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Sustainable transportation : a case study of telework and carpool in Atlanta, Georgia

Jessica A. Tharpe

To the Graduate Council:

I am submitting herewith a thesis written by Jessica A. Tharpe entitled "Sustainable transportation : a case study of telework and carpool in Atlanta, Georgia." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Geography.

Shih-Lung Shaw, Major Professor

We have read this thesis and recommend its acceptance:

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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SUSTAINABLE TRANSPORTATION:

A CASE STUDY OF TELEWORK AND CARPOOL IN ATLANTA, GEORGIA

A Thesis
Presented for the
Master of Science
Degree
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Jessica A. Tharpe
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DEDICATION

This thesis is dedicated to my parents, without whom I would have had neither the desire nor drive to continue my pursuit of higher education. And to Michael, whose day-to-day support and friendship ensured this work's completion, and whose love and companionship ensured my sanity.

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Abstract

This study examined Atlanta, Georgia's 13-county metropolitan area, a region currently plagued by traffic congestion and air pollution. Two alternative transportation options, namely telework and carpool, were evaluated in respect to their current status and future potential as a method to assist Atlanta in achieving a sustainable transportation system.

A telework survey was conducted including 118 area commuters with access to telework programs, and a portion of the Atlanta Regional Commission's Commute Connections' carpool database was acquired in order to examine the pattern of telework and carpool participation, participants' socio-economic and demographic characteristics, and telework and carpool's significance in mitigating traffic congestion and air pollution. Furthermore, strategies to increase telework and carpool participation were explored.

These data were examined using both spatial and statistical analyses, with results including geographic locations and typical socio-economic and demographic descriptions of teleworkers, non-teleworkers, and carpoolers. Teleworkers appeared to reside in a more dispersed pattern than non-teleworkers, while also living farther from their respective employers than their non-teleworking counterparts. Carpoolers reported residences in the immediate outskirts of downtown Atlanta as well as in its suburbs. Teleworkers were determined generally to be females earning incomes in excess of $60,000, while non-teleworkers were most often males earning $30,000-$45,000 annually. Teleworkers also reported information-related job functions compatible with telework, as non-teleworkers cited job functions more focused on a central workplace. Carpooler characteristics gathered from literature resulted in a typical description of such

commuters as those with low incomes and low vehicle access. Carpoolers were also suspected to populate job functions more focused on a central workplace. The locations of teleworkers and carpoolers with such socio-economic and demographic descriptions were compared with appropriate census tract data to assess such data's strength in determining regions of telework and carpool potential. The comparisons revealed that teleworkers *were not* residing in census tracts reporting high median incomes and large female populations. In contrast, carpoolers *were* residing in census tracts with low median incomes and low numbers of information and professional, scientific, and technical workers. Therefore, mapping census data served to be a more reliable method for identifying carpool potential than for identifying telework potential. In fact, this study suggests that *job function* may be more appropriate for detecting telework potential. Both telework and carpool were quantitatively characterized as significant to mitigating traffic-related problems by decreasing vehicle miles traveled and the number of single occupancy vehicles on the highways. Finally, commuters' comments collected in the telework survey were synthesized, resulting in suggested strategies to increase telework and carpool participation. These strategies include providing personal telework and/or carpool experience to the commuter, as well as marketing telework and carpool as avenues of saving money and time.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Purpose

As researchers demonstrate that increasing highway capacity often induces additional traffic, many urban areas are encouraging commuters to utilize alternative transport modes (*e.g.*, mass transit) rather than building additional infrastructure to resolve transport-related problems. Attempting to use existing infrastructure more efficiently is a main element of sustainable transportation systems: systems that provide for current transport needs, while accounting for future ones by using depleted resources (*i.e.*, land, fuel) sparingly. Attempting to achieve sustainable transportation systems has become a strategy not only to manage transportation, but also to address transport-related air pollution.

The relationship between transportation and air pollution has been nationally recognized. Pertinent federal legislation directly linking transportation and air pollution includes the 1990 Clean Air Act Amendments (CAAA), the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA), and the 1998 Transportation Equity Act for the 21st Century (TEA-21), all of which outline regulations concerning acceptable pollutant levels and management of the transportation-air pollution relationship. The Environmental Protection Agency (EPA) enforces these regulations, currently classifying over 150 cities throughout the United States as having federally unacceptable pollutant levels (Greene 1997). Atlanta, Georgia is one such city whose 13-county metropolitan area has been in violation of these standards since 1990 (Shelton 2002a). Also since 1990, each of these counties' population has grown (Atlanta Region Transportation

Planning Fact Book 2001). In fact, Forsyth County has more than doubled its 1990 population, growing by 123.2 percent by 2000. Other counties experiencing considerable growth (>50%) include Cherokee, Coweta, Gwinnett, Henry, and Paulding. Forecasts predict the Atlanta Metropolitan Area's (AMA) population to approach five million people by 2025, at a rate double the national average. Unless considerable change in commuting behavior occurs, the AMA's rapidly expanding population will continue to strain existing transport infrastructure and intensify the area's air pollution.

In order to mitigate the AMA's traffic congestion and air pollution, government agencies and businesses offer alternative transport options to area commuters, including telework and carpool programs. Telework programs reduce the number of single occupancy vehicles (SOVs) using area highways by allowing commuters to work from home via information and communication technologies (ICT), reducing or eliminating the daily commute. Carpool programs assist commuters by matching them with commuters traveling to either the same or other nearby work destinations. These matches create potential carpools, which if formed, also reduce the number of SOVs using area highways. The purpose of this thesis is to examine telework and carpool as alternatives to the SOV within the AMA. Current participation levels and impacts of each alternative are investigated, and methods to encourage future participation are explored.

1.2 Justification

Geography is frequently defined as the study of spatial phenomena and provides an ideal framework in which to address commuting alternatives. Centered on changing the mode humans use to move over Earth's surface, this thesis addresses an inherently spatial issue. The sub-discipline of transportation geography offers the vehicle through which the environmental consequences of transportation can be examined. The spatial separation of the commuter's residence and place of employment requires a daily commute. The travel created from this separation generates harmful emissions; the effect of these emissions must be evaluated as to minimize transport's negative effect on the Earth and its inhabitants.

1.3 Scope and Limitations

This research examines only two of many alternative transport modes available in the AMA. Other multiple occupancy modes exist (*e.g.*, Metropolitan Atlanta Rapid Transit Authority, regional bus systems, vanpools), none of which are accounted for in this thesis.

This study's foundation lies upon primary data collected within the AMA during Summer 2002 via a telework activity survey and a portion of an existing carpool database currently utilized by the Atlanta Regional Commission (ARC). One brief survey was administered to a limited sample of AMA residents, and although surveys have been accepted as an appropriate tool for studying travel mode choice, problems associated with the tool remain. For example, survey participants often omit questions or complete questions improperly. Such responses were included in the sample; however, any invalid data contained in these surveys were excluded from the study's database. The ARC's carpool database contains over 26,000 entries, with multiple characteristics for each entry. The ARC agreed to release only a portion of their database and could not release many characteristics due to confidentiality requirements. Therefore, the portion of the database used in this study contains only 1690 randomly chosen entries, with characteristics including home ZIP code, full employer address, required arrival and departure times with flexibility level, vehicle ownership, and normal commute mode for each participant.

1.4 Research Objectives

This research has the following objectives:

1) To identify spatial patterns of current availability and participation in telework and carpool programs in the AMA by locating each telework survey participant and carpool database entry on a map. All businesses included in the telework survey and identified in the carpool database will be mapped as well. These identifications will demonstrate various tendencies surrounding each particular alternative's use;
2) To identify socio-economic and demographic patterns associated with telework and carpool participation by generating descriptive statistics for telework survey participants and by confirming carpooler characteristics gathered from the literature with 2000 census data. This research will also identify potential regions for telework and carpool adoption by integrating and mapping 2000 census data;
3) To determine whether telework and carpool programs can be judged as significant in reducing transport-related air pollution by examining their current effects in the AMA. Resulting information will suggest various issues that should be addressed in order to increase each alternative's efficacy;

4) To determine factors considered significant when encouraging commuters to participate in telework and carpool programs by analyzing commuters' comments concerning the mitigation of traffic congestion and transport-related air pollution. This knowledge will offer officials an insight into increasing the participation and significance of each mode.

1.5 Thesis Organization

The remainder of this thesis is organized into four chapters of literature review, methodology, analyses, and conclusions. Chapter Two provides a literature review first discussing the broad concept of sustainable transportation, and then focusing more specifically on transport-related air pollution, travel behavior, and telework and carpool activity. Chapter Three describes this study's methodology, detailing data acquisition, organization, and analyses. Chapter Four discusses results of telework and carpool analyses, as well as contains statements to the present status and future potential of telework and carpool in the AMA. Chapter Five generalizes the study's significance to other metropolitan areas and suggests extended research possibilities.

Chapter 2: Literature Review

2.1 Sustainable Transportation

Urban areas across the United States are experiencing problems with traffic congestion and air pollution. Cities are currently employing various strategies in attempts to mitigate these problems. Alternative transport strategies such as telework and carpool have the capacity to assist cities in achieving more efficient and effective transportation systems without increasing infrastructure or depleting resources. Such an achievement would benefit current system users, as well as provide for future users. This type of system is often termed 'sustainable'. Developing sustainable transportation systems would mitigate both traffic congestion and air pollution.

Sustainable transportation systems are only one component of sustainable development. In 1987, the United Nations' World Commission on Environment and Development defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, 43; cited in Geerlings 1999, 26). Sustainable development is comprised of three main components: economic, social, and environmental sustainability (Geerlings 1999; OECD 1997). Economic and social sustainability address technological and institutional issues, while environmental sustainability focuses on restoring and safeguarding ecological systems. Black (1996) declares environmental sustainability to be of most significance within the United States, while Greene and Wegener (1997) support Black's claim by maintaining that the abundance of automobiles utilizing transportation systems in the United States has created an unsustainable environmental future.

Sustainable transportation is broadly defined as "satisfying current transport and mobility needs without compromising the ability of future generations to meet these needs" (Black 1996, 151), or more basically, "sustainable development within the transportation sector" (OECD 1997, 11). Hanson (1998, 246) offers a more explicit definition by Cluett *et al.*: "An anticipative and adaptive system for meeting the mobility and access needs of all segments of society over the long term, without compromising the ability of future generations to meet their own transportation needs, and without jeopardizing the energy resource base, the quality of the environment, or the quality of social life with which these systems interact." Black (1996, 1997) suggests conditions by which existing transport systems can be judged unsustainable, including limited petroleum reserves, petroleum-based emissions' negative effect on both air quality and the global environment, and extreme traffic congestion in urban areas. Clearly, the basic premise of sustainable transportation is to efficiently and effectively provide for both current and future transport demands, while taking economic, social, and environmental issues into account.

2.2 Transportation and Air Pollution

Motorized transportation negatively affects the environment (Marshall and Banister 2000; Nilsson and Kuller 2000). Globally, the transportation sector is responsible for emitting one-fifth of all greenhouse gases (*e.g.*, CO_2, CH_4, CFCs) (Greene 1997). Each year in the United States, transportation releases about one-third, or two trillion pounds, of anthropogenic CO_2 into the atmosphere (Black 1997; Greene and Wegener 1997). Fuels widely used by the transportation sector produce these greenhouse gases, which contribute to global warming (Black 2000; Button and Nijkamp 1997). Research focusing on transport-related climatic impacts, however, remains modest (Black 1997). Controversy surrounds the certainty of global warming theories. Some researchers have expressed concern that transportation's effects on global warming will not be assessed seriously until actual climatic changes occur (Welch 1999; Black 1997). These climatic changes may not occur for a long period of time, and by then these changes may be irreversible. Transport-related air pollution problems currently facing urban areas are less controversial because they threaten these regions daily. Focusing on the relationship between air pollution and transportation is a means by which to address long-term environmental sustainability while restoring air quality in threatened regions and safeguarding currently unaffected areas (Blickstein and Hanson 2001).

Federal legislation has acknowledged the relationship between transportation and air quality, instructing urban areas to gain control of pollution levels. The 1990 Clean Air Act Amendments (CAAA) "identify the automobile as a major contributor to the nation's air pollution problems and explicitly enlist transportation planners in the effort to meet air quality goals" and "require the integration of clean air planning and transportation planning at a regional level" (Hanson 1995, 22). Recent modifications to the CAAA have caused controversy; however, these modifications have applied only to industrial emissions (http://pubs.acs.org/cen/topstory/8048/8048notw1.html 2003; www.sierraclub.org/sierra/202211/1o14.asp 2003). The 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) supplements CAAA regulations by "linking transportation policy explicitly to other planning areas such as those in air quality..." and allocates highway funding to alternative transportation programs (Hanson 1995, 22). The Transportation

Equity Act for the 21st Century (TEA-21), enacted in 1998, strengthens ISTEA by refining existing legislation as well as adding new goals for managing the relationship between transportation and the environment (http://www.fhwa.dot.gov///////tea21/sumover.htm 2002). The Environmental Protection Agency (EPA) serves as an enforcer of such legislation, having set standards for ozone, particulate matter, sulfur dioxide, carbon monoxide, and nitrogen dioxide (Shelton 2002b). Non-attainment of these standards constitutes limitation or refusal of federal funding for highway construction (Shelton 2002a). These penalties have actually been employed, as the Atlanta Metropolitan Area (AMA) was refused funding for adding highway capacity from January 1998 until 2000, when the United States Department of Transportation accepted the AMA's new CAAA-compliant transportation plan.

In order to avoid the withholding of federal transport funding, urban areas must actively address transport-related air pollution problems. Marshall and Bannister (2000) cite reducing vehicle trips as essential to the minimization of adverse environmental impacts. Convincing commuters to choose alternate travel modes (*e.g.*, public transit, carpool, vanpool, bicycle) over the overwhelmingly preferred single occupancy vehicle (SOV) is essential to achieving such vehicle trip reduction (Blickstein and Hanson 2001; Baldassare, *et al.* 1998). Many strategies that encourage these types of travel mode changes allow for current travel lifestyles to be maintained while transforming existing transportation systems into sustainability (Gordon 1995). Actually altering commuters' behavior, however, is quite difficult due to the complexities associated with travel mode choice.

2.3 Travel Behavior

Much research has been conducted concerning the likelihood of successfully changing commuters' travel behavior both in Europe and North America. Although the specifics of travel behavior in different cultures often vary, fundamentals of human behavior can be applied universally. For example, many cultures perceive the automobile as a symbol of independence and wealth; therefore attempts to reduce its use are often met with resistance (Nilsson and Kuller 2000; Baldassare, *et al.* 1998; Tertoolen, *et al.* 1998). Furthermore, because social costs (*e.g.,* congestion, pollution) are not always detected in the aspects of individual travel (*e.g.,* convenience), commuters may not behave in a socially acceptable manner (Salomon and Mokhtarian 1997). That is, commuters are more likely to submit to their personal transportation needs and desires rather than take the entire transportation system's operation into account (Mokhtarian, *et al.* 2000). In order to successfully encourage behavioral change, people must both understand the specific environmental problem and believe that other commuters will change their behaviors as well. Elaborated upon by Tertoolen, *et al.* (1998, 179), pro-environmental campaigns will only cause commuters to change their behavior if: "1) environmentally friendly behavior is not disadvantageous for the individual, 2) valid social norms are positive toward environmentally friendly behavior, and 3) sufficient opportunities to demonstrate environmentally friendly behavior exist."

Commuters' behaviors stem from complex interactions among their personal attitudes, perceptions, and beliefs. Nilsson and Kuller (2000) identify individual attitudes concerning the environment as key to generating pro-environmental behavioral intentions. However, they continue to explain that attitudes correlate strongly with behavioral *intentions* rather than actual travel behavior. Supporting these assertions, Garling, *et al.* (2000) state in their study that households indicating intentions to reduce vehicle travel by increasing vehicle efficiency failed to significantly do so. These results demonstrate that stated intentions to change travel behavior do not always result actual change. However, as Kingham, *et al.*(2001, 159) conclude, "There is a willingness to use alternatives to the car…*if* the conditions are right" (emphasis added), demonstrating potential for actual behavioral change, ***given*** simple, convenient access to personally beneficial, alternative modes. For example, commuters may actually try telework (rather than just state the intention) if their employers readily provide a receptive environment, required equipment, and appropriate training.

Some researchers have studied the complex manner in which commuters choose alternative modes. Mokhtarian, *et al.* (1997) describe a three-tiered approach to categorizing behavioral responses to traffic congestion. The first tier contains responses maintaining existing travel behavior (*e.g.*, buying a cell phone or car stereo to utilize time spent en route), while second-tier responses make attempts to actually reduce travel (*e.g.*, carpool, trip-chaining). Third-tier responses consist of long-term lifestyle modifications (*e.g.*, relocation of employment and/or residence). Raney, *et al.* (2000) consider these responses more closely, finding that SOV drivers are significantly more likely to opt primarily for first-tier strategies, demonstrating the above-mentioned resistance to yielding a personal vehicle. Urban areas should be aware of such choice hierarchies and make attempts to encourage commuters to make second-tier responses. Such responses would allow commuters to maintain their existing lifestyle while also decreasing traffic congestion and air pollution.

Strategies attempting to entice commuters to change their travel mode must take such behavioral complexities into account. Extreme measures emphasizing detrimental commuter behaviors or controlling vehicle use through disincentives may result in a backlash of harmful behaviors and anti-environmental attitudes (Garling, *et al.* 1998; Tertoolen, *et al.* 1998). To avoid such a negative backlash, knowledge of political acceptability to such trip measures is vital (Baldassare, *et al.* 1998). For example, if a given city suddenly begins charging congestion tolls along major thoroughfares, commuters are likely to have a violent reaction. Such reaction will only reinforce existing travel habits. Therefore, city officials must take citizens' opinions and likely reactions into account prior to any disincentive program. The concept of cognitive dissonance also provides insight when forming a strategic foundation for encouraging behavioral change. Cognitive dissonance occurs when a discrepancy between travel behavior and environmental attitude exists (OECD 1997). This discrepancy causes discomfort for the commuter. According to the degree of inconsistency, the commuter will adjust either an attitude or a behavior to relieve the psychological tension. Pointing out this discrepancy, however, may cause *already* environmentally aware commuters to modify their *attitude* rather than their behavior (Tertoolen, *et al.* 1998). Again, awareness of such psychological theories of human response is paramount for those officials attempting to encourage travel behavior change.

A myriad of strategies has been applied seeking to decrease vehicle trips by changing commuter behavior. Distributing pro-environmental literature is one strategy often used to encourage such change. Marshall and Bannister (2000) assert that merely raising 'awareness' can stimulate behavioral change. In their study, they distributed environmentally persuasive literature to one neighborhood while withholding it from another. According to statements given by residents of both neighborhoods, 20 percent of those receiving literature used their vehicles more efficiently, while 11 percent of those not receiving literature did so. In an eight-week study conducted by Tertoolen, *et al.* (1998), however, study participants were presented with pro-environmental literature, and some were asked to reduce vehicle trips. No significant trip reduction was detected. Evidently, pro-environmental literature may encourage behavioral change in some commuters while having little or no effect on others. Because this strategy is occasionally successful, it should not be completely overlooked (Nilsson and Kuller 2000).

While information and education should be components of any attempt to modify commuters' attitudes, the key to persuading commuters to choose alternative transport modes is personal experience on the part of the commuter. In fact, the Organization for Economic Cooperation and Development (OECD) (1997, 52) states that "...individual transport behaviour can change quite radically...changes are most likely to occur through experiencing alternatives." Therefore, those commuters who have had beneficial experiences with a given form of alternative transportation prove to be more likely to change their commuting behavior over the long-term. Those commuters who have yet to experience a given mode may state an intention to alter their habits, but until personally experiencing the mode, the probability of a commuter changing his or her travel behavior is considered low.

Another key to successfully encouraging travel mode change is targeting appropriate commuters. Behavioral choice models provide evidence showing that a given alternative's utility depends highly on the personal characteristics of a given commuter

(Mokhtarian and Bagley 2000). That is, characteristics such as gender and income affect the manner by which commuters assess the value of various mode choices. Obviously, the values that a given commuter assigns to different modes will affect his or her mode choice. Knowledge of these value assignments can assist officials in determining which commuters are more likely to alter their travel behavior. For example, Nilsson and Kuller (2000, 220) find that females behave in a manner "more friendly towards the environment." With females having more than doubled in the US workforce population since 1969, the implications of their travel behaviors have increased dramatically (Root and Schintler 1999). Therefore, working females commuting by SOV may be more likely to switch to more environmentally friendly travel modes than their male counterparts. Nilsson and Kuller (2000) also identify young people as significant avenues of attaining sustainability, as attitudes are formed during childhood.

2.4 Alternative Transport Options

Many alternative transport modes exist, two of which are telework and carpool. Telework programs actively employ information and communication technologies (ICT) in order to enable commuters to work from home. Carpool programs create connections among commuters so they can easily combine work trips with other commuters. These modes were chosen for examination in this research because they have the potential to assist in moving toward sustainable transportation systems with relatively little economic investment.

2.4.1 Telework

Jack Nilles, president of JALA International, coined the term 'telework' in the 1970s, defining it as "any form of substitution of information technologies for work-related travel" (www.jala.com/faq.htm 2002). He also defined 'telecommute' as "moving the work to the workers instead of moving the workers to the work," emphasizing the reduction and/or elimination of daily commutes. 'Work' is not confined in these definitions to computer-based work; any cognitive-based tasks (*e.g.*, research, writing) can fall under the scope of telework or telecommute (Brewer and Hensher 2000). Dziak (2001, 3) discusses the differences between these terms, suggesting the use of 'telework' when attempting to convince others of the alternative's viability. Specifically, he regards telework as "more palatable to resistive managers because it stresses work." Reflecting Dziak's thoughts, current literature seems to use 'telework' most often, however 'telecommute' is still used occasionally. Each study takes care to choose one of the two, explicitly defines the choice, and uses that choice consistently throughout the study. Pratt (2000) points out that such practice is vital to any study of telework because it eliminates ambiguity in study results. For the purposes of this research, 'telework' will be used because of its apparent wider acceptance in the business world.

2.4.2 The Past, Present, and Future of Telework

Estimates of the teleworking population vary. This variability may be accounted for by the age of the study, sampling methodologies, and the speed of technological development (Nie 1999). At the word's first inception, Nilles states that several thousands of workers were partaking in telework (www.jala.com/faq.htm 2002). He estimates 100,000 people were teleworkers in 1980, with the number growing to 2.4 million by 1990. In 1994, Tom Brokaw reported the existence of 7.8 million teleworkers, and projected that 30 million teleworkers would be active by 2001 (www.teleworker.com/quotes.html 2002). In 2000, JALA, in connection with the International Telework Association and Council, counted 18 million regular US teleworkers by survey (*i.e.*, those who telework on a regular basis), with the number rising to 24 million if the survey's definition of telework was relaxed to include those who telework only occasionally (www.jala.com/faq.htm 2002). Currently, JALA claims that 12-18 percent of the US workforce is composed of teleworkers. Nie (1999) forecasts that 25 percent of the US workforce will be teleworkers by 2005. Global or even regional estimates of the teleworking population are difficult to locate. The literature is more focused on the specifics of telework adoption and success rather than sheer numbers of teleworkers.

Telework, although proclaimed as the "wave of the future," has been poorly adopted (Hanson 1998). The potential for telework adoption is, however, considerable. Information workers (*i.e.*, people with jobs that primarily involve creating, manipulating, transforming, and transmitting information) are often able to complete job requirements via ICT, eliminating or reducing daily visits to a central office (Mulvihill 1999). JALA reports 60 percent of the current US workforce to be comprised of information workers, with 80 percent of those being potential teleworkers (www.jala.com/faq.htm 2002). Furthermore, information-related jobs are growing rapidly, displaying an increasing potential for telework adoption (Nie 1999). In fact, "Two-thirds of Fortune 1000 companies currently have telecommuting programs, half of which were instituted in the past two years. A majority of those with telecommuting programs expect them to continue to grow, while nearly 60 percent of executives from companies without programs expect to institute one with[in] the next three years" (www.teleworker.com/quotes.html 2002). To successfully capitalize on this telework potential, telework programs must be carefully implemented, accounting for the complex relationships between employers and employees.

2.4.3 Encouraging Telework Adoption and Success

Telework's adoption and success hinges on the employer/employee relationship. In order to encourage adoption and success, it is imperative that both groups are made aware of the advantages and disadvantages of telework (Mokhtarian and Bagley 2000; Bagley and Mokhtarian 1997). Without such disclosure, those without a clear understanding or previous experience with telework may misinterpret the alternative (Brewer and Hensher 2000; Mokhtarian and Salomon 1997). It is also important for employers and employees to clearly understand the effects place and time have on working relationships (Brewer and Hensher 2000; Hanson 1998). The *place* of employers and employees has a significant effect on these relationships because 'face-to-face interactions' maintain a certain rapport among workers. Furthermore, employers often equate *time* spent at work to loyalty. Because work is frequently judged by quantity (hours input) rather than quality (level of output), employees want to be *seen* performing work. Telework programs must, therefore, be clearly defined to account for these effects and avoid any discrepancies in each group's expectations. For example, employers may expect employees to report their progress daily. If this expectation is not defined in the program, employees may not report, which may result in employers viewing their employees as non-productive.

The successful adoption of telework also hinges on targeting telework-compatible commuters. Some studies have attempted to characterize currently active teleworkers. Mokhtarian and Bagley (2000) characterize their study's sample of teleworkers (n = 188) as well-educated, affluent, mid-career professionals. They continue to describe the sample as having long distance commutes and jobs well suited for telework. Mokhtarian and Salomon (1997) also describe their study's sample (n = 628) as primarily professionals between the age of 31 and 50, most often reporting respectable incomes in the $35,000-$54,999 range. These teleworkers also report an average round-trip commute of 25.8 miles. Mokhtarian, *et al.* (1995) summarize eight telework studies (n = 382), confirming a positive correlation between telework and income, and income and commuting distance. They point out, however, that early adopters of telework typically commute distances 1.8 – 2.3 times longer than traditional commuters. Due to this difference, it is important to note that these teleworkers may not accurately reflect characteristics of potential teleworkers. Research is, therefore, warranted to study teleworkers with shorter distance commutes. Brewer and Hensher (2000) state the need for more quantitative research on telework so as to better characterize teleworkers.

2.4.4 Studying Telework

Carefully designing telework studies is vital to their accuracy and value. Mokhtarian, *et al.* (1995) summarize eight studies of pilot telework programs and their respective methodologies, each of which employs strict guidelines to insure valid, usable results. They first address sampling procedures, stating that involving a control group of non-teleworkers in such an evaluation is crucial because such participants serve as a norm against which teleworkers' characteristics and activities can be compared. That is, this control group allows the researcher to discern which factors influence all participants, and which are unique to teleworkers. Also, Mokhtarian, *et al.* (1995) emphasize that study participants must be *able* to commute in the traditional fashion. For example, several participants of one study were eliminated from analysis because they would not have commuted at all unless they did so by telework (*e.g.*, an employee living in another state). These same researchers cite travel diaries pre- and post-telework adoption as the ideal data collection method. However, they explain that researchers must decide between the complexities of a given analysis and the quality of the collected data because lengthy, complex data collection often suffers from participant attrition, fatigue, and/or conditioning. Attrition occurs as participants withdraw from a given study due to a variety of reasons. Fatigue and conditioning occur as participants respond less accurately over time due to either declining interest in the study or by the influence of their own earlier responses. One-time surveys, on the other hand, demand little time of the participant, but may return less robust data.

Instrument design is also vital to data accuracy and value. Pratt (2000) notes the importance of carefully designing research instruments such as surveys. She stresses the need to explicitly define telework and/or telecommute at the beginning of the study to avoid uncertainties. Such definitions should be clearly communicated to study participants, including information concerning work location, and the days and time spent performing work from home. Various definitions include various commuters; for example, "higher or lower counts were obtained depending upon whether the sample included 'anyone who performed work for any job at home,' or 'regularly scheduled work done for the principal employer at home'" (Pratt 2000, 102).

Various techniques can be used to determine telework's effects on transport-related air pollution problems. According to Mokhtarian, *et al.* (1995), Arizona/AT&T used a survey asking telework employees their typical commute distances. Reported round-trip commute distances were used as a means to calculate telework-related travel reduction. Two studies (Southern California Association of Governments and San Diego) also employed surveys to assess non-work travel conducted by teleworkers on telework days. Participants were asked to list trips made during their most recent telework occasion, including whether each trip would have been made at a different time, to a different place, or by a different person on a non-telework day, or whether the trip would have been made at all. Such questions allow for evaluation of whether non-work trip generation on telework days diminishes the environmental benefits of telework.

2.4.5 The Effects of Telework

Telework shows potential as a strategy for mitigating traffic congestion and its resulting air pollution (Mokhtarian and Bagley 2000; Yen 2000; Hanson 1998). The overall impacts of telework's use have, however, been a source of debate (Janelle 1997). Mokhtarian, *et al.* (1995) characterize telework as a viable strategy, but state that as telework improves traffic flow and reduces emissions over time, its relative effect will decrease as increased speeds allow for increased fuel efficiency and decreased emissions. Shen (1999) agrees that telework is a viable strategy, but argues that teleworkers generally reduce, rather than eliminate trips. He points out a certain amount of 'face-to-face interaction' is often required by telework programs, and that occasionally teleworkers must travel to work for need of a specific facility, only available at the central workplace. Other researchers point out that employees may move further from their workplace as a result of telework, increasing their commute distance on days they do commute (Black 1997; Mokhtarian, *et al.* 1995). Such an increase in commute distance on non-telework days may negate the environmental savings of telework days. Telework skeptics worry that telework may also increase daytime trip frequency, as constraints associated with a traditional workplace are relaxed (Janelle 1997). With this additional freedom, teleworkers may make more single purpose trips rather than highly organized chained trips, actually increasing overall travel (Black 1996). Furthermore, some researchers voice concern that teleworkers' unused vehicles may induce other household members to make trips. Mokhtarian, *et al.* (1995) counter both of these matters, stating first that trip reductions may occur as trips are shifted to non-telework days or different places closer to the home, or they may be simply eliminated. They also respond to the unused vehicle concern, pointing out that the majority of telework households own one vehicle per licensed driver, therefore an additional available vehicle would be insignificant to increasing trips. Due to the disagreement and uncertainty surrounding telework's impact as a mitigation method, more research on the issue is warranted (Black 1997).

The eight pilot telework program studies that Mokhtarian, *et al.* (1995) reviewed showed overall travel reduction. Studies found total travel savings either surpassed or equaled commute savings, demonstrating that non-commute travel decreases or remains the same as a result of telework. In other words, the commute mileage saved by eliminating work commutes was not diminished by non-commute trips that were generated on the telework day. In fact, these studies showed a 75.2 percent reduction in total person-miles traveled, while an average of 36.1 person-miles per day was eliminated. Such changes, however, do not automatically equal a reduction in vehicle-miles. For instance, if a commuter who usually travels by bicycle teleworks, no vehicle-miles, and therefore no emissions, are reduced. Therefore, knowledge of a commuter's normal mode is crucial because reducing SOV trips is the primary method to reduce vehicle-miles. Upon examination, the five studies containing normal mode data showed between 63 and 81 percent SOVs, equaling an average of 26.3 commute vehicle-miles reduced by each telework occasion. Another study shows that typically, the most difficult trips are eliminated first (*e.g.,* walking, biking, transit), those which often do not reduce vehicle-miles. Mokhtarian, *et al.* (1995) conclude, however, that *all* eight studies reviewed also display an overall decrease of vehicle-miles. Such conclusion affirms telework's viability as a traffic and air pollution mitigation method.

2.4.6 Carpool

Carpool can be defined as sharing a personally owned vehicle with household and/or non-household members for commute trips. Commuters that carpool may save money and time, as well as decrease commute stress. Carpool also conserves fuel and decreases emissions. According to the Association for Commuter Transportation (ACT), two basic carpool arrangements exist: 1) carpoolers alternate driving responsibilities; and 2) carpoolers use one carpooler's car, and each passenger contributes a portion of the operating costs (Makower 1992). Ferguson (1997) characterizes the former to be the most common.

2.4.7 The Past, Present, and Future of Carpool

Carpool began in earnest during WWII as a means to conserve rubber and oil, but participation decreased dramatically after the war ended (Ferguson 1997). Carpool enjoyed renewed participation in the mid-1970s as a method to conserve gasoline during the Organization of Petroleum Exporting Countries (OPEC) crisis. Following the OPEC crisis, and over the past two decades of falling gasoline prices, carpool has again experienced declining participation. In fact, carpool has lost mode share continually since 1980 (Cervero 1999). Ferguson (1997) reports an overall 32 percent decline in carpool from 1980-1990, noting however, that all SOV alternatives lost mode share during this time period, with the exception of telework. Clearly, current carpool participation is low; however, it is important to note that people seem to readily utilize this alternative during times of crisis.

Literature describes carpool as a viable, yet severely underused alternative transport mode (Hirten and Beroldo 1997; Pisarski 1997). Although specialized infrastructure (*i.e.*, high occupancy vehicle (HOV) lanes/on and off ramps) and various other incentives (*e.g.*, free parking) exist, many factors have discouraged carpool adoption (Ferguson 1997; Pisarski 1997). Commuting geography has shifted to suburb-to-suburb commuting rather than traditional, linear suburb-to-central business district commuting (Cervero 1999; Baldassare, *et al.* 1998). Consequently, the probability of finding compatible carpool partners is low (Pisarski 1997). Complex travel patterns hinder carpool formation as well, as personal trips are often chained to the commute trip. In fact, one-third of 1995's work trips were chained with other trips (Cervero 1999). High auto availability, low fuel costs, decreasing family size, increasing education and age, and increased suburbanization have all been characterized as sources of carpool decline (Ferguson 1997; Pisarski 1997). Furthermore, Americans' ever increasing wealth encourages personal vehicle ownership, directly increasing the number of SOV trips (Cervero 1999). Pisarski (1997) elaborates on this point, explaining that as poorer demographic segments that typically utilize carpool (*e.g.*, African- and Hispanic-Americans) have enjoyed these rising incomes, their travel behavior has also shifted to the mainstream SOV trend.

Despite the consistently declining mode share for carpool, it still remains to be the dominant mode of mass transportation in the United States (Cervero 1999). Household based carpools are actually rising. In fact, more than twice as many Americans commute by carpool relative to mass transit. Fifteen percent of California's 13 million commuters carpool, making the mode the primary alternative to the SOV (Pisarski 1997). During peak traffic hours in Houston, Texas, a city with a population comparable to Atlanta, carpools comprise 94 percent of vehicles occupying HOV lanes (these lanes can also be used by buses, emergency vehicles, and alternatively fueled vehicles) (Cervero 1999). These examples clearly exhibit carpool's potential for adoption and success.

2.4.8 Encouraging Carpool Adoption and Success

The adoption and success of carpool relies on issues surrounding the mode's utility. Because perceptions of a carpool's utility vary by each commuter's amount of experience with the mode, it is crucial to provide commuters with personal carpool experience. Therefore, strategies attempting to encourage carpool participation must aggressively promote the mode with participation incentives (*e.g.*, free parking for carpools) (Baldassare, *et al.* 1998; Ferguson 1997). Cervero (1999) suggests strategies such as increasing workplace density are also likely to encourage carpool. For example, areas of dense employment would increase the likelihood of commuters locating possible carpool partners because work destinations would be consolidated. After initial formation, carpool programs must offer support to participants in order to promote carpool sustainability (Ferguson 1997; Pisarski 1997).

Some effort has been spent attempting to characterize carpoolers. Commuters choose to carpool for a variety of reasons; strategies encouraging carpool adoption should be aware of these reasons and take care to design programs specifically for these commuters. Pisarski (1997) categorizes carpoolers into two main types: cost-driven and congestion driven. Cost-driven carpools are typically comprised of long distance commuters, interested in reducing both commuting costs and boredom. Strategies targeting these commuters should focus on minimizing monetary commute costs (*e.g.*, provide price-reduced fuel). Commuters with a shorter commuting distance are likely to form congestion-driven carpools as a means to take advantage of incentives such as HOV lanes. Strategies targeting these commuters should concentrate on minimizing the time spent in commute. Likewise, some commuters appear to be inclined to carpool due to social reasons. After analyzing almost 20,000 one-way commute trips, Ferguson (1997) states that carpoolers are more likely to live in urban fringe areas and often live near or under the poverty line. The research of Baldassare, *et al.* (1998) support Ferguson's claims, stating that carpoolers are likely to have low income, low vehicle access, and/or long distance commutes. Although carpool has been characterized as a cost-effective means to reducing congestion and improving air quality, relatively little study is currently being conducted specifically concerning carpool (Hirten and Beroldo 1997). Ferguson (1997, 374) cites the "paucity of reliable data" as a key reason. Therefore, in order to successfully capitalize on this alternative's potential, new research is warranted.

Chapter 3: Methodology

3.1 Data Acquisition

3.1.1 Telework Database

During Summer 2002, The University of Tennessee's Scholarly Activity Research Incentive Fund (SARIF) financially supported the collection and compilation of a telework database for the Atlanta Metropolitan Area (AMA). With the assistance of Michael Dziak, an area telework consultant, a survey was designed, geared toward both teleworkers and non-teleworkers, containing questions regarding personal socio-economic and demographic characteristics, telework activities, commuting habits, and opinions concerning how to best mitigate air pollution problems in Atlanta. In order to comply with academically accepted surveying methodologies (see Chapter 2), non-teleworkers were included to serve as a control group and "telework" was explicitly defined as "...an employee working at home instead of the office two days or more per month." The survey questionnaire can be viewed in the Appendix. After acquiring a list of 26 businesses with known telework activity from Mr. Dziak, each business was contacted and asked to participate in the survey. Six businesses agreed. Surveys were delivered to a designated employee in each of these businesses who then distributed the surveys to other employees. This method assured confidentiality of the survey participants. Surveys were retrieved from each designated employee two weeks after survey distribution, as well as business information sheets and business participation consent forms, completed by each designated employee (see the Appendix). Unique identifiers were assigned to valid surveys, and all data were organized into a database containing the location of businesses with telework programs and socio-economic, demographic, and locational data for survey participants. Furthermore, data concerning the teleworking and commuting habits and opinions of survey participants were included in the database. In sum, 118 AMA employees of the six participating businesses were surveyed, 77 of whom teleworked and 41 of whom did not. Participating businesses and the number of employees surveyed in each are described in Table 3.1.

Each participating business represents a unique segment of industry. City of Atlanta's employees include government officials and public servants. IBM, whose employees specialize in information technology, provides computing capabilities for residential, commercial, governmental, and educational purposes. MAPICS's employees also specialize in information technology; however, they concentrate solely on applications in manufacturing. Raydeo Enterprises is a small custom design and manufacturing company, specializing in custom metals, cabinetry, signage, and art for restaurant and retail outlets. SchlumbergerSema provides information technology consulting and support to multiple markets sectors (*e.g.*, transport, utilities,

Table 3.1 Participating Businesses

Business Name	Employees Surveyed	Employees in the AMA	Organization Type	Business Description
City of Atlanta	17	7000	City/ Municipality	Atlanta City Government
IBM	5	5000	Corporation	Information Technology
MAPICS	41	250	Corporation	Manufacturing Technology
Raydeo Enterprises	8	12	Corporation	Custom Design/ Manufacturing
SchlumbergerSema	16	375	Corporation	Information Technology
The Trillium Group	31	42	Limited Partnership	Medical Billing

telecommunications). Finally, The Trillium Group is a medical billing company, with employees performing technical tasks, such as data entry.

3.1.2 Carpool Database

A portion of the Atlanta Regional Commission's (ARC) Commute Connections division's carpool database (which includes over 26,000 non-household based carpoolers) was obtained through direct cooperation with the ARC. Commute Connections employees randomly chose records and compiled them into the study database, eliminating all confidential data. The resulting database contains 1690 carpool participant entries, providing a home ZIP code, full employer address, required arrival and departure times with flexibility level, vehicle ownership, and normal commute mode for each participant.

3.2 Broad Methodology Explanation

Geographic Information Systems (GIS) provide a medium in which spatial and non-spatial data can be stored, organized, analyzed, and visualized. Implementation of GIS software allows spatial issues to be examined using various software capabilities and extensions. Many GIS formats exist; in this study, an ArcGIS geodatabase containing all data provided by telework survey participants was compiled. ArcMap was used to perform all spatial and many non-spatial analyses of the telework and carpool databases. To complement GIS analyses, descriptive and inferential statistical analyses were performed and will be discussed in Chapter Four.

3.3 Data Processing

3.3.1 Determination of Telework and Carpool Availability and Participation

In order to identify spatial patterns of current availability and participation in telework programs, location data (*i.e.*, addresses, intersections) from the telework database were geocoded in ArcMap. StreetMap USA's usa.edg file, an electronic file containing the majority of the United States' streets, was used as a reference map. ArcMap automatically matched telework database entries providing location data with matching scores of 80 percent or higher. This score represents the average accuracy of the match. That is, each component of the address is scored for correctness, generating a matching score. Following automatic geocoding, many addresses within the database remained unmatched because of inexact address matches with the usa.edg file. The unmatched addresses containing sufficient data were then interactively identified and matched. Interactive geocoding entailed matching addresses with ArcMap-provided candidates with the highest matching score and the correct ZIP code. When more than one candidate provided equal characteristics, the most physically centered candidate relative to all candidates for a specific location was matched. This methodology minimized matching errors because the 'average' candidate was chosen as the best match. For those addresses remaining after this first stage of interactive geocoding, address data was altered (*e.g.*, the address was found on an Atlanta street map, then a nearby street was used instead) until an acceptable candidate became available. Twenty-five records remain unmatched, 12 of which contain location information. ArcMap was unable to generate acceptable candidates for these records, and they could not be located on area maps. The remaining 13 records contain no location information. Each geocoded record was assigned a confidence score to qualify location use in further analyses (see Table 3.2). The resulting map depicts the residential locations of both teleworking and non-teleworking survey participants. Teleworkers' residential locations were also mapped using the values of various characteristics rendering (*e.g.*, age, income) to search for existence of spatial patterns. These patterns will be discussed in Chapter Four.

In order to identify spatial patterns of current availability of carpool programs, employer location data from the study portion of the ARC's carpool database were geocoded in ArcMap. In order to account for multiple employer entries, employer names were summarized using ArcMap's summarize function, and employers' addresses were appended into the resulting 508-entry table. The geocoding methodology described above was applied to carpool data as well. Fifty-six locations remain unmatched, due of ArcMap's inability to generate acceptable candidates for these records upon address alteration. Each geocoded record was assigned a confidence score to qualify location use in further analyses (see Table 3.3) To identify spatial patterns of current participation as well as availability, matched employer locations were mapped by ZIP code using graduated symbol rendering by number of carpoolers each business ZIP code employs. Furthermore, carpoolers' home ZIP Codes were summarized using ArcMap's summarize function, joined to a table containing all ZIP Codes in the AMA, and then mapped using graduated symbol rendering by carpooler population.

3.3.2 Identification of Typical Teleworker and Carpooler Characteristics

The 2000 census data pertaining to the AMA were integrated into ArcMap for visualization of potential regions for telework and carpool adoption and success. Census

Table 3.2 Telework Geocoding Confidence Scores

Confidence Score	Description
A	Automatically matched or suitable candidates were provided automatically
B	Suitable candidates became available when addresses were altered, matching ZIP codes
C	Candidates have matching ZIP codes only
D	Unmatched

Table 3.3 Carpool Geocoding Confidence Scores

Confidence Score	Description
1	Automatically matched or suitable candidates were provided automatically
2	Suitable candidates became available when addresses were altered, matching ZIP codes
3	Candidates have matching addresses, but ZIP codes do not match
4	Unmatched

tract and block group shapefiles for all 13 AMA counties were downloaded from www.esri.com and converted into ArcGIS feature classes. First, census tracts were merged, providing one feature class containing all census tracts in the AMA. Then, block groups were merged, again providing one feature class including all block groups in the AMA. All of Georgia's census files were downloaded from www.census.gov, and then data concerning total population, gender, age, race, median income per capita in 1999 dollars, industry identification, vehicle ownership, and journey-to-work mode were extracted at tract and block group levels using GIS Tools' SF3toTable program, supplied by Dr. Bruce Ralston. The resulting database files were imported into ArcMap, joined with the appropriate feature class, and then mapped using graduated color by standard deviation rendering. Each map was examined for general spatial patterns, relying on information found in the literature as a basis for expected patterns. Also, census maps were overlaid with telework survey participant and carpooler feature classes to search for correlations with telework survey participant and carpoolers' residences patterns.

Prior to integrating and mapping 2000 Census data for the AMA, telework survey data were entered into a Microsoft Excel workbook. Frequencies of each personal characteristic were calculated for teleworkers and non-teleworkers, including data such as gender, age, income range, vehicle ownership, primary job function, and primary commute mode. To assist the evaluation and comparison of these statistics, representative graphs were generated for all characteristics. To infer significance from these descriptive statistics, binary logistic regressions, Chi-square tests, and Komologrov-Smirnov tests were performed using the Statistical Package for the Social Sciences (SPSS). These tests will be discussed further in Chapter Four.

3.3.3 Determination of the Significance of Telework and Carpool

In order to determine the significance of telework's effect on traffic congestion and transport-related air pollution in the AMA, a separate table was compiled including typical trips teleworkers reported being made with their commute vehicles during days on which they telework, as well as the time, length, and primary driver of these trips. Literature supports this methodology (see Chapter 2), as other studies have compiled similar tables as a means to test telework's significance in reducing overall vehicle and person miles traveled. The trip purpose table and teleworker table (that contains all data for each teleworker) were imported into ArcMap, and then joined so all teleworker data were available for analysis. In these analyses, records were determined useable if and only if they contained entries for the particular characteristics being analyzed, and they reported a residence in the AMA. For instance, when determining whether total trip mileage traveled by all teleworkers on a typical telework day negated the benefit of reducing or eliminating the round-trip commute distance they would have normally traveled, only records reporting a round-trip daily commute distance, trip mileage data for typical trips made on teleworking days, and an AMA residence were used. Because some teleworkers reported that multiple trips are made on a typical telework day, 65 records were used to calculate total mileage for typical trips made on teleworking days, while only 37 records were used to calculate total round-trip commute distance. Basic statistics were generated for these records using ArcMap's statistics function. The statistics function was also used to create a frequency distribution for the time of these trips (61 records), and then for time by trip purpose to compare these times to peak traffic congestion and sensitive air pollution hours. Such a comparison allows one to determine whether or not telework alters the times at which commuters normally make trips. Similar frequency distributions for trip mileage were also generated, first for all trips (72 records), and then by trip purpose to determine whether telework reduces vehicle miles traveled. Reported trip purposes (78 records) and the primary driver (73 records) of these trips were tallied using ArcMap's summarize function.

In order to determine the significance of carpool's effect on traffic congestion and transport-related air pollution in the AMA, two descriptive statistical analyses were performed. The study portion of the ARC's carpool database was imported into ArcMap, and then the statistics function was used to produce statistics representative of vehicle ownership and normal commute mode database characteristics. Interpretation of these statistics speaks to whether formally organized carpools effectively reduce single occupancy vehicles (SOVs) on the highway, as well as their ability to change carpoolers' commuting habits.

3.3.4 Determination of Important Factors to Encouraging Telework and Carpool

Qualitative data including comments regarding mitigation of traffic congestion and air pollution in the AMA and reasons stated by survey participants concerning their choice of whether to telework are included in the telework database. By synthesizing these data, comments can be offered concerning factors that are important to consider when encouraging commuters to telework.

In order to analyze the data gathered from the telework survey question (answered by all survey participants), "How do you believe traffic and air quality problems in Atlanta could be improved," two Excel tables were created: one for teleworkers and one for non-teleworkers. The following filters were chosen to search for patterns in the written responses: gender, age, income, vehicle ownership, job function, and affiliated business. Due to the self-reported nature of the responses, each filter was given three entries, primary, secondary and tertiary. For a given filter, the most cited method was recorded in the primary field, second-most cited method in the secondary field, and so on. Then, the teleworker and non-teleworker database tables (that contain data for each survey participant) and comment tables were opened in ArcMap, joined, and examined by selecting records by various filters. In each selection, the records were scanned for the most cited methods to improve traffic and air pollution and these methods were recorded in the appropriate entry field (*i.e.*, primary, secondary, or tertiary). Anomalies were reexamined by counting the number of times each method was cited, eliminating all but one of the unexpected results. The remaining anomaly is discussed in Chapter Four.

The survey question (answered by non-teleworkers only), "Why don't you telework," supplied four answers: (a.) My job prohibits teleworking, (b.) I lack the equipment I need to telework, (c.) I don't know much about teleworking, and (d.) I don't want to telework. A blank was also provided in which participants had the opportunity to explain other reasons. To analyze these data, each supplied answer's frequency was examined using ArcMap's select by attributes tool. Participants' comments were then examined by using the socio-economic and demographic filters discussed in the previous paragraph to search for any other patterns or trends.

Because the ARC's carpool database includes no qualitative information, no comment can be offered concerning factors important to consider when encouraging commuters to carpool.

Chapter 4: Telework and Carpool Analyses

4.1 Introduction to Telework Analyses

Two major categories were chosen to frame all telework analyses: 1) current telework patterns were assessed in order to determine telework's existing status in the Atlanta Metropolitan Area (AMA); and 2) future telework potential was explored to provide insight to AMA officials encouraging commuters to telework. By framing the analyses in this manner, the following assertions and conclusions provide useful information on telework today, as well as information on increasing telework participation in the future.

To assess telework's current status, many questions were addressed. Telework's spatial availability and participation were explored by asking the following questions:

- Where, and by whom, is telework currently being promoted?
- Where do teleworkers reside?
- Where do non-teleworkers reside?
- How do these residential locations differ, and to what degree?

Socio-economic and demographic data reported by telework survey participants (see Chapter 3 and the Appendix) were examined by asking the following questions:

- What are typical characteristics of a teleworker and a non-teleworker in the AMA?
- Are these two groups of characteristics significantly different from one another?

The current significance of telework's contribution to controlling traffic congestion and/or air pollution in the AMA was also addressed by asking the following questions:

- To what degree does telework decrease vehicle miles traveled (VMTs)?

- Is telework being applied solely as a substitution for the traditional commute trip, or is telework generating new trips? If new trips are generated, how significantly do they negate the benefit of decreased VMTs?

In addition to considering telework's current status, the potential for its adoption and methods to increasing its use were examined by asking the following questions:

- Which AMA commuters are most likely to participate in telework? What are their socio-economic and demographic characteristics?
- What areas within the AMA have the greatest potential for adopting telework?
- How should these commuters be best encouraged to telework?

These categorized questions provide the framework by which the following analyses were conducted.

4.2 Discussion of Telework Analyses

4.2.1 Current Telework Patterns

Upon matching all location data included in the telework database to a map of the AMA (See Figures 4.1 and 4.2 for AMA counties and highways), several preliminary spatial patterns emerged. The six businesses that participated in the telework survey cover the AMA's commercial areas for the most part, and include a variety of business types (see Chapter 3). However, due the low number of participating businesses, no clear spatial pattern could be discerned among them (see Figure 4.3). Overall, teleworkers' residences are more scattered around the AMA, while non-teleworkers tend to reside closer to the AMA's center. More specifically, teleworkers appear more likely than non-teleworkers to reside in the northeastern quadrant of the AMA. Teleworkers also appear

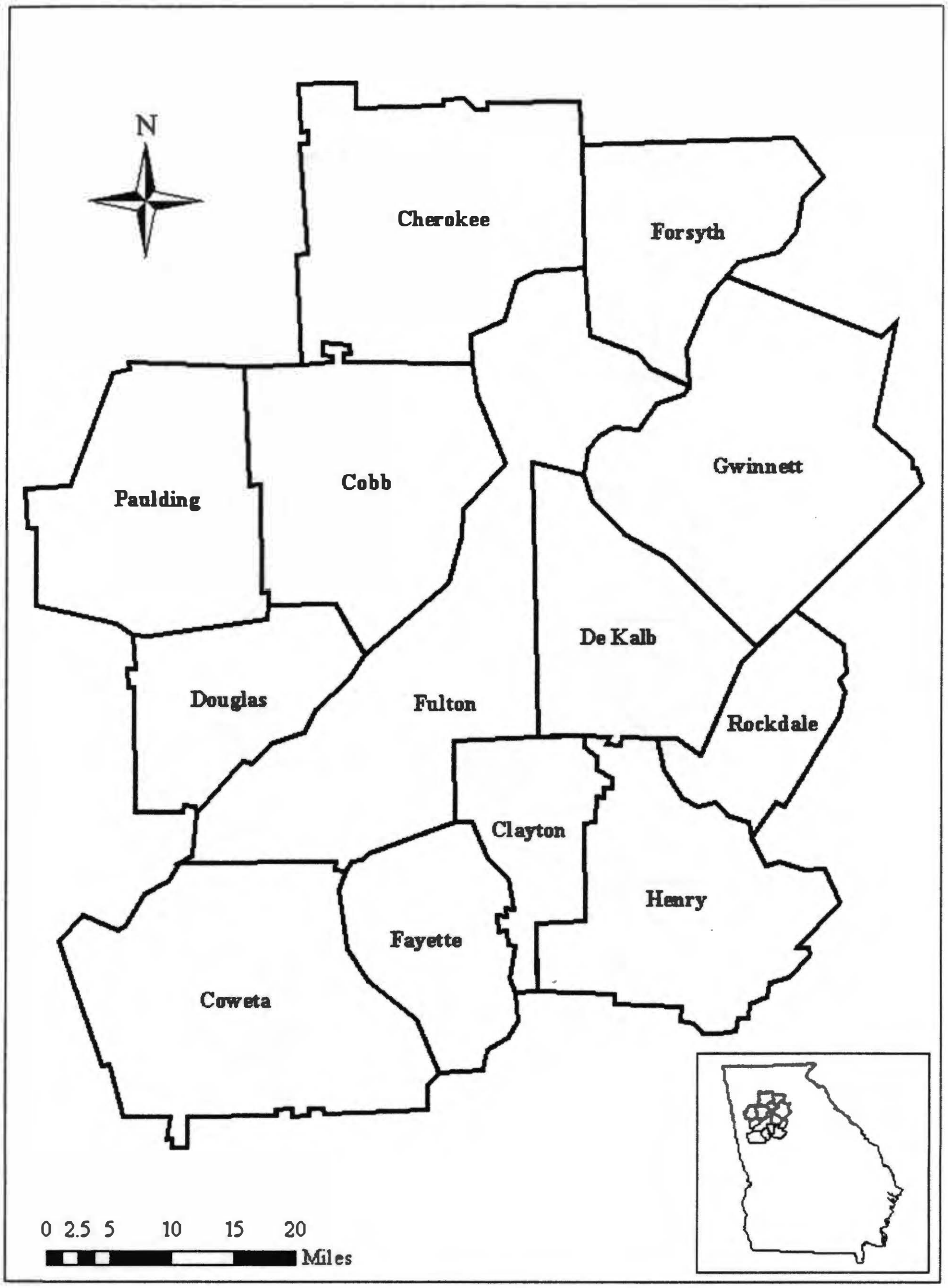

Figure 4.1 Counties within the Atlanta Metropolitan Area

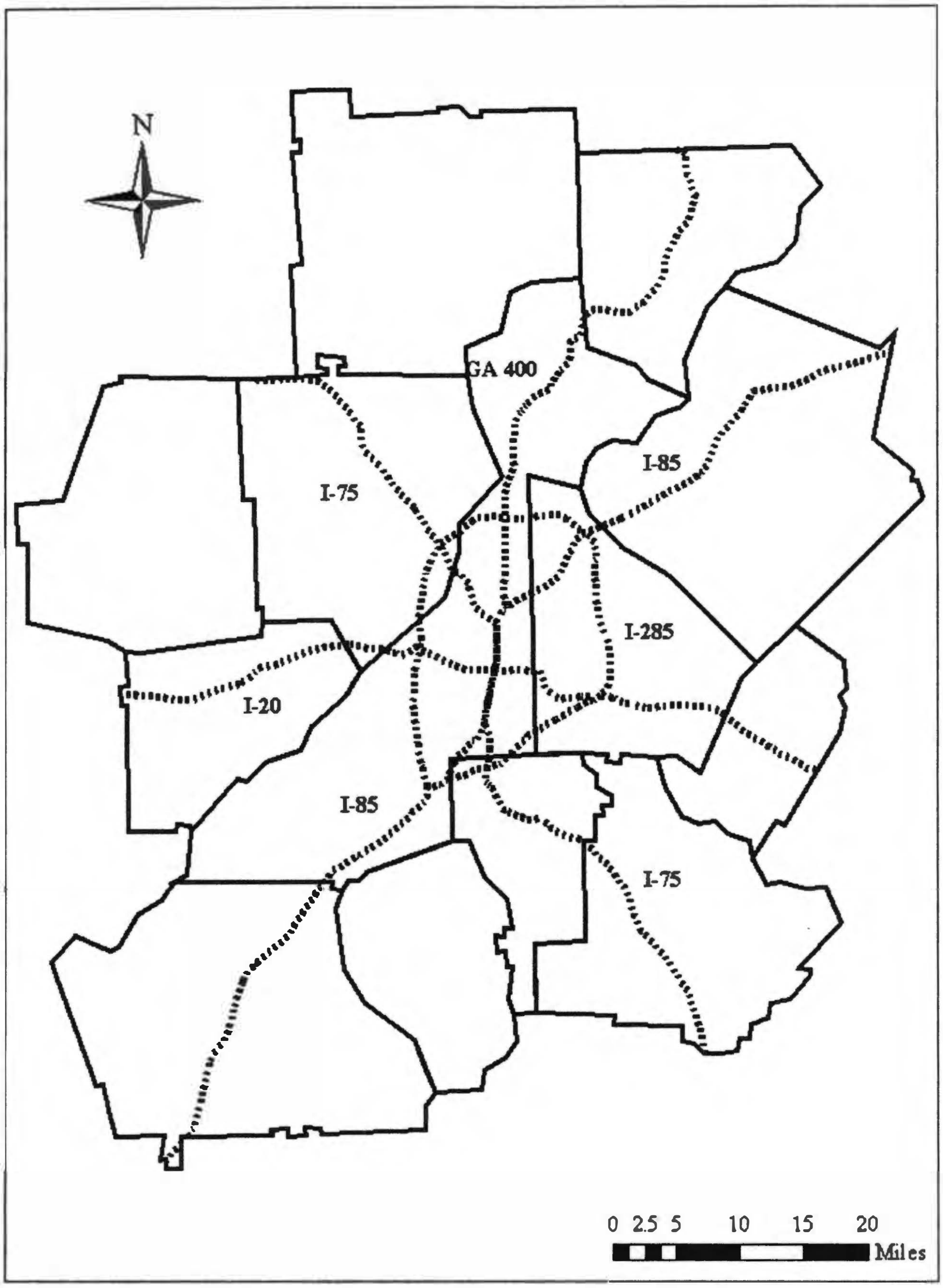

Figure 4.2 Major Highways within the Atlanta Metropolitan Area

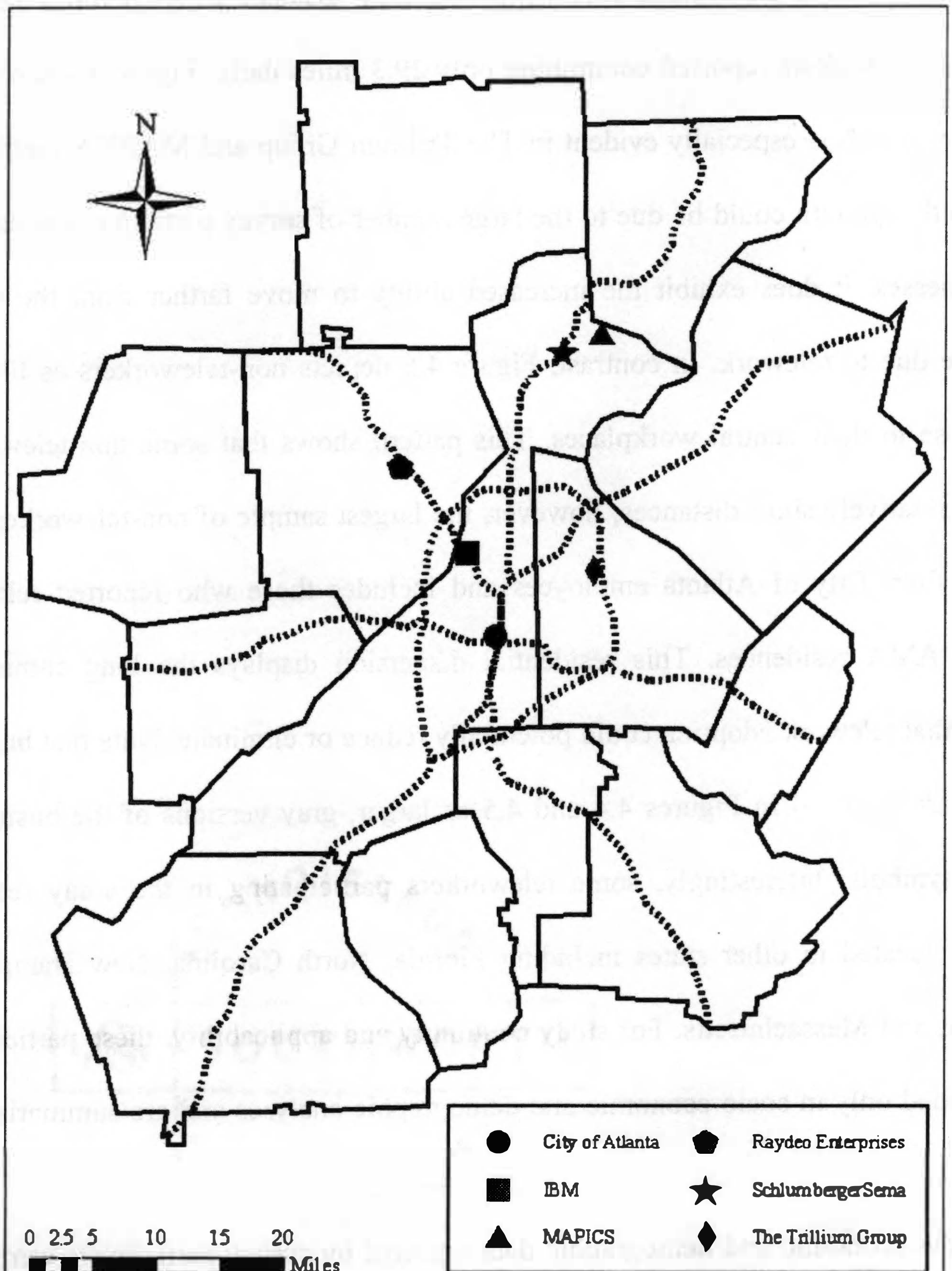

Figure 4.3 The Locations of Businesses Participating in the Telework Survey

to reside farther away from their respective employers than do non-teleworkers. In fact, teleworkers reported an average round-trip commute distance of 44.6 miles per day, while non-teleworkers reported commuting only 29.3 miles daily. Figure 4.4 shows this dispersion, which is especially evident in The Trillium Group and MAPICS employees. Although this pattern could be due to the large number of survey participants from these two businesses, it does exhibit the increased ability to move farther from the central workplace due to telework. In contrast, Figure 4.5 depicts non-teleworkers as likely to reside close to their central workplaces. This pattern shows that some non-teleworkers commute relatively short distances; however, the largest sample of non-teleworkers was collected from City of Atlanta employees and includes those who reported relatively dispersed AMA residences. This residential dispersion displays the long commuting distances that telework adoption could potentially reduce or eliminate. Note that business locations are depicted in Figures 4.4 and 4.5 as larger, gray versions of the businesses assigned symbols. Interestingly, some teleworkers participating in the study reported residences located in other states including Florida, North Carolina, New Hampshire, New York, and Massachusetts. For study continuity and applicability, these participants were included only in socio-economic and demographic analyses and are summarized in Table 4.1.

Socio-economic and demographic data reported by survey participants were also evaluated. Females were found more likely to be teleworkers. In fact, 65 percent of the teleworkers in the study sample were female, and 63 percent of non-teleworkers were male (see Figure 4.6). It is important to note, however, possible bias exists in this sample, as 40 percent of the sample was collected from The Trillium Group, a business almost

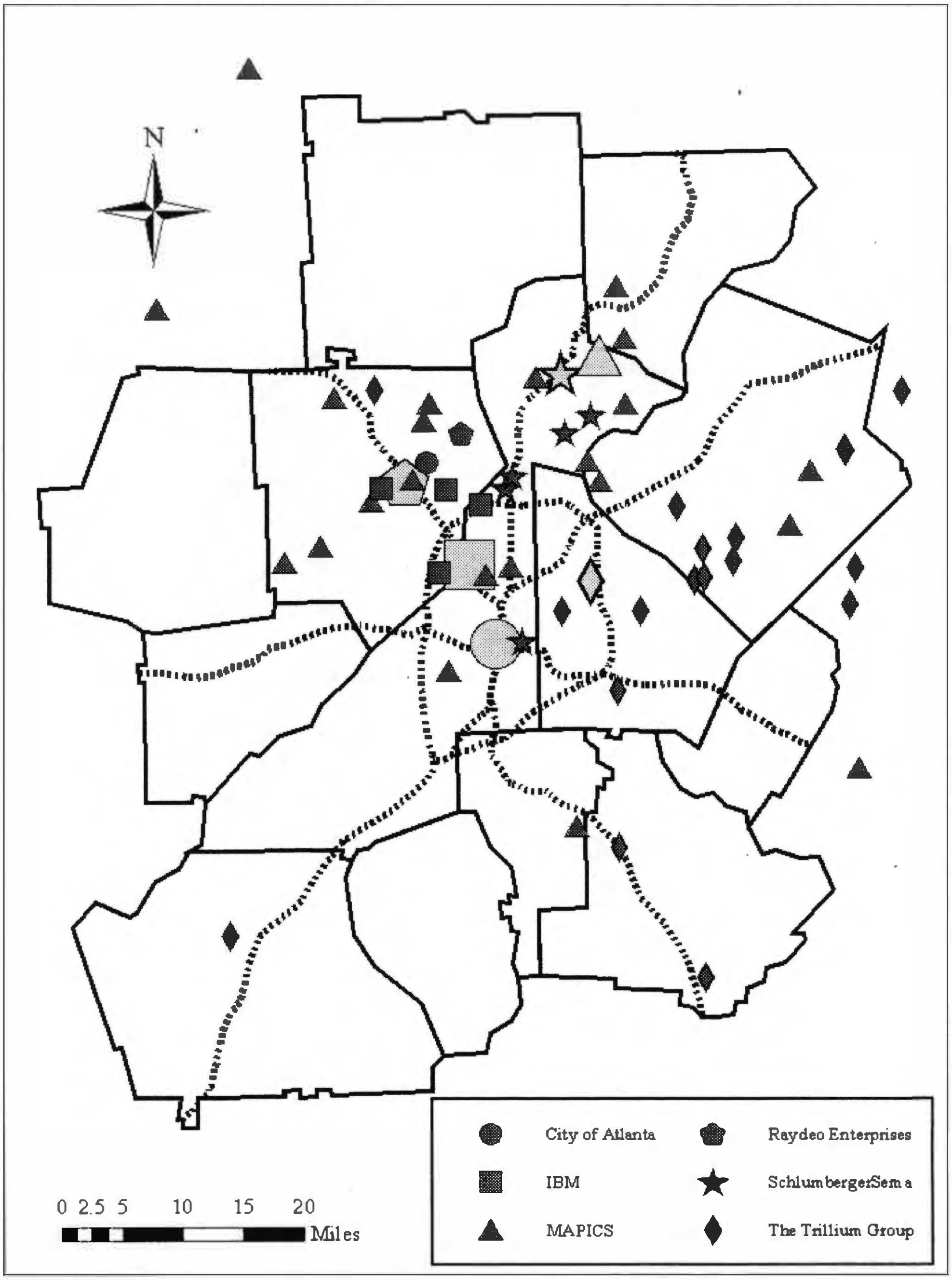

Figure 4.4 Teleworker Residential Locations by Employer

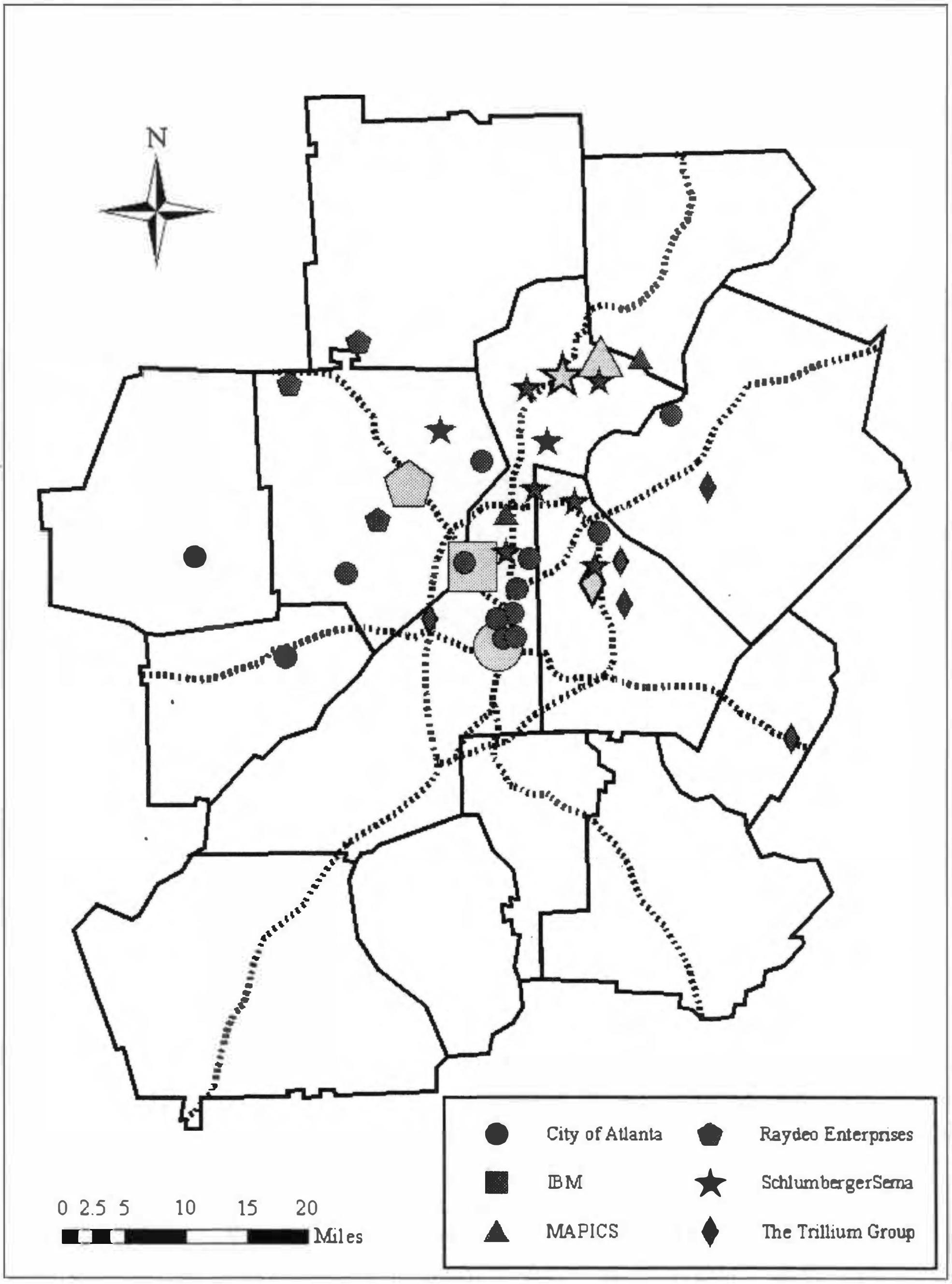

Figure 4.5 Non-Teleworker Residential Locations by Employer

Table 4.1 Out-of-State Teleworkers Participating in the Survey

State	Number of Teleworkers	Employer	Primary Job Function(s)
Florida	2	MAPICS	Sales/Marketing
North Carolina	1	MAPICS	Customer Service
New Hampshire	2	MAPICS	Customer Service Software Design
New York	1	MAPICS	Management/ Administration
Massachusetts	4	MAPICS	Sales/Marketing Customer Service Programming

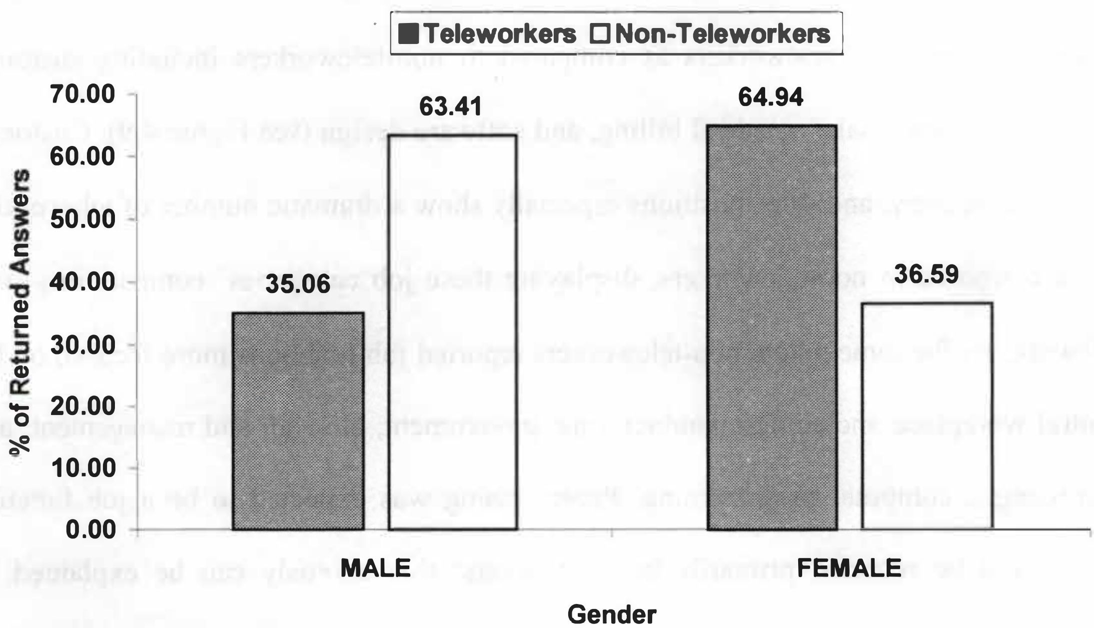

Figure 4.6 Gender of Teleworkers vs. Non-Teleworkers

completely composed of female employees. Teleworkers' age typically ranged from 36 to 45 (45%), while non-teleworkers were more likely to fall between 25 and 35 (43%) (see Figure 4.7). One possible explanation for this trend is that employers may trust older and more experienced workers with the freedom of telework. Sixty-two percent of teleworkers earned above $60,000, while only 31 percent of non-teleworkers earned as much. Figure 4.8 displays the direct relationship between telework and income, showing that relative to the opposing group, a higher percentage of non-teleworkers fall into the $30,000-$60,000 income bracket, and a higher percentage teleworkers fall above the $60,000 income level. It is interesting to note that for those survey participants reporting an income below $30,000, no significant difference appears between non-teleworkers and teleworkers. These statistics depict workers enjoying higher incomes as the most likely candidates for telework. Additionally, information-related job functions accounted for a higher percentage of teleworkers as compared to non-teleworkers including customer service, data entry, sales, medical billing, and software design (see Figure 4.9). Customer service, data entry, and sales positions especially show a dramatic number of teleworkers when compared to non-teleworkers, displaying these job categories' compatibility with telework. By the same token, non-teleworkers reported job functions more focused on the central workplace, including manufacturing, government, clerical, and management, and surprisingly, computer programming. Programming was expected to be a job function that would be reported primarily by teleworkers; this anomaly can be explained by personal comments provided by these workers, citing the proximity of their residences to their workplaces as the key reason for not participating in telework. Job functions included in the legal category show almost no difference between teleworkers and

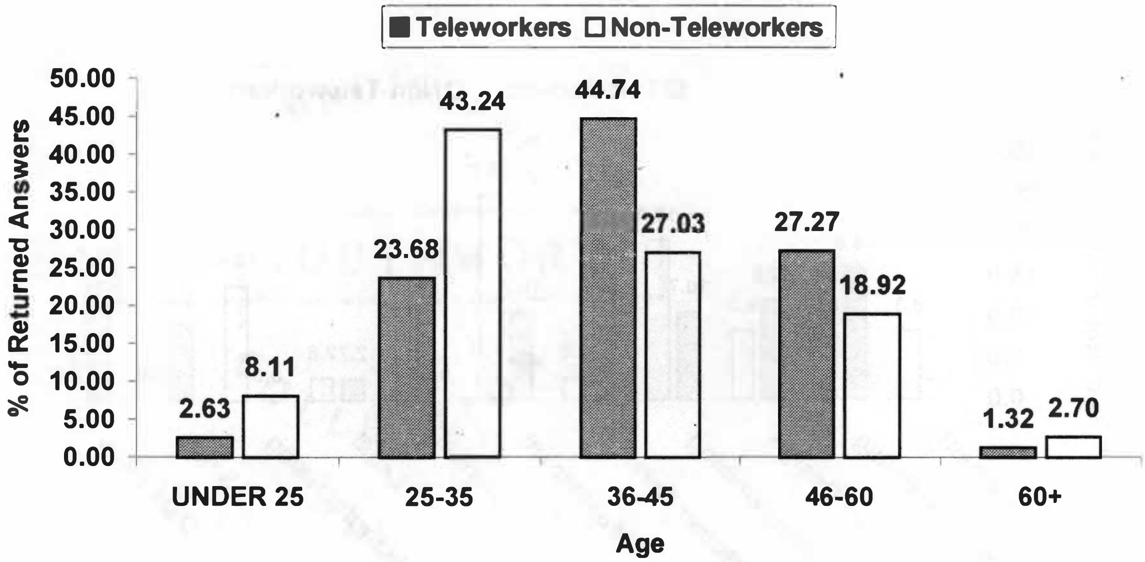

Figure 4.7 Age of Teleworkers vs. Non -Teleworkers

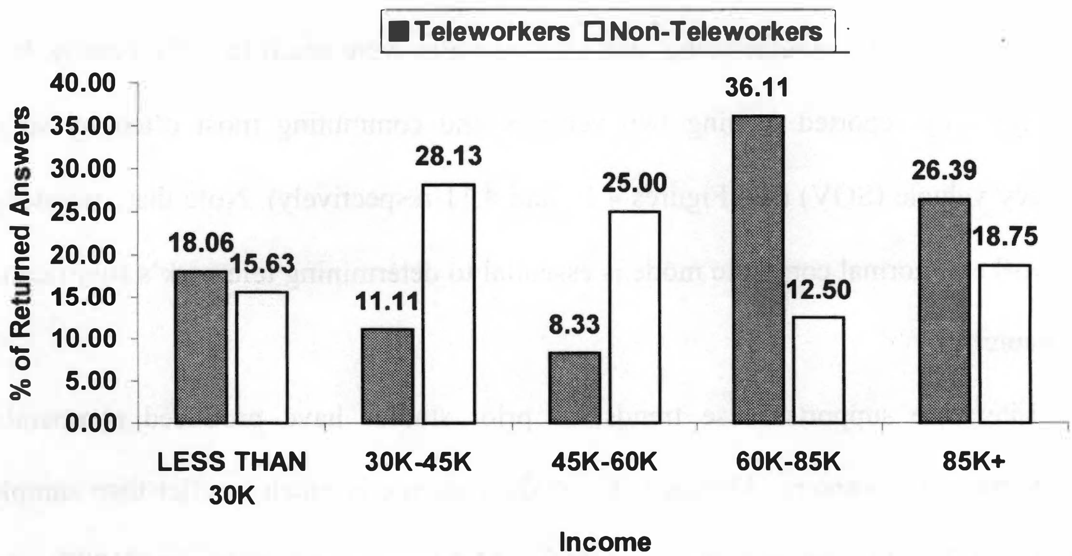

Figure 4.8 Income Range of Teleworkers vs. Non -Teleworkers

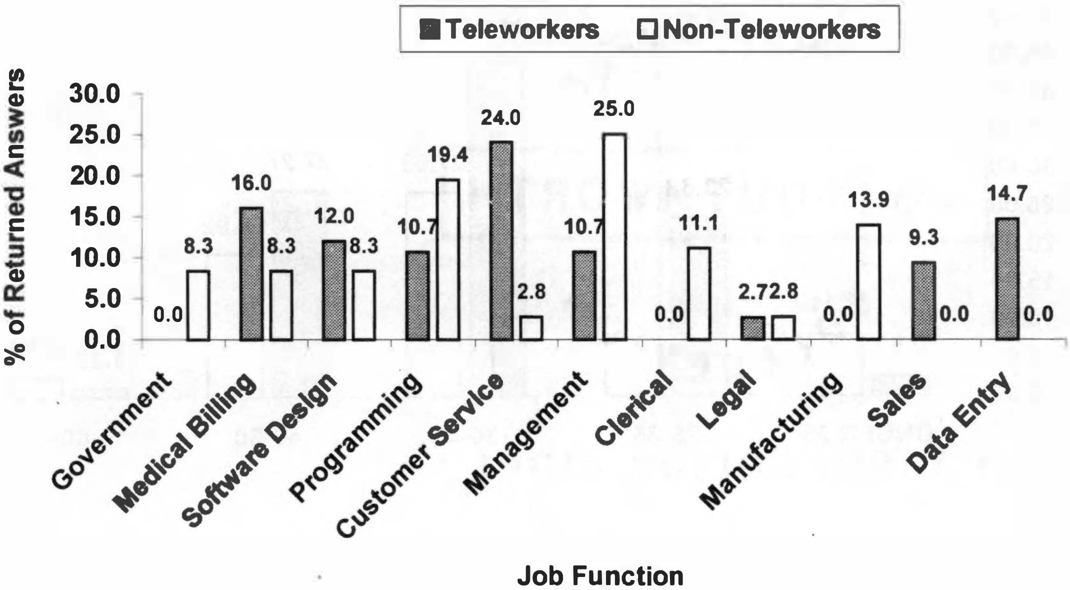

Figure 4.9 Job Function of Teleworkers vs. Non-Teleworkers

non-teleworkers. Note however, due to the number of job function categories, legal, government, clerical, manufacturing, and sales samples were small (n < 8). Finally, both groups typically reported owning two vehicles and commuting most often by single occupancy vehicle (SOV) (see Figures 4.10 and 4.11 respectively). Note that knowledge of teleworkers' normal commute mode is essential to determining telework's significance (see Chapter 2).

Literature supports these trends, as prior studies have produced comparable descriptions of teleworkers. Although this study's sample is much smaller than samples gathered by Mokhtarian and Bagley (2000), Mokhtarian and Salomon (1997), and Mokhtarian, *et al.* (1995), this study's characterization of teleworkers closely resembles those of the larger samples, in which teleworkers are described as affluent, mid-career

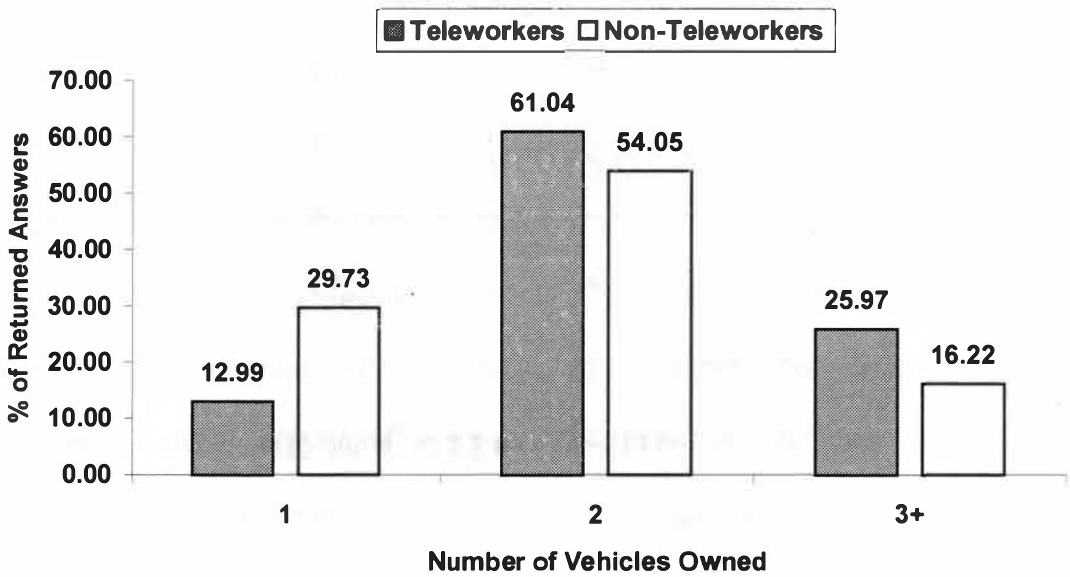

Figure 4.10 Vehicle Ownership of Teleworkers vs. Non -Teleworkers

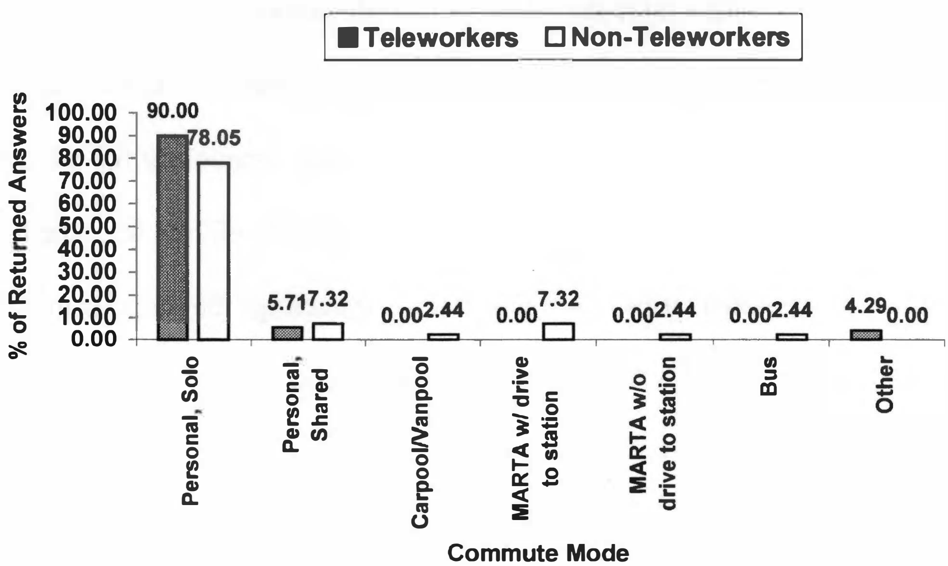

Figure 4.11 Commute Mode of Teleworkers vs. Non -Teleworkers

professionals aged 31-50 with jobs well suited for telework (see Chapter 2). Furthermore, Mokhtarian, *et al.* (1995) describe a positive correlation between telework and income in their study similar to the correlation found between comparable variables.in this study.

Telework's significance as a mitigation method for traffic congestion and/or air pollution was also analyzed. Some disagreements exist in the literature (see Chapter 2) concerning whether telework serves as a substitute for daily commute trips or actually generates additional non-commute trips. Those authors supporting telework's trip generation effect argue that an additional vehicle at home will generate trips by the teleworker and possibly even other members of the teleworker's family. To account for this issue, teleworkers were asked whether their *primary commute vehicles* were used for non-commuting trips, assuring that the data gathered included *all* non-commuting trips made with the teleworker's vehicle rather than only those made by the teleworker. This question was followed with a table the teleworker could complete with trip purpose, time, mileage, and primary driver data (see Chapter 3 and the Appendix). In this study, VMTs decreased as a result of telework participation, even after accounting for all extra trips generated by teleworkers' vehicles. These 'extra' trips will be referred to in the following text as telework-generated trips. In fact, after subtracting the combined telework-generated trip mileage of 657.8 from the initial commute savings of 1777.3 miles (driven by 37 teleworkers), an overall daily commute savings of 1119.5 miles can be attributed to telework participation. Telework succeeded, therefore, in reducing VMTs. This specific daily commute savings would occur *only* if all 37 teleworkers were to telework on the same day. Although such an occurrence is unlikely, it is important to note that 25 of these teleworkers do so at least one week per month, with ten teleworking full time (see Figure

4.12, noting that 36 teleworkers reported their frequencies of telework). Such frequencies of telework participation show that this study's calculated savings is representative of telework's significance in reducing traffic-related problems. Furthermore, all but one of the 37 teleworkers included in this analysis reported commuting normally by SOV, strengthening telework's significance to mitigating traffic congestion and air pollution.

Most of the telework-generated trips tended to vary somewhat from traditional peak traffic times and were conducted over short distances (see Figures 4.13 and 4.14 respectively). Relatively high trip frequencies *did* remain at traditional peak traffic times (*i.e.*, morning and evening rush hours, lunch time), but peaks also occurred during mid-morning and mid-afternoon hours. The resulting distribution displays telework's capacity to spread some trips to less congested traffic hours, as well as to serve as a method to reducing emissions during high air pollution hours. It is important to note however, that simply starting a cold engine produces harmful emissions; therefore, the length of trips has a somewhat minor effect on mitigating air pollution.

The vast majority (88%) of telework-generated trips were made by teleworkers, dispelling the concern that an extra vehicle at home generates trips by other household members (see Chapter 2). Of trips where the teleworker was the primary driver, 44 percent were child-related and 31 percent were for personal reasons. Medical (13%), lunch (5%), and work-related (8%) trips were marginal (see Figure 4.15). Interestingly, 75 percent of child-related trips were made by female teleworkers, many of whom reside in the northeastern quadrant of the AMA (see Figure 4.16), while many child-related trips falling outside of the AMA's northeastern quadrant were made in relatively high income areas.

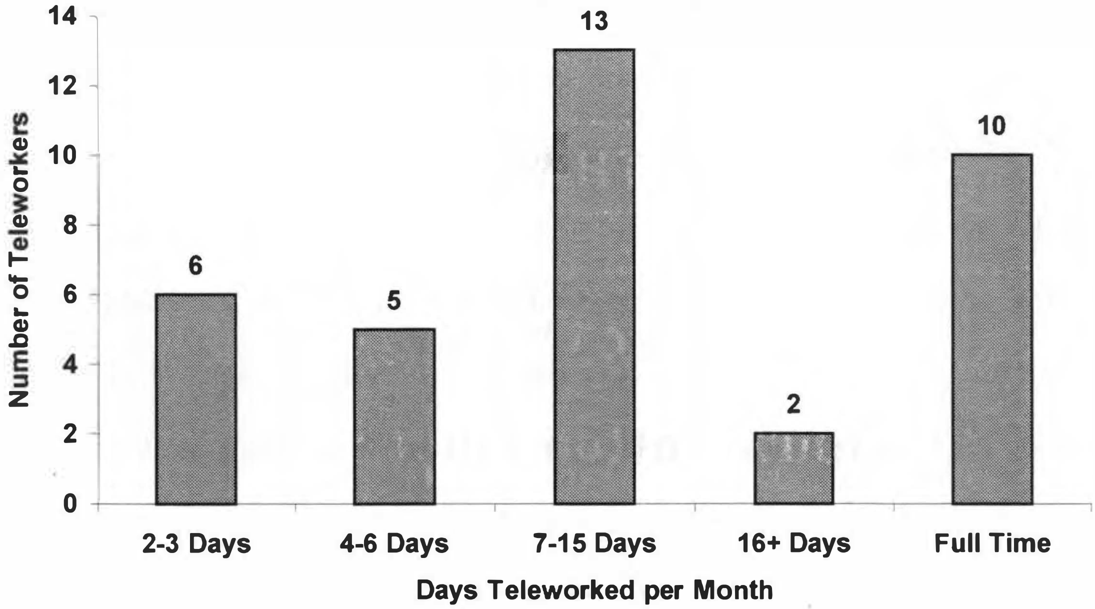

Figure 4.12 Frequency of Telework Participation

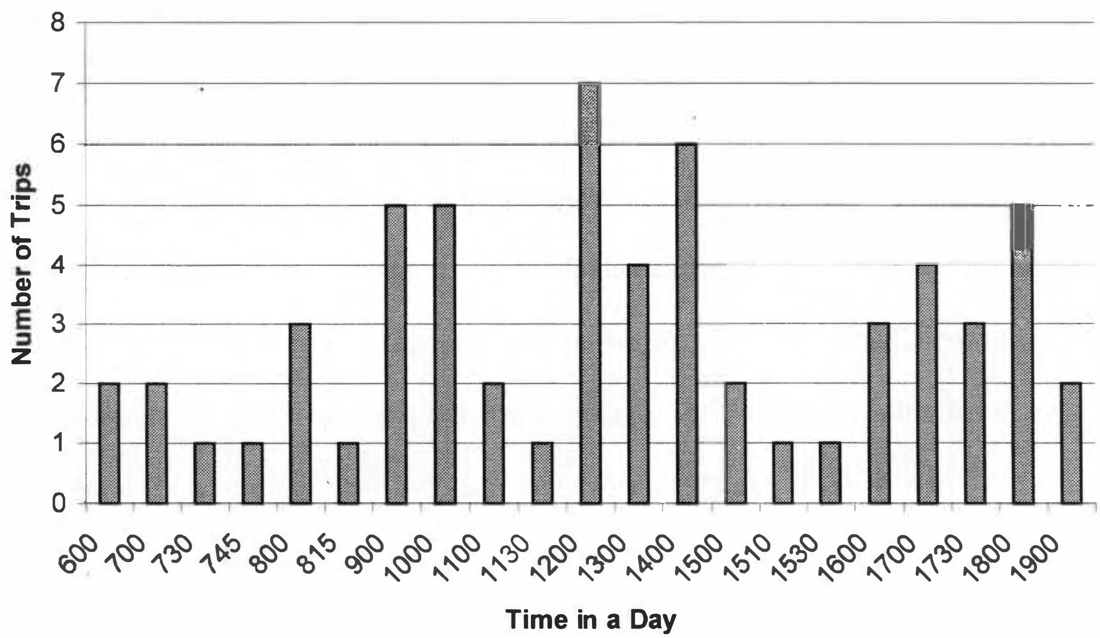

Figure 4.13 Telework-Generated Trip Times

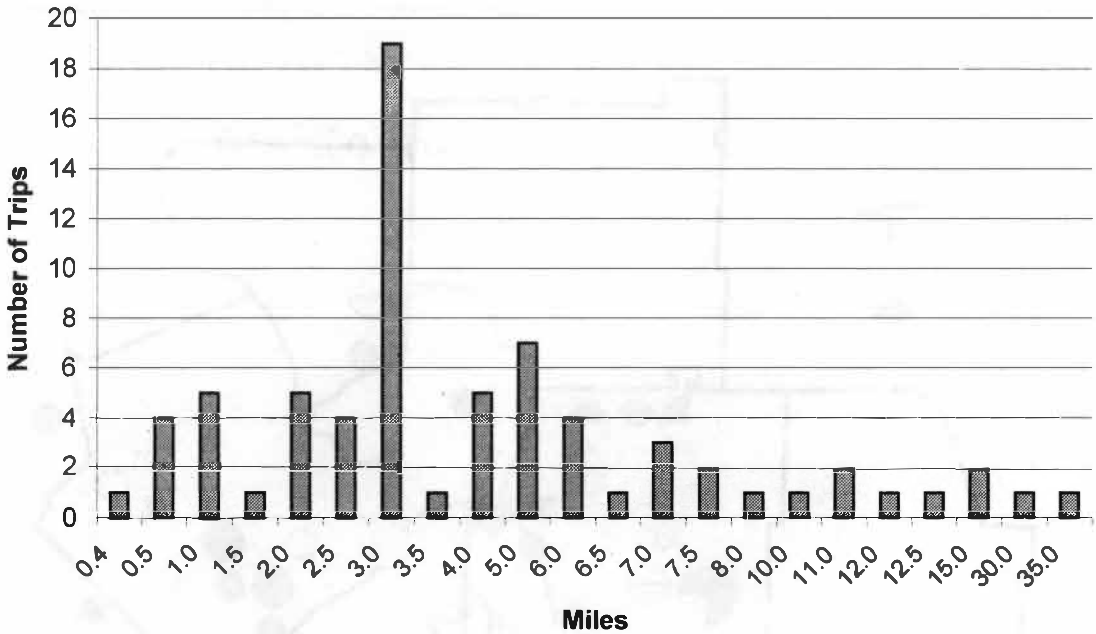

Figure 4.14 Telework-Generated Trip Mileage

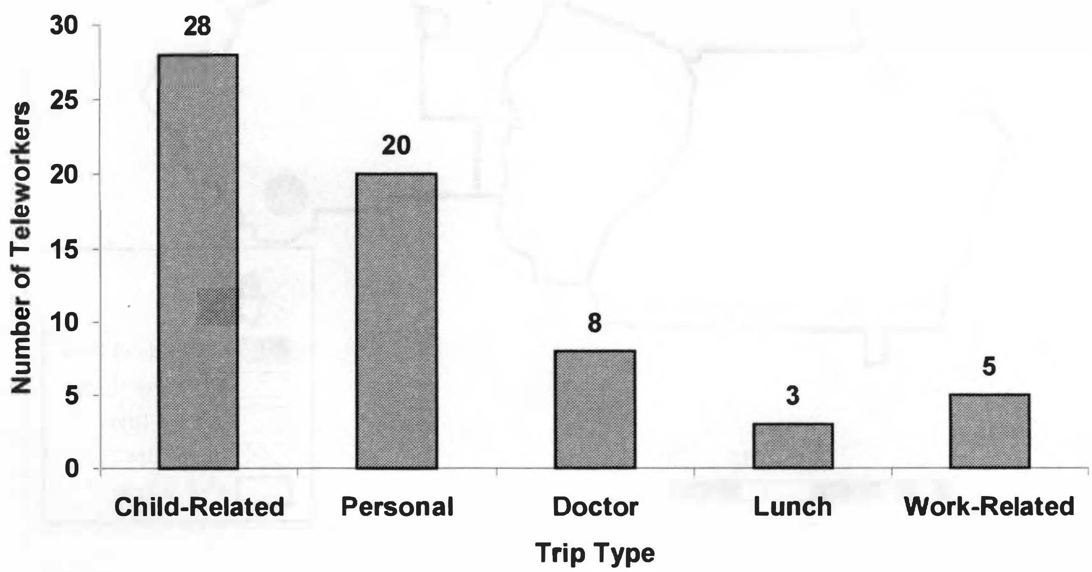

Figure 4.15 Telework-Generated Trip Purposes

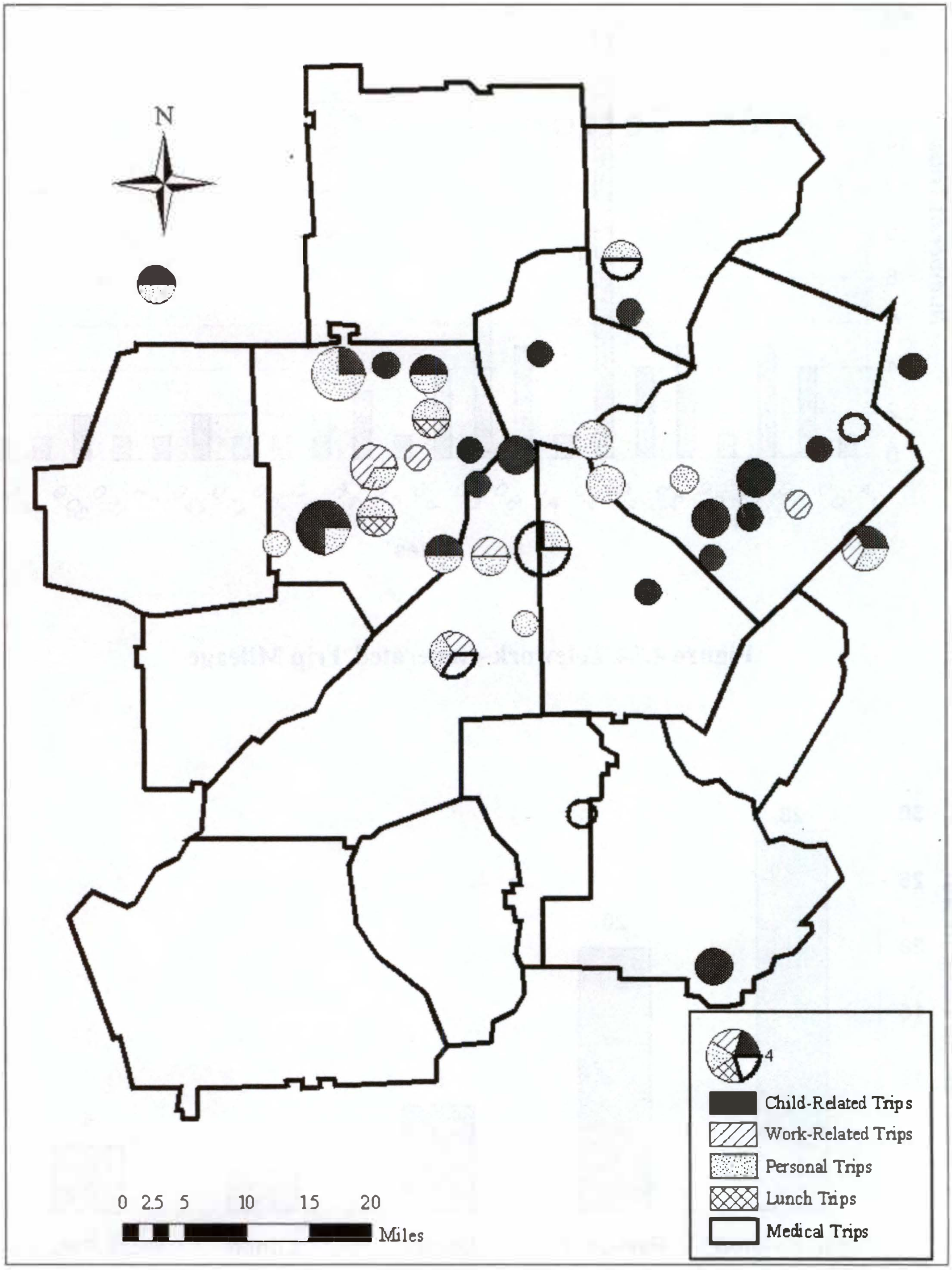

Figure 4.16 The Spatial Distribution of Telework-Generated Trip Purposes

Other spatial patterns exist linking teleworker characteristics to the AMA's northeastern quadrant. Gender, age, income, and vehicle ownership data are mapped on the following pages (See Figures 4.17-4.20). In Figure 4.17, female teleworkers appear to be dispersed throughout the AMA, while male teleworkers reside more often in the AMA's northwestern quadrant. In fact, 100 percent of the sample's male teleworkers reside in North Fulton, Cobb, or Forsyth Counties. This pattern is quite likely due to the small sample size, however, because one would expect that the spatial distribution of males and females would be relatively similar across any metropolitan area. In Figure 4.18, survey participants reporting ages of 36-45 clearly overshadow the other age groups and display a tendency to reside in the northeastern quadrant of the AMA. Figure 4.19 shows survey participants reporting incomes in excess of $60,000 residing in a fairly dispersed manner, while those teleworkers earning $85,000 or more are clustered in the central portion of the AMA's northern half. Figure 4.20 displays no distinctive pattern in vehicle ownership, indicating that most participants own two or more vehicles. Clearly, many middle-aged and affluent females owning at least two vehicles appear to reside in the AMA's northeastern quadrant.

Drawing from these exploratory analyses, a description of the typical teleworker can be offered. The typical teleworker appears to be a middle-aged (36-45 in this study) female with children, earning a higher than average income. These characteristics are combined in the *Working Mother Hypothesis*, which states that the aforementioned segment of the commuting population is more likely to telework than other population segments, and therefore should be actively targeted by telework programs.

Several inferential statistics were computed to test the validity of this hypothesis.

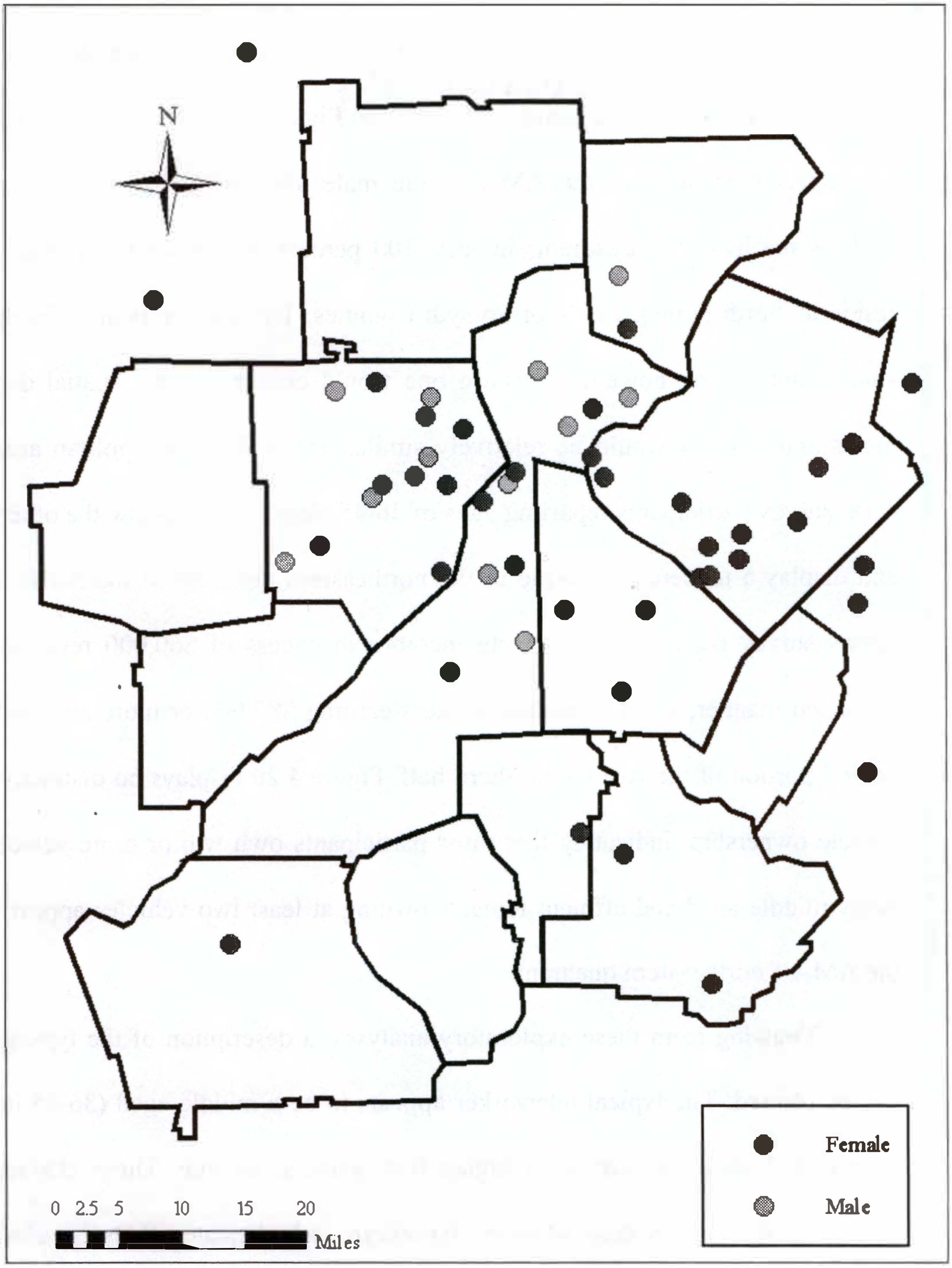

Figure 4.17 The Spatial Distribution of Teleworkers by Gender

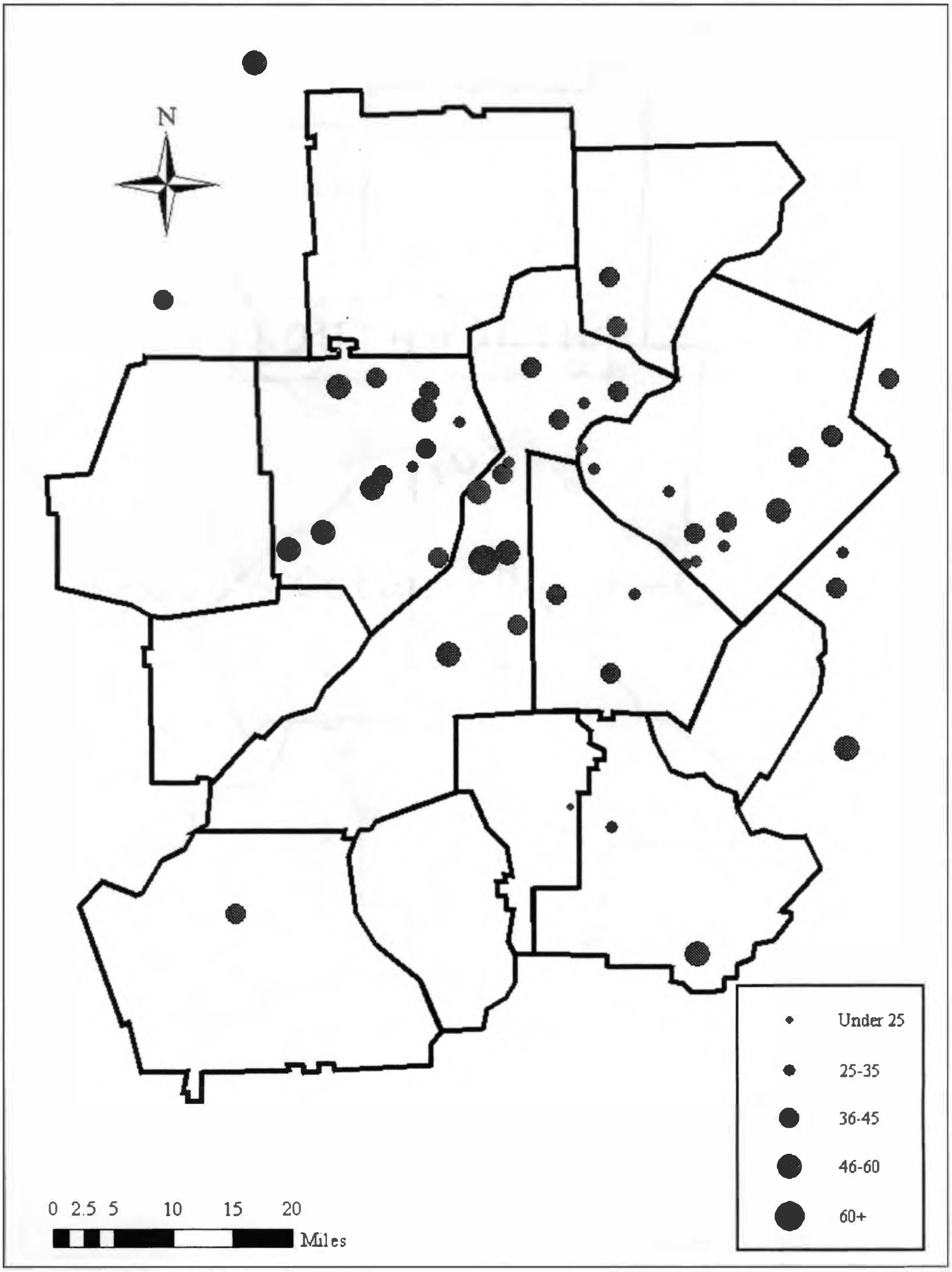

Figure 4.18 The Spatial Distribution of Teleworkers by Age

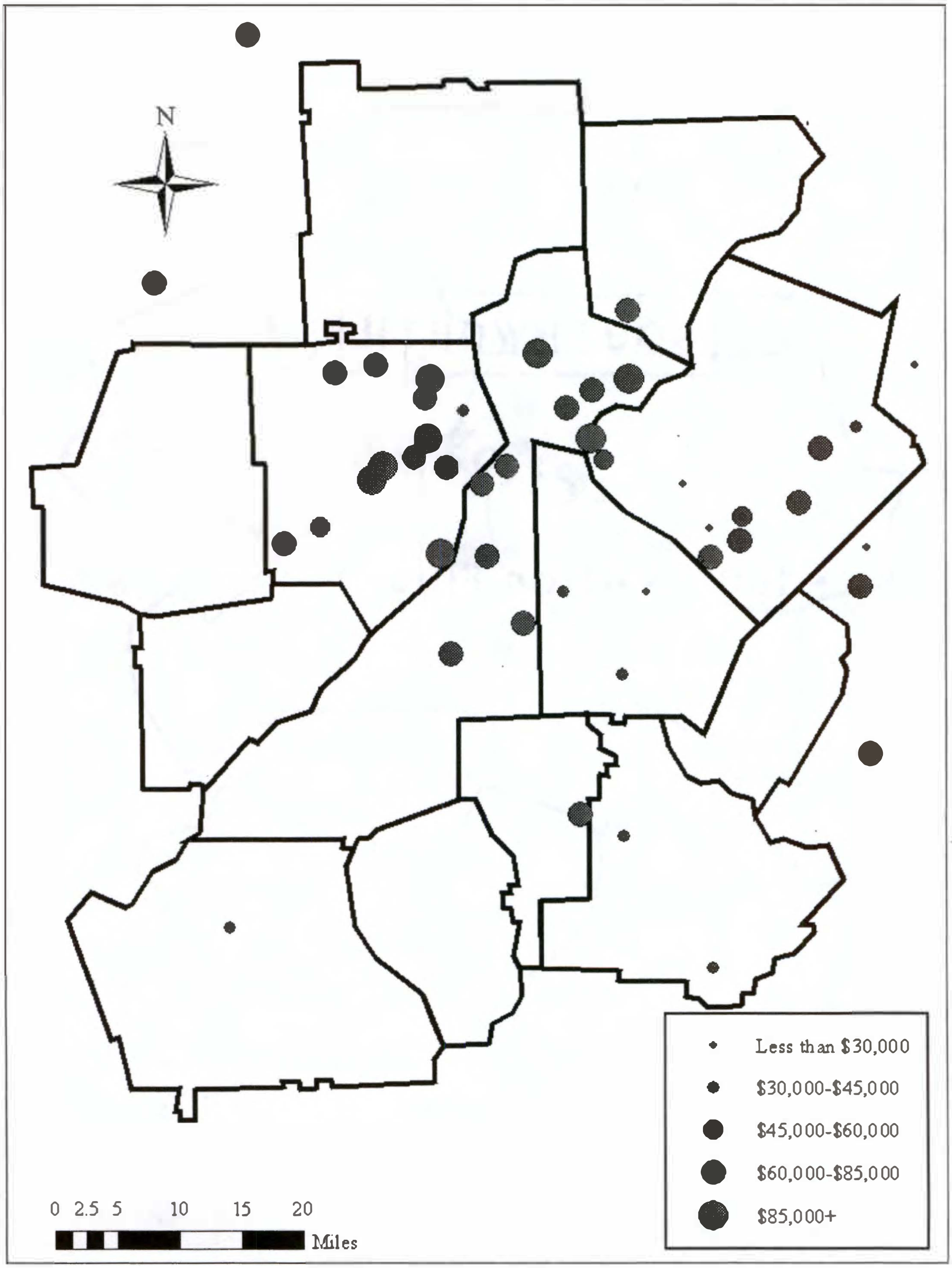

Figure 4.19 The Spatial Distribution of Teleworkers by Income

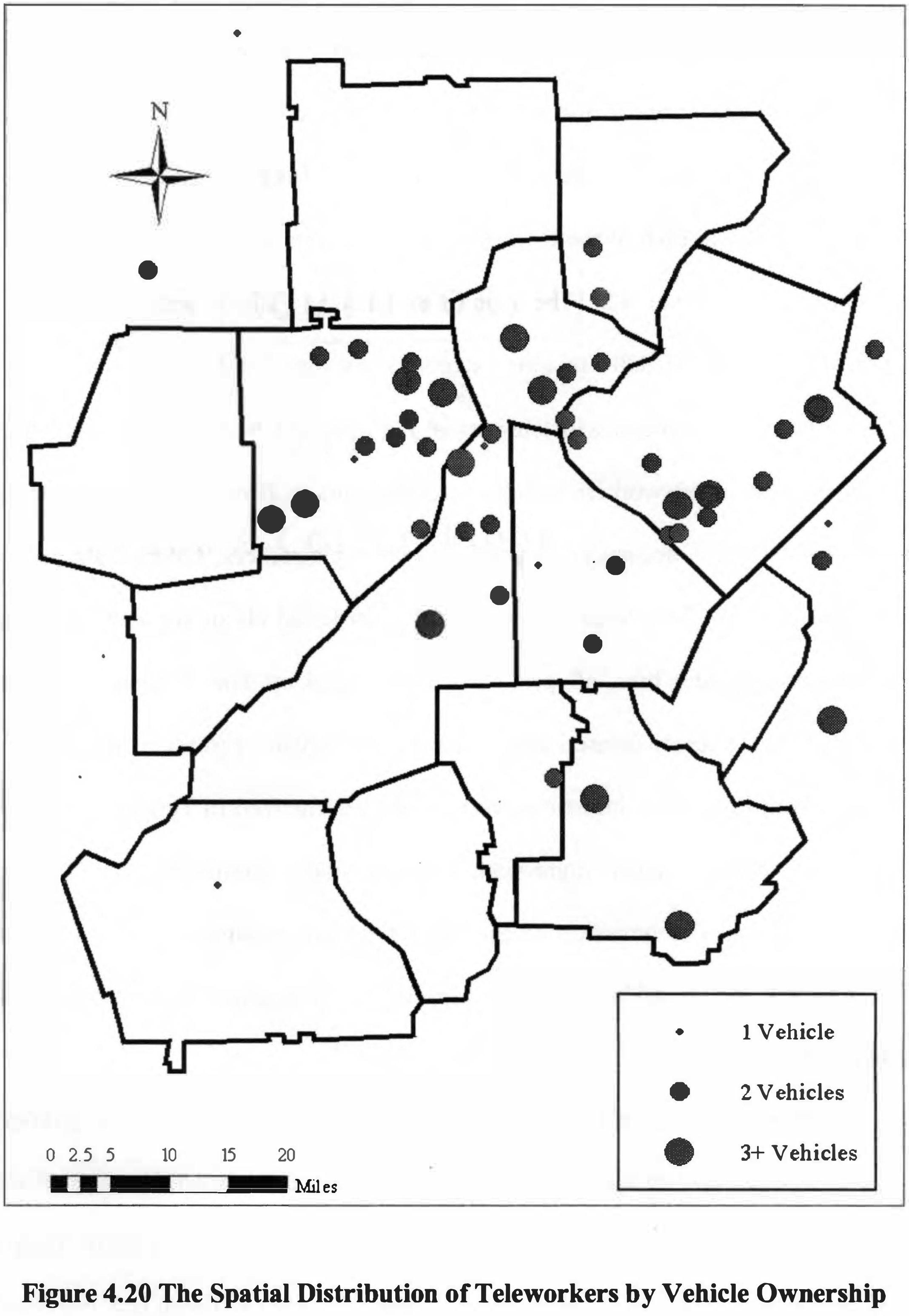

Figure 4.20 The Spatial Distribution of Teleworkers by Vehicle Ownership

Due to the categorical nature of the study's dependent variable (*i.e.*, teleworker or non-teleworker), a binary logistic regression was performed. Statistical testing was somewhat restricted due to the nominal and ordinal scales defined in the telework survey (*i.e.*, gender, age, income); therefore, dummy variables were used as a method for evaluating a presence or absence in each of the categories. Results from this binary logistic regression are summarized in Table 4.2. The resulting statistics indicate that gender and the $30,000-$45,000 and $86,000+ income categories are significant variables in predicting whether particular commuters will telework at a 95 percent confidence interval. In fact, the model can predict teleworkers with 93 percent accuracy. However, the model is much less successful (53.1% accuracy) in predicting non-teleworkers. Overall, the model is 80.6 percent accurate. This binary logistic regression tested all survey data: To account for the potential gender bias, all participants employed by The Trillium Group were eliminated from the larger dataset, and a new binary logistic regression was performed. The results from this binary logistic regression are summarized in Table 4.3. According to this second binary logistic regression, gender remains significant at a 95 percent confidence interval. The omission of the largely female employment of The Trillium Group increases the model's predictive capacity to 93.5 percent for teleworkers, 63 percent for non-teleworkers, and 82.2 percent for overall accuracy.

To further verify gender and income's significance at a 95 percent confidence interval, non-parametric testing was employed. This choice was made because all socio-economic and demographic data were recorded in a categorical fashion; therefore, quantitative means could not be calculated and cumulative frequency distributions associated with non-parametric testing were more appropriate to evaluate the data.

Table 4.2 Binary Logistic Regression Results

a. Regression Results

Attribute	B	Significance	Exp(B)
Gender	-2.233	.001	.107
Income ($30,000-$45,000)	-2.085	.017	.124
Income ($86,000+)	(omitted dummy)	.031	(omitted dummy)

b. Binary Logistic Model Results

	Predicted NTW	Predicted TW	% Correct
Observed NTW = 32	17	15	53.1
Observed TW = 71	5	66	93.0
		Overall %	80.6

Table 4.3 Binary Logistic Regression Results Without The Tri llium Group Data

a. Regression Results

Attribute	B	Significance	Exp(B)
Gender	-1.691	.031	.184
Income ($30,000-$45,000)	-3.580	.006	.028
Income ($86,000+)	(omitted dummy)	.022	(omitted dummy)

b. Binary Logistic Model Results

	Predicted NTW	Predicted TW	% Correct
Observed NTW = 27	17	10	63
Observed TW = 46	3	43	93.5
		Overall %	82.2

Gender data were cross-tabulated, and a Pearson Chi-Square test statistic was derived. This non-parametric test statistic offers a measure of the closeness of fit between two sets of data by assessing the differences between observed and expected data frequencies (Burt and Barber 1996). This test was performed with both the entire dataset and the dataset without The Trillium Group employees. Results from both Chi-Square tests are summarized in Table 4.4. Both sets of results confirm that the gender of teleworkers is significantly different from those of non-teleworkers. Finally, Kolmogorov-Smirnov Z tests were run for both income and age data to confirm the binary logistic regression results. This non-parametric test has been characterized as beneficial to employ when evaluating ordered, categorical data because it eliminates the problematic issue of multiple ties that are present in comparable non-parametric tests (Blalock 1972). The Kolmogorov-Smirnov test statistic reflects the maximum difference between the expected and observed cumulative frequency distributions; as this statistic increases, distributions are depicted as increasingly different from one another. Results from the Kolmogorov-Smirnov Z tests are summarized in Tables 4.5 and 4.6. These tests support the significance of income reported by both binary logistic regression analyses, while also supporting that age is not significant to predicting the tendency to telework. Interestingly though, if the confidence interval was decreased to 90 percent, age would be significantly different between teleworkers and non-teleworkers as well.

Due to telework's compatibility with information-related occupations, another binary logistic regression was run including the same socio-economic and demographic data used in the first regression, while adding the job functions supplied by telework survey participants. In this regression, the WALD/forward stepwise method was used.

Table 4.4 Chi-Square Test Results

a. Cross-Tabulation of Gender and Telework Choice

	Male	Female	TOTAL
Teleworker	27	50	77
Non-Teleworker	26	15	41
TOTAL	53	65	118

b. Cross-Tabulation of Gender and Telework Choice without The Trillium Group Data

	Male	Female	TOTAL
Teleworker	26	26	52
Non-Teleworker	26	9	35
TOTAL	52	35	87

c. Chi-Square Statistics

	Test Statistic	Significance
Pearson Chi-Square	8.691	.003
Pearson Chi-Square (without The Trillium Group Data)	5.131	.023

Table 4.5 Kolmogorov–Smirnov Z Test Results for Income

	Test Statistic	Significance
Kolmogorov-Smirnov Z	1.471	.026

Table 4.6 Kolmogorov–Smirnov Z Test Results for Age

	Test Statistic	Significance
Kolmogorov-Smirnov Z	1.249	.088

This method enters variables into the regression equation individually, after testing whether the variable's addition will significantly add to the equation's overall accuracy. The resulting logistic regression equation includes *only* the job function variable to predict telework participation. The job function variable, however, is not significant at the 95 percent confidence interval. Nonetheless, this result depicts the strength of job function in predicting the likelihood that given commuters will telework.

These inferential statistics partially support the *Working Mother Hypothesis*, confirming that, at a 95 percent confidence interval, gender and income level are indeed statistically significantly different between teleworkers and non-teleworkers. This confirmation, however, holds true when only socio-economic variables are included in the logistic regression analysis. When the job function variable is added into the analysis, job function becomes the only variable entered into the logistic regression equation. This result suggests that telework participation appears to be influenced by characteristics of employment as well as the socio-economic characteristics of employees.

4.2.2 Telework Potential

Maps of 2000 census data display large concentrations of residents with characteristics compatible with telework in the northeastern quadrant of the AMA. Upon mapping gender, age, income, industry identification, and journey-to-work mode data using standard deviation rendering at census tract levels, spatial patterns were produced depicting a high concentration of commuters in this area that could be removed from the AMA's major highways if they were to participate in telework. Such participation would assist in strengthening telework's significance as a mitigation method for controlling traffic congestion and air pollution in the AMA. Note that these patterns were confirmed by remapping the data at the census block group level.

Figures of AMA census tracts display several patterns depicting the northeastern quadrant of the AMA as an area of potential telework participation. Females falling into the 35 to 44 age range (this age range was used for this portion of analysis due to definitions used by the Census Bureau) appear to reside in a broad circular pattern surrounding downtown Atlanta, most heavily populating the northeastern quadrant of the AMA (see Figure 4.21). Census tracts reporting high median income levels (in 1999 US Dollars) are also quite concentrated, with such residents primarily populating the central northern half of the AMA (see Figure 4.22). These patterns appear to support patterns found in telework survey participant responses, which show a concentration of teleworkers aged 36-45 residing in the AMA's northeastern quadrant (refer to Figure 4.18) and teleworkers earning $85,000+ primarily as residents of the AMA's central northern half (refer to Figure 4.19). In addition to these characteristics, census tracts located in the northeastern quadrant of the AMA display a high concentration of residents reporting occupations in the information and professional, scientific, and technical sectors (see Figures 4.23 and 4.24 respectively). Many information and professional-related businesses are located in this area as well. All other portions of the AMA show a smaller tendency toward providing residences to commuters with such occupations. As expected, census tracts reporting higher than average levels of residents commuting by SOVs form a circular pattern around downtown Atlanta (see Figure 4.25). These tracts are suburban areas, where established families are more likely to reside.

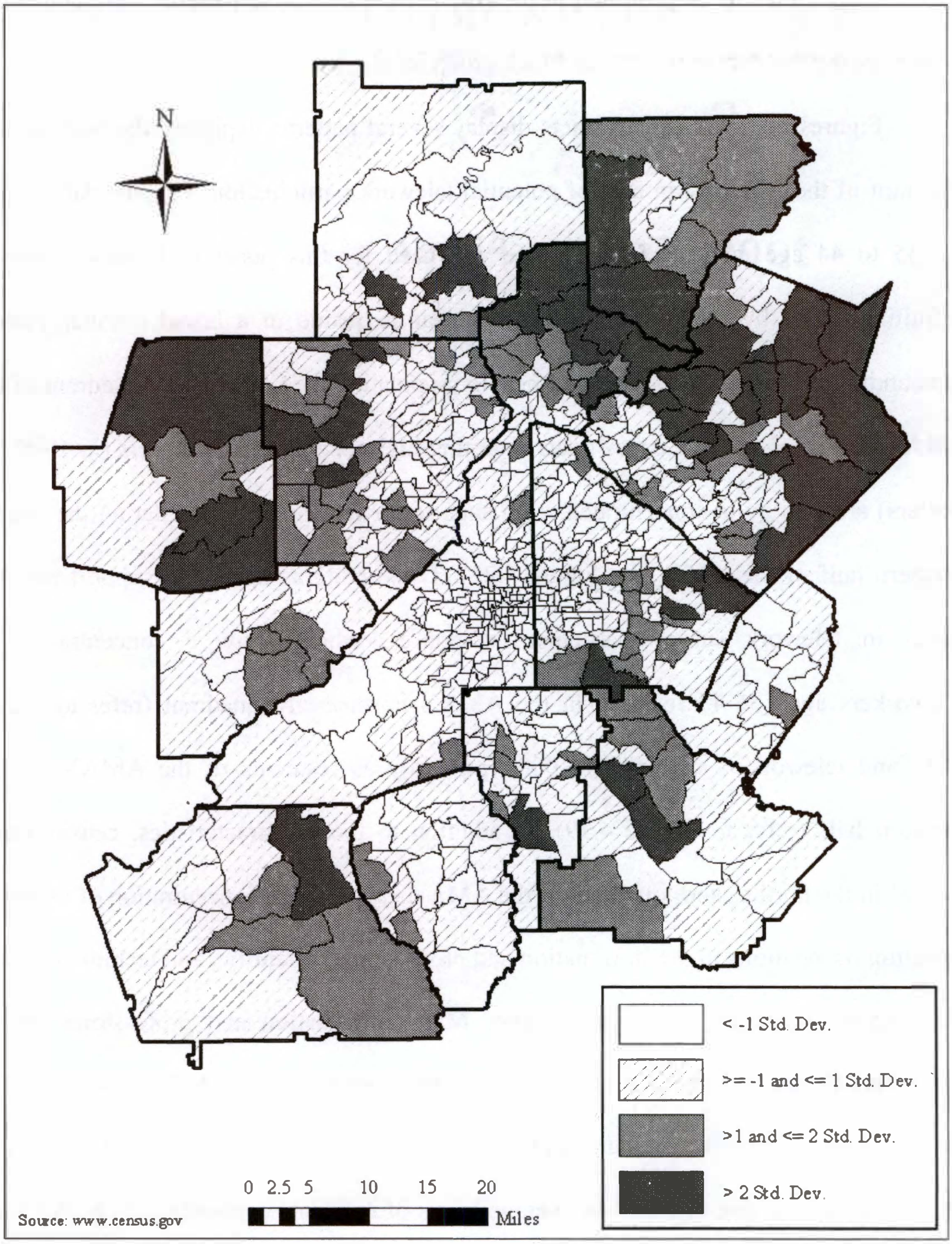

Figure 4.21 Females Aged 35 to 44 by Census Tract

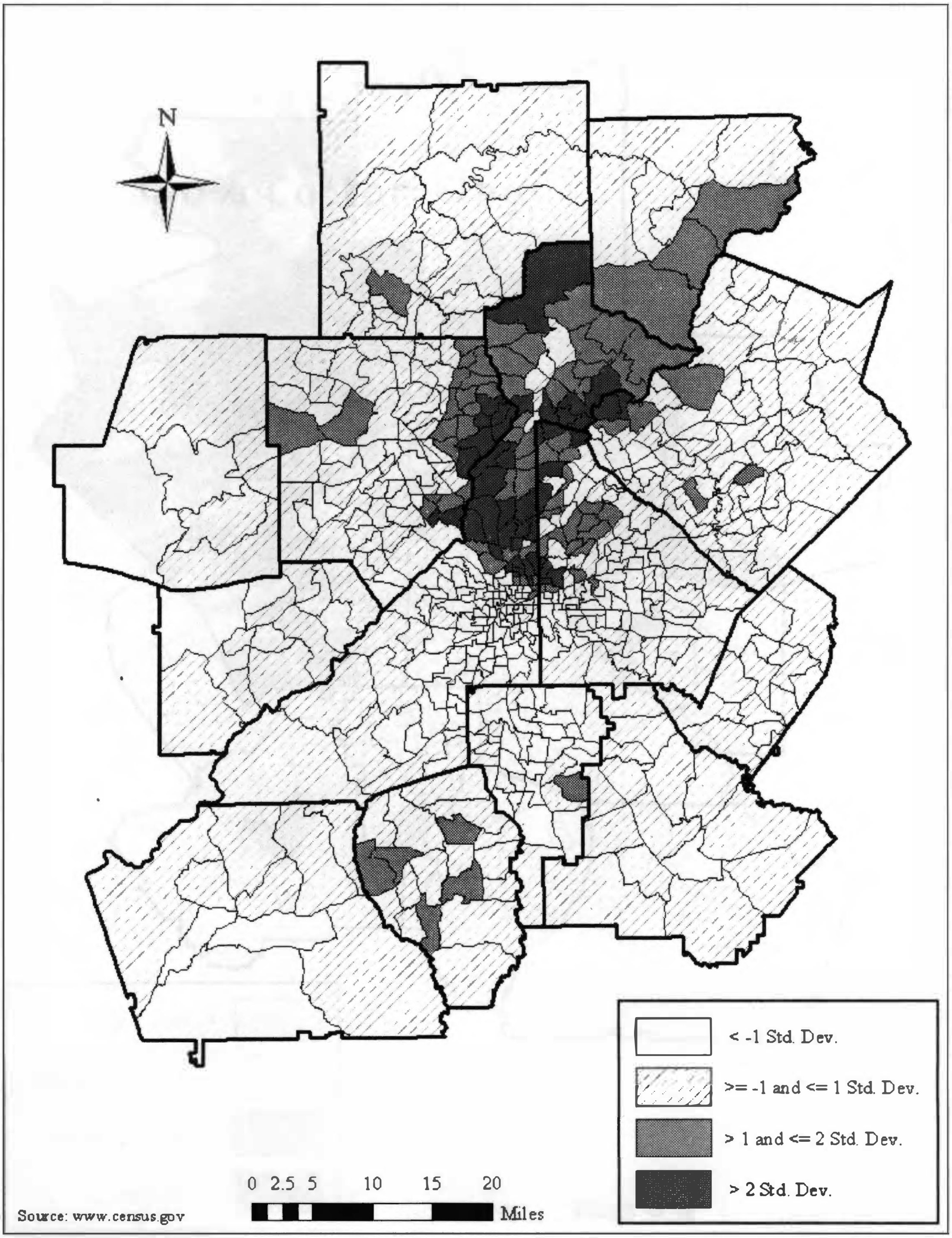

Figure 4.22 Median Income Per Capita by Census Tract

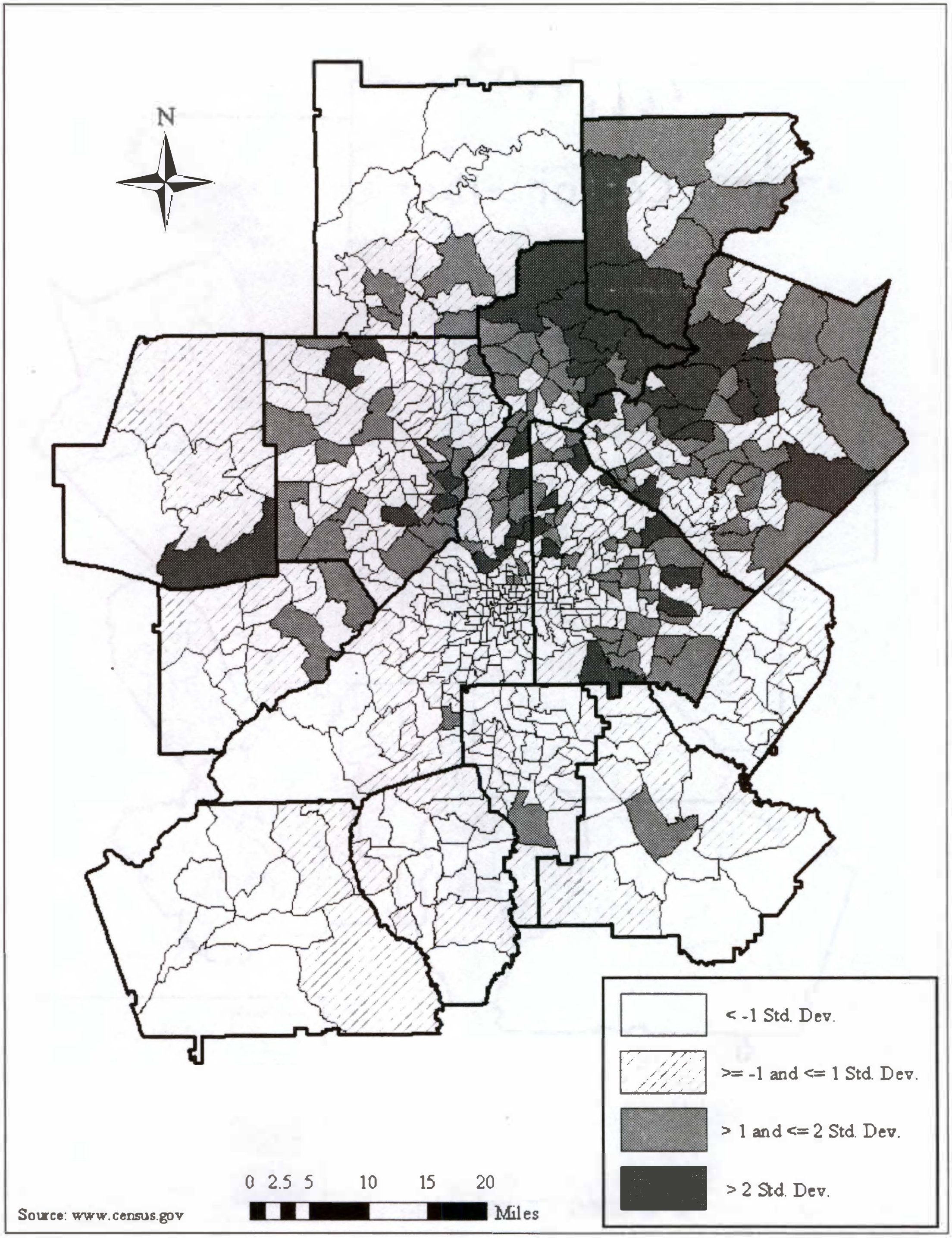

Figure 4.23 Information Workers by Census Tract

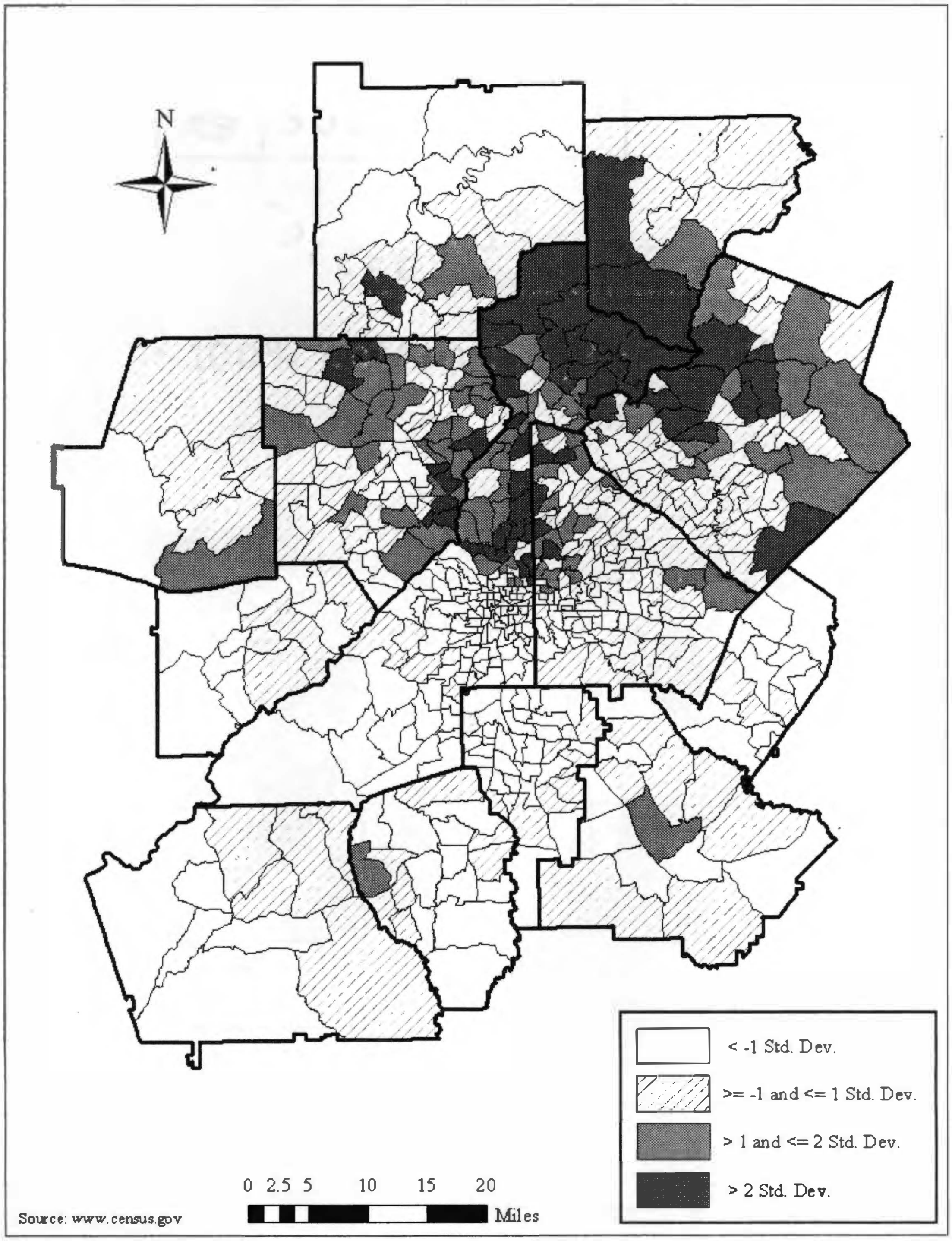

Figure 4.24 Professional, Scientific, and Technical Workers by Census Tract

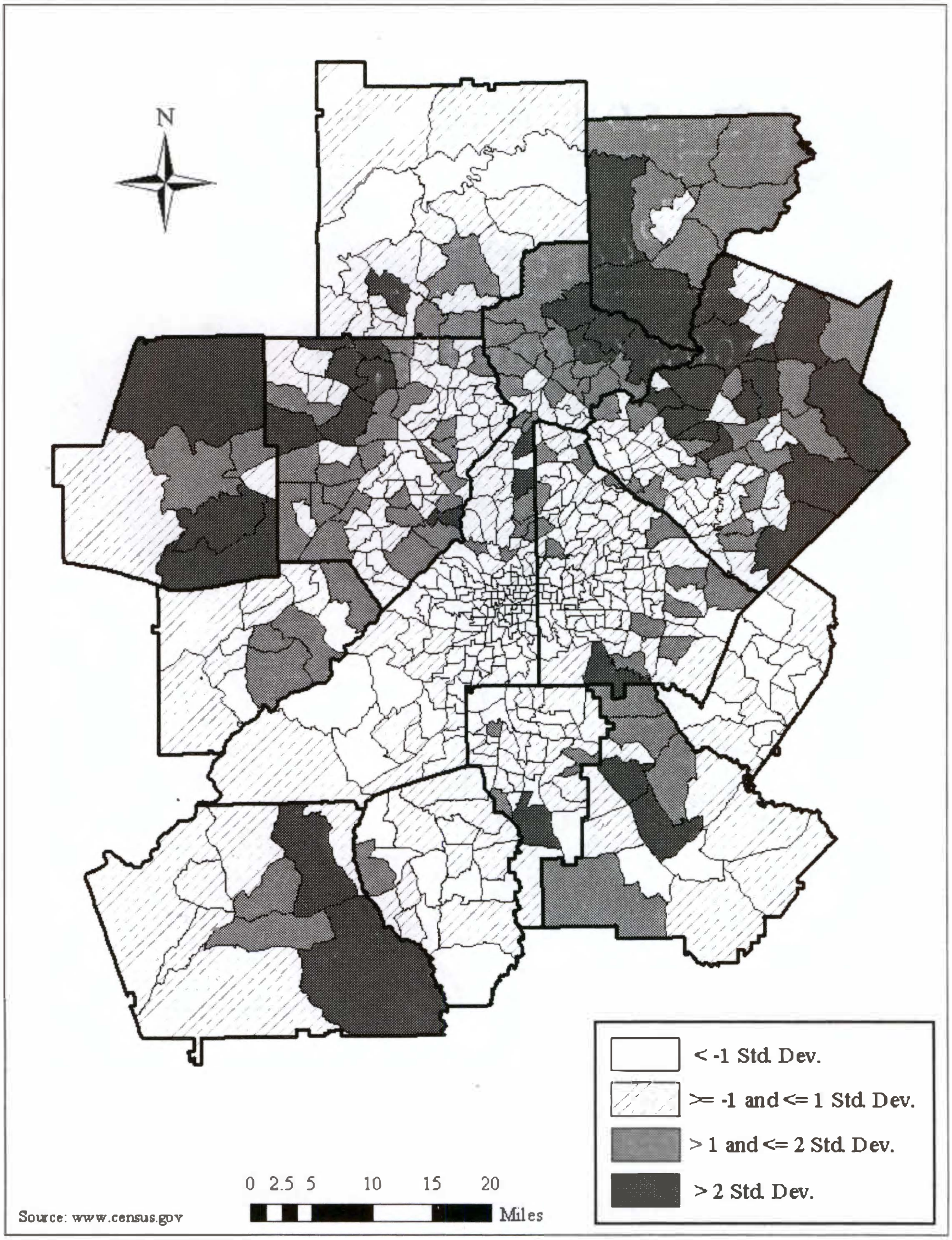

Figure 4.25 Single Occupancy Vehicles as a Journey-to-Work Mode by Census Tract

In order to compare telework's current status and future potential identified by this study, teleworkers' residential locations were mapped simultaneously with census tract maps of median income and gender populations. Income levels and gender populations were crosschecked to determine whether teleworkers and non-teleworkers reported residences within the census tracts that would be expected by this study. According to this analysis, the majority of all survey participants reside in lower-income tracts (*i.e.*, under $30,000 and $30,000 to $45,000) (see Table 4.7 and Figures 4.26 and 4.27), while most female teleworkers reside in tracts not heavily populated by females, and male teleworkers reside equally in all tracts (see Table 4.8 and Figures 4.28 and 4.29). This result implies that mapping census data may not be the most appropriate method of identifying areas of potential telework adoption. Although statistical evaluation confirmed income and gender characteristics as significant in differentiating teleworkers from non-teleworkers, these attributes may not accurately indicate telework's potential when projected spatially across a metropolitan area, using census data that are aggregated to census tracts.

Finally, personal comments supplied by all survey participants were examined. First, comments concerning mitigation of traffic congestion and air pollution in the AMA were evaluated to determine the best ways to encourage these commuters to telework. Upon selecting database entries by various attributes (*i.e.,* gender, age, income, vehicle ownership, job function, and affiliated business) and scanning the selected records for patterns (see Chapter 3), one strong trend was discerned. Overall, non-teleworkers cited public transportation as the primary strategy to mitigating traffic congestion and air pollution problems, while teleworkers cited telework as the primary strategy. This finding

Table 4.7 Teleworker/Non-Teleworker Incomes by Census Tract Median Income

Tract Median Income	Under $30,000	$30,000-$45,000	$45,000-$60,000	$60,000-$85,000	$85,000+
TW Income					
Under $30,000	6	0	0	0	0
$30,000-$45,000	4	3	0	0	0
$45,000-$60,000	3	0	0	0	0
$60,000-$85,000	10	7	0	2	0
$85,000+	4	3	1	0	0
Subtotal	27	13	1	2	0
NTW Income					
Under $30,000	5	0	0	0	0
$30,000-$45,000	5	0	1	0	0
$45,000-$60,000	4	1	2	0	0
$60,000-$85,000	1	2	0	1	0
$85,000+	0	4	1	0	1
Subtotal	15	7	4	1	1

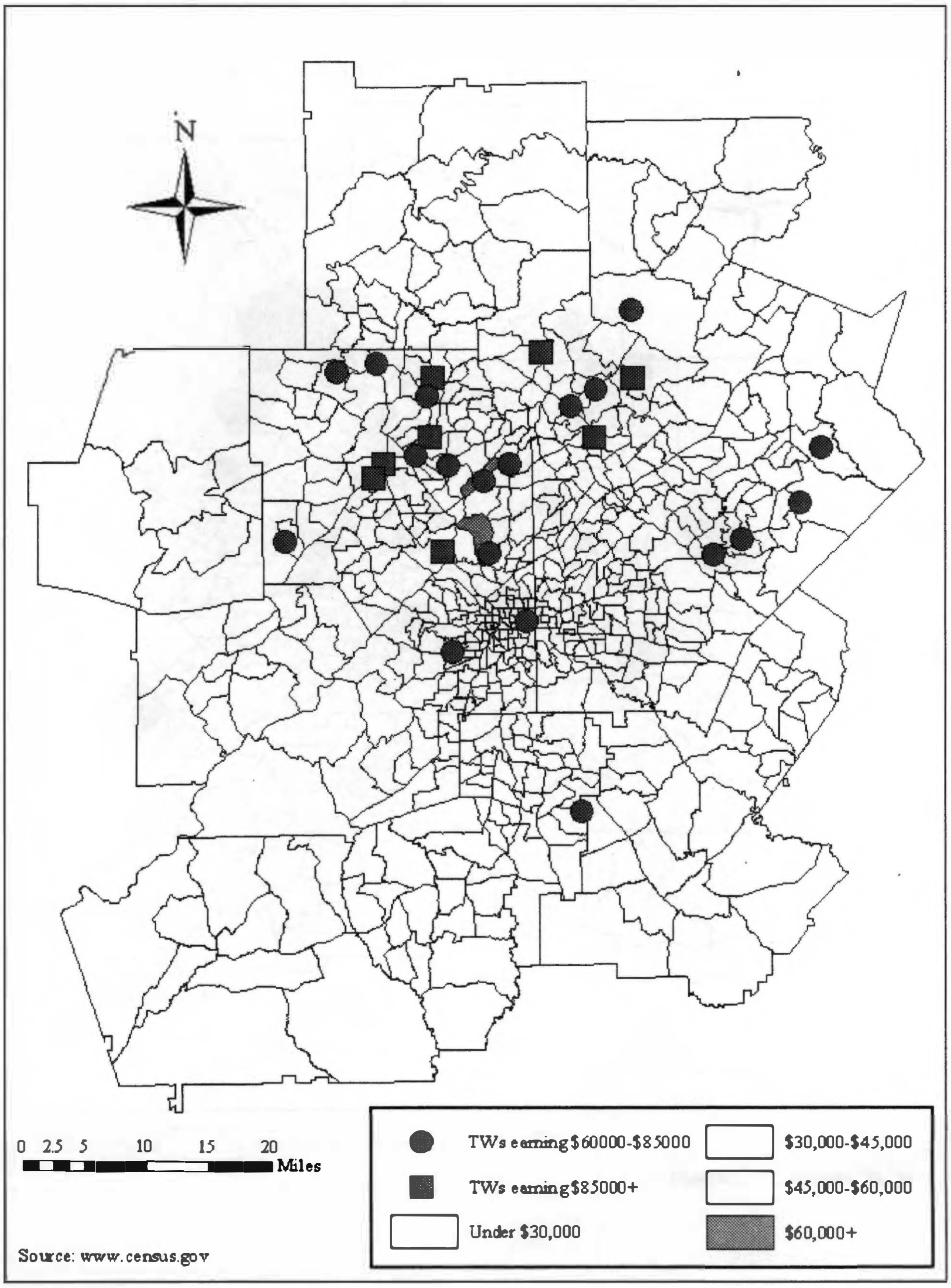

Figure 4.26 Select Teleworkers and Census Tracts with High Median Income Ranges

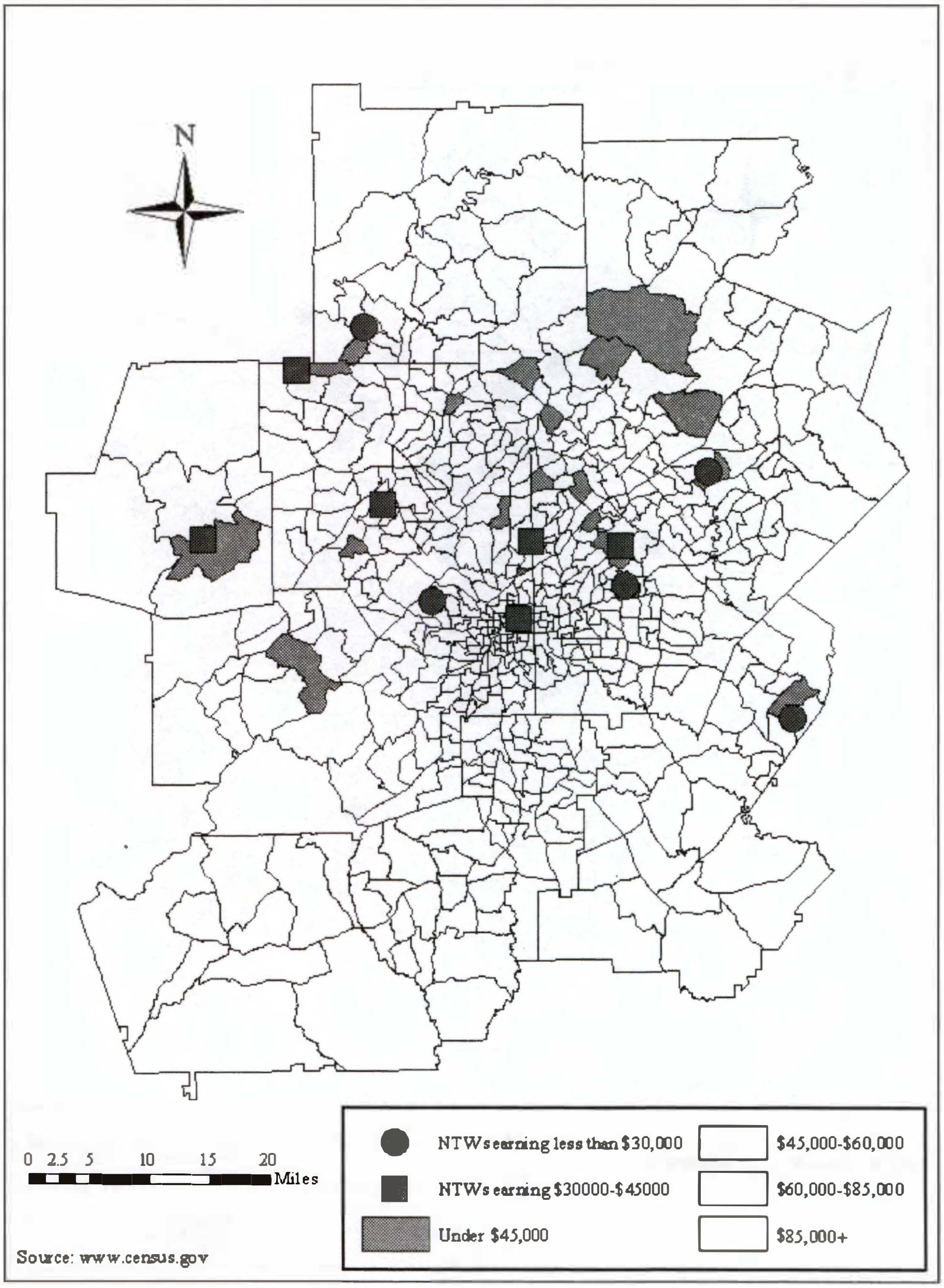

Figure 4.27 Select Non-Teleworkers and Census Tracts with Low Median Income Ranges

Table 4.8 Teleworker/Non-Teleworker Genders by Census Tract Gender Population

Tract Female Population	0-2295	2296-4065	4066-5836	5837+
Teleworker Gender				
Male	1	6	3	2
Female	2	19	7	6
Tract Male Population	**0-2218**	**2219-3981**	**3982-5744**	**5745+**
Teleworker Gender				
Male	1	6	3	2
Female	2	20	6	6

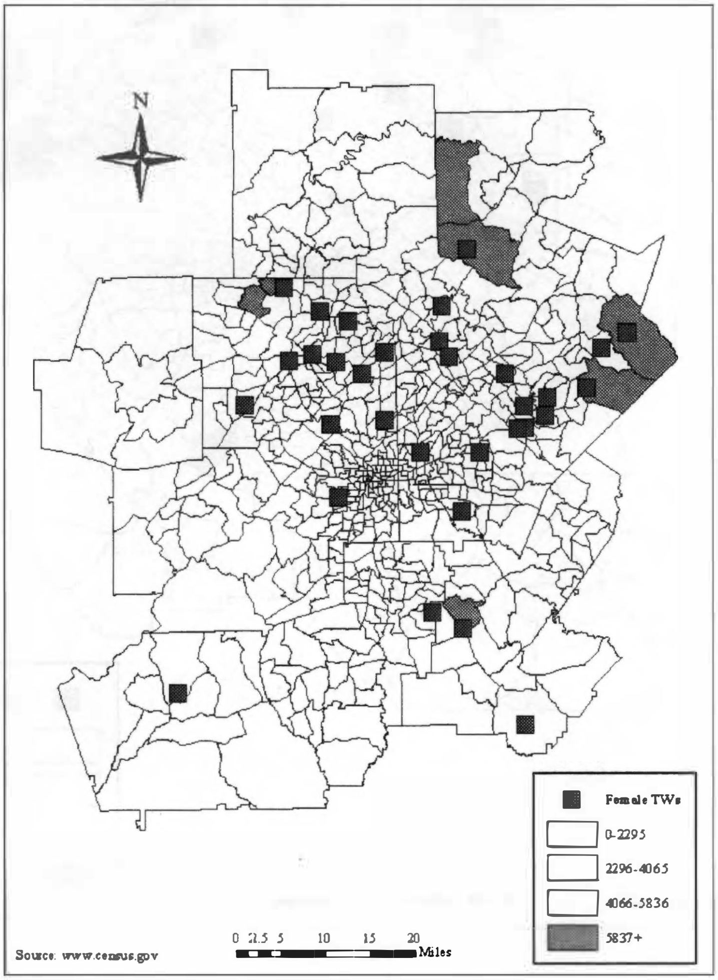

Figure 4.28 Female Teleworkers and Census Tracts with Large Female Populations

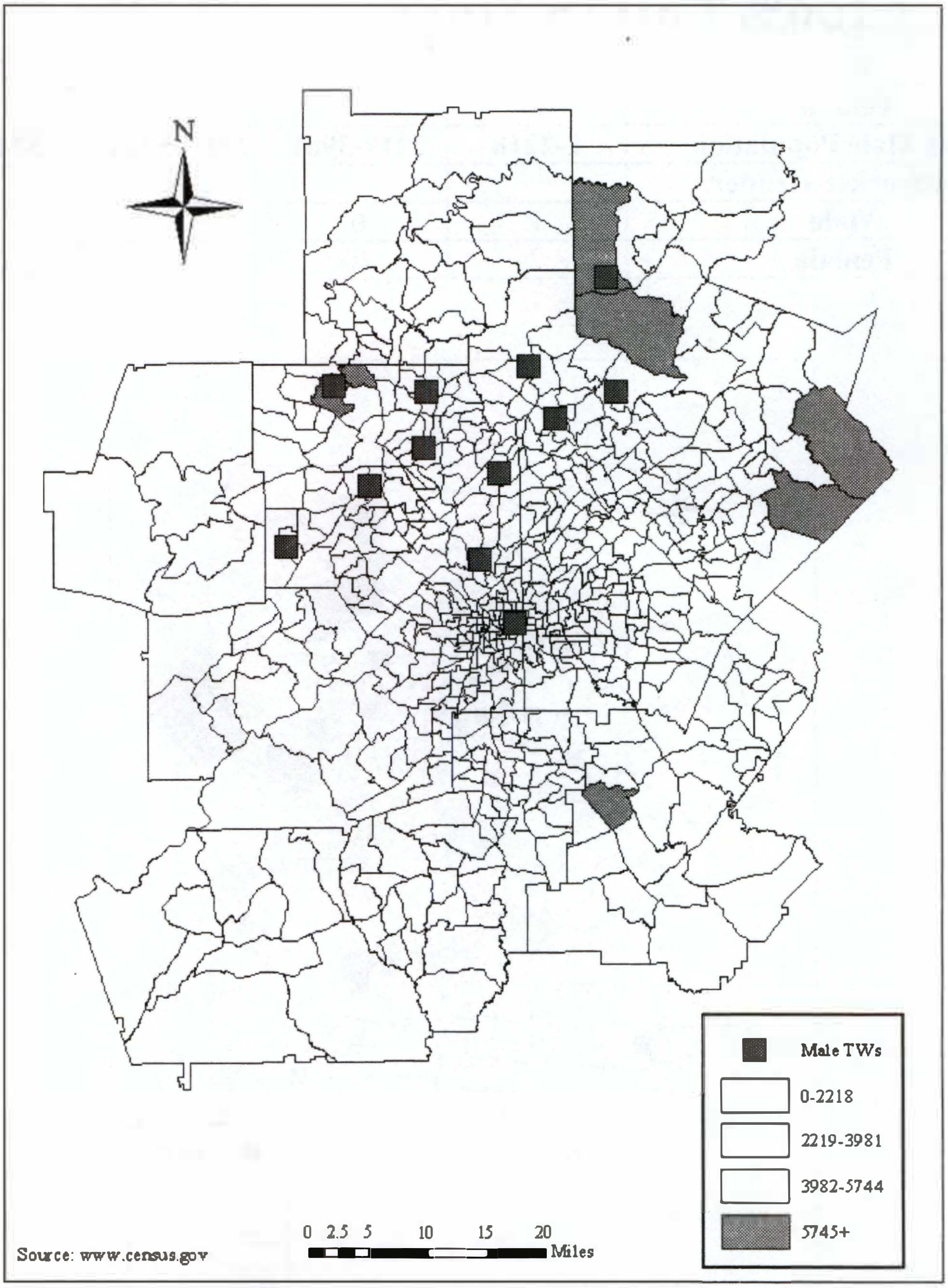

Figure 4.29 Male Teleworkers and Census Tracts with Large Male Populations

is in keeping with 1996 OECD proceedings (1997), stating that "...individual transport behavior can change quite radically...changes are most likely to occur through experiencing alternatives." That is, those survey participants who have *experienced* telework report telework as the primary method to mitigating traffic and air pollution problems, while those who have not experienced telework cite public transportation as the best method.

Related preliminary trends existed, but most were eliminated when scrutinized. Those trends eliminated include teleworkers' comments filtered by income and vehicle ownership and non-teleworkers' comments filtered by vehicle ownership, job function, and affiliated business. These trends were reassessed by counting the number of times a particular comment was made in each of the trends perceived by the initial filtering and scanning of the records (see Chapter 3). One trend, however, surviving such scrutiny was female teleworkers preferring telework to public transportation at a 20:9 ratio (69%), while male teleworkers cited public transportation, 8:5 (62%). This trend can be explained in several ways. Public transportation is typically viewed as a somewhat less safe travel mode; so accordingly, females would be less likely than males to suggest this mode. Also, females are traditionally more closely tied to domestic responsibilities, and therefore would cite telework more often than males due to its attached personal benefits.

Reasons given by non-teleworkers as to why they are not currently teleworking were then examined. Sixty-six percent (27/41) of participants stated their job was not conducive to such an arrangement. Of these, most participants cited management as their primary job function. Also, 24 percent (10/41) of participants expressed their main reason for not teleworking as lack of appropriate equipment. Thirty-seven percent (15/41) of participants supplied self-written responses, but examination of these responses displayed no additional trends. Eighty-one percent (33/41) of participants stated they would be willing to telework, most often citing saving money and reducing traffic as the primary reasons. These participants represent all participating businesses and most job functions within the scope of the survey. This willingness warrants attention, as 76 percent of this group drive SOVs, 58 percent have a fuel efficiency of less than 25 mpg, and 55 percent commute a round-trip distance of more than 30 miles daily. Eliminating these commutes would assist in mitigating traffic and air pollution problems.

Complex concepts of travel behavior (see Chapter 2) must be considered, however, while assessing any information provided by survey participants. The literature indicates that survey-collected data is often erroneous due to various uncertainties associated with participant responses. Participants may offer responses they believe will please the researcher, or simply supply an answer that is not representative of their own behavior. That is, survey responses may reflect the participant's attitudes and intentions, rather than his or her actual travel behavior. As such, this study did not lean too heavily upon survey responses and instead compared trends detected in survey data against the area-wide patterns present in 2000 census data (*i.e.*, not by various census summary levels) as well as the researcher's knowledge of the AMA.

4.3 Conclusion of Telework Analyses

For the most part, the objectives listed in the introduction of this chapter were clearly answered by the above analyses. Teleworkers' and non-teleworkers' residential locations *do* differ. Teleworkers appear to reside in a more dispersed pattern than do non-teleworkers. Non-teleworkers' residences are located more closely to downtown Atlanta, as well as much more closely to their respective employers. Specifically, the northeastern quadrant of the AMA currently seems to be telework's hotspot, as many teleworking survey participants reported residing in this region. The teleworkers in this study can be best characterized as affluent, middle-aged females in professional occupations, while the non-teleworkers appear to be more often younger males earning incomes lower than those enjoyed by teleworkers. Statistical evaluation indicated that gender and income differed significantly between teleworkers and non-teleworkers, while job function appeared to most strongly affect the likelihood of a given commuter to telework.

Maps created from 2000 census data also portray the northeastern quadrant of the AMA as providing a wealth of residents in information- and professional-related occupations who are affluent and often female. These patterns suggest that this area may provide a great deal of telework potential. However, upon mapping the combination of teleworker and census data, many teleworkers were found to reside in tracts unexpected by this study. Therefore, census data may not be the best method of fully identifying regions of telework potential. Although affluent, female commuters may be more likely to be teleworkers than others, these characteristics may not fully indicate telework potential when broadly applied across a geographic region. Judging from these survey participants, telework does serve as a substitute for the journey-to-work and also as a generator of new trips. However in this study, the VMTs saved more than compensated for telework-generated trips, allowing telework to serve well in reducing overall VMTs.

In order to encourage more commuters to telework, and therefore increase telework's significance, certain strategies were identified that should be employed by businesses interested in telework. Obviously, convenience is a considerable component to the process of choosing a commute mode; therefore, telework should be portrayed as a way of increasing convenience for commuters as well as employers. The alternative should not only be characterized as a way for the commuter to better balance work and family or continue in a career after having children, but also as a way for all involved to save money and reduce traffic. Eighty-one percent of non-teleworkers in this study's sample cite these monetary savings and traffic reduction as key motivators to adopting telework. However, according to OECD's 1996 Proceedings (1997), any business desiring its employees to actually make a change in their commuting habits must offer more than educational literature on the subject. To truly convert these traditional commuters to telework, they must *experience* telework. In order to account for this need, businesses could strengthen or instate telework programs by having compatible employees telework for a trial period, so that a given employee can personally determine whether he or she is willing and able to make the change.

Businesses with potential to implement telework programs include those where a central workplace is relatively unimportant, such as computer-based companies. Possible employees include those with a high level of portable work such as customer service representatives, sales and marketing professionals, and data entry technicians. Trial periods could be used for conducting work not requiring additional technical equipment (*e.g.*, research, report/presentation writing), as to keep costs low. (Vega 2000)

4.4 Introduction to Carpool Analyses

Although telework has potential to serve as an alternative to the traditional commute for many commuters, telework will always be incompatible with some occupations. Therefore this section examines the current status of carpool and its potential to account for those commuters unable or unwilling to participate in telework. Note that this study examines carpools composed only of non-household members and will be referred to simply as carpools in the following text (see Chapter 2).

The two major categories of analyses used for telework were also chosen to frame carpool analyses. To assess carpool's current status, several questions were addressed. The pattern of carpool participation was evaluated by asking the following questions:

- Where do carpoolers reside in the AMA?
- Where do carpoolers work in the AMA?
- What, if any, relationship exists between these two locations?

The current significance of carpool's contribution to controlling traffic congestion and/or air pollution in the AMA was also addressed by asking the following question:

- Does carpool decrease the number of SOVs being driven in the AMA?

In addition to considering carpool's current status, the potential for its adoption was examined by asking the following question:

- Which portions of the AMA provide commuters with the greatest potential for adopting carpool?

These questions frame carpool analyses in a manner that produces information on both current carpool participation and its future potential.

4.5 Discussion of Carpool Analyses

4.5.1 Current Carpool Patterns

Upon matching all location data included in the carpool database to a map of the AMA, several spatial patterns emerged. The map of employers' locations (see Figure 4.30) displays a strong tendency for businesses employing carpoolers to be located close to downtown Atlanta, with other small clusters of businesses following the northern routes of I-75, I-85, and GA 400. The map of employers' ZIP codes (see Figure 4.31) supports this pattern. Businesses in downtown Atlanta may be characterized as employing more carpoolers than businesses in other areas. Carpoolers' residences, however, display a different pattern. The map of carpoolers' home ZIP codes (see Figure 4.32) shows a slight concentration of carpoolers living close to downtown Atlanta, but also depicts many carpoolers as suburbanites. This pattern was somewhat expected, as lower income commuters who reside closer to the city may choose to carpool due to the associated cost savings, while higher income suburbanites may carpool as a convenience (see Chapter 2). Note than carpool is available to all AMA residents by either registering with the Atlanta Regional Commission's (ARC) Commute Connections division or by forming their own carpools with neighbors and/or co-workers. The relationship between residential and business locations is typical of commuting geography. Carpools collectively serve to transport commuters residing in suburban areas and the immediate outskirts of downtown Atlanta into downtown Atlanta. A cross-tabulation of carpoolers' home ZIP codes and business ZIP codes supports this relationship, as home ZIP codes of carpoolers mostly represent downtown outskirt and suburban areas, while business ZIP codes are more focused on the downtown Atlanta area (see Table 4.9, n > 5).

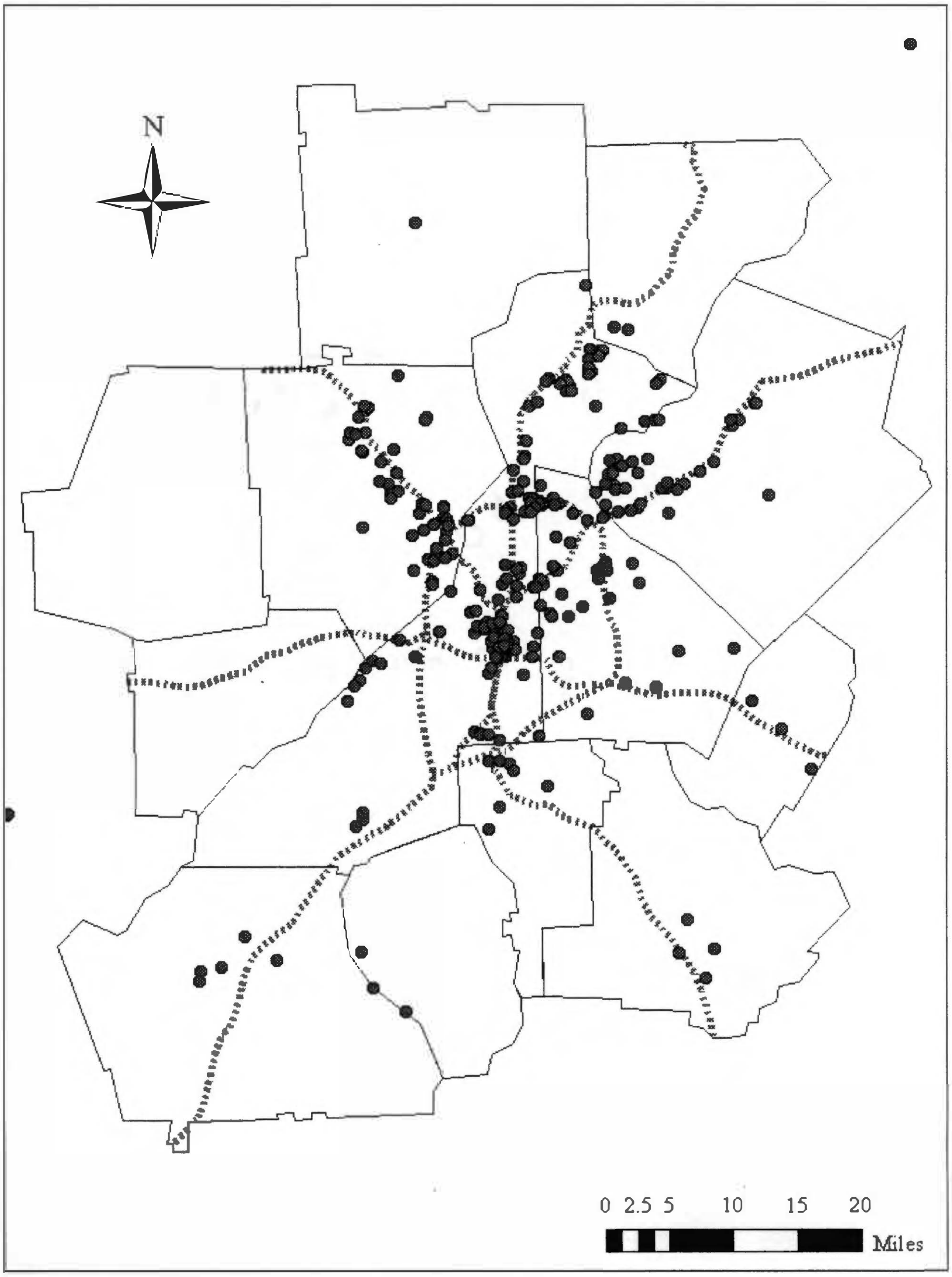

Figure 4.30 Locations of Businesses Employing Carpoolers

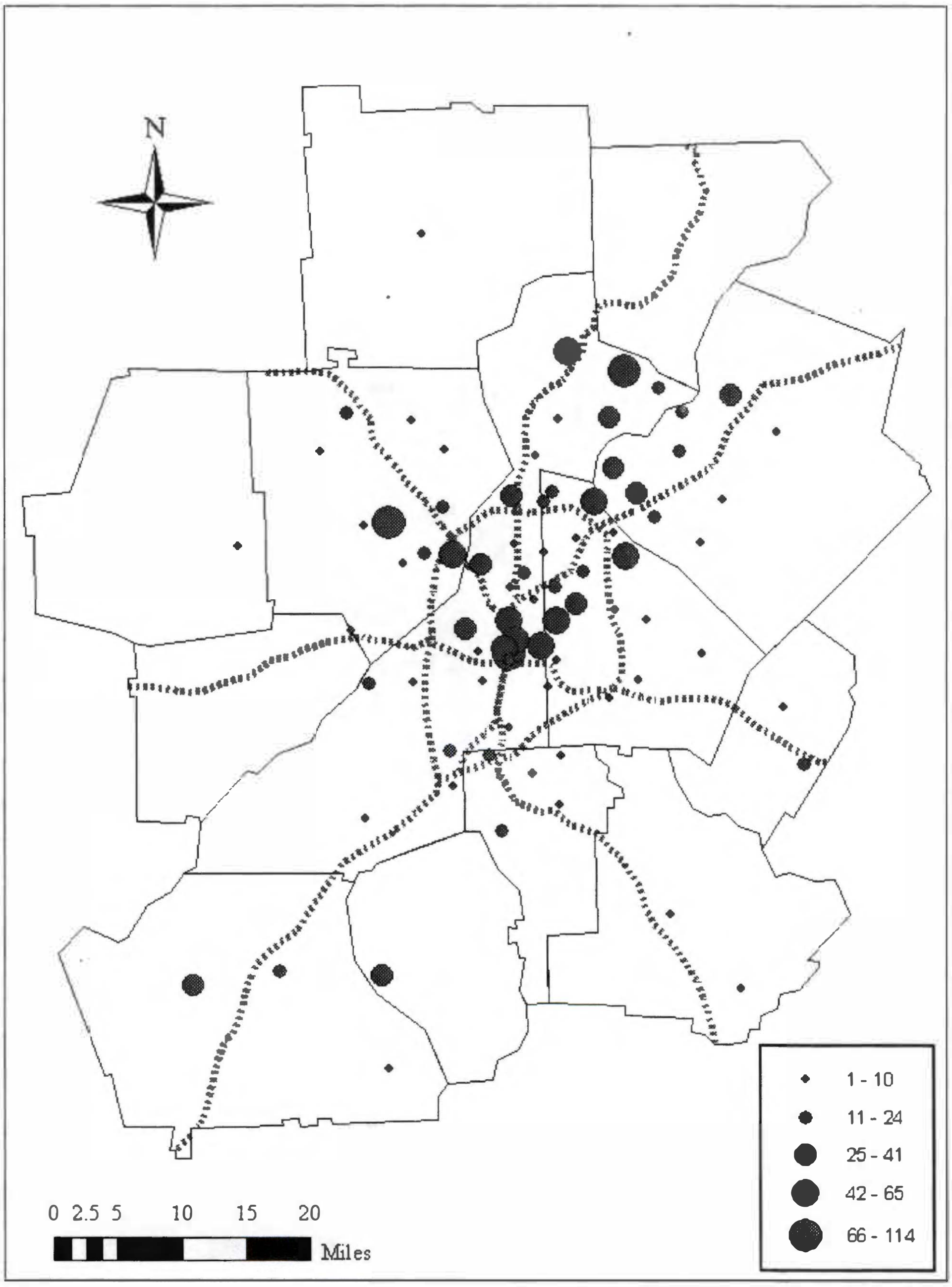

Figure 4.31 Business ZIP Codes by Number of Carpoolers Employed in Each ZIP Code

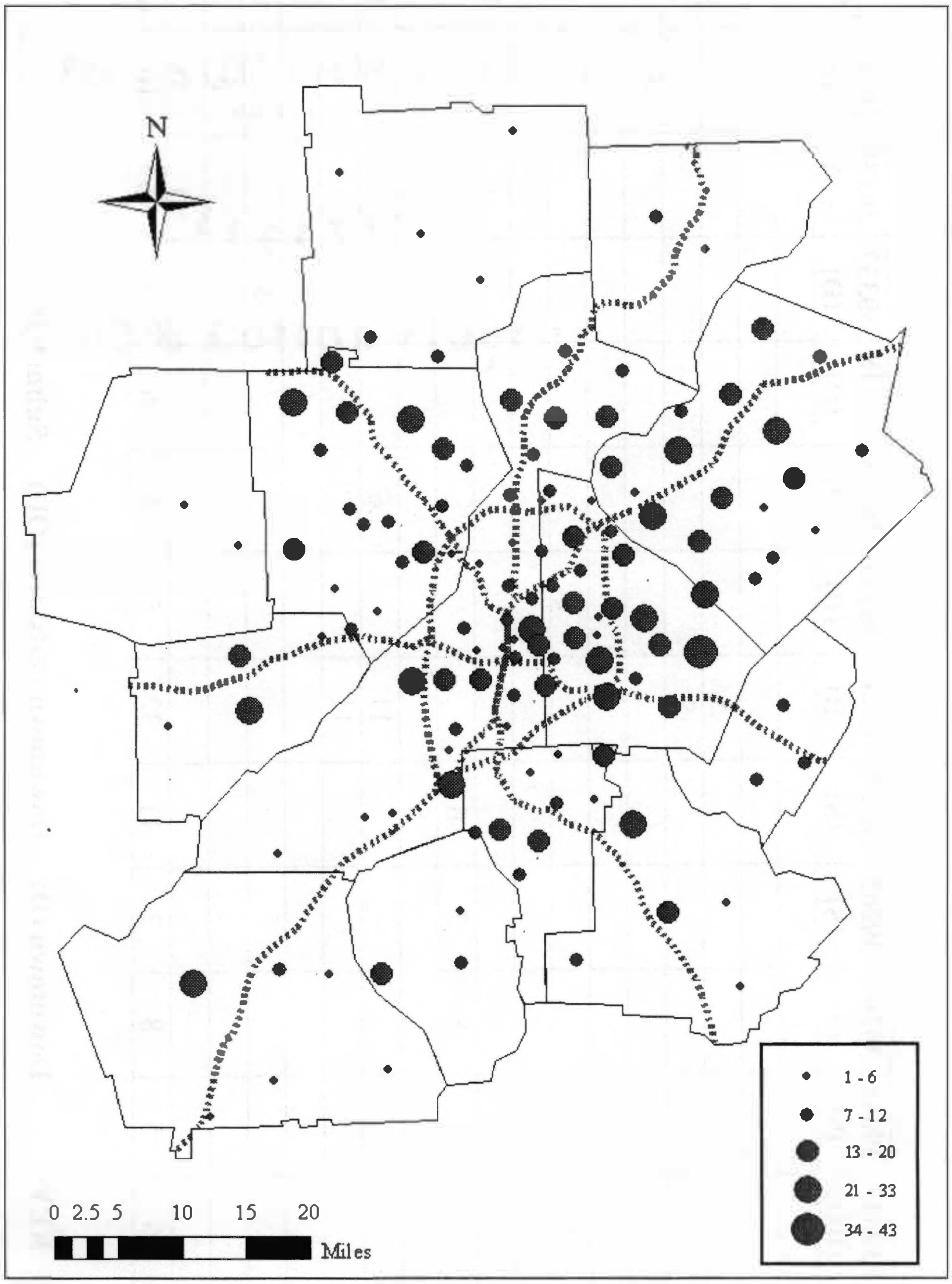

Figure 4.32 Home ZIP Codes by Number of Carpoolers Residing in Each ZIP Code

Table 4.9 Origins-Destinations of Carpoolers by ZIP Code

Business ZIP	30005 (S)	30033 (DO)	30066 (S)	30263 (S)	30265 (S)	30269 (S)	30307 (D)	30309 (D)	30313 (D)	30318 (D)	30337 (D)	30339 (D)	30360 (D)	Total
Home ZIP														
30005 (S)	5													5
30030(DO)							5							5
30033(DO)							5							5
30034(DO)													5	5
30040 (S)	6													6
30058 (S)		6						5						11
30076 (S)	5													5
30101 (S)			5									6		11
30263 (S)				8	7	6								21
30269 (S)						5								5
30306 (D)							11		6					17
30307 (D)							11							11
30318 (D)										6				6
30331 (D)											5			5
30349 (D)													5	5
30350 (D)	5													5
Total	21	6	5	8	7	11	32	5	6	6	5	6	10	128

KEY: Downtown (D) Downtown Outskirts (OD) Suburb (S)

Carpool's significance as a mitigation method for traffic congestion and air pollution was also analyzed. Some concern existed that commuters who normal utilize other alternative transportation modes (*e.g.*, MARTA, vanpool) might be carpooling. Such occurrence does *not* remove SOVs from the highway, therefore decreasing the significance of carpool. According to the study's carpool database, however, SOVs *are* being removed from area highways in response to carpool participation. In fact, 92 percent (1555/1690) of carpoolers reported owning a personal vehicle. Many of these vehicles are therefore not used as a result of carpool participation (see Figure 4.33). Sixty-seven percent of carpoolers stated their normal commute mode to be a SOV, showing that without carpooling, 1125 additional SOVs would be on AMA highways. The remaining 33 percent of carpoolers reported their normal commute modes as bus/rail transit, other, telework, vanpool, walk, or no response (see Figure 4.34).

4.5.2 Carpool Potential

A review of the literature (see Chapter 2) provided information of the characteristics of the typical carpooler. Carpoolers are often depicted as living in urban fringe areas and as having low incomes and low vehicle access. Furthermore, African- and Hispanic-American demographic segments are suggested as having high tendencies to carpool with non-household members. Because the ARC was unable to release any socio-economic or demographic data, this study was constrained to leaning on literature for this information.

To detect areas of carpool potential, 2000 census data were mapped at tract level for all 13 counties in the AMA. Again, it is important to note that this study focuses strictly on carpools composed of non-household members, while the Census Bureau

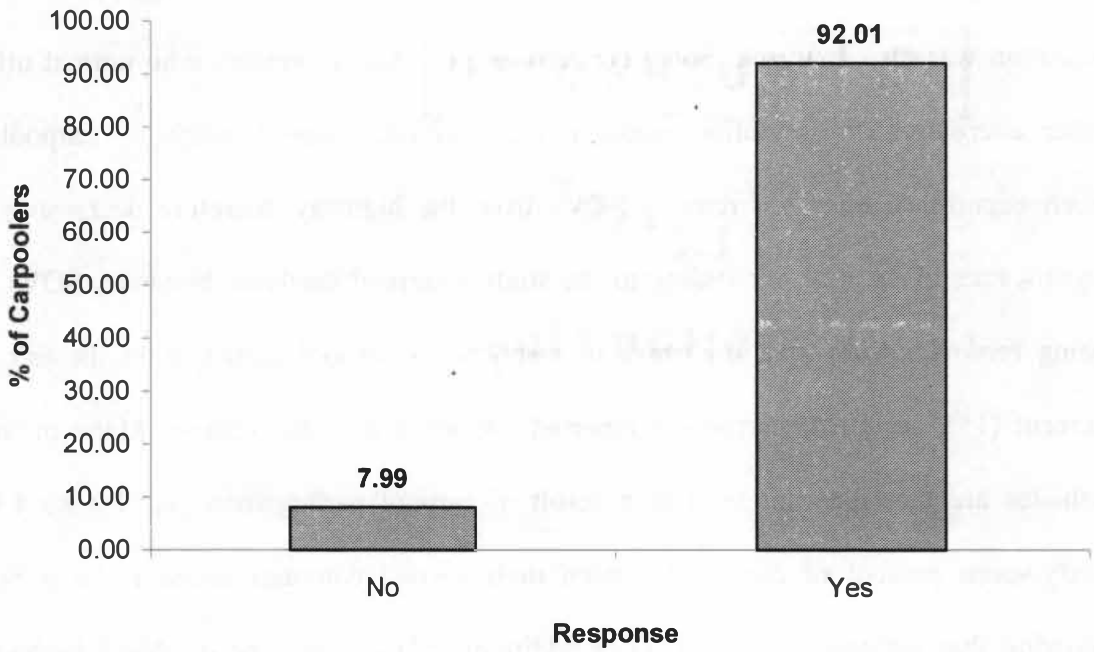

Figure 4.33 Vehicle Ownership of Carpoolers

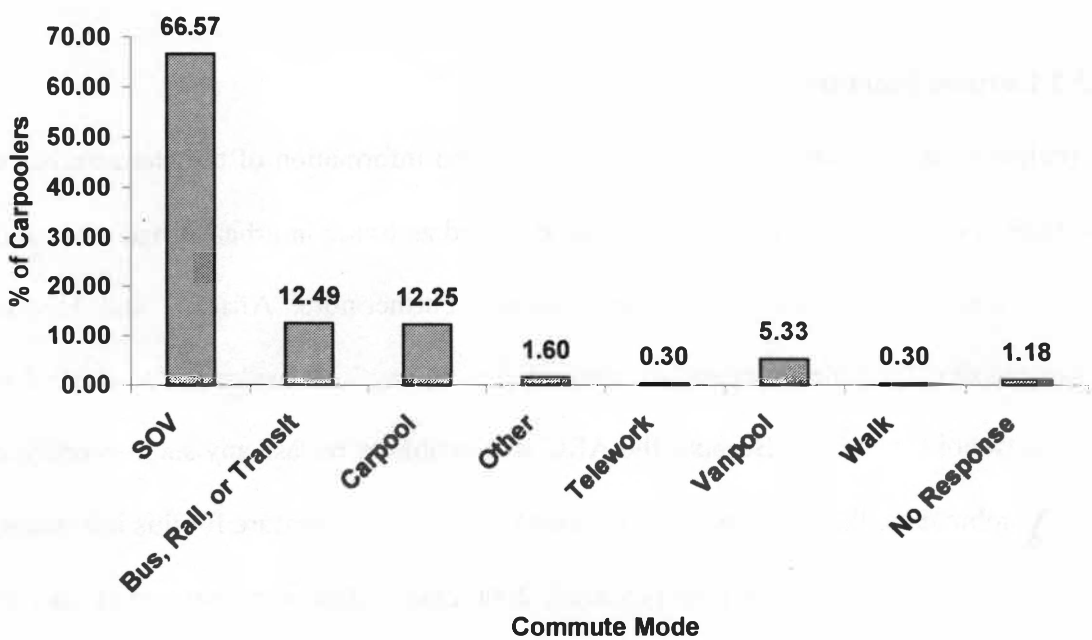

Figure 4.34 Normal Commute Mode of Carpoolers

defines a carpool as "two or more people who usually rode to work in the vehicle," a definition including all carpools, whether composed of household or non-household members (http://www.census.gov/prod/cen2000/doc/sf3.pdf 2003). Therefore, the following maps depict potential of carpools composed of both household and non-household members.

According to 2000 census data and characteristics of carpoolers noted in the literature, the central portion of the AMA's southern half displays strong potential for carpool adoption. Income, industry identification, race, and vehicle ownership data were mapped using standard deviation rendering at census tract level, producing maps depicting a high concentration of carpool-compatible commuters in this area. The central portion of the AMA's southern half, therefore, provides a target region for attempting to remove SOVs from AMA highways. Increasing participation in this region would assist in strengthening the carpool's significance as a mitigation method for controlling traffic congestion and air pollution in the AMA. These patterns were also confirmed by remapping the data at the census block group level.

Reexamination of Figures 4.22-4.24 of AMA census tracts displays several patterns depicting the central portion of the AMA's southern half as an area of potential carpool participation. Census tracts reporting low median income levels (in 1999 US Dollars) are mostly concentrated in southern-central counties in the outskirts of downtown Atlanta (Fulton, DeKalb, Clayton) (refer to Figure 4.22). A few other low-income areas appear on the map; however, these peripheral areas are primarily rural, and therefore would be expected to report lower median incomes. Low numbers of information and professional, scientific, and technical workers report residences in the central portion of the AMA's southern half (refer to Figures 4.23 and 4.24 respectively). This lack of telework-compatible jobs presents a niche of potential carpoolers. Figure 4.35 indicates that a good portion of residents of the central southern half of the AMA own only one personal vehicle. African Americans are also highly concentrated in the central portion of the AMA's southern half, especially in South Fulton, DeKalb, and Clayton Counties (see Figure 4.36). Referring back to information in the literature (see Chapter 2), African Americans have traditionally been good candidates for carpools. Literature also describes Hispanic Americans as being more likely to carpool than other demographic groups. In the AMA, however, where the potential for carpools composed of non-household members seems to be highest in the central portion of the AMA's southern half, Hispanic Americans are most heavily concentrated in the *northeastern* quadrant, especially in tracts around the western-northern boundary of Gwinnett and DeKalb County (see Figure 4.37). These tracts are historically Hispanic areas with a local market geared toward their needs. There is, however, a smaller concentration of Hispanic Americans with high potential to form carpools in the southern AMA as well.

In order to compare carpool's current status with its future potential as identified by this study, the carpooler population by ZIP code was mapped simultaneously with census tract maps of median income, industry identification, race, and vehicle ownership. Each map's pattern was compared with the carpooler population per tract to determine whether carpoolers populate the census tracts expected by this study. According to this analysis, 26 percent of carpoolers reside in tracts reporting median incomes equal to or less than $18,650, while 77 percent have median income less than $31,422 (see Table 4.10 and Figure 4.38). Also, a clear majority of carpoolers reside in tracts representing

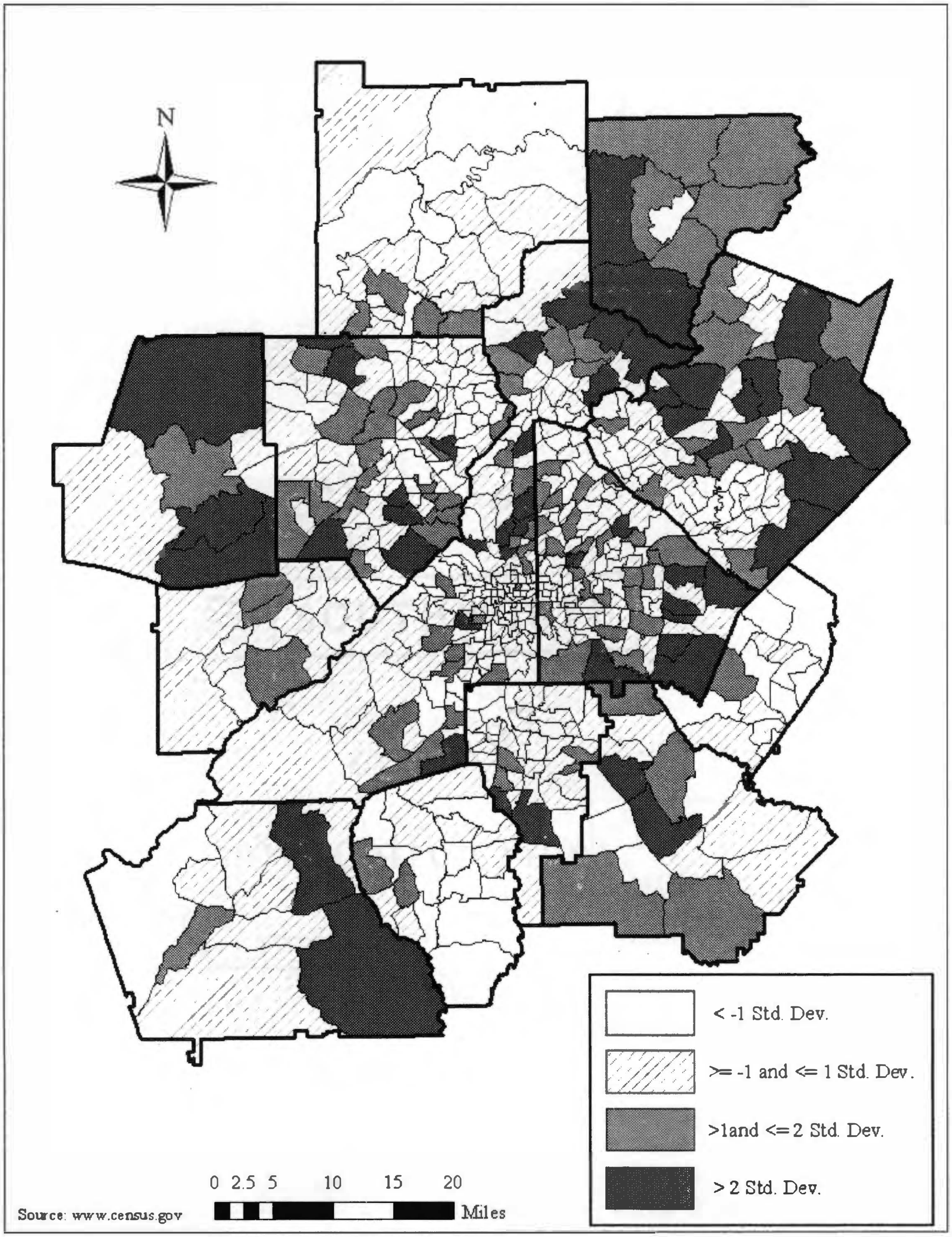

Figure 4.35 Total Population with Access to One Personal Vehicle by Census Tract

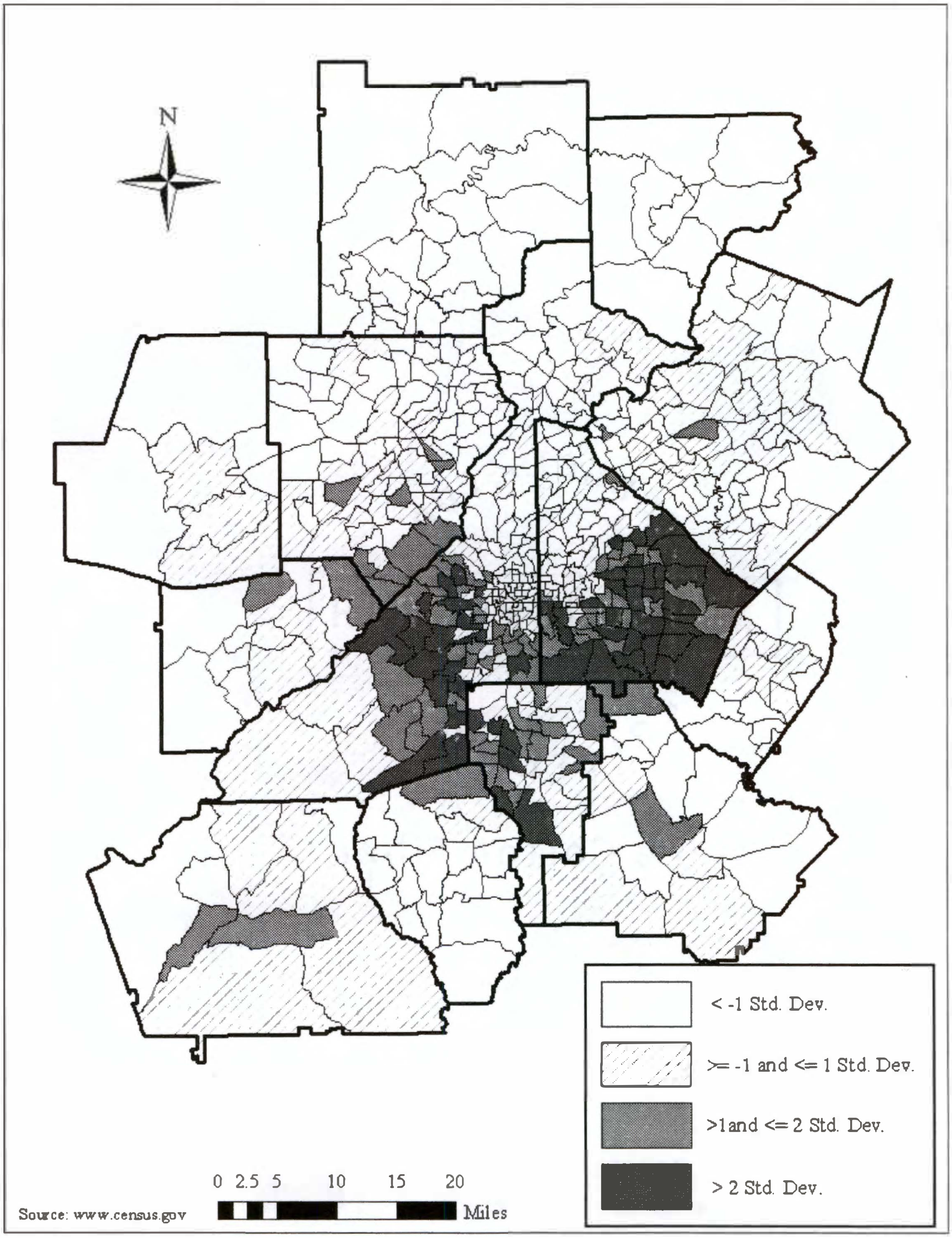

Figure 4.36 Total African Americans by Census Tract

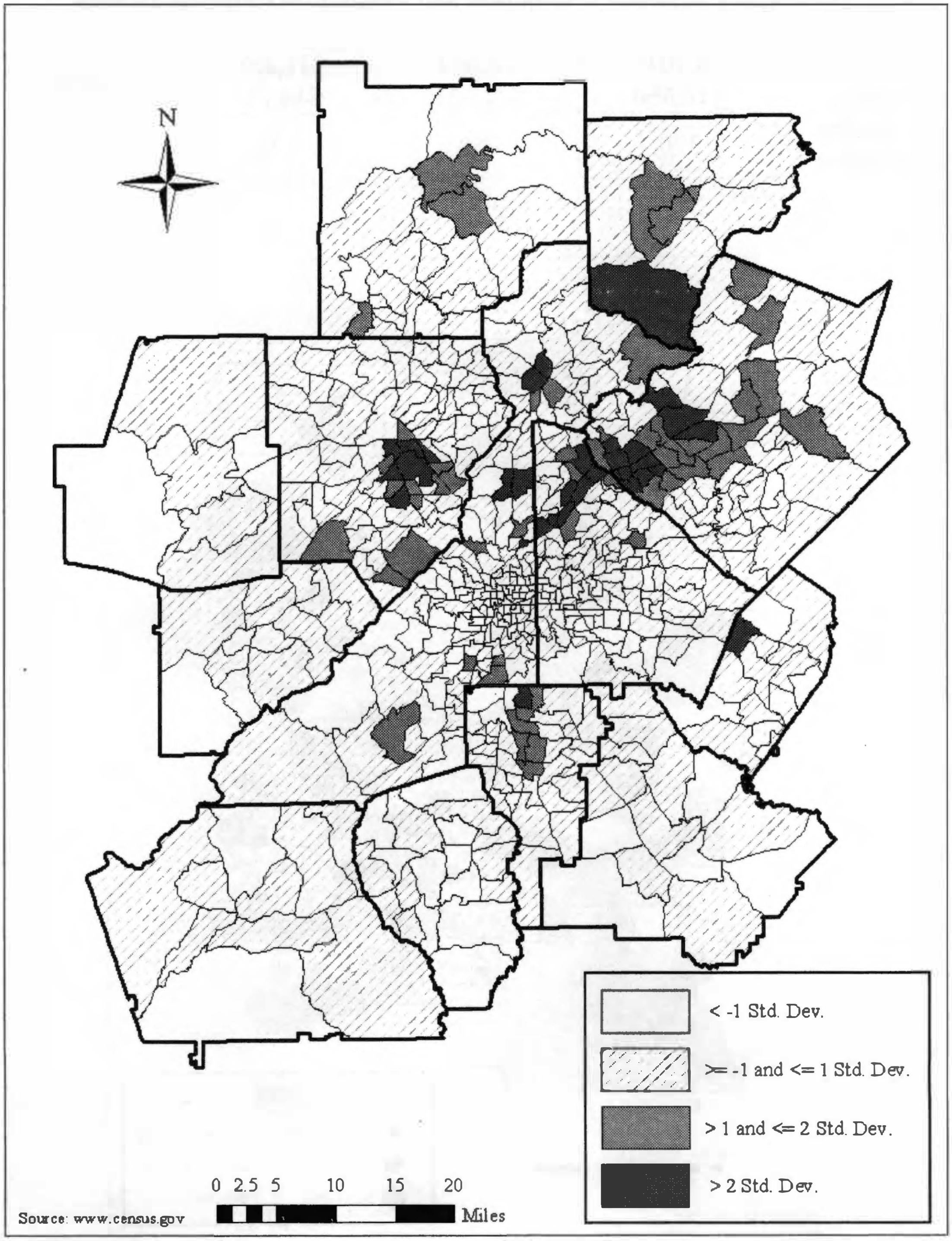

Figure 4.37 Total Hispanic Americans by Census Tract

Table 4.10 Carpooler Population by Census Tract Median Income

Tract Median Income	$4,101-$18,650	$18,651-$31,421	$31,422-$44,193	$44,194+
Carpooler Population	390	758	278	58

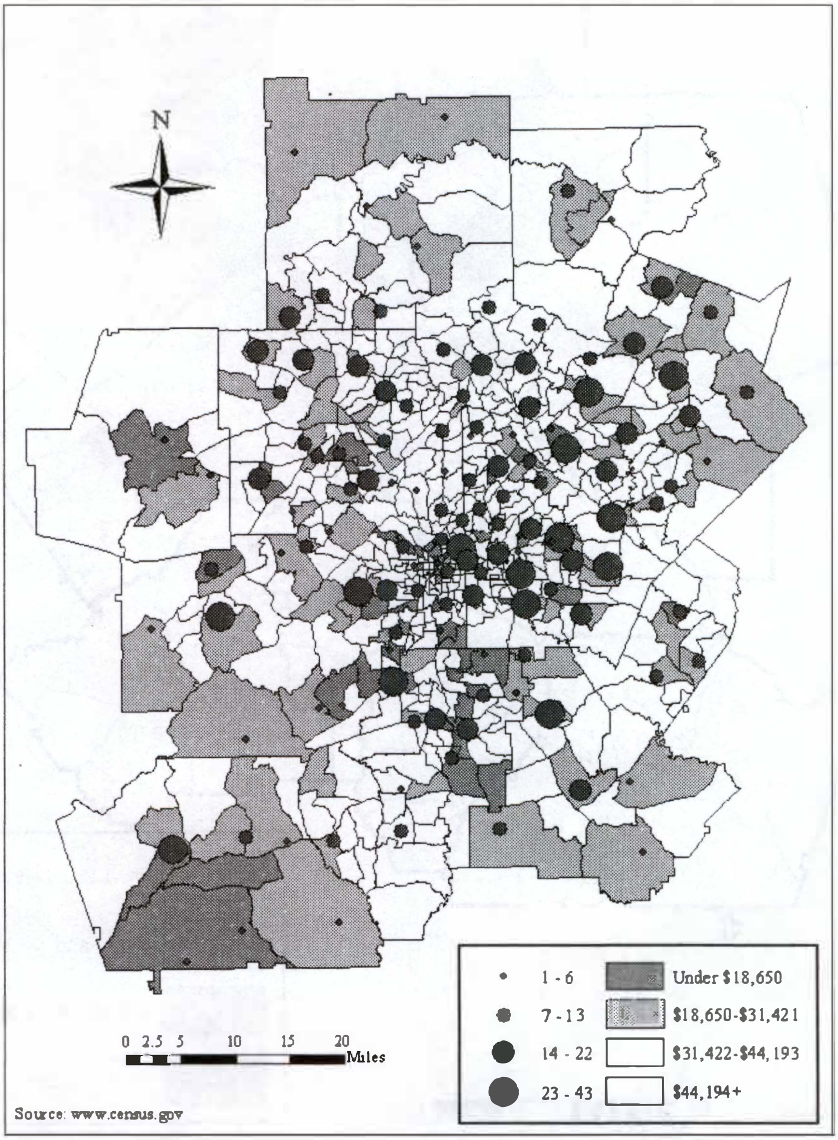

Figure 4.38 Carpooler Population and Census Tracts with Low Median Incomes

low populations of residents with information- and professional-related occupations (see Tables 4.11 and 4.12 and Figures 4.39 and 4.40). Finally, tracts with populations reporting low vehicle access (*i.e.*, owning one car at maximum) also show a small concentration of carpoolers. Tracts heavily populated with African- or Hispanic-Americans exhibit no significant carpooler concentration. Note that this cross-tabulation analysis supports the significance of lower incomes and low numbers of information and professional workers to the identification of carpool potential. These income- and job-based characteristics were often indicative of the census tracts encompassing carpoolers' home ZIP codes. Therefore in this case, certain census data items may be valuable in the identification of carpool potential.

4.6 Conclusion of Carpool Analyses

Again, the above analyses served well to answer the study's objectives. The central portion of the AMA (downtown Atlanta) is the most popular area for businesses employing carpoolers. This is logical given the large number of businesses in the AMA located in this area. Upon examining the home origin and work destination for each carpooler, the commuting geography hypothesis was supported. Carpoolers' homes appeared to include a mixture of suburban and urban-outskirt areas, whereas businesses were more often located in downtown Atlanta or in its immediate outskirts. Typical carpooler characteristics gathered from a review of literature include low income, low vehicle access, and African- and Hispanic-American ethnicities. According to maps of 2000 census data, the central portion of the AMA's southern half provides homes to residents with such characteristics. This area also contains a lower than average

Table 4.11 Carpooler Population by Census Tract Information Worker Population

Tract Information Industry Population	0-98	99-241	242-383	384+
Carpooler Population	313	718	290	163

Table 4.12 Carpooler Population by Census Tract Professional, Scientific, and Technical (PST) Worker Population

Tract PST Industry Population	0-147	148-414	415-682	683+
Carpooler Population	425	681	165	213

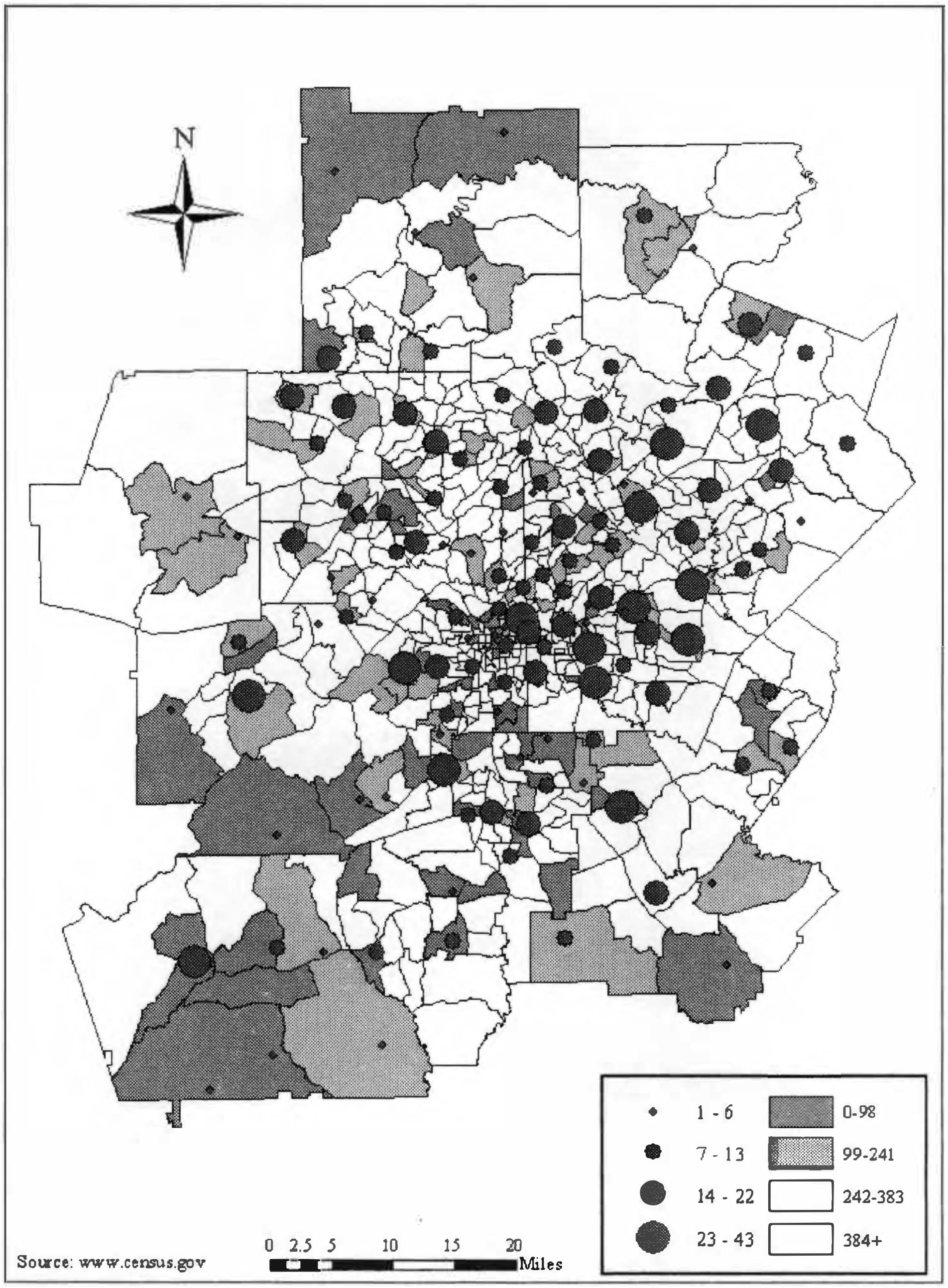

Figure 4.39 Carpooler Population and Census Tracts with Low Information Worker Populations

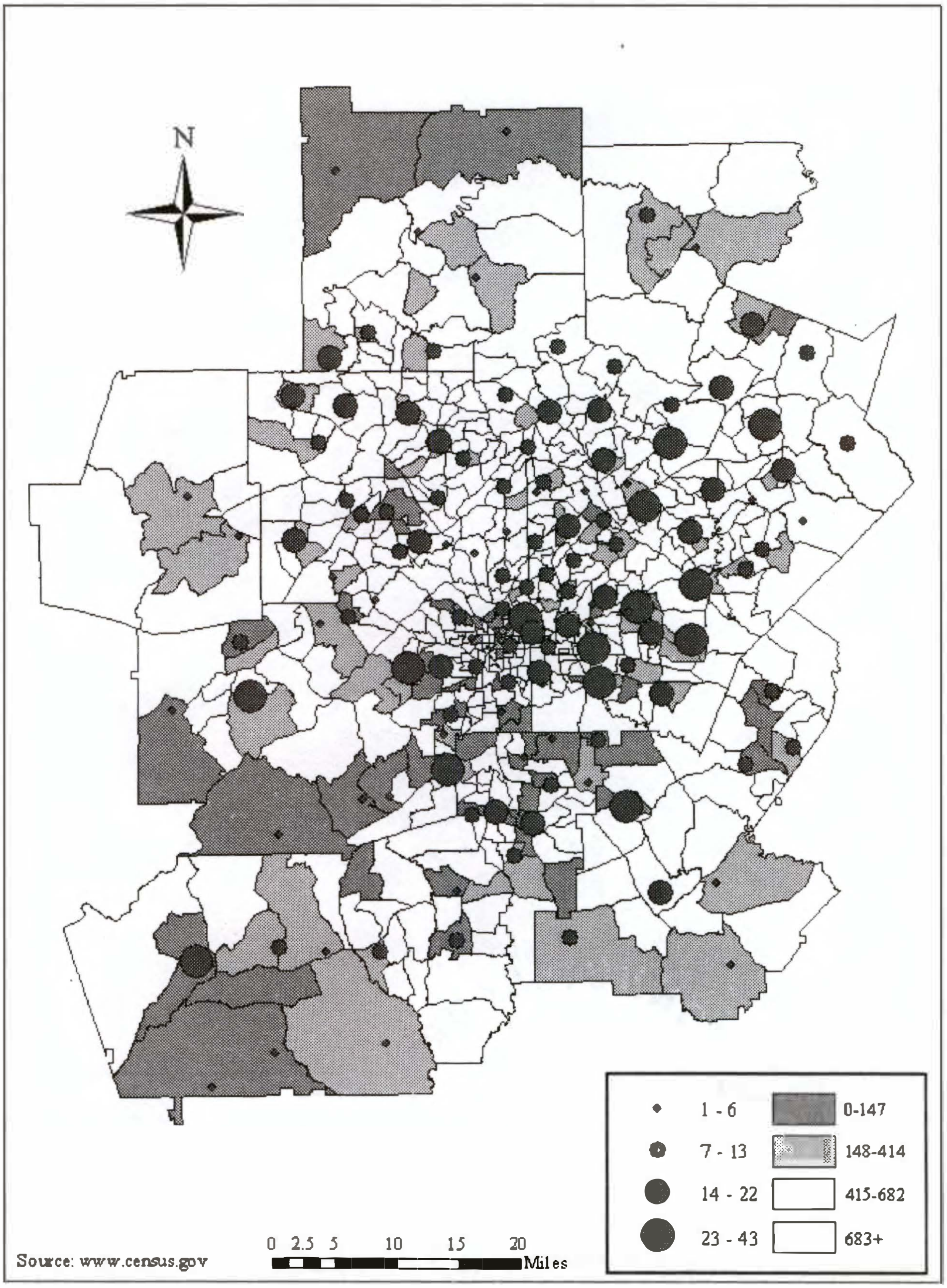

Figure 4.40 Carpooler Population and Census Tracts with Low Professional, Scientific and Technical Worker Populations

population of information and professional, scientific, and technical workers. Upon mapping the combination of carpooler and census data, a majority of carpoolers reported residences within census tracts representing lower median incomes and low populations of information and professional related occupations. These socio-economic, demographic, and job-related variables derived from the census offer an acceptable method to identify carpool potential. This conclusion hinges, however, solely on carpooler characteristics gathered from a review of the literature, and therefore should be investigated further to verify its validity. Specifically, data should be gathered from active carpoolers to confirm these trends. Finally, judging from the carpoolers represented in the study database, carpool does significantly decrease the number of SOVs on area highways.

Chapter 5: Conclusion

5.1 Telework and Carpool in Atlanta

Many metropolitan areas across the United States are currently being confronted with severe traffic-related problems. Some cities are employing alternative transportation as a means to mitigate these problems, as well as to promote more sustainable transportation systems. Atlanta, Georgia is one such city that offers various alternative transportation options to its residents as a method to relieve the traffic congestion and air pollution caused by the high number of single occupancy vehicles (SOVs) driven daily. As a result of present commuting choices, especially the overwhelming use of the SOV for commuting, the Atlanta Metropolitan Area (AMA) is in violation of federally set air quality regulations, and the city's highways are regularly choked with high traffic volumes. In response to Atlanta's problems, this thesis has examined the participation, significance, and potential of two specific alternative transportation options: telework and carpool.

This thesis attempts to identify the current status and future potential of telework and carpool in the AMA. A telework survey was conducted with employees of six area businesses to collect data on active teleworkers and non-teleworkers, generating a telework database. These data consisted of locational, socio-economic, and demographic information, teleworking and commuting habits, and personal comments regarding traffic-related problems in the AMA. Also, the Atlanta Regional Commission's (ARC) Commute Connections division provided a randomly selected portion of its carpool database, including data concerning carpoolers' residences, employers, and commuting choices. In order to evaluate these data, analyses were framed by questions exploring the residential and employment patterns of telework survey and carpool participants, the socio-economic and demographic characteristics of telework survey participants, the overall significance of telework and carpool to mitigate traffic-related problems, and the identification of potential areas for future adoption of telework and carpool within the AMA. Furthermore, personal comments collected by the telework survey were examined to determine methods that might better encourage AMA commuters to participate in transportation alternative to the SOV.

Overall, these objectives were achieved. Teleworkers' residences were found to be more dispersed than non-teleworkers' and were located most often in the northeastern quadrant of the AMA. Furthermore, teleworkers appeared to reside at a greater distance from their employers than their non-teleworking counterparts. In contrast, carpoolers were most heavily concentrated in the central portion of the AMA's southern half. Exploratory analyses of the telework database provided socio-economic and demographic patterns that resulted in the *Working Mother Hypothesis*. This hypothesis characterizes many teleworkers as affluent, middle-aged females with children, occupying high paying, information- and/or professional-related jobs. This hypothesis was partially validated by an inferential statistical evaluation, comprised of binary logistic regression, Chi-square, and Kolmogorov-Smirnov Z tests. These analyses confirmed both gender and income as significantly related to telework participation. However, both logistic regression and Kolmogorov-Smirnov Z analyses refuted the significance of age as a predictor of telework. Another binary logistic regression confirmed that job function has a strong effect on the likelihood of commuters to telework. Other analyses confirmed both telework and carpool's significance to mitigating the AMA's traffic-related problems.

Telework participation reduced SOV commuting mileage by more than 1000 miles per day, even after accounting for all extra trips generated by such participation (on a given day when all teleworkers included in the analysis teleworked). Carpool also decreased vehicle miles traveled (VMTs), as most carpoolers reported owning a personal vehicle and stated SOVs to be their typical commute mode.

Maps of 2000 census data depicted the AMA's northeastern quadrant to be the region of greatest telework potential, displaying a large female population earning high incomes in information- and/or professional-related job functions. However, upon combining telework survey data and census maps, teleworkers were often found to reside in lower income tracts, only moderately populated by females. Therefore, mapping census data may not be the most appropriate method to identify telework potential. It is important to note that the potential for telework adoption appears to have a stronger relationship with particular socio-economic and demographic characteristics, as well as job-related characteristics, rather than with their geographic patterns. These census maps also depicted the central portion of the AMA's southern half to be the region of greatest carpool potential, exhibiting tracts with high populations of residents earning lower incomes, having low vehicle access, and populated by large numbers of African-Americans, as well as having low populations of information or professional workers. In contrast to telework, these census-derived patterns were validated by carpooler home locations, indicating that census data may be more helpful in determining locations of carpool potential than that of telework. The carpool database contained substantially more carpoolers than did the telework database, signifying that sample size may have affected these outcomes. Because of the lack of socio-economic and demographic data in the ARC's carpool database, the literature on carpool was used to gather these characteristics.

Development of telework and carpool programs is warranted, as both appear to significantly decrease traffic-related problems, albeit for differing population segments. According to pertinent literature (see Chapter 2), commuters that simply learn or read about telework or carpool options may have *intentions* to alter their travel behavior, but they most likely will not actually utilize alternative transportation options. Rather, personally experiencing a given option provides an impression of the benefits and challenges associated with that option, supplying the commuter with either a positive or negative *attitude* concerning alternative transportation. Those commuters that have both intentions to alter their travel behavior and a positive attitude concerning a given alternative transportation option are more likely to *actually change* their travel behavior. Analyses of telework survey participant comments regarding mitigation of traffic-related problems in the AMA are in keeping with the literature, and therefore leads this thesis to conclude that, in order to successfully develop the potential of both telework and carpool, compatible commuters must *experience* these SOV alternatives to successfully convert from traditional SOV commuting. Clearly, such a change in commuter behavior is essential to combat the AMA's traffic-related problems.

5.2 Generalizable Results

Ideally, this study would be generalized to other metropolitan areas of comparable size and market. However, each city has a unique socio-economic and demographic composition, as well as a distinct economic and transportation infrastructure. Taking this issue into account, it would be impractical to broadly extrapolate this study's conclusions to other US cities. However, applying the *Working Mother Hypothesis* to city-specific socio-economic and demographic data would produce a map depicting population concentrations of telework-compatible commuters. It is important to note though, that such a map will not completely identify all areas of telework potential. By the same token, delimiting areas of carpool potential would entail searching for residential concentrations of commuters with low incomes and low vehicle access, as well as occupations outside of the information and professional, scientific, and technical sectors. As a whole, this study contributes a method of searching for alternative transportation potential and advice to developing this potential.

5.3 Implications for Further Research

Conclusions from this study provide several implications for additional research that warrant attention from both academic researchers and transportation professionals. Supplementary research should be conducted to gather comprehensive socio-economic and demographic data describing teleworking and non-teleworking commuters, as well as carpoolers. Such data are in short supply. Therefore, it would be beneficial for researchers to acquire quantitatively specific data concerning income and age characteristics, rather using a less invasive, categorized data structure, such as the one imposed by the constraints of the present study. With more comprehensive teleworker data, more robust parametric tests could be applied, the strength of the *Working Mother Hypothesis* could be more rigorously evaluated, and the specifics of telework's participation and success would be better understood. Additional data concerning teleworkers' job functions could also be analyzed to further address the effects that commuters' occupations have on their likelihood to participate in telework. Also, specific carpooler data would allow analyses that could support or refute typical characteristics offered by literature, as well as strengthen methods used to identify carpool potential. More specific data regarding telework and carpool's significance to mitigating traffic-related problems would also be valuable to address the debate concerning telework's substitution and generation effects. Furthermore, personal interaction with commuters would assist in better assessing strategies for encouraging behavioral changes in commuting habits. Perhaps interviewing commuters that have successfully changed their own travel behavior could offer information as to the reasons for which they ultimately chose to utilize alternative transportation options.

Due to the small number of businesses participating in the telework survey, analyses concerning business type and characteristics' impact on telework participation were impractical. There is a need to examine telework programs' success as a function of the type of business within which the program operates. For example, does the size of a business affect telework's success? The literature briefly suggests that telework is often more successful in smaller companies. This suggestion should be scientifically addressed and examined. Furthermore, does the type of business (*e.g.*, manufacturing, government) affect telework's participation? Some business types are more appropriate for telework implementation. But on a relative scale, are certain types of economic activities more successful than others? Some literature blames telework program failures on miscommunication between management and employees. The structure and implementation of telework programs, therefore, should also be evaluated to determine what, if any, effects program management has upon telework's success.

Finally, additional research in the AMA and similar research in other metropolitan areas should be conducted as to verify whether this study accurately represents the commuting population, and therefore is generalizable to other metropolitan areas. Such comparative study would not only serve to support or refute this research, but it would also continue to promote alternative transportation options and foster the pursuit of sustainable transportation systems.

Atlanta Region Transportation FACT Book. 2001. The Atlanta Regional Commission. Atlanta, GA.

Bagley, Michael N. and Patricia L. Mokhtarian. 1997. Analyzing the preference for non-exclusive forms of telecommuting: Modeling and policy implications. *Transportation* 24: 203-226.

Baldassare, Mark, Sherry Ryan and Cheryl Katz. 1998. Suburban attitudes toward policies aimed at reducing solo driving. *Transportation* 25: 99-117.

Black, William R. 2000. Socio-economic barriers to sustainable transport. *Journal of Transport Geography* 8: 141-147.

Black, William R. 1997. North American Transportation: perspectives on research needs and sustainable transportation. *Journal of Transport Geography* 5 (1): 12-19.

Black, William R. 1996. Sustainable transportation: a US perspective. *Journal of Transport Geography* 4 (3): 151-159.

Blalock, Hubert M. Jr. 1972. *Social Statistics*. New York: McGraw-Hill Book Company.

Blickstein, Susan, and Susan Hanson. 2001. Critical mass: forging a politics of sustainable mobility in the information age. *Transportation* 28: 347-363.

Brewer, Ann M. and David A. Hensher. 2000. Distributed work and travel behaviour: The dynamics of interactive agency choices between employers and employees. *Transportation* 27: 117-148.

Burt, James E. and Gerald M. Barber. 1996. *Elementary Statistics for Geographers.* New York, New York: The Guilford Press.

Button, Kenneth and Peter Nijkamp. 1997. Social change and sustainable transport. *Journal of Transport Geography* 5 (3): 215-218.

Cervero, Robert. 1999. Reviving HOV Lanes. *Transportation Quarterly* 53 (4): 67-81.

Dziak, Michael J. 2001. *Telecommuting Success: A Practical Guide for Staying in the Loop While Working Away from the Office*. Indianapolis, IN: Park Avenue.

Ferguson, Erik. 1997. The rise and fall of the American carpool: 1970-1990. *Transportation* 24: 349-376.

Garling, Tommy, Anita Garling, and Anders Johansson. 2000. Household choices of car-use reduction measures. *Transportation Research A* 34: 309-320.

Geerlings, Harry. 1999. *Meeting the Challenge of Sustainable Mobility: The Role of Technological Innovations*. Berlin, Germany: Springer.

Gordon, Deborah. 1995. *Sustainable Transportation: What Do We Mean and How Do We Get There?* In *Transportation and Energy: Strategies for a Sustainable Transportation System,* eds. Daniel Sperling and Susan A. Shaheen. Washington, D.C.: American Council for an Energy-Efficient Economy.

Greene, David L. 1997. Environmental Impacts. *Journal of Transport Geography* 5 (1): 28-29.

Greene, David L. and Michael Wegener. 1997. Sustainable transport. *Journal of Transport Geography* 5 (3): 177-190.

Hanson, Susan. 1998. Off the Road? Reflections on transportation geography in the information age. *Journal of Transport Geography* 6 (4): 241-249.

Hanson, Susan. 1995. Getting There: Urban Transportation in Context. In *The Geography of Urban Transportation,* ed. Susan Hanson. New York: The Guilford Press.

Hirten, John and Steve Beroldo. 1997. Ridesharing Programs Cost Little, Do a Lot. *Transportation Quarterly* 51 (2): 9-13.

Janelle, Donald G. 1997. Sustainable transportation and information technology: suggested research issues. *Journal of Transport Geography* 5 (1): 30-40.

Kingham, S., J. Dickinson, and S. Copsey. 2001. Travelling to work: will people move out of their cars. *Transport Policy* 8 (2): 151-160.

Makower, Joel. 1992. *The Green Commuter*. Washington, D.C.: National Press Books.

Marshall, Stephen and David Banister. 2000. Travel reduction strategies: intentions and outcomes. *Transportation Research A* 34: 321-338.

Mokhtarian, Patricia L. and Michael N. Bagley. 2000. Modeling employees' perceptions and proportional preferences of work locations: the regular workplace and telecommuting alternatives. *Transportation Research A* 34: 223-242.

Mokhtarian, Patricia L., Susan L. Handy, and Ilan Salomon. 1995. Methodological Issues in the Estimation of the Travel, Energy, and Air Quality Impacts of Telecommuting. *Transportation* 4: 283-302.

Mokhtarian, Patricia L., Elizabeth A. Raney, and Ilan Salomon. 1997. Behavioral Responses to Congestion: Identifying Patterns and Socioeconomic Differences in Adoption. *Transport Policy* 4(3): 147-160.

Mokhtarian, Patricia L. and Ilan Salomon. 1997. Modeling the Desire to Telecommute: The Importance of Attitudinal Factors in Behavioral Models. *Transportation Research A* 31 (1): 35-50.

Mulvihill, Robert Kelly. 1999. *An Examination of Telework and the Physical Impacts on Community and Regional Development.* Masters Thesis, University of Tennessee, Department of Planning.

Nie, Norman H. 1999. Tracking Our Techno-Future. *American Demographics* (June): 50-52.

Nilsson, Maria and Rikard Kuller. 2000. Travel Behavior and Environmental Concern. *Transportation Research D* 5: 211-234.

Organization for Economic Cooperation and Development (OECD). 1997. *Towards Sustainable Transportation: The Vancouver Conference.* 1996 Proceedings. Vancouver, British Columbia.

Pisarski, Alan E. 1997. Carpooling: Past Trends and Future Prospects. *Transportation Quarterly* 51 (2): 5-13.

Pratt, Joanne H. 2000. Asking the right questions about telecommuting: Avoiding pitfalls in surveying homebased work. *Transportation* 27: 99-116.

Raney, Elizabeth A., Patricia L. Mokhtarian, and Ilan Salomon. 2000. Modeling individuals' consideration of strategies to cope with congestion. *Transportation Research F* 3: 141-165.

Root, Amanda and Laurie Schintler. 1999. Women, motorization, and the environment. *Transportation Research D* 4: 353-355.

Salomon, Ilan and Patricia Mokhtarian. 1997. Coping with Congestion: Understanding the Gap Between Policy Assumptions and Behavior. *Transportation Research D* 2 (2): 107-123.

Shelton, Stacy (a). 5/1/02. Atlanta air still among nation's dirtiest. Atlanta Journal-Constitution. Atlanta, Georgia.

Shelton, Stacy (b). 6/13/02. Smog season is off to a powerful start. Atlanta Journal-Constitution. Atlanta, Georgia.

Shen, Qing. 1999. Transportation, Telecommunications, and the Changing Geography of Opportunity. *Urban Geography* 20(4): 334-355.

Tertoolen, Gerard, Dik Van Kreveld, and Ben Verstraten. 1998. Psychological Resistance Against Attempts to Reduce Private Car Use. *Transportation Research A* 32 (3): 171-181.

Vega, Gina and Louis Brennan. 2000. Managing Telecommuting in the Federal Government: An Interim Report. The PricewaterhouseCoopers Endowment for the Business of Government.

Welch, Rupert. 1999. Two Climatologists Discuss the Issue of Global Warming. *Transportation Quarterly* 53 (1): 67-82.

World Commission on Environment and Development (WCED). 1987. *Our Common Future*. Oxford University Press, Oxford, England.

Yen, Jin-Ru. 2000. Interpreting employee telecommuting adoption: An economics perspective. *Transportation* 27: 149-164.

Web Page References:

http://pubs.acs.org/cen/topstory/8048/8048notw1.html, January 12, 2003.

http://www.census.gov/prod/cen2000/doc/sf3.pdf, February 19, 2003.

www.fhwa.dot.gov/////tea21/sumover.htm, November 19, 2002.

www.jala.com/faq.htm, May 28, 2002.

www.sierraclub.org/sierra/200211/1o14.asp, January 12, 2003

www.teleworker.com/quotes.html, May 28, 2002.

Appendix

TELEWORK ACTIVITY SURVEY

A study conducted by Jessica Tharpe and Dr. Shih-Lung Shaw
Department of Geography, University of Tennessee
Knoxville, TN 37996

Dear **insert company name** employee:

Thank you for agreeing to participate in this research study designed to examine telework activity in Metro Atlanta. Data gathered through this study will be processed by geographic software to map teleworking availability and participation in the Atlanta metropolitan area. From this survey, we hope to account for the existing stock of teleworkers in the region, as well as identify new ways to encourage more commuters to take part in telework.

How long will this take? Unless you specifically request to be contacted later, your time is limited to completion of this brief survey, which should require approximately seven-to-ten minutes. The survey can be completed at your convenience in either your office or your home.

The Definition of Telework: Telework is defined here as an employee working at home instead of the office two days or more per month.

Confidentiality and Consent: Your participation in this study is strictly voluntary. *Information detail gathered through this survey will be kept confidential and will be made available only to persons conducting the study unless you specifically give permission in writing to do so otherwise.* No reference will be made in oral or written reports that could link you to this study. **Completion and return of this survey constitutes your consent to participate**.

Thank you again for your time. If you have any questions or require clarification concerning this study, please contact the researcher. If you have any questions about your rights as a participant, contact the Research Compliance Services section of the Office of Research at the University of Tennessee, (865) 974-3466.

Very truly yours,

Jessica A. Tharpe

Jessica Tharpe
Principal Project Researcher
E-mail at jtharpe1@utk.edu

If you telework, please answer questions 1-8, 13-14.
If you do not telework, please answer questions 1, 9-14.

1. Please provide the following profile attributes:

A. GENDER
a. Male
b. Female

B. AGE
a. Under 25
b. 25-35
c. 36-45
d. 46-60
e. 60+

C. INCOME RANGE
a. Less than $30,000
b. $30,000-$45,000
c. $45,000-$60,000
d. $60,000-$85,000
e. $85,000+

D. NUMBER OF OPERATING VEHICLES OWNED IN YOUR HOUSEHOLD
a. 0
b. 1
c. 2
d. 3+

E. ZIP + 4 CODE OF YOUR HOME

_ _ _ _ _ - _ _ _ _

and, CLOSEST STREET INTERSECTION TO YOUR HOME

____

F. WHAT IS YOUR PRIMARY JOB FUNCTION? (*e.g.*, data entry, computer programming, telemarketing, product design, sales, accountant, etc.)

____

G. DO YOU HAVE ANY EMPLOYEES REPORTING TO YOU?
a. ___ no
b. ___ yes IF YES. HOW MANY? ___

2. Why do you telework? (Please order the TOP THREE REASONS that apply, 1 being most the important reason)

a. ___Personal convenience
b. ___Children at home
c. ___Environmental concerns
d. ___Employer-initiated program offers the option
e. ___Save money on commuting, dry cleaning, food, etc.
f. ___I have a disability/illness that makes it difficult to get to work
g. ___To complete work tasks requiring uninterrupted work time
h. ___My employer's main office is a considerable distance from my home
i. ___To reduce commuting stress
j. ___To help me better balance my work and family life
k.___To allow me to remain productive during inclement weather or unusually heavy traffic
l. ___To help me keep up with my work load
m.___Other: ____

3. While teleworking, opportunities to make trips during the hours you would have normally been at work exist. On telework days, is your primary commute vehicle used occasionally for non-commuting trips?

a. ___Y or ___N

b. If Y, how would you characterize the frequency of trips by you or other members of the household? __Hardly ever __Occasionally __ Regularly

c. Please list typical purposes and other details for such trips:

<u>Trip purpose</u> (*e.g.*, grocery, pick/drop kids, dry cleaners, office supplies, etc.)	<u>Travel distance</u> (in miles)	<u>Time of day</u> (*e.g.*, 3 P.M.)	<u>Primary driver</u> (*e.g.*, teleworker, other family member)

4. Your telework activity:
a. How long have you considered yourself a teleworking employee? ___ months
b. How frequently do you telework?
___2-3 days per month
___4-6 days per month
___7-15 days per month
___16+ days per month
___Full-Time

c. What days do you usually telework? (mark all that apply)

__M __T __W __R __F __Sat __Sun __Random days

d. When teleworking, do you work the same hours at home that you do while at the main office?

i. __Y __N
ii. If N, while teleworking, how do your work hours differ? (mark and circle all that apply)

___I usually work [slightly/several/many] fewer hours when teleworking
___I usually work [slightly/several/many] more hours when teleworking
___I usually [work later/stop working earlier] in the workday
___I usually [work extra time before/start work later than] my normal work hours
___I find myself working [more/less] frequently on weekends since I began teleworking

5. On days you do not telework, what mode of transport do you usually use?

a. Personal vehicle (drive alone)
b. Personal vehicle (shared with at least one passenger)
c. Formally organized carpool or vanpool
d. MARTA Train [Drive to MARTA Station __Y __N]
e. MARTA Train and Bus [Drive to park-n-ride __Y __N]
f. Bus [Drive to park-n-ride __Y __N]
g. Walk
h. Bicycle
i. Motorcycle
j. Other, Please specify (*e.g.*, taxi, CCT, C-Tran):
____

6. Before you began teleworking, what was your normal commute mode?
a. Personal vehicle (drive alone)
b. Personal vehicle (shared with at least one passenger)
c. Formally organized carpool or vanpool
d. MARTA Train [Drive to MARTA Station __Y __N]
e. MARTA Train and Bus [Drive to park-n-ride __Y __N]
f. Bus [Drive to park-n-ride __Y __N]
g. Walk
h. Bicycle
i. Motorcycle
j. Other, please specify (*e.g.*, taxi, CCT, C-Tran):
____

7. On days you **do** commute to work:

a. What is your round-trip travel distance? ____ miles ____ Not applicable (*e.g.*, if you never commute, if the main office is located in another state, you work for a virtual corporation, etc.)

b. If you commute by personal vehicle, what is your vehicle's estimated fuel efficiency? ____ miles per gallon (MPG)

8. In order to effectively telework at home, which of the following information and communication equipment do you use for teleworking? (Please mark all that apply)

ITEM USED FOR TELEWORKING	WHO PROVIDES IT?
___a. Desktop personal computer	___ Yourself ___ Employer
___b. Portable personal computer	___ Yourself ___ Employer
___c. High speed Internet connection (*e.g.*, cable modem, DSL, ISDN)	___ Yourself ___ Employer
___d. Extra telephone line for dial-up data connection	___ Yourself ___ Employer
___e. Extra telephone line for business calls	___ Yourself ___ Employer
___f. Basic software for work tasks	___ Yourself ___ Employer
___g. Specialized software for work tasks	___ Yourself ___ Employer
___h. Fax machine/fax modem	___ Yourself ___ Employer
___i. Document scanner	___ Yourself ___ Employer
___j. Basic office furniture	___ Yourself ___ Employer
___k. Ergonomically correct office furniture	___ Yourself ___ Employer
___l. Teleconferencing equipment	___ Yourself ___ Employer
___m. Printer	___ Yourself ___ Employer
___n. Cell phone	___ Yourself ___ Employer
___o. Hand-held palm device	___ Yourself ___ Employer
___p. Pager	___ Yourself ___ Employer
___Other______________________	___ Yourself ___ Employer
___Other______________________	___ Yourself ___ Employer

Teleworkers, please go to question 13.

9. What is your normal mode of commute?

a. Personal vehicle (drive alone)
b. Personal vehicle (shared with at least one passenger)
c. Formally organized carpool or vanpool
d. MARTA Train [Drive to MARTA Station ___Y ___N]
e. MARTA Train and Bus [Drive to park-n-ride ___Y ___N]
f. Bus [Drive to park-n-ride ___Y ___N]
g. Walk
h. Bicycle
i. Motorcycle
j. Other, please specify (*e.g.*, taxi, CCT, C-Tran):

____

10. If you commute by personal vehicle:

a. What is your total daily travel distance? _______________ miles

b. What is your vehicle's estimated fuel efficiency? _________ miles per gallon

11. Why don't you telework? (Please circle all that apply)

a. My job prohibits teleworking
b. I lack the equipment I need to telework
c. I don't know much about teleworking
d. I don't want to telework
e. Other, please explain

____
____
____
____

12. If teleworking options were made available to you at no personal cost, would you be willing to participate?

a. Y or N

b. Why or why not?

____
____
____
____

13. How do you believe traffic and air quality problems in Atlanta could be improved?

____
____
____
____
____
____
____
____

Please see question 14 on the next page.

14. May I contact you to schedule an interview to discuss your teleworking and commuting habits in more detail?

___Y or ___N

If Yes, please include your name and contact information to best reach you.

Name: ________________________

Phone: ________________________

E-mail: ________________________

Thank you for your participation.

Questions?

Contact Jessica Tharpe, Principal Project Researcher

E-mail her at jtharpe1@utk.edu.

BUSINESS INFORMATION SHEET

Please provide the following organizational profile attributes:

Address:

Total number of employees ____

Total number of employees in Metro Atlanta ____

Does the organization have more than one employment location in Metro Atlanta?
___Y ___N

If Y, list the Zip code and number of employees for each
Location 2 Zip: ______-___ (include +4 number) _________ employees
Location 3 Zip: ______-___ (include +4 number) _________ employees
Location 4 Zip: ______-___ (include +4 number) _________ employees
Location 5 Zip: ______-___ (include +4 number) _________ employees
___ more than 5 (we will contact you for this detail)

Type of Organization: (mark all that apply)
___ Public sector
___ Federal Agency
___ State Agency
___ County
___ City/Municipality
___ Other __________________________
___ Private sector
___ Corporation
___ Limited Partnership
___ Sole Proprietor
___ Non-Profit
___ Association
___ Other __________________________
SIC Code _______________________

BUSINESS PARTICIPATION CONSENT

We, **insert company name** agree to allow Jessica Tharpe to conduct a brief survey concerning our employees' telework participation and commuting habits.

Surveys will be distributed during the week of **insert delivery data,** and they will be returned to Jessica Tharpe by **insert date of two weeks after delivery date,** at which time our participation will officially end.

Signed and dated:

____________________________________ ___/___/___

Please print your name and position

____

Vita

An Atlanta native, Jessica A. Tharpe grew up in the midst of the city's traffic and air pollution problems. In search of cleaner air and less crowded streets, Jessica left Atlanta in September 1997 for Valdosta, Georgia, home of Valdosta State University. There she enjoyed hot, humid, gnat-filled days, made friends that became a family, and earned a Bachelor's degree in Environmental Geography in May 2001. In August 2001, Jessica moved to Knoxville to pursue a Master's degree in Geography at The University of Tennessee. There, she learned the joys and horrors of higher education, met the one with whom she will spend the rest of her life, and was blessed to find her first-born yorkie, Charlie. As she now leaves with the graduating class of May 2003, she hopes her work here has been salient, and that her 22 years of education serves to be well worth the effort.