labor, or employment should be contacted for information about similar efforts.

PUBLIC TRANSPORTATION DATA

A database that contains information about transportation services is also needed to develop GIS-based planning and service delivery applications. Public transit data may include fixed-route service information. It might also include information about demand responsive services, such as paratransit or dial-a-ride programs, or ridesharing programs.

In many GIS-based welfare to work transportation applications, public transit information is displayed with other key data to analyze needs or develop service options. For example, regional transit routes can be displayed along with recipient locations and employment opportunities to examine

[21] http://www.census.gov/epcd/www/naics.html (U.S. Census Webpage)

where service gaps exist during various times of day. Modifications that may help improve transit options for welfare recipients can then be identified. Proximity to transit service can also help locate potential employment sites for welfare recipients.

Types of Public Transportation Data

Depending on the area and the GIS application being developed, different public transportation service data may be needed. If public (or private) fixed-route services exist in the area, a line database depicting the route network will be needed. A point database for stops/stations may also be needed. Other key attribute data might also be developed to provide level of service (LOS) information. For fixed-route systems, attribute data often includes:

- Days and hours of operation,
- Special features such as wheelchair-lifts or ramps,
- Fare information,
- Detailed schedule information, and
- Service performance information (ridership, service frequency, etc.).

If paratransit, dial-a-ride, or ridesharing programs exist and this information is needed for the desired application, area databases will be needed that display the area (or areas if there are multiple regions) served by each program. For these types of demand responsive services, associated attribute information often includes:

- Days and hours of operation,
- Persons served/eligibility requirements,
- Trip purposes served,
- Fare information,
- Contact information (phone number), and
- Service performance information (ridership, etc.).

Sources of Public Transportation Data

Information about public transportation routes can be collected from various sources including local, regional, or state agencies, and the Federal Transit Administration (FTA).

Local Agencies

The best source of transit information is often the local public transportation agency. Many transportation agencies have and use GIS and may be able to share fixed-route and stop data in an electronic format. The FTA, the American Public Transportation Association (APTA), and the Community Transportation Association of America (CTAA) all maintain electronic links to transit properties at their web pages (http://www.fta.dot.gov, http://www.apta.com, and http://www.ctaa.org). Sometimes, planning agencies, such as local MPOs, maintain public transportation-related geographic data for local transit providers.

Public transit data that may be available could be as low-tech as paper bus schedules or printed survey results; however, many public transportation networks have already been geocoded and are available electronically in a GIS format. Some private transportation systems are available electronically as well. If geographic information is available, the user should request that the provider export the geographic files into a format compatible with the user's software.

FTA Database

The FTA maintains a geographic database of nearly all transit systems across the country at the Geographics Laboratory, located at the J. Joseph Moakley Center for Technological Applications at Bridgewater State College in Bridgewater, Massachusetts. Work on this database began in 1994 as part of the FTA's Transit GIS Initiative, which was an integral part of the National Spatial Database Infrastructure Initiative. Through this initiative, FTA has made a commitment to the development of transit GIS databases, which provide essential information for a variety of GIS applications.

Several different databases have been developed, including:

- A line database of fixed-route systems, containing route network information.
- A fixed-route LOS database that contains headway, span of service, and schedule information, as well as information about wheelchair accessibility and fare structure.
- An area database of ADA-complementary paratransit service areas.
- A paratransit LOS database that contains contact information.

Databases were compiled by Bridgewater State staff and students using paper schedules and other service data submitted by transit agencies across the nation. Any transit agency that submitted paper schedules is now included in both the FTA GIS and FTA LOS databases.

Information is available, in spreadsheet format, for each fixed-route system or paratransit service contained in the FTA GIS database (currently over 550 transit agencies). In an effort to promote the use of GIS as an analytical tool within the transit industry, users can download any of these transit networks directly from the Geographics Laboratory Internet site, located at http://www.bridgew.edu/DEPTS/MOAKLEY/resgis.htm. The database currently contains route systems as they existed in 1994–1997. It also includes several updates that were requested by individual transit agencies (continued updates are contingent upon additional funding). Data are available in several GIS formats, including TransCAD, ArcView, and MapInfo. Spreadsheets can be downloaded from the GeoGraphics Lab webpage and subsequently joined to route data. While it is assumed that the user will join the LOS data to the FTA GIS database, the LOS data may be joined to a different GIS database so long as the route ID is the same in both databases.

Reviewing, Modifying, and Entering Public Transit Routes

Once transit routes and stop information is obtained from local agencies, the FTA, or other sources, this information should be reviewed against paper transit schedules or other sources to determine if the information is accurate enough to be used. It is possible that some bus routes or bus stops may have been entered inaccurately or incompletely. Even the most accurate geographic files will probably have to be updated because bus routes and stops are modified frequently.

Users also should consider the specific applications planned (and available resources) before deciding how much effort should be expended on entering/modifying transit-related geographic information. While some applications, such as trip planners, require very precise geographic information, other applications necessitate far less precise data.

Transit-Related Databases Required for Trip Planning Applications

The most important databases necessary to run trip planners include transit routes, bus stops, streets, and landmarks. The street network must often be improved to allow input of precise transit routes (i.e., if the street network is missing links to shopping malls, these links must be added to the street network for the bus route to travel correctly through the mall area.) The bus stop listing is another vital database. The more accurate the bus stop data, the better the trip plan. If particular bus stops are missing from the database, the trip planner may recommend a completely different itinerary. Trip planners also must include all bus stop variations and schedule information. These data must also be accurate for the program to work well. Updating the databases, particularly route schedule and route path information, is necessary for accurate trip-planning recommendations.

Transit-Related Databases Required for General Policy and Planning Applications

General policy and planning applications normally require a lower level of precision than that required to run trip-planning applications. Often, only a skeleton version of the transit network is all that is necessary to complete the analysis. Maps A, B, C, and D in Figure 5.1 illustrate varying levels of effort that may be required to create a single route in a route system. Map A illustrates the bus route in its simplest, skeleton form (one-way). Map B shows both directions of the route.

Bus routes often deviate off the trunk portion of the path to serve a particular facility at a certain time of day (i.e., a high school may be served only twice daily). Map C shows a simple route with two variations. Depending on the GIS software and applications planned, each route variation can be entered as a unique route (i.e., if there are three variations of route 1, the user may enter three separate routes: 1A, 1B, and 1C). Alternatively, a single route can be entered that contains all of the street segments covered by any portion of the route, including all route variations. Adding to the complexity, many transit agencies short-turn buses, skip stops, interline routes, or perform various other deviations during the course of the day for scheduling and other purposes. Routes may differ significantly during off-peak, holiday, or weekend hours. With all these peculiarities, a system that has only 10 bus routes may end up with hundreds of individual route variations. For most planning and policy applications, the user would not need to enter all of these variations; a less complex route structure may be sufficient.

Finally, Map D shows the simple route, with its two variations and all bus stops. Depending on the software being used and applications planned, users may want to add either physical bus stops or route bus stops. Physical stops match the "real world," where a single bus stop is entered into the database for each stop on the street (regardless of the number of bus routes that serve that particular bus stop). In a route stop database, a separate point is entered for each route pattern using each bus stop.

It is difficult to estimate the time required to modify/enter a route system since time requirements are determined by several factors. In addition to the various options for entering a route listed above (level of complexity desired, route stops vs. physical stops), time requirements are also influenced by the proficiency of the user, the user's familiarity with the region, the sophistication of the GIS software being used, the computing environment itself, the complexity and overlapping nature of the route system, as well as other competing tasks. As a general rule, it may take several hours to prepare to enter bus routes (setting up the street layer and network files) and about one-half hour to enter a simple bus route. Each variation of that particular bus route can typically then be entered in less than one-half hour. Additional time should be factored in if entering bus stops.

Privately Operated Fixed-Route Transportation Information

In some areas, private companies provide a significant amount of the public transportation that is available to

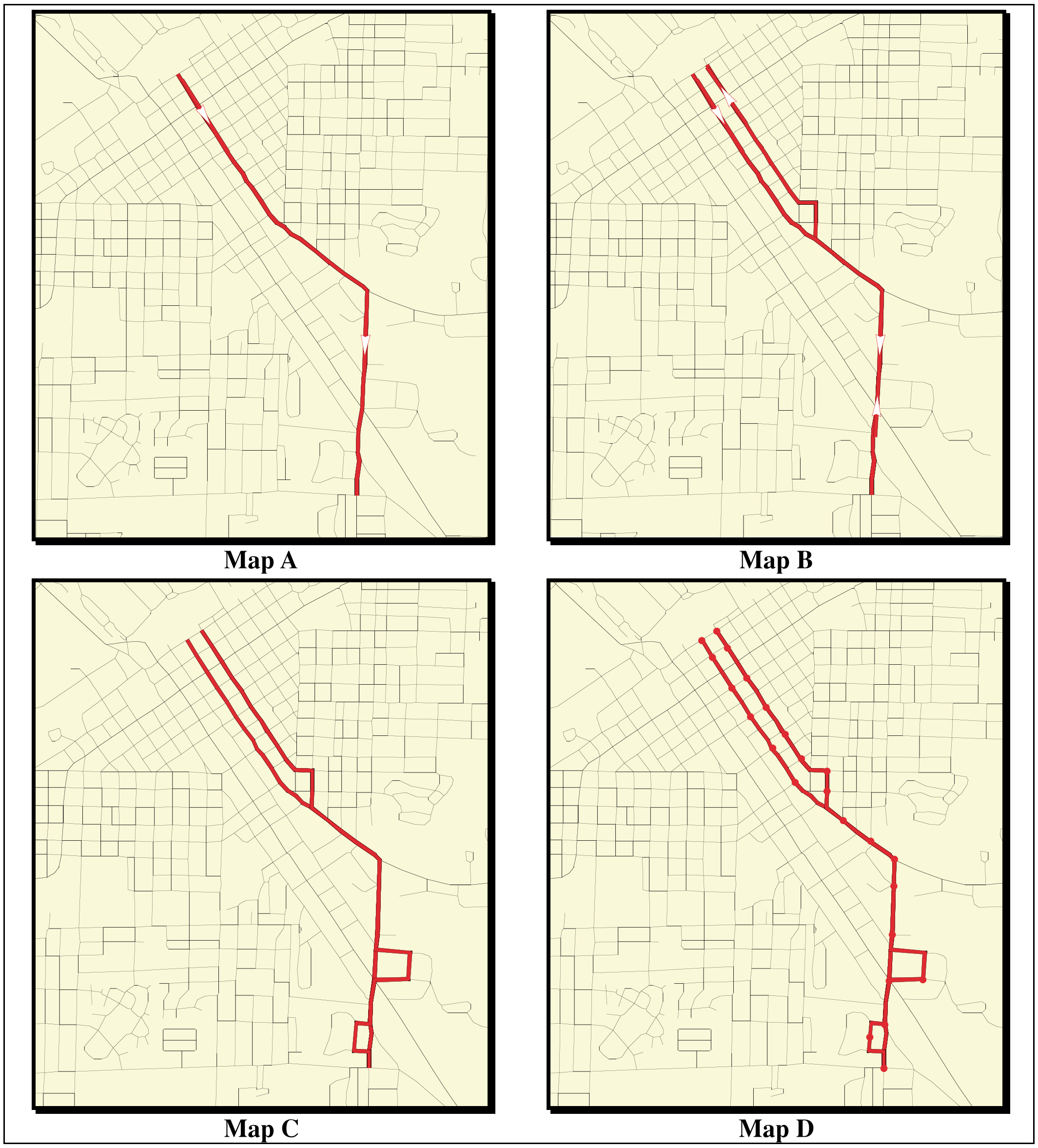

Figure 5.1. Different levels of fixed-route information.

residents. If a welfare to work transportation application is being developed in these areas, it may be useful to contact the state agency that regulates and licenses private transportation companies. As part of the licensing process, these agencies often collect information about the services provided.

Typically, route and schedule information is not available in electronic format. Route and stop databases will need to be developed by the user.

Using Attribute Information

GIS allows users to attach transit-related attributes to the geography to visualize and analyze trends. There are many examples of transit-related attribute data that may be relevant to welfare to work issues, such as:

- Number of welfare recipients living within one-quarter or one-half mile of a bus route/stop,
- Employment near a rail station,
- Bus fare in a particular zone,
- Frequency of bus service on a bus route,
- Number of passengers riding on a bus route,
- Number of parking spots at a park-and-ride lot,
- Accessibility of bus stops (curb cuts near bus stops),
- Fare charged in each zone,
- Hours of bus service, and
- Routes serving each bus stop.

These are only a few examples of a wide variety of data that can be attached to transit-related geography. Almost any type of attribute data that can be collected can be displayed using GIS. Most public transit agencies have collected a significant amount of data about their services from a variety of data collection techniques. Additional public-transportation-related information may be available from local or regional agencies.

Table 5.5 is an example of a fixed-route database. This particular database contains information about each variation of routes 468 and 470. Attribute data in this example include bus fare, start hour, end hour, length, type of service, and the direction for each route variation (inbound or outbound). Additional information could be added through adding columns (additional attribute information) and/or adding rows (additional bus routes). This attribute information can typically be joined to the geographic files for each bus route by joining both databases using a common field (such as ID number).

There are a variety of ways to use and display transit-related attribute information for presentation and analysis purposes. Figure 5.2 illustrates ways of displaying ridership information for bus stops. Map A uses scaled symbols to illustrate bus ridership at each stop – the larger the circle, the higher the ridership; Map B uses ranges to classify and present ridership at each stop as high, medium or low, using a different symbol for each range.

In addition to illustrating point-level (bus stop) attribute data, the user can illustrate information for line-level (segment) attribute data. Map C, for example, displays the three fare zones for segments along a route. Finally, Map D shows a one-quarter-mile band around the route. The user can then calculate characteristics within the one-quarter-mile band (i.e., the example shows that 100 welfare clients and 500 jobs are located within the one-quarter-mile band around the route).

CHILD-CARE DATA

There are many important issues facing welfare recipients who are transitioning into the workforce. One critical issue is finding appropriate child care or after-school care for children and arranging for transportation to and from these programs. While some day-care providers offer transportation, most do not. In some cases, voucher programs and stipends for transportation assistance might be available. The location of child-care programs and the specific services that they offer are two important factors that should be considered in welfare to work planning and service delivery.

Sources of Information

State or county welfare and social service agencies are a good starting point for information about child-care programs and services. The state agency that licenses child-care programs should be able to provide an up-to-date listing of sites. State or county welfare offices should also be able to identify child-care centers that are vendors. At the federal level, the Department of Health and Human Service's Administration for Children and Families can provide information about appropriate contacts at the state level.

There are also several sites on the Internet that contain information about or leads for information about child-care services. The Child Care Parent Provider Information Network,

TABLE 5.5 Example of a route database with selected attributes

ID	Route	Variation	Dir	Length	Type	Start	End	Fare
10386	468	468_A	1	5.13	Local	5.30	20.00	$1.00
10387	468	468_B	0	5.13	Local	5.30	20.00	$1.00
10388	468	468_C	1	4.45	Local	5.00	20.00	$1.00
10389	468	468_D	0	4.38	Local	7.00	20.00	$1.00
10390	468	468_E	1	5.20	Local	5.30	12.00	$1.00
10391	468	468_F	0	5.25	Local	6.00	12.00	$1.00
10392	468	468_G	1	5.13	Local	7.00	20.00	$1.00
10393	468	468_H	0	5.13	Local	7.00	20.00	$1.00
10394	468	468_I	1	3.48	Local	10.00	11.00	$0.50
10395	468	468_J	0	3.48	Local	11.00	12.00	$0.50
10396	468	468_K	1	5.94	Local	5.00	16.00	$1.00
10397	468	468_L	0	5.94	Local	5.00	16.00	$1.00
50568	470	402_A	1	35.89	Interstate	0.00	0.00	Zonal
50570	470	402_B	0	35.08	Interstate	0.00	0.00	Zonal

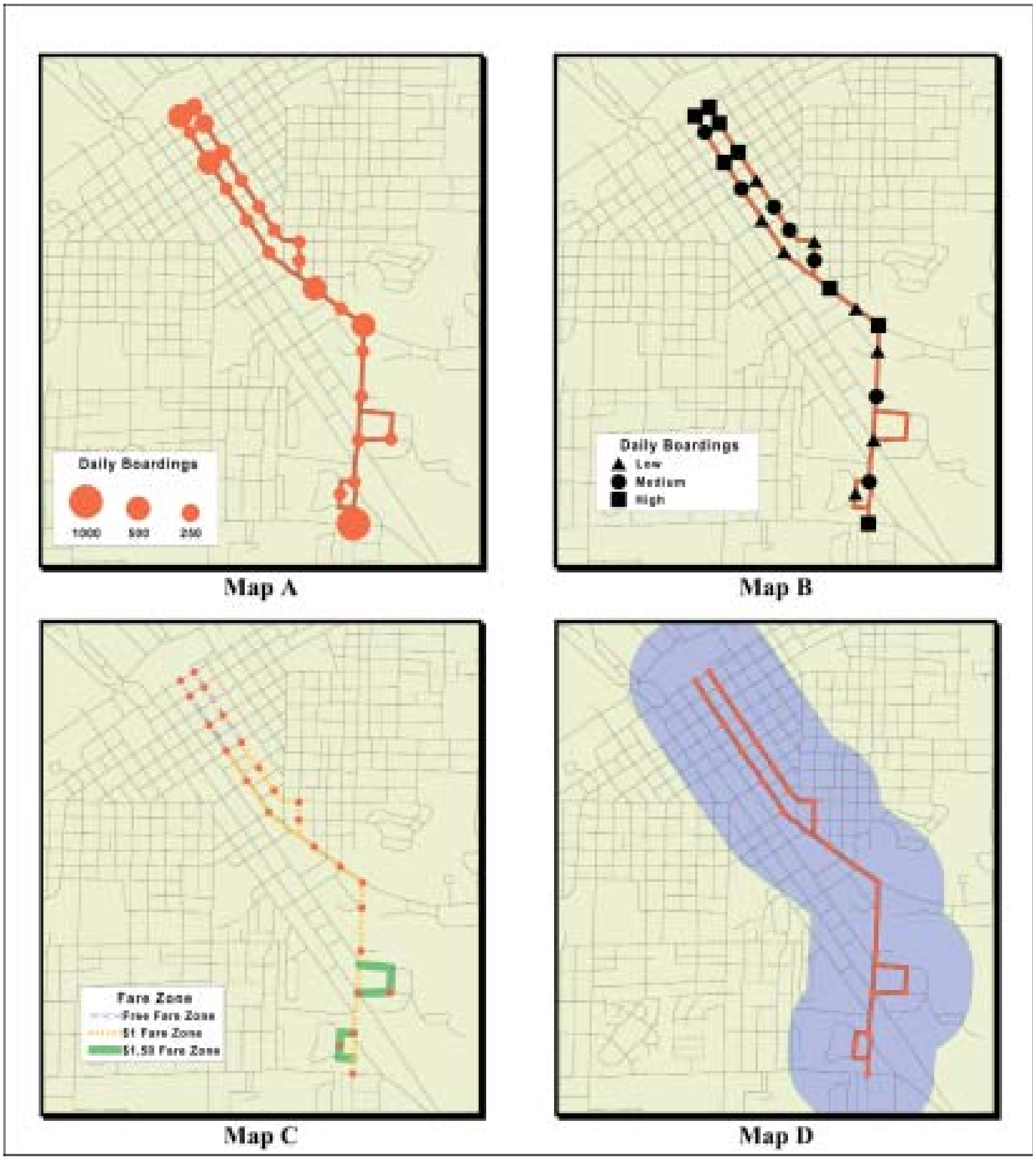

Figure 5.2. Displaying bus stop attribute information.

a nationwide service, lists information at http://www.child-care-ppin.com Several states also post information on the Web. For example, Arkansas Childcare Information provides data at http://www.state.ar.us/childcare. State welfare or child-care agencies should be able to identify similar information services in their area.

Developing a GIS Child-Care Database

Like any other point data discussed in this chapter, detailed address information will be needed to accurately and successfully geocode program sites. This should include a unique identifier (an ID number), street address information (rather than P.O. boxes), city/town, and zip code. As with other data sets, some cleanup and review will be necessary to maximize the "hit" rate when program sites are geocoded.

Table 5.6 provides an example of a child-care database structure.

The accuracy and level of detail needed in developing child-care data will depend on the planned uses of this information. For general policy and service planning analysis, it may be sufficient to have reasonably accurate program locations. For trip planning or job placement applications, more detailed information may be required. Up-to-date and accurate information will also be important for trip planning and placement applications. For these uses, accurate information

TABLE 5.6 Sample child-care facility database

ID NUM	NAME	ADDRESS	CITY/ TOWN	STATE	ZIP CODE
12	Little Bird Day Care	150 North Rd	Bristol	NV	03293
267	The Smiley Baby	7 St. Christopher Ln	Flaxer	NV	03467
47	The Learning Center	218 Phoenix Blvd	Stone	NV	03281
3	YMCA- Day Care	82 Odgepodge St	Middleston	NV	03699

about child-care programs (the services provided, the status of licensing, etc.) must be provided to recipients.

Possible Child-Care Attribute Information

In addition to program name and location information, several other fields can be included in the child-care database if the information is available. Some attributes that might be useful in service planning or service delivery include:

- The range of ages of children served by each center;
- The hours of operation;
- Contact information for facilities, such as director's name and phone;
- Program costs;
- Funding sources accepted at facilities; and
- Provision and cost of transportation provided by the center.

This additional information might be particularly helpful for caseworkers assisting clients with job placement options and support service options. It will also be helpful for trip-planning purposes. Table 5.7 below is an example of an attribute database. This information could be added to a master child-care file or could be linked to a separate address file using the unique ID number assigned to each center.

After geocoding a dataset of child-care facilities and entering additional attributes, thematic maps can be developed. For example, using the information provided in Tables 5.6 and 5.7, a map showing child-care programs that offer transportation services and those that do not can be created. As shown in Figure 5.3, different symbols can be used to depict centers that offer transportation.

Maintaining Child-Care Data

The level of effort needed to update child-care databases will depend on the GIS application. For general policy and service planning applications, data may only need to be updated periodically (when plans are updated). For trip planning and placement/referral applications, a more regular process for maintaining accurate information will be needed.

Because child-care data do not need to be treated as confidential, it should be possible to arrange for regular downloads of program lists from the state or county agency that first provided the information. This master list can then be manipulated as needed by the transportation planning or service provider agency. To determine how frequently data should be refreshed, determine how often child-care program data are updated by the state licensing or funding agency.

OTHER KEY SUPPORT SERVICES DATA

Information about other key support services can also be helpful in welfare to work transportation planning and service delivery. Other key support services include:

- Welfare offices,
- Job training sites, and
- Community colleges.

TABLE 5.7 Sample child-care attribute information

ID	Age	Hours	Contact Info	Costs	Funding Avail	Transportation?
12	Open	6am – 7pm	Maryellen Greene 456-3572	$120/wk	Y	Y
267	> 6 mos.	5:15am – 6:15pm	Gina Jefferson 427-4366	$200/wk	N	N
47	2-7 yrs.	9 – 5/fee after hrs.	Bob Huff 428-9000	$25/day add'l child discount	Y	N
3	6-12 mos.	7am – 7pm	Bev Viverios 587-2122	$6/hr	Y	N

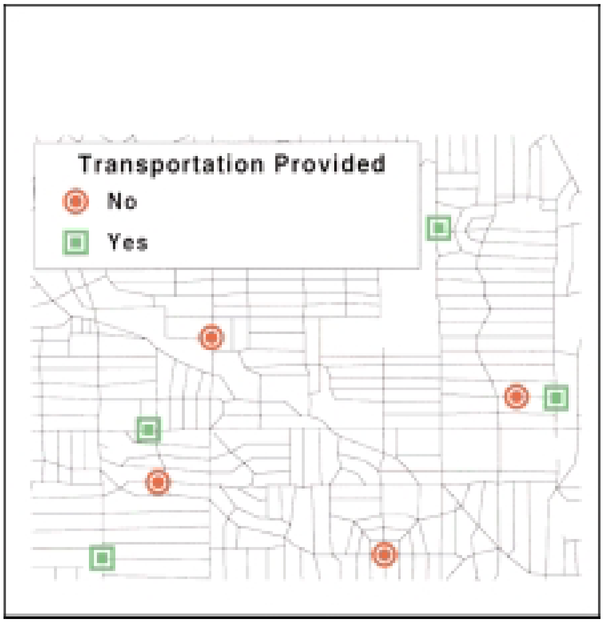

Figure 5.3. A sample thematic map showing child-care programs that provide transportation services for participants.

The location of each of these types of services can be displayed together with recipient locations and bus routes/rail lines to determine if public transit service to these locations is adequate. Information about these services can also be incorporated into trip planning or job placement software and provided to recipients when requested.

Point databases can be created for each type of support service. As with other point data, complete address information (street address, city/town, and zip code) will help to ensure accurate and complete geocoding of locations. Databases with appropriate attribute information can then be created and linked to each service using unique ID numbers.

Welfare Office Locations

Information about welfare service office locations can be obtained through county or state welfare agencies. This information remains relatively constant, so minimal data maintenance should be required. Possible attribute information that can be linked to each location might include days and hours of operation, types of assistance provided at each site, and contact information. Figure 5.4 provides an example of a map of welfare service locations.

Job Training Sites

There are a number of organizations that provide job training for welfare recipients. Workforce Investment Boards (WIBs), Private Industry Councils (PICs) and Job Training Councils are all involved in funding and providing job training. These groups are good sources of information about local training programs. State and county welfare offices also maintain job training program information.

Job training information is relatively constant, but will change more frequently than welfare office locations. Some mechanism for periodic updating of data should be considered. Attributes might include program hours, costs, funding sources used, and type of training provided. Generally, training includes learning centers, actual business locations, or

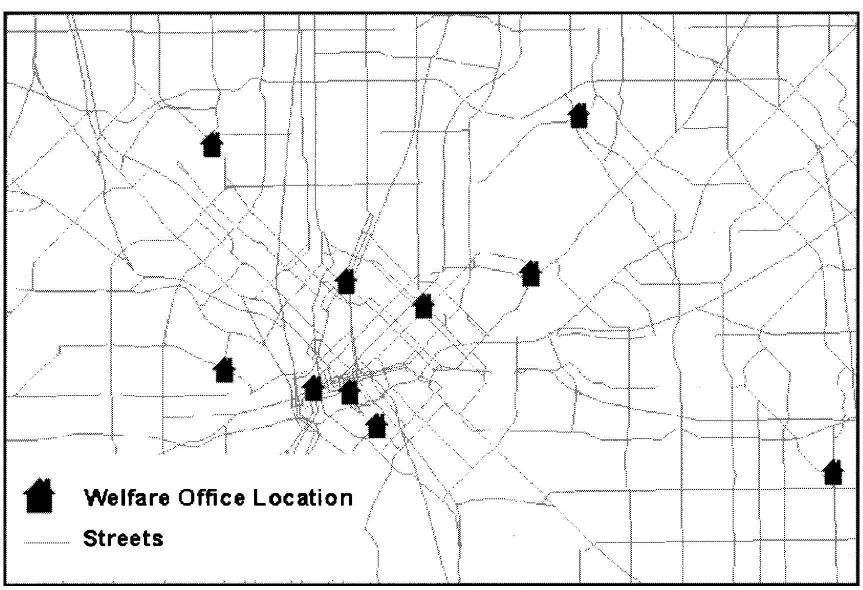

Figure 5.4. Sample map of welfare office locations.

technical schools. Figure 5.5 is a sample map of training programs by type.

In addition to the technical schools offering job training, transitioning individuals may also be interested in continuing education. There are many community colleges, state colleges, and technical training colleges that offer a range of learning and training opportunities. State education agencies can provide address and other information about colleges and universities in the area. Local planning organizations also often have information about college locations in their jurisdiction.

Many colleges and universities offer classes and training offsite. To develop a complete listing of locations, it may be necessary to contact each institution. While this information is also relatively constant, offsite locations and types of training may change each semester. Periodic updating of these data (two or three times a year) may be needed. Figure 5.6 provides an example of a map of local educational institutions.

CREATING UNIQUE GEOGRAPHIC DATA

In addition to the common types of data described in previous sections of this chapter, it is often useful for GIS users to create geographic databases that are unique to the region

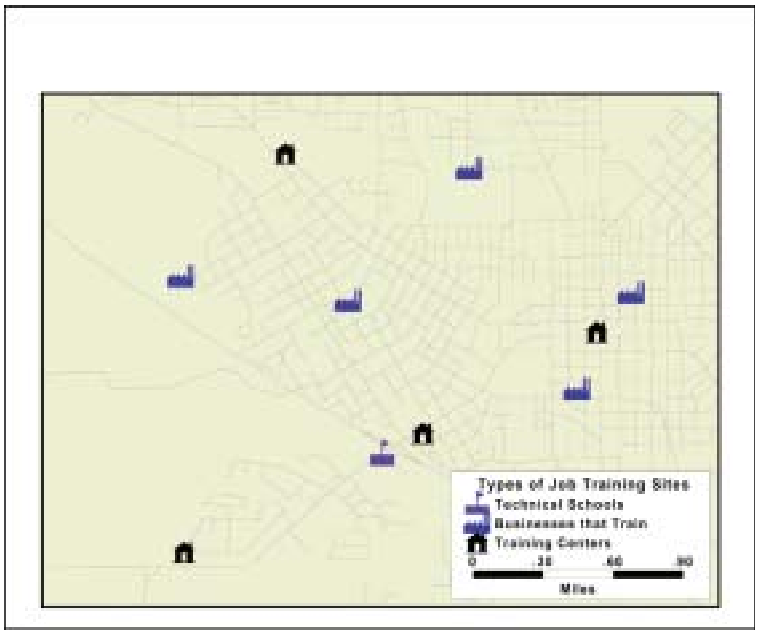

Figure 5.5. *Sample map showing job training facilities by type.*

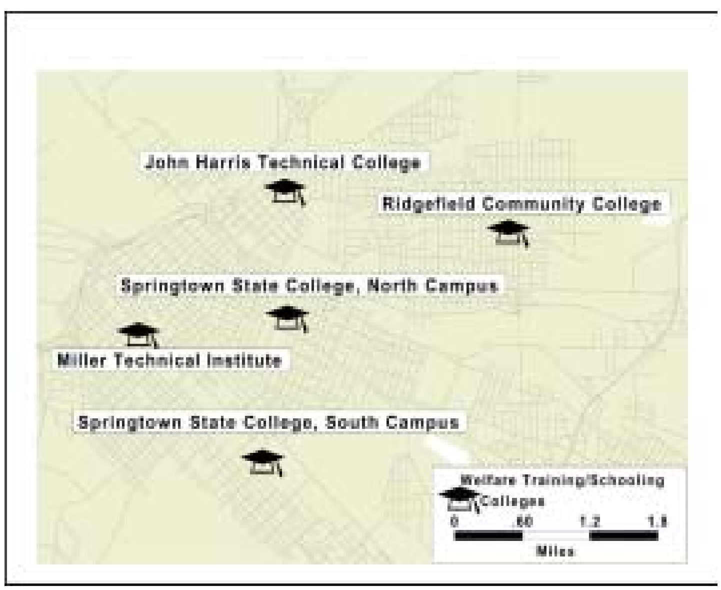

Figure 5.6. *Sample map of educational institutions.*

or needed for specific applications. For example, GIS users can create various area databases such as transit districts, call-a-ride service zones, fare zones, and service areas (coverage). Figure 5.7 illustrates the "coverage" area within one-quarter mile of a bus route. Attribute data can then be associated with and calculated for this coverage area. For example, the user can quickly calculate the number of recipients living within this quarter-mile area. Data presentation can also be simplified by grouping geographic boundaries into larger units, sometimes called "super zones," "districts," or "analysis zones."

This grouping is accomplished by merging all geographic units based on a data field. Table 5.8, for example, displays data associated with five TAZs and shows how these data can be merged into two zones. The first step is to create a new data field in the TAZ attribute database (called "district" in Table 5.8). The next step is to select all those TAZs to be merged and enter a unique number in the combine zone field for those TAZs to be merged. Finally, the GIS "districting," "merge by value," or similar function can be used to combine all TAZs with the same number in the combine zone data field. Most GIS programs allow the user to maintain selected attribute information when merging data. Population and area totals for each TAZ are summarized and maintained for both of the resulting analysis zones in Table 5.8. This merging process allows the user to maintain attribute information while simplifying the geography.

The merging process is also illustrated in Figure 5.8. Map A in this figure illustrates the population density by thematically shading the 93 TAZs that compose the county. After the merging process has been completed, a total of seven "zones"

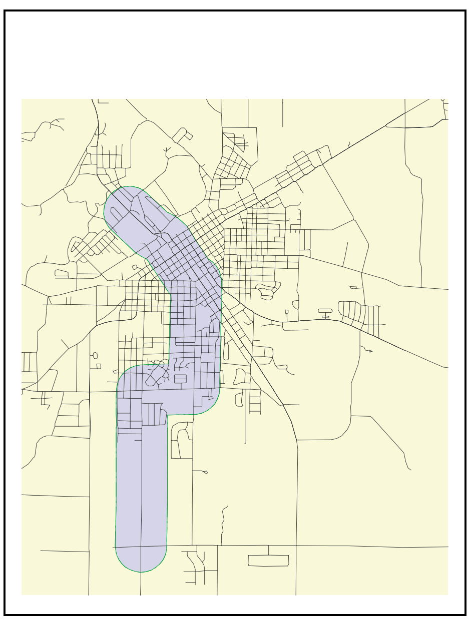

Figure 5.7. Quarter-mile area around a bus route in a city.

TABLE 5.8 Merging geography and attribute information

TAZ	Area	Population	District
1	**0.5**	**500**	**1**
2	**1.7**	**505**	**1**
3	**0.8**	**750**	**1**
4	1.1	450	2
5	0.3	1000	2

District	*Area*	*Population*
1	**3.0**	**1755**
2	**1.4**	**1450**

result. Since each TAZ's population and area characteristics have been summarized and are now associated with each zone, a population density map based on the seven zones can be created. This is shown in Map B, which is less detailed than Map A, but simpler to understand.

DATA PRESENTATION ISSUES

Selecting Appropriate Cut-Offs

The ability to create informative maps can be very powerful, but it can also be deceptive.[22] One of the most frequently misused visualization problems is found in the way that levels are chosen to be represented by the thematic colors. For example, consider the display of a thematic map showing the number of welfare recipients by block group. Because the area of interest is in the poorer neighborhoods, one might choose to zoom in on the poorer neighborhoods. But then when displaying the thematic map the user discovers that 90 percent of the recipients live in one block group. The remainder of the area is displayed in a single color. A user is tempted to break up the levels used to display the data so that the first level covers 0 percent to 1 percent, the second level covers 1 percent to 2 percent, the third level covers 2 percent to 3 percent, and the fourth level covers 3 percent to 90 percent, and the final level covers 90 percent to 100 percent. While this makes a more pleasing display, it is misleading the viewer to think that the distribution of recipients is more variable than it really is.

Most mainstream GIS packages provide the ability to select a method for breaking up the levels. The most common two methods are the quartile and the equal intervals methods. Using the quartile method, the GIS will break up the levels of display such that there are an equal number of observations in

[22] The following books by Edward R. Tufte illustrate the ways in which visual impressions of data can be misleading and describe how to visually present information: *The Visual Display of Quantitative Information*, Graphics Press, Cheshire, Connecticut; 1983; and *Envisioning Information*, Graphics Press, Cheshire, Connecticut (1990). Another useful reference is *How to Lie with Maps*, Mark Monmonier, University of Chicago Press, Chicago, Illinois (1991).

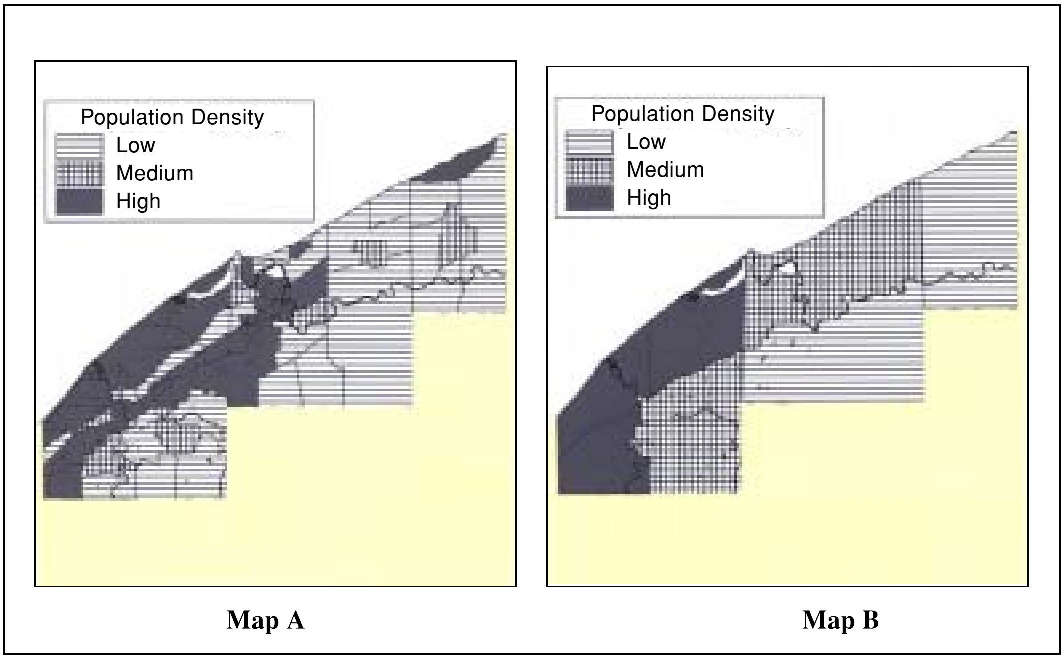

Figure 5.8. Merging geography and data by value.

each level. The equal intervals method will combine observations such that the range of values is equal in each level. The type of method to use depends entirely upon the data you are using and the information you are trying to communicate.

Identifying Limitations of the Display

There are other limitations of the use of GIS to display information. A common error is the tendency to use absolute numbers for attributes that represent spatial characteristics. For example, suppose that you have two census tracts each with 1,000 households. One tract covers one acre and the other contains two acres. You want to display a map that illustrates how the population is distributed across the study area. Both tracts would show up in a thematic map of population in the same color coding, implying that they are identical. In fact, one tract is twice the size of the other and has a much lower population density. Illustrating the location of the population using a population map not considering the area of the unit of analysis would be visually misleading.

Similarly, it is important to remember that the data, which contribute to a given display, may not necessarily be evenly distributed within the polygon in which they are located. For example, a census tract, which is halfway consumed by a wetland, will have nearly all of its population clustered in the other half. A map that color codes the entire tract to reflect the total population of the tract would not show the discrepancy between the two sides of the tract.

Another limitation is found in the conflict between wanting to communicate a clear message and needing to provide accuracy. For example, a map of the number of jobs in a block group may be displayed with a range of jobs per block group of 0 to 10. While the map communicates the general location of job opportunities, it does not tell the viewer the exact number of jobs in that block group.

Finally, an additional limitation of the GIS display is the inability to include detailed information about the sources and reliability of the data. Many maps are produced with extensive documentation and disclaimers lodged in the corners of the map. There simply is not enough space on the page to completely describe the sources, limitations, accuracy, and completeness of the underlying data.