EQUITY ISSUES IN HOV-TO-HOT CONVERSION ON I-85 NORTH IN ATLANTA

A Thesis
Presented to
The Academic Faculty

by

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In Partial Fulfillment
of the Requirements for the Degree of Master of Science
in the School of Civil and Environmental Engineering

Georgia Institute of Technology
May 2009

Equity Issues in HOV-to-HOT Conversion

on I-85 North in Atlanta

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ACKNOWLEDGEMENTS

I would like to thank my graduate research colleagues Jennifer Indech-Nelson, David Kall, Nick Wood, Yanzhi Ann Xu, Philip Blaiklock and Vetri Elango for their contribution to this project and for helping me think through some of the issues. I would also like to acknowledge the Georgia Institute of Technology undergraduate students who collected and processed the license plate data during the Summer 2007 License Plate study: they put in many tireless hours of standing on the overpasses in the sun, and many hours reviewing the video data.

To all the teachers who have made my progress to this point possible I extend my gratitude. Nicole Kintz has been particularly instrumental in my life, in helping me develop focus and inner fortitude. I would also like to thank my husband, Daniel Harvey, for his continued patience and support. To Paula and Jim Huffman I extend a thank you from the bottom of my heart for accepting me as a member of their family when I first came to the U.S. as an exchange student. And thank you to my family and friends for adding depth and joy to my life.

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LIST OF SYMBOLS AND ABBREVIATIONS

HOV-2	Carpool vehicles with two occupants; alternatively, a requirement on HOV and HOT lanes that vehicles using the facility carry at least one person other than the driver
HOV-3+	Carpool vehicles with three or more occupants; alternatively, a requirement on HOV and HOT lanes that vehicles using the facility carry at least two people other than the driver
SOV	Single-occupancy vehicle
VMT	Vehicular Miles Traveled
Xpress Bus	Suburb-to-central city or central city-to-suburbs coach express bus service operating in the Metropolitan Atlanta region
CBD	Central Business District; in the context of the City of Atlanta generally refers to the combined area of Downtown and Midtown

SUMMARY

This paper examines the issues of equity, as applicable to the HOV-to-HOT conversion project planned for the I-85 North corridor in the Metropolitan Atlanta Region. A review of literature is undertaken to describe the typology of transportation equity issues within the wider context of environmental justice, and to highlight socio-economic factors and local and national transportation funding factors that influence people's travel choices and their mobility and accessibility options. Demographic data on the I-85 corridor peak period commuters in Metropolitan Atlanta is analyzed, in addition to results of focus groups polling current Metropolitan Atlanta interstate commuters on the topic of managed lanes during 2008. The thesis makes a conclusion that a final decision about the equity impact of the I-85 HOV-to-HOT conversion is likely not possible without undertaking a Metropolitan area-wide analysis. Some of the equity findings that emerge indicate that there are no significant income differences between the the HOV lane users and general purpose lane I-85 commuters; that there are differences between median incomes of block groups represented by current I-85 commuters (both HOV lane users and general purpose lane users) and median incomes of block groups typical for the base geography; and that investing in Xpress bus service improvements would primarily serve those households with more vehicles than drivers, unless improvements to reverse commute options and feeder bus networks are made. The focus group findings suggest that current interstate highway users in Metropolitan Atlanta, originating in the suburbs, are generally accepting of the HOT concept and recognize the value of travel time savings.

CHAPTER 1

INTRODUCTION

Atlanta Transportation Planning Context

The basis for this paper is the planned conversion of a portion or the entire network of the HOV lanes in metro Atlanta to HOT (High Occupancy-Toll) lanes. The federal government has announced in November 2008 a decision to invest $110 million to convert 14 miles of HOV lanes on I-85 in Gwinnett County and DeKalb County to HOT lanes, as a demonstration project, with possible future conversion of the entire HOV network in the metro Atlanta area to HOT; $30 million of the grant funds will be allocated to purchasing 36 new Xpress buses and building and improving park-and-ride lots along the corridor (State of Georgia Office of the Governor, 2008). Figure 1.1 below illustrates the location of the I-85 North pilot HOV-to-HOT conversion (referred to as Phase 1 in some of the Georgia DOT documents.)

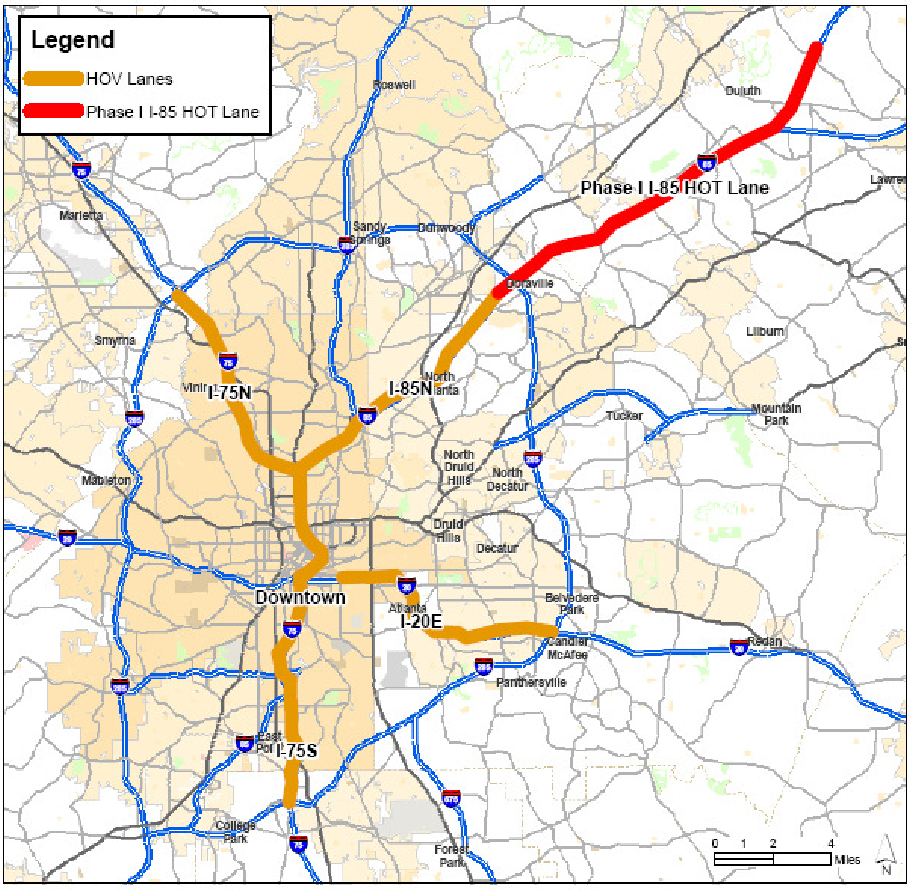

Figure 1.1 Map of the Metro Atlanta HOV Lane System, and the I-85 Pilot HOV-to-HOT Conversion Corridor (Phase 1). Source: Georgia DOT, 2009.

Approximately $37 million of the HOV-to-HOT conversion pilot project will be funded by the Georgia State DOT funds (Georgia DOT, 2009.) Georgia State laws specifically prohibit Georgia State motor fuel sales tax revenue from being spent on non-roadway projects (Transportation Research Board, 1998), and so the funding for the transit improvement has to come from the federal government, or from another source. Currently, the I-85 North HOV lanes suffer a very high occupancy violation rate, with approximately 13 % of all HOV lane use in metro Atlanta coming from single-occupancy vehicle drivers breaking the rules (DataSmarts, 2003). As documented by Guin, et al. (2008), the HOV lanes in Metropolitan Atlanta can only accommodate up to 1500 vehicles per lane per hour, and the HOV lanes on I-85 North in Atlanta break down at peak congestion, and thus no longer can serve their purpose of guaranteeing a faster travel speed for carpools and transit buses. Even without the HOV-to-HOT conversion, raising the occupancy requirement to HOV-3+ would likely be necessary in the near future.

If the carpool requirement is raised, the lane would likely be underutilized due to the low numbers of 3+ carpools. Selling excess capacity to SOVs (single-occupancy vehicles) and 2-person carpools (possibly at a discount) would optimize the future efficient use of the facility. However, simultaneously raising the carpooling limit while allowing single-occupancy drivers access to the facility for a fee raises equity concerns, indicated by the term “Lexus Lanes”. The purpose of this thesis is to examine the equity concerns pertaining to the HOV-to-HOT conversion on I-85 corridor through literature review, analysis of I-85 corridor commuter demographics, and analysis of Atlanta congestion pricing focus groups results.

Project Scope

This paper will examine the equity issues associated with conversion of an HOV-2 lane to an HOT lane with HOV-3+ requirement on I-85 North in Atlanta, based on the following data sources:

- Literature review on the types of equity issues present in transportation, especially as applied to congestion pricing, and on socio-economic factors affecting people’s travel choices, mobility and accessibility
- Demographic commuter profiles of I-85 users in metropolitan Atlanta based on license plate data collected on the I-85 corridor at rush hour during the summer of 2007

- Metropolitan Atlanta interstate highway commuters' perceptions of congestion pricing and HOT lanes based on 19 focus groups conducted during 2008

Chapter 2 will summarize the literature reviewed on the topics of environmental justice and equity in transportation, transportation issues for minorities and lower income groups, spatial mismatch in the Atlanta context, and equity issues within the current transportation funding system. Given the findings of no significant air quality impacts of the I-85 HOV-to-HOT conversion by Kall (2008), this paper will consider the environmental pollution impacts of the project as negligible. The primary focus will be geared more towards distributive equity concerns related to the project, specifically towards potential displacement of current HOV users and the allocation of benefits. Chapter 3 will address the demographics of I-85 commuters, based on the license plate data collected during the summer of 2007. A search for potential negative equity impacts of the HOV-to-HOT conversion on I-85 North was conducted by comparing the typical HOV lane user demographics with the typical general purpose lane driver demographics, and by comparing I-85 users with typical profile of base geography residents. Chapter 4 discusses the results of focus groups on the topic of congestion pricing conducted in metro Atlanta during 2008, taking into account that perceived fairness of congestion pricing is just as important for successful implementation of a project as the actual underlying equity issues. Chapter 5 summarizes the limitations and results of the study, and provides the conclusions and recommendations.

CHAPTER 2

LITERATURE REVIEW

Environmental Justice and Equity in the Transportation Context

Since the 1970s, environmental justice and equity issues have come to the forefront in the field of transportation. Environmental justice concepts flow from the provisions of Title VI of the Civil Rights Act of 1964, which prohibits discriminatory actions by the federal agencies against disadvantaged populations (Hartell, 2007). The USDOT environmental justice guidelines, however, remain fairly vague in defining environmental justice review for transportation projects (Hartell, 2007). Hartell (2007) suggests that the intent of Executive Order 12898 is not to stop projects from going forward if disproportionate negative impacts are found, but to incorporate environmental justice into the "genetic engineering" of transportation decision-making at the federal and local level, and to find ways to mitigate any disproportionate negative impacts.

Researchers such as Schweitzer and Valenzuela (2004) separate the issues pertaining to environmental justice in transportation into two main categories: distributive justice (whether low-income and minority groups are afforded equitable access to facilities) and environmental impacts (concerned with who carries the burden of externalities such as air pollution.) More often, though, three sub-categories of environmental justice are recognized, with public participation being the third component. For example, Ungemah (2007) summarizes the existing U.S. legislature and directives pertaining to environmental justice in transportation into the following three key requirements:

"*1. To avoid, minimize, or mitigate disproportionately high and* *adverse human health or environmental effects, including social and economic effects, on minority populations and low-income populations;*

2. To ensure the full and fair participation by all potentially affected communities in the transportation decision-making process; and

3. To prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority populations and low-income populations."

Duthie, et al. (2007) see the concept of equity as very similarly to Ungemah's understanding of environmental justice as it applies to transportation, and indicate that ensuring equity is a three-fold process, requiring equity in public participation, equity in funding, and equity in impacts. Other literature sources (Ikeme, 2003; Litman, 2007), interpret the concept of equity (also understood as justice, or fairness) as the distribution of positive and negative impacts. Ikeme (2003) sees equity as falling under the broader umbrella of environmental justice, which incorporates procedural concerns in addition to fairness considerations. For the purpose of this thesis, the interpretation of equity used by Ikeme (2003) and Litman (2007) will be used, where equity incorporates fairness in the distribution of costs and benefits, but does not incorporate participation in the decision-making process.

If we were to look for parameters of fairness and equity within the nineteenth century literature, long before environmental justice was a concept in existence, Utilitarian thinkers and nineteenth-century economists converged on a philosophical doctrine of *Pareto Improvement* as an alternative that optimizes the public interest (Rescher, 1982). Rescher (1982), drawing from Utilitarian theory, explains a Pareto improvement as a small change in society's circumstances, under which the well-being of at least some individuals is improved and nobody is made worse off, although the well-being of some individuals may remain the same as before; similarly, a Pareto optimal distribution is a set of existing circumstances such, that none of the considered alternatives can produce a Pareto improvement (Rescher, 1982.) Rescher (1982) also states that the drawback to using the Pareto improvement yardstick for evaluating alternatives is that in real-world scenarios, it is typical to have many alternatives none of which would be a Pareto improvement, i.e. some persons would have to give up a portion of their well-being in each case.

Similarly to Pareto improvement, Rosenbloom and Altshuler (1977) recognize a “hold harmless” approach as a potential point of evaluation for transportation projects. Akin to Pareto optimality, the “hold harmless” concept suggest that any policy that benefits some portions of society, or even society as a whole, should not leave any society members significantly worse off than before (Rosenbloom and Altshuler, 1977).

While researchers tend to agree that the negative costs from a government action for any group of individuals should be minimized, there are a variety of approaches to what is perceived as equitable distribution of benefits. First of all, there is the issue of how to subdivide groups of transportation system users, so as to check for inequitable distribution of costs and benefits between them. Ungemah (2007) suggests that equity, as applicable to transportation tolling projects, should be considered across five dimensions potentially dividing the users:

- geographic equity (defined by whether improvements are distributed across various communities in a logical manner, based on objective criteria
- income equity (“do improvements negatively affect economically disadvantaged communities?)

- participation equity ("do disadvantaged communities have a voice in the decision-making process, and is that voice adequately represented relative to the scale of the impact")
- opportunity equity (whether various communities are given a fair access to education and employment opportunities through the publicly-sponsored infrastructure (Litman, 2007))
- modal equity ("do activities conflict with public perception for the encouragement of multimodal transportation?")

Of those, Ungemah (2007) suggests that geographic and income equity are of primary importance during the planning process, and are generally at the forefront of the public concern. Income equity incorporates both opportunity equity and modal equity concerns (Ungemah, 2007).

Litman (2007) further classifies equity into vertical and horizontal (see Table 2.1 below), where comparing the benefits received by two communities similar in all but geographic location would be a question of horizontal equity, whereas comparing benefits received by people of various income groups, or by people of various physical abilities, would constitute questions of vertical equity. For the pilot I-85 HOV-to-HOT conversion project, an obvious horizontal equity issue emerges in that the drivers using the I-75 north corridor, for example, will not be able to see the benefits of the project until the HOV-to-HOT conversion is extended to other portions of the currently-existing HOV network. However, this is probably typical for a pilot project (you have to start somewhere), and this specific horizontal equity issue would probably be resolved with successful implementation of HOT network. Vertical equity issues are more likely to be compounded over time, and thus receive a greater consideration in this thesis.

Table 2.1 Equity Classification Parameters (Litman, 2007).

Types of Equity	Categories	Impacts	Measurement Units
• Horizontal • Vertical with-respect-to income and social class. • Vertical with-respect-to need and ability.	• Demographics (age, gender, race, ethnic group, family status, etc.) • Income class. • Geographic location. • Ability (e.g., people with disabilities, licensed drivers, etc.). • Mode (walkers, cyclists, motorists, bus users, etc.). • Vehicle type (cars, trucks, buses, etc.). • Industry (truckers, transit, taxis, vehicle manufactures, etc.). • Trip type and value.	• Price or fare structure. • Tax burdens. • Transportation service quality. • External costs (crash risk, congestion, pollution, etc.). • Economic opportunity and development. • Transport industry employment and business opportunities.	• Per capita. • Per vehicle-mile or kilometer. • Per passenger-mile or kilometer. • Per trip. • Per peak-period trip. • Per dollar paid in fare or tax subsidy.

Whether looking at two different population groups divided by income or by geography, the issue of what is a fair and equitable distribution of costs and benefits of a particular transportation project is key. Rosenbloom and Altshuler (1977) recognize the following three main equitable distribution approaches in the urban transportation field:

- Provision of services based on fees paid ("to each according to his or her financial contribution")
- Equal provision of services (regardless of needs or financial contribution)
- Provision of services based on need

In applying the third approach, provision of services based on need, Rosenbloom and Altshuler (1977) note that it is not generally clear what population groups are most deserving of services based on need, or how to deliver the services. That is, it is difficult to determine what users groups need in terms of transportation services. Similarly to provision of services based on need, Rescher (1982) envisions a certain "utility floor" as a useful addition to other considerations employed in improving the public good, such that "nobody receives less of *the good* than a certain minimum amount." For example, Rescher (1982) indicates that the concept of the "living wage" functions as a sort of utility floor, or providing for the basic needs of the individuals. Some people might consider a "utility floor" analogous to a human right, as decided for a given society at a certain point of time-culture continuum.

Without making a decision between equity based on fee-for-service, equal rights, or based on needs, the thesis accepts as a basic assumption that for an equitable distribution of transportation project benefits, the basic minimum transportation needs of all persons in the region have to be met.

Whether the equitable distribution based on need, based on fee-for-service, or based on equal access for everyone (or a hybrid combination of these concepts) is advocated, the size of the geographical area considered and the timeframe are both likely to influence the analysis. Duthie, et al. (2007), advocate for a holistic, system-level equity analysis at the metropolitan area level for transportation decision-making, even if it is more difficult than corridor-level analysis. Analyzing the full spectrum of environmental justice implications of the Atlanta Metro area transportation planning is outside of the scope of this thesis, and the primary focus of the demographic analysis will be on corridor-specific distributive equity concerns for the proposed I-85 North HOV lane conversion to an HOT lane. However, Metropolitan Atlanta region transportation equity issues, including transit equity issues, play an integral role in the discussion and thus will be addressed in further sections of the literature review and in conclusions.

Litman (2007) suggests that "There is no single correct way to evaluate transportation equity", and recommends considering a variety of perspectives, impacts and analysis methods. When evaluating policy decisions, equity considerations should probably be weighed against efficiency, i.e. maximizing the society's net benefit (Field and Field, 2006). While the interests of efficiency and benefits to the Metropolitan Atlanta region overall might suggest that the I-85 pilot HOV-to-HOT conversion project should go forward, the purpose of this thesis is to determine whether significant cause for vertical equity concern exist, both when comparing the I-85 HOV lane users to the typical general purpose lane I-85 user within the Metropolitan Atlanta, and when comparing typical interstate highway users with the wider population of the Metropolitan Atlanta. The demographic analysis of I-85 corridor commuters will be used to attempt to address those issues, with recognized limitations in the data available and the methodology employed.

Travel by Individuals in Lower-Income Groups

Murray, Chambers, et al. (1999) indicate that low-income, and especially very low income individuals tend to make less trips than those living in households belonging to the middle-income and higher-income categories: "Individuals with incomes below $10,000 make about one trip per day less than individuals with incomes over $40,000 per year ." Hine and Mitchell (2001), as cited in Litman (2007), indicate that "*economically disadvantaged* people are often unable to afford the most convenient travel modes or locations (for example, they cannot afford an automobile, their vehicles have frequent mechanical problems, or they must live in more remote locations where housing costs are lower) and so are often *transportation disadvantaged*." There is also a feedback loop present in the relationship between income and transportation, such that the transportation disadvantaged people tend to have more difficulty in accessing employment, education, and affordable goods, which contributes to their economically disadvantaged status; improving mobility and accessibility is one of the key factors in helping the disadvantaged populations (Litman, 2007).

Schweitzer and Taylor (2008) suggest that when considering whether congestion pricing might disproportionately affect the lower-income groups, we should compare congestion pricing with other means of transportation funding. While local sales taxes are becoming an increasingly popular form of transportation funding, such a tax is regressive both in terms of income and in terms of highway usage (Schweitzer and Taylor, 2008). Gasoline sales tax, on the other hand, is only regressive in terms of income, but progressive with respect to driving (Schweitzer and Taylor, 2008). Schweitzer and Taylor (2008) conclude that using sales tax for roadway funding is inequitable in that it shifts some of the costs of driving to the society at large, and favors higher-income drivers at the expense of lower-income population groups; furthermore, a sales tax is inefficient in that it is distributed across a number of small transactions, and hides the true costs of transportation choices from the drivers.

Ungemah (2007) indicates that HOT lanes are unlikely to disproportionately affect the low-income groups, given that they create a new mobility option, with no negative effect on general-purpose lane users:

> *"Provided that HOT lane operations enhance HOV lane operations, with no net harm to HOV lane users by the increased travel on the facility, then HOT lanes provide a new mobility option without detriment. Furthermore, the extent to which HOT lane revenues can be used to pay for more corridor-based services (such as improved transit services, park-and ride services, or operational improvements) will only further extend the equity to lower-income communities."*

On SR-91 Express Lanes in California, at least a third of households with income under $40,000 per year use the facility at least occasionally (Schweitzer and Taylor, 2008).

Women Commuters

Division of household labor and income potential differentiation remain important factors for women's transportation choices, and affects their propensity to travel on the highway. Some of the literature reviewed suggests that in a two-income household, women tend to sacrifice some of the income in order to find a job closer to home, so that they are more able to take care of the other everyday household needs, especially if children are present (Turner and Niemeier, 1997). Women do take advantage of the HOT lanes when they are available: they represented an equal share of QuickRide HOT facility users in Houston (Burris and Stockton, 2004), and a higher percentage of transponder users than men on the SR-91 Express Lanes (Parkany, 1999, as cited in Schweitzer and Taylor, 2008). It is possible that predictable travel times are more important to women than men, especially when they assume the daycare pick-up responsibilities. Giuliano (1994) indicates that women are more likely to be constrained in their daily schedules.

Marion and Horner (2007) found that males are more likely to be extreme commuters than females, although there is no significant difference by gender for extreme commuters who live in the inner city areas, possibly due to a larger number of women-headed households.

Murray, Chambers, et al. (1999) indicate that while women take more trips than men, a large portion of them (23% of full-time working mothers and 60% of part-time working mothers) have non-traditional work schedules, which prohibits them from joining carpools or effectively taking advantage of transit options available. In addition, Murray, Chambers, et al. (1999) indicate that 70% of adults in zero-vehicle households are women. This suggests that while women might be more in need of reliable transportation options to handle their household responsibilities, they are more likely than men to be transportation-disadvantaged in relation to car transportation, as well as in relation to joining carpools and using transit.

Overall, the literature reviewed suggests that women do have slightly different travel patterns than men, and typically their job and subsequent travel choices are made in order to optimize the overall household utility. For the purpose of equity issues in HOV-to-HOT conversion analysis, it appears that women's' use of the highway and HOT lanes is tied to the household income, and protecting the lower-income households from the disproportionate impacts of a transportation decision would also protect the women as a group.

Education Level

Those with higher education levels tend to take more trips and to have more flexibility in their job search and job schedule. According to Murray, Chambers, et al. (1999), trip-taking rates increase with higher education level; even when accounting for positive education-income correlation, "a change in education produces a greater overall effect on trip rates than the change in income." Marion and Horner (2007) found that those with a bachelor's degree were less likely to be extreme commuters, possibly due to those individuals facing less constraints and more attractive options in their job search.

Minorities

Minority populations, especially those living in the inner cities in the U.S., have been historically economically and transportation-disadvantaged. Murray, Chambers, et al. (1999) indicate that approximately 40% of central city African-American households have no access to an automobile, as compared with less than 20% of zero vehicle white central city households. Murray, Chambers, et al. (1999), in quoting the 1990

Nationwide Personal Transportation Survey Results, suggest that African-Americans display a higher use of public transit (over twice the rate of white population transit use), and therefore have less immobility due to the absence of a vehicle. However, the jobs-housing imbalance leads to higher-rate growth of entry-level jobs closer to the suburbs, and further away from minority-concentrating and transit-rich inner-city areas.

Figure 2.1 below indicates higher concentration of minorities in the inside-the-perimeter Metropolitan Atlanta as of 2000 U.S. Census, whereas the areas to the north of the I-285 tend to have lower concentrations of minorities (Institute on Race and Poverty at University of Minnesota, 2006).

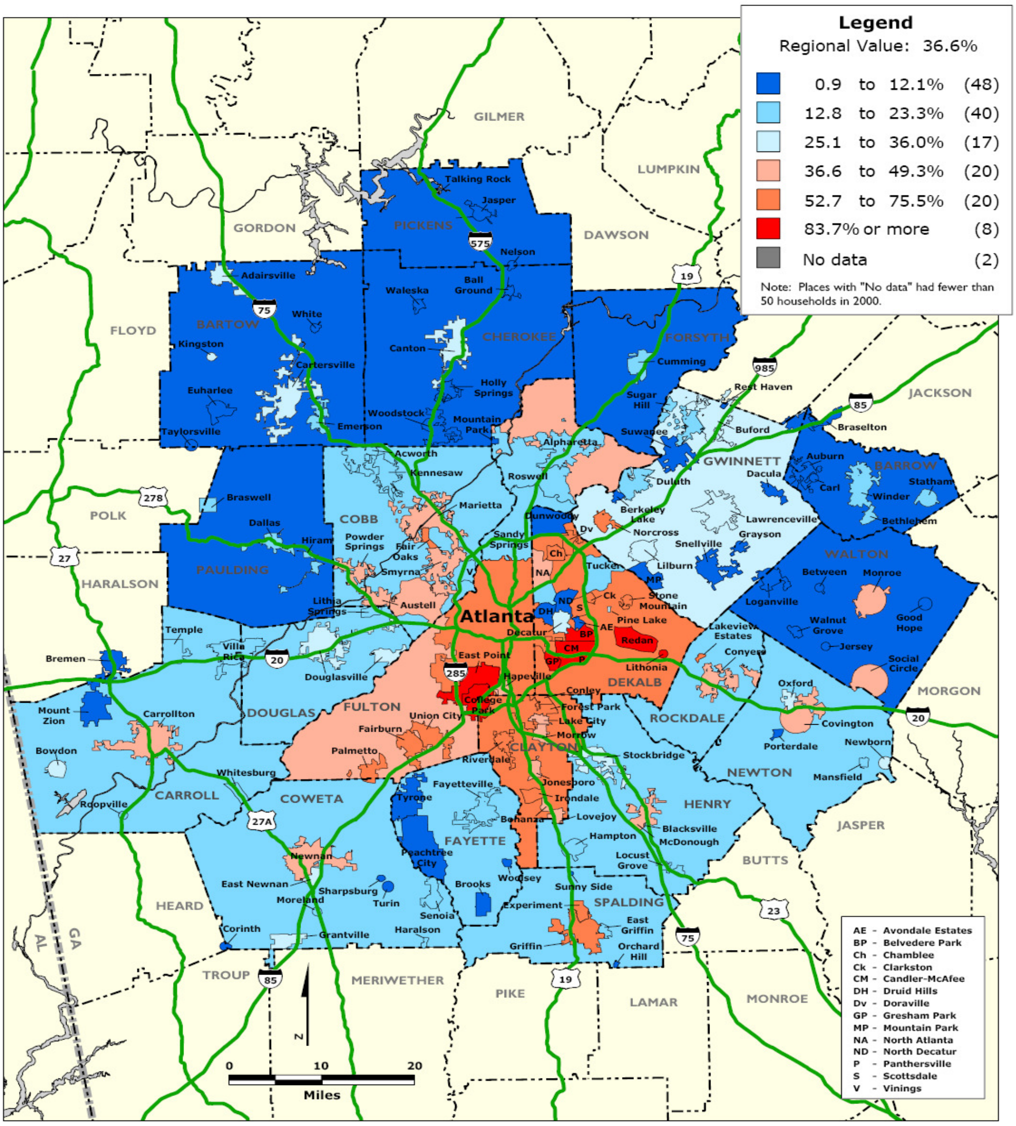

Figure 2.1 Concentration of Non-Asian Minority Population for Atlanta Metro Region, 2000. Source: Institute on Race and Poverty at University of Minnesota (2006).

Racial and economic patterns suggest that Metropolitan Atlanta is divided into the southern and the northern parts by the I-20, with greater infrastructure and job growth to the north, and greater concentration of poverty in the near-south part (Institute on Race and Poverty at University of Minnesota, 2006). The northern suburbs of metro Atlanta attracted the majority of job growth for all types of jobs, including lower-paid, entry-level jobs, in the 1990s (Ihlanfeldt, 1997). MARTA rail only provides access within Fulton and DeKalb counties, thus making more sparse transit connections from the central city to the job clusters in Cobb and Gwinnett counties.

Atlanta region remains a migration magnet for African-Americans (who represent 29% of the population), and has increased its Hispanic population from 1% in 1980 to 6% in 2000 (Institute on Race and Poverty at University of Minnesota, 2006). 95% of Atlanta's white residents, 93% of Hispanic residents, and 78% of African-American residents of Atlanta region live in the suburbs, with 34% of neighborhoods being integrated, double the amount in 1980 (Institute on Race and Poverty at University of Minnesota, 2006). However, 57% of African-Americans still reside in racially-segregated communities (Institute on Race and Poverty at University of Minnesota, 2006). There have been many positive changes in the Atlanta region during the 1980s and 1990s leading to better racial integration. However, a disparity between the faster-growing northern suburbs and the lower income inside-the-perimeter neighborhoods and closer-in suburbs to the south remains.

A recent environmental justice analysis, undertaken for the Atlanta Regional Commission by the Boston Consulting Group, developed a Community Attribute Index (CAI), ranging from 0 to 1, where 1 indicates a very economically and socially stable neighborhood (Boston and Boston, 2007). The CAI ranking analysis of Metropolitan Atlanta resulted in suggested corrections to the previously used EJ criteria used in the regional transportation planning process (for example, a higher than region's average percentage of Asian population does not appear to be an appropriate indicator that a neighborhood should be monitored for Environmental Justice issues) (Boston and Boston, 2007). Similar to the United Nations' Human Development Index, CAI includes the following dimensions: Economic Opportunity, Poverty Status, Educational Attainment, Housing and Population Mix, and Family Stability (Boston and Boston, 2007). A CAI-based analysis of Atlanta neighborhoods (see Figure 2.2 below) revealed a picture similar to the one suggested by the Institute on Race and Poverty at University of Minnesota analysis (Figure 2.1 above). The disadvantaged neighborhoods, based on CAI, tend to be concentrated in Fulton County (except for its northern portion), DeKalb County, and in Clayton County.

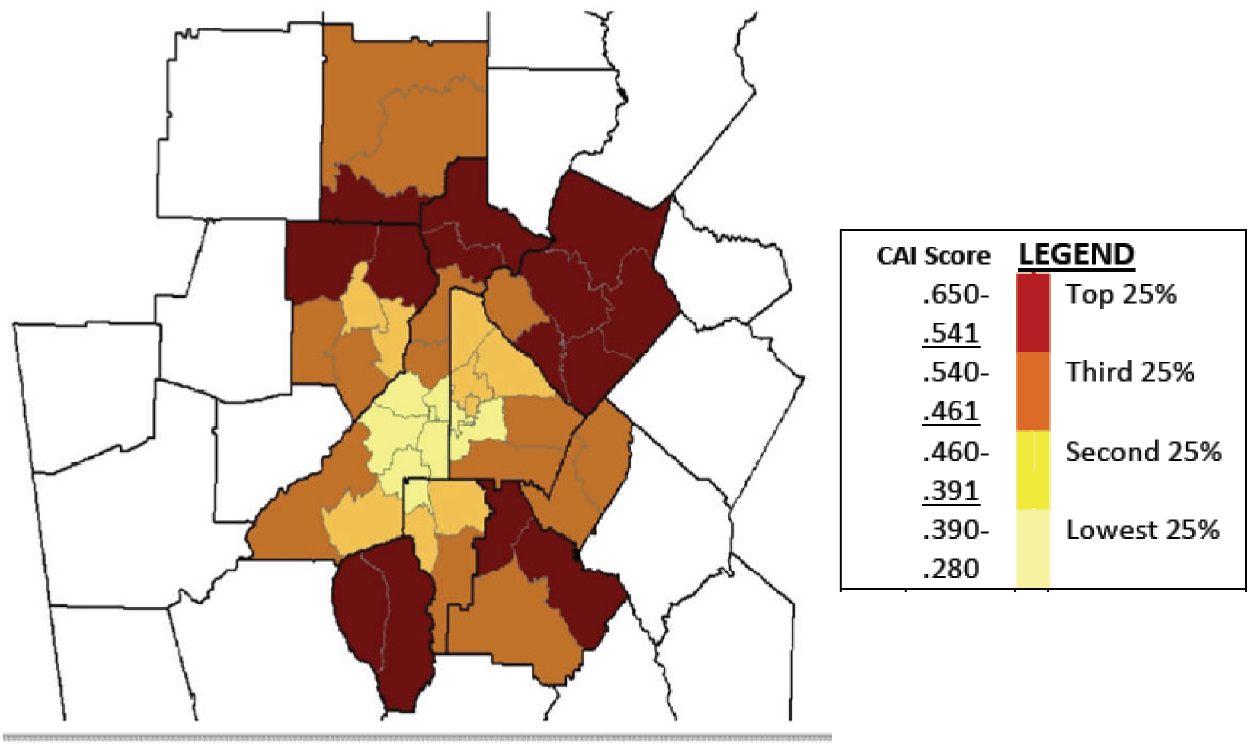

Figure 2.2 Geographic Illustration of CAI Percentile Scores in ARC Region
Source: Boston and Boston (2007).

The Spatial Mismatch in the Atlanta Context

A spatial mismatch phenomenon is understood as new jobs being created in geographic separation from the residential location of job-seekers. The spatial mismatch is particularly detrimental to those seeking entry-level jobs. The spatial mismatch compounds the economic hardships and transportation disadvantages experienced by minority populations and those with low income. Van Horn and Storen

(2000) indicate that home location inconvenient to perspective jobs, coupled with poor transportation options, is a severe handicap to the working poor families:

> *"In a Work Trends study of the working poor (defined as those earning at or below 200% of the poverty level), respondents said that that their location presented a significant barrier to their success in the labor market. Nearly nine in ten (88%) of the working poor expressed the need for better jobs in their community. "*

According to the United States Department of Health and Human Services (2009), a household with two persons would be considered below the poverty threshold in 2009 if they had an annual household income below $ 14,570, which corresponds to approximately $29,140 per year household income for a two-person household earning at the 200% of the poverty level. A single-person household would be earning below 200% of the poverty level, as of 2009 (and thus be a member of the working poor), if the household income was below $21,660 per year (United States Department of Health and Human Services, 2009).

Murray, Chambers, et al. (1999) indicate that two-thirds of the new jobs created over the past 40 years in the U.S. have been located in the suburbs, and are not generally accessibly by public transportation. For example, FIRE (financial, insurance and real estate) sector has been a very fast-growing aspect of the U.S. economy, and many of those firms choose to locate in the suburbs, and offer back office and clerical positions at those locations, attracted by lower land prices and the available pool of mostly female second-earner workers (Murray, Chambers, et al., 1999). With the increase in suburban jobs, some of the workers follow: between 1970 and 1990, the work trips from central cities to the suburbs grew by a quarter (Murray, Chambers, et al., 1999). However, many of the potential entry-level workers living in the cities are disadvantaged by the lack of information and transportation options and cannot access those jobs (Ihlanfeldt, 1997).

The spatial mismatch trends occurring nationwide were probably compounded by the higher suburban sprawl rates in Atlanta in the 1980s and 1990s. Ihlanfeldt (1997) notes the high growth of all types of jobs, including lower-paid, low-skill jobs, and higher vacancies in the northern suburbs of Atlanta in the early 1990s, and indicates a present disconnection in terms of geography and information between the available entry-level jobs and the job seekers. Workers seeking low-paying, low education level jobs tend to have poor information about the geographic distribution of available jobs (Ihlanfeldt, 1997). Pugh (1998) indicates that Atlanta is likely "one of the nation's most severe cases of spatial mismatch", citing racial segregation in both inner-city and in the suburbs. The outer-ring northern suburbs of Atlanta have been experiencing an economic boom, have plenty of entry-level jobs, and are overwhelmingly white, whereas the African Americans moving to the suburbs are largely migrating to the southern suburbs, which are less job-rich (Pugh, 1998).

Mobility- Disadvantaged and Social Exclusion

Ahmend, Lu, et al. (2008) point out that transportation plays a key role in human life, providing access to amenities and services such as employment, education, health services and leisure. There are strong and self-reinforcing relationships between poverty, mobility disadvantage and social exclusion. Mobility disadvantage is typically characterized by "poor or unavailable transport" and "reduced accessibility to social networks, facilities, goods and services" (Kenyon, et al., 2002). Rosenbloom and Altshuler (1997) note that the mobility disadvantaged are a very heterogeneous group, including "the elderly, the young, the blind, the wheelchair-bound, all others with acute physical disabilities, and the very poor." Through mobility disadvantage people are prevented from participating in the economic, political and social services of society, and are in effect socially excluded in a society where high mobility is the norm (Kenyon, et al., 2002). Kenyon, et al. (2002) define social exclusion as follows:

> *"The unique interplay of a number of factors, whose consequence is the denial of access, to an individual or group, to the opportunity to participate in the social and political life of the community, resulting not only in diminished material and non-material quality of life, but also in tempered life chances, choices and reduced citizenship."*

Social exclusion tends to occur in the conditions of relative mobility disadvantage, and relative poverty. According to Kenyon, et al. (2002), car ownership becomes a defining factor in both social exclusion and poverty in the current day U.S. society, although it would not have been the case several decades ago, when "car ownership was more restricted" and "the urban environment were less influenced by the assumption of mass car ownership." Dimensions of social exclusion are culturally and time-appropriate. For example, Ahmed, Lu, et al. (2008) document the recent tendency to build more car-oriented infrastructure in the cities of Karachi and Beijing, where less than 12% of the population have access to a private vehicle for transportation. In those societies, taking a bus or walking for transportation likely carries a different meaning than it would in Metropolitan Atlanta of today.

As the U.S. society built up an expectation of prevalent car ownership, and as more people have moved out to the suburbs, accessibility to transit has declined for a typical U.S. household. Murray, Chambers, et al. (1999) indicate that almost 40% of American households do not have public transit access available to them within a two-mile radius, with a much higher rate of transit access in central cities (83% have access to transit within two miles) than in non-urbanized areas (20% have public transit access within two miles). Where available in metro areas with population over one million, transit does allow zero-vehicle households with access to heavy rail to take 30% more trips than do zero-vehicle households living in similar urban areas without heavy rail (Murray, Chambers, et al.) However, people's lifestyle choices (such as the "ageing in place" phenomena, or moving out to the suburbs in search of cheaper housing) sometimes dictate that they live in the suburbs, where transit accessibility could be very poor. Transportation planners are oftentimes facing a difficult task to coordinate mobility and accessibility for the transportation-disadvantaged in the low-density development context, not well suited for transit, or elderly services. As mentioned by Sandra Rosenbloom (2009) in one of her recent presentations, if people make lifestyle choices that make it difficult to provide them with necessary services, it does not mean that planners can walk away and wash their hands of the problem. However, it does suggest that it is likely impossible to provide a cohesive solution to social exclusion through transportation alone (Rosenbloom, 2009).

Xpress Bus Riders in Metropolitan Atlanta

Transit service connecting the inner city and the suburbs could be part of a solution connecting the job seekers with the jobs without requiring the use of a private vehicle, and ameliorating mobility disadvantage and social exclusion. Xpress buses could potentially serve this role in the Metropolitan Atlanta region. Xpress buses are primarily a suburbs-to-CBD transit service, currently accommodating passengers from 12 counties: Clayton, Cobb, Coweta, Cherokee, DeKalb, Douglas, Forsyth, Fulton, Gwinnett, Henry, Paulding, and Rockdale (GRTA, 2005; GRTA, 2009(A)). Xpress bus routes are geared towards people working regular schedules, with service operating between 5:30 a.m. and 8:00 a.m., and again in the afternoon between 3:30 p.m. and 6:00 p.m. Some routes accommodate reverse commute. Off-peak service is available on some routes (between 8:00 a.m. and 3:30 p.m.) Free parking is available at the Park-and-Ride lots throughout the region, and all Xpress buses are wheelchair-accessible and accommodate bicycle storage (GRTA, 2009 (A)). Cobb County Transit and Gwinnett County Transit systems operate several Xpress buses along the I-75 and I-85 corridors. For the purpose of this paper, the term “Xpress bus” will refer to GRTA-operated Xpress buses as well as Cobb County and Gwinnett County buses operating on the interstates and connecting suburban communities with Atlanta CBD and other employment centers of regional importance, similarly to GRTA-operated Xpress buses.

Figure 2.2 below displays of Xpress bus routes currently available (GRTA, 2009 (B)), with Gwinnett buses 101, 102 and 103 and Xpress routes 400 and 412 operating along the I-85 North corridor. Xpress routes 400, and 412 do not offer reverse commute option (GRTA 2009 (C)). Gwinett bus routes 101A and 103A offer limited reverse commute options from Atlanta CBD to Discover Mills, the Mall of Georgia and Briscoe Field; the reverse commute is priced at half of the regular Xpress bus fares, with free transfers from MARTA service if using a Breeze card (Gwinnett County Transit, 2009).

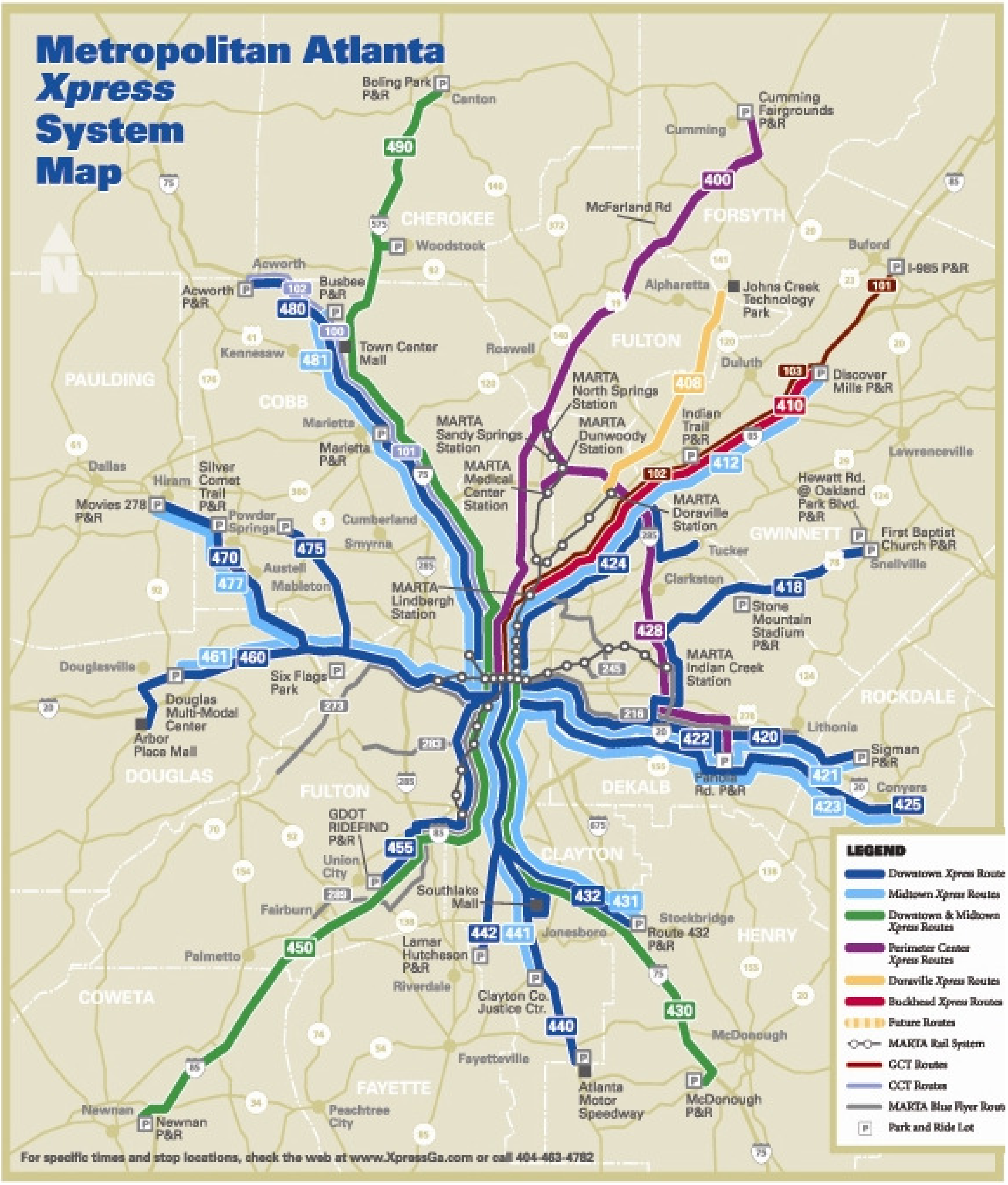

Figure 2.3 Xpress Bus Routes Map.
Source: GRTA, 2009 (B).

Given that $30 million of the federal funding for the HOV-to-HOT conversion on I-85 North will be dedicated to new Xpress buses, and new and improved park-and-ride lots (State of Georgia Office of the Governor, 2008), the transit riders will likely benefit from added options. However, the resulting benefits seen by the income and transportation-disadvantaged populations might be insignificant. Information from 2008 GRTA survey of Xpress bus riders indicates that the majority (83%) of Xpress bus users come from households with more vehicles than drivers available, and 86% of Xpress bus riders accessed the initial transit mode by driving (GRTA, 2009 (D)). 58% of Xpress bus users come from households with annual income over $60,000 and more vehicles than drivers available (GRTA, 2009). Only 3% of 2008 Xpress bus survey respondents came from zero vehicle households, with another 14% coming from households of all income levels where the number of drivers was higher than the number of vehicles (GRTA, 2009 (D)).

In contrast with Xpress bus riders, users of other transit types within the Metropolitan Atlanta region are much more likely to have limited transportation options:

- On average, 65 % of weekday transit riders did not have a car or truck available to make the trip
- 78 % of MARTA bus riders did not have a vehicle available for the trip
- 71 % of CCT riders did not have a vehicle available.
- Over 40 % of MARTA rail riders did not have a vehicle available
- 51 % of Clayton and Gwinnett transit riders did not have a vehicle available to make the trip (Atlanta Regional Commission, 2002).

The Xpress bus riders overwhelmingly take the trip for the purpose of commuting to work: 96% of trips, based on 2008 survey (GRTA, 2009 (D)). Given the respondents' propensity to be in higher-income categories, it appears unlikely that the transportation-disadvantaged population in zero-vehicle, low income households benefits significantly from the Xpress bus options. Looking at the origins (Figure 2.3

below) and the destinations (Figure 2.4) of Xpress bus trips, it appears that the majority of Xpress bus riders originate in the suburbs, and the majority of destinations are concentrated in the Downtown and Midtown Atlanta CBD area, in the Perimeter Center (GA-400 and I-285 intersection), and along the I-75 North and I-85 North corridors. While riders from some of the southern suburbs in DeKalb, Fulton and Clayton counties do appear to take advantage of the Xpress bus system, the inner-city and inner-ring suburb communities with the concentrated minority presence and job-housing mismatch issues are largely absent among the Xpress bus users. This is in agreement with findings from a recent report by The Atlanta Transit Riders' Union (2008), which suggests that "The large coach express buses serve high income riders with cars from the suburbs while regular local buses serve low income riders in urban areas without cars."

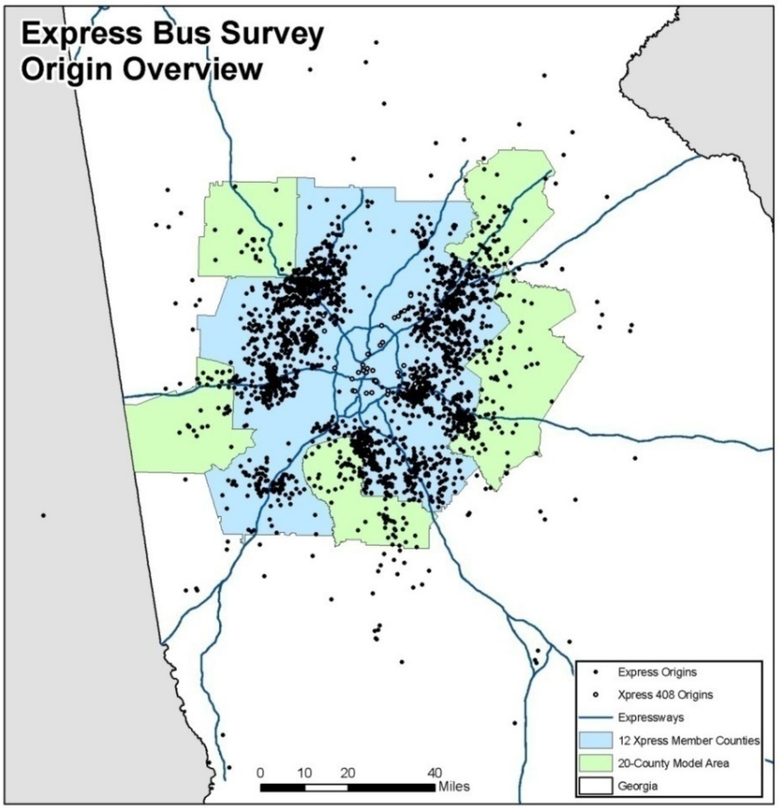

Figure 2.4 Origin Locations of Xpress Bus Riders Surveyed.
Source: GRTA, 2009 (D).

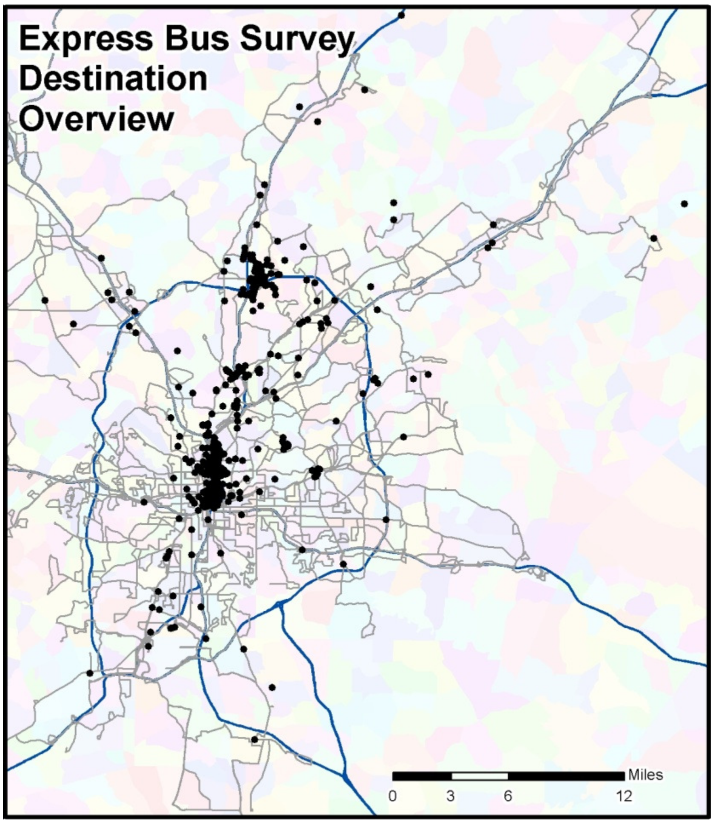

Figure 2.5 Destination Locations of Xpress Bus Riders Surveyed.
Source: GRTA, 2009 (D).

In follow up to the jobs-housing mismatch discussed in the previous section, the GRTA bus rider survey results suggest that Xpress bus system does not currently answer the needs of inner-city job seekers looking for low-entry jobs in the suburbs, especially if such jobs would have a schedule other than nine-to-five. The Xpress bus system is likely serving its desired purpose of providing suburban commuters with additional travel options and relieving congestion on the highways. However, the GRTA Xpress bus survey findings do suggest that committing funding towards Xpress buses as part of the HOV-to-HOT conversion project does not automatically improve the transportation equity with respect to income and geography in the metro Atlanta region. Providing additional funding for feeder bus routes and improving the reverse commute options on the Xpress bus routes throughout the day could help make the Xpress buses more accessible and usable to entry-level job seekers from the inner-city and inner-ring suburbs, as well as accommodate trip purposes other than work trips.

Access to the Internet, Bank Accounts and Credit Cards

Ungemah (2007) indicates that apart from actual monetary costs, other factors such as requiring online transactions, bank accounts, transponders and large up-front investments for every toll user are likely to deter some customers, and that the use of electronic tolling technology is a significant component of equity concerns associated with toll projects. Specifically, Ungemah (2007) suggests that in order to avoid disproportionate effects of obtaining an electronic tolling account, customers should be given the option to obtain a transponder for a low fee, and be able to start an account without using a credit card or a checking account. A Villanova University study found that for low-income users of the SR-91 Xpress lanes, requiring a transponder and a credit card or a checking account was a more significant barrier than the actual cost of using the facility (Parkany, 2005, as cited in Ungemah, 2007).

Just like access to a checking account, access to the internet should not be assumed or required to start an electronic tolling account. A study by Van Horn and Storen (2000) indicates that household income, educational attainment and race are all strong factors in whether households have access to the internet, with households making over $75,000 annually 9 times as likely to have home computer access, as compared with households earning less than $15,000, and whites twice as likely as Blacks and Hispanics to have home computer access. Van Horn and Storen (2000) cite the Office of Technology in describing the effect of technology and Internet access further disadvantaging the already racially and economically segregated communities as "the concentration of poverty and the de-concentration of opportunity."

Schedule Flexibility and Teleworking Options

A Volpe National Transportation Center study found, in evaluating the results of focus groups in Philadelphia and Northern Virginia, that some of the participants perceived equity issues with congestion pricing due to differences in work schedule flexibility: commuters with less flexible work schedule would be unfairly disadvantaged by having to pay for congestion pricing, whereas drivers who could use the highway during off-peak periods would get to use the facility for free (Petrella, et al., 2007). Telecommuting is often discussed in the literature (Salomon and Mokhtarian, 1997) as one of the options available to drivers in lieu of paying a congestion fee or being stuck in congested traffic. However, telecommuting option requires employer's support and might be dependent on home environment that is relatively free from distractions and space constraints (Salomon and Mokhtarian, 1997). Some of the lower-paying jobs (such as service and retail jobs) might be the ones that offer the least opportunity for working from home. As previously discussed, Van Horn and Storen (2000) indicate that the economically disadvantaged, less-educated and racial minority groups are less likely to have access to a home computer and broadband internet, thus prohibiting the groups that might be transportation-disadvantaged from making use of teleworking options, otherwise appealing to them due to lower embedded transportation costs. Therefore, assigning commuter credits for teleworking, to be used towards an HOT lane toll in the future, is not likely to serve the needs of the most income-disadvantaged groups.

Fairness Issues in Current Transportation Funding System

Findings from the focus groups in Northern Virginia and Philadelphia (Petrella, et al., 2007) indicate that the road users are generally not aware of transportation funding sources currently used, other than gasoline taxes. Generally, people do not give transportation funding too much thought, although congestion is an easily identifiable issue (Petrella, et al., 2007). However, the current transportation funding system is at the heart of the transportation equity issue.

Ungemah (2007) indicates that in considering the fairness of a new toll project, the current road finance structure should be taken into consideration. Giuliano (1994) specifies that evaluating the equity impacts of congestion pricing is “only appropriate if it can be compared with existing policy”, and suggests that a full accounting of the current transportation funding sources, an accounting of how those funding sources are distributed different income and interest groups, and a complete analysis of how the benefits (both direct and indirect) from the funding are currently distributed are all necessary steps to a full equity analysis of congestion pricing. While a complete evaluation of the current transportation finance program is outside the scope of this thesis, some of the key factors in current transportation finance will be addressed in this section.

TCRP Report 42 (Transportation Research Board, 1998) traces the inequity in transportation funding by mode in the U.S. starting in mid-twentieth century, and indicates that “one effect of the interstate highway system was to bias transportation investments in favor of building urban limited-access highways rather than pursuing other solutions to urban transportation problems.” Investing in the interstate system led to improved travel conditions by auto, which decreased the number of transit riders and transit revenue, and led to cuts in transit service as a result (Vuchic,1981, as cited in

Transportation Research Board, 1998). The interstate highway funding formula (90% federal, 10% state or local) encouraged U.S. cities in the 1950s and early 1960s to only invest in highway improvements, which led to increased suburbanization of households and jobs, and further disadvantaged transit as a mode (Transportation Research Board, 1998).

Schweitzer and Taylor (2008) indicate that while tax progressivity or regressivity in relationship to income is generally considered, in transportation, regressivity with respect to transportation facility use is more important. While the fuel sales tax might be regressive with respect to income, it is generally progressive with respect to highway use because drivers who drive more miles in larger, heavier vehicles pay more (Schweitzer and Taylor, 2008). Fuel sales tax can be contrasted with a local sales tax dedicated to funding transportation improvements, which is regressive both in terms of income and in terms of transportation use (Goldstein et al., 2001, as cited in Schweitzer and Taylor, 2008).

A Brookings Institute report indicates that user fees, even when accounting for all highway user fees such as tolls, cover less than 60% of the highway revenue, with the balance covered by non-user fees coming from sources like property taxes and local sales taxes (Wachs, 2003). Federal income and corporate taxes are generally progressive, whereas state and local taxes (especially sales and property taxes), are generally regressive (Murray, Chambers, et al., 1999). When comparing implementing congestion pricing with adding a local sales tax to fund transportation, the literature suggests that a local sales tax would be less equitable and burden the lower-income population groups more than congestion pricing (Wachs, 2003; Schweitzer and Taylor, 2008).

Funding of transit presents special issues with respect to equity considerations. Subsidizing transit redistributes income from higher-income population groups to the lower-income population groups (Murray, Chambers, et al., 1999). However, a distinction between walk-accessible and car-accessible transit modes can be made. Currently, the transit subsidies are fairly inequitable in that long-distance, peak-hour, suburban transit trips receive a higher percentage of subsidies, and those types of transit trips are more likely to be undertaken by significantly higher income riders than the other types of transit trips (Murray, Chambers, et al., 1999).

Some sources suggest that a new transportation funding system, based on pay-per-use principle and utilizing congestion pricing would be a more fair way to link user-imposed costs with appropriate fees for using the system (Krusee, 2006, as cited in DeCorla-Souza, 2008). Proposals for fixing the system include creating HOV-C lanes which would give all users some credit towards using those lanes, or possibly tolling all highway lanes in a metropolitan area, while providing improved transit options and discounted access for carpools and vanpools (DeCorla-Souza, 2008).

In addition, a variety of literature sources reviewed suggest replacing the current motor fuel tax with a mileage-based user fee applicable to all vehicle travel, regardless of the fuel used by the vehicle, with fees variable based on the type of roadway, and possibly based on congestion costs imposed on society by users of the facility at the given time of day (Forkenbrock, 2008; Congress of the United States Congressional Budget Office, 2009; NSTIFC, 2009). It is not currently clear how transit and other transportation modes would be funded within the context of a mileage-based user fee system.

Short of a full reform of transportation funding system for the metropolitan areas, a fully equitable system would be unlikely. However, HOT lanes might provide a step in the right direction by equating marginal costs imposed by the highway users with a fee paid by the drivers in exchange for reliable time savings.

Do HOV Lanes Function Efficiently?

Safirova, Gillingham et al. (2003) raise the concern of whether HOV lanes do function efficiently. A steady decline in carpooling rates has been documented, from 19.7% of all work trips in 1980, down to 12.6% of work trips by carpooling in 2000 (U.S. Census, as cited by Safirova, Gillingham et al., 2003). Given that a whole lane at a time has to be allocated to HOVs, a “lumpiness” issue emerges, where an HOV-2 requirement might lead to congestion on the HOV lane, and an HOV-3+ requirement might lead to under-ulitization, and the road capacity is not distributed optimally in either case. On the other hand, an HOT lane allows a self-regulating mechanism through increase and decrease in toll levels, leading to a more optimal utilization of the roadway (Safirova, Gillingham et al., 2003).

Conversion of HOV lanes to HOT lanes generally allows for a better enforcement mechanism. Safirova, Gillingham, et al. (2003) indicate that an average of 17% of the HOV lane users in Northern Virginia are single-occupancy vehicle drivers violating the restrictions. More specific to Atlanta, a 2003 Georgia DOT study indicates that the HOV lanes in the metropolitan Atlanta experience, on average, a 13% SOV violation rate (DataSmarts, 2003). Guin, Hunter, et al. (2008) suggest that the HOV lanes on the I-85 north corridor in Atlanta currently breakdown during peak periods, and the slow speed might be partially due to the drivers’ caution in anticipation of possible illegal merging from the general-purpose lanes.

In the view of current breakdowns during congestions, converting the HOV-2 to HOV-3 requirement would be beneficial for maintaining the free-flow speed (or at least 45-55 miles per hour) on the I-85 Atlanta HOV lane during peak periods. Keeping the

HOV-2 lane on I-85 as it currently functions is not a very good option, because it can no longer guarantee reliable travel times to carpools and Xpress buses. Given the breakdown in I-85 HOV lane travel times, the HOV lane as it stands currently is unlikely to present a strong incentive for people to carpool or take transit. While stricter enforcement of the HOV requirement might remove the extra congestion from the I-85 HOV lane during peak periods, continuous increase in traffic over several years is likely to once again put the pressure on changing the occupancy requirement to 3+, even with better enforcement. For the purpose of this paper, then, it will be considered that raising the occupancy requirement is likely justified for the purpose of efficient functioning of the HOV lane itself, apart from the HOV-to-HOT conversion considerations. Nationwide, several other managed lanes have experienced a need to increase the HOV requirement in the past. For example, Katy Freeway in Houston went from an HOV-2 to an HOV-3 requirement during peak periods in 1988, long before a conversion to an HOT facility (Burris and Stockton, 2004).

Factors suggesting that efficiency should be considered along with equity concerns as a factor in evaluating the I-85 HOV-to-HOT conversion project could be summarized are as follows:

- Efficient use of the HOV facility suggests that the HOV-2+ requirement be raised to HOV-3+ requirement along the I-85 corridor, at least during peak period, as the system is not working as planned, and tends to experience congestion and break down during heavy use times, no longer providing the Xpress buses and carpoolers with a reliable travel time option
- Once the HOV-2 requirement is raised to HOV-3+ requirement, a “lumpiness” issue emerges where there is extra capacity not taken up by 3-person carpools; effectively, raising the carpool requirement to three or more

persons introduced inefficiency, which can only be solved through allowing some SOVs or at least two-person carpools buy their way in

- When equity analysis is conducted at the corridor level, the primary user group that is made worse off in absolute terms is the group of current HOV-2 carpoolers that currently use the existing HOV lane for free and will not be able to use the HOT lane for free under the HOV-3 requirement; however, this group is currently not guaranteed a congestion-free travel time on the I-85 HOV lanes due to the lane breaking down at peak congestion times and might actually see some positive gains from a more reliable travel time with the HOV-2 to HOV-3+ requirement change and the HOT lane introduction, albeit only available to them for a fee
- Opportunity cost for the Pilot HOV-to-HOT conversion pilot project in Georgia is limited because the capital funding coming from the federal government is not very flexible in its nature, and Metropolitan Atlanta would not be able to easily receive a similar pot of money towards other transportation improvements in lieu of the HOV-to-HOT conversion. The state DOT portion of the funding ($37 million) is coming from the motor fuel sales tax, which according to Georgia laws currently has to be spent on roadway projects. However, the situation might be different for future implementation of HOV-to-HOT conversion in Metropolitan Atlanta, and opportunity costs might need to be reconsidered in the future

Congestion Pricing, HOT Lanes and Equity

From the economics perspective, congestion on the roadways occurs because an individual traveler does not take into account the additional costs that her or his trip imposes on the other travelers, thus creating a congestion externality of extra travel time for every traveler using the roadway link at that time (McCarthy, 2001). Congestion pricing (also known as value pricing) allows the transportation facility operator to impose a cost on an individual, roughly equal to the marginal cost to the society of their travel on the roadway at congested times (McCarthy, 2001). When converting an HOV lane to an HOT lane, optimizing the use of the roadway through value pricing might come at the expense of the current carpoolers and "slug" casual carpoolers who might face a shortage of SOVs willing to pick up additional riders if an HOV lane is converted to an HOT lane (Safirova, Gillingham et al., 2003). From anecdotal evidence, casual carpoolers, or "slugs", are a less-present factor in the Atlanta carpooling scene, but they are a significant factor of carpooling strategies in Northern Virginia.

Experience from existing HOT projects in the U.S. suggests that they have a positive effect on general-purpose lanes (Safirova, Gilligham et al., 2003). In addition, evidence from San Diego I-15 Express lanes indicates that guaranteed ride time for SOVs might actually encourage carpooling by giving the carpoolers a sort of "insurance" for travel time in case their ride cannot make it (SANDAG, 1999, and Kim, 2000, as cited in Safirova, Gillingham, et al, 2003). While SR-91 Express lanes in the greater Los Angeles area are predominantly used by higher-income commuters, they do provide a guaranteed travel time option for lower-income commuters in emergency situations (Sullivan, 1998). Safirova, Gillingham, et al. (2003) indicate that one of the arguments in favor of equitable distribution of benefits from HOT lanes is that while the users of such facilities tend to be wealthier, the toll revenue could be partially directed towards public transit, which is more likely to be used by lower-income groups, thus mitigating any inequitable effects present.

A network approach to assessing the impacts of HOT lanes on all travelers is suggested by Safirova, Gillingham, et al. (2003) as preferable to a facility-specific equity analysis approach. When modeling the impact of conversion all of the HOV lanes in the Washington, D.C. area to HOT facilities, Safirova, Gillingham, et al. (2003) found that the general purpose lanes adjacent to the HOT lanes would see a decrease in congestion, while congestion and travel times would increase slightly in the HOT lanes from the current HOV lane status, as an average of 38% of the HOT lane usage would come from SOVs. In addition, Safirova, Gillingham, et al. (2003) predicted the following results, based on the modeling of an HOT network for Washington, D.C. area, and a 20 cents per mile toll charge:

- A small increase in the total number of trips taken in the area affected
- Shifting of some of the local trips to the highway
- Mode shift from carpooling to solo driving (with a 0.42% increase in SOV trips, and a 0.35% decrease in HOV trips)
- Wealthier households showing a stronger travel response, with the highest income quartile SOV trips increasing by 0.5% and the lowest income quartile SOV trips increasing by 0.4%
- Lower-income households benefiting from less congestion on the general-purpose lanes and side roads
- The highest income quartile drivers would pay 53% of the HOT tolls and receive the highest welfare benefits (approximately $51 million worth) as a result of improved travel options
- The lowest income quartile drivers would pay 4.8% of the HOT tolls and receive approximately $3 million worth of welfare benefits, or about 1/17th of the highest income quartile drivers benefits

In a geographic equity analysis, the areas with HOT lane access would benefit, while some regions would see a loss in welfare due to the increased congestion in the inner core, with the gains to those benefitting outweighing the costs to those losing in this situation (Safirova, Gillingha, et al., 2003). The revenue from an HOT network would be relatively small: in the Northern Virginia example, toll revenue from charging 20 cents per mile would be around $40 million, as compared with $641 million in annual funding required for the Northern Virginia 2020 local transportation improvements plan (Safirova, Gillingham, et al., 2003). Based on modeling analysis presented by Safirova, Gillingham, et al. (2003), all income groups would benefit from an HOV-to-HOT network conversion in the Washington, D.C. area; the wealthiest households would benefit the most, but no income category would be a loser; while some geographical areas would suffer a small net welfare loss from the HOV-to-HOT conversion, there would be an aggregate improvement in the citizens' welfare. Depending on the negative impact carried by some geographical areas, such a network-wide conversion of HOV-to-HOT might or might not pass the "hold harmless" criteria based on no group carrying a disproportionate impact, previously discussed in the *Environmental Justice and Equity in the Transportation Context* section of this literature review.

Burris and Stockton (2004) indicate that the current HOT lane users in Houston tend to use the QuickRide (HOT lane) program infrequently (on average, less than 1.5 QuickRide trips per week); 67% of QuickRide trips are for commuting purposes, followed by school trips (11%). Most frequent carpools were with a coworker (at 35% of all QuickRide users), and carpools with a family member (31%) and a child (21%) accounted for over half of the QuickRide users (Burris and Stockton, 2004). HOT lane users in Houston tended to be well-to-do professionals (79% are in households with over $75,000 per year incomes), with the following additional characteristics:

- 61% married with children
- 30% married without children
- 65% in professional and managerial positions
- 64% aged 35-54
- 74% have college degrees
- Evenly divided between male and female drivers (Burris and Stockton, 2004).

A recent Congressional Budget Office report suggests two different options for compensating lower-income groups for disadvantages associated with congestion pricing projects: using full amount of toll revenue to fund alternative transportation modes or routes, or giving credits to low-income drivers (Congress of the United States Congressional Budget Office, 2009). The first option is slightly more realistic, according to the authors of the report, and both have limitations: the first option would not compensate people who choose not to travel altogether, and the second option would require determining who exactly is eligible for a low-income commuter credit, and how to determine the amount of the credit (Congress of the United States Congressional Budget Office, 2009). To develop the thought further, even if the revenue from a congestion pricing project is used to improve transit options and give credits to low-income commuters, it would not help those members of the population who are too young or too old to drive, might be seeking entry-level jobs and cannot find them without access to a vehicle and internet, or maybe would like to undertake leisure or medical trips, and cannot do so because of physical ability or income limitations. For the members of society who suffer from social exclusion, transportation is not the only cause of their situation, and thus additional transportation options alone cannot solve the issues of mobility and accessibility (Rosenbloom, 2009). However, providing viable transportation options is generally a critical step required for other supportive services to be accessible (Rosenbloom, 2009; Kenyon, et al., 2002).

While the I-85 HOV-to-HOT conversion project could potentially make some toll revenue available to other purposes, currently is appears likely that the tolls collected on the 14-mile I-85 North initial HOV-to-HOT conversion corridor would only cover its own operating costs, in combination with covering some additional HERO units and HOT lane enforcement (Vu, 2009). There would likely be a ramp-up period before this project recovers enough in tolls to pay its own operating costs (Vu, 2009). The tolls from the project are not expected to cover the capital investment costs (Vu, 2009). This would limit the compensation options for the lower-income commuters available to the policy makers in conjunction with the project.

Public Perception of Equity Issues Pertaining to Congestion Pricing in the U.S.

Ungemah (2007) suggests that the public perception of congestion pricing fairness, rather than the factual equity considerations, drives the decision-making and project implementation. Thoughtful and thorough public education campaigns could improve the public's perception of a proposed congestion pricing project.

Previous HOT experience in the U.S. shows mixed results, with people generally more accepting of the HOT facilities after their implementation, than prior to implementation. Users already familiar with a tolling or a congestion pricing project in their area are more likely to be accepting of future similar projects (Podgorski and Kockelman, 2006). Relative fairness of tolling as compared to other methods of road financing emerges as favorable in the public opinion polls. Texans (except San Antonio residents) all preferred toll roads to fuel sales tax (Podgorski and Kockelman, 2006).

HOT lanes are generally more preferable in the public opinion than tolled new or existing roads. Texas residents were 52% in favor of HOT lanes, while opposed to tolling in general (Podgorski and Kockelman, 2006).

Lower-income groups tend to approve of HOT facilities, even though they typically have lower usage rates than higher-income groups. A study of SR-91 Express Lanes users soon after the opening of the facility found that over 50% of the respondents in the under $25,000 per year income category were in favor of the Express Lanes (Sullivan, 2000, as cited in Ungemah, 2007). Research on the opinions of I-15 HOT lane users found that while the lower-income group used the HOT lane less frequently, they generally perceived the HOT lanes as fair (Supernak, et al., 2000, as cited in Ungemah, 2007). In studying the public opinion of future expansion of the HOT lanes in San Diego, Redman, et al. (2002, as cited in Ungemah, 2007) found that 60% of low-income respondents were in favor of HOT lane concept, and 78% of low-income respondents believed the HOT lanes to be fair. Those percentages were similar to approval percentages among the higher-income groups (Redman, et al., as cited in Ungemah, 2007).

Focus groups on congestion pricing conduced in Northern Virginia and Philadelphia asked respondents about their perception of replacing a variety of currently used transportation user fees (including vehicle registration) and taxes with a congestion pricing program set up to charge drivers based on the amount of time they drive on the highways during the peak periods (Petrella, et al., 2007). The focus group respondents were given a worksheet to calculate their current transportation fees and taxes, and to calculate their future costs if congestion pricing were to replace the existing tax and fee structure. Petrella, et al. (2007) noted that the equity concerns were brought up in conjunction with congestion pricing, primarily by higher-income, more educated Northern Virginia focus group respondents. Lower-income Philadelphia participants, who were on average of lower incomes than Northern Virginia participants, were mostly concerned with their own potentially higher transportation costs as a result of the new transportation funding system (Petrella, et al., 2007). While those findings clearly suggest that the issues of affordability and equity both are at the forefront of people's thought when confronted with the concept of congestion pricing, there is a big difference between a system-wide transportation funding approach as the one suggested in the Philadelphia and Northern Virginia focus groups, and a corridor-specific project like the HOV-to-HOT conversion on the I-85 in Atlanta.

Potential Negative Impacts of HOV to HOT Lane Conversion on the I-85 North Corridor in Atlanta

Given the importance of protecting the disadvantaged population groups from the disproportionate negative impacts of HOT lanes (equity in terms of environmental impacts), the potential negative side-effects of converting HOV lanes to HOT lanes should be addressed. The potential negative impacts can be divided into typical highway expansion externalities, and HOT conversion-specific externalities. NCHRP Synthesis report 221 categorizes the impacts from highway widening into social, economic and environmental impacts; some of the most typical concerns are as follows:

- Right-of-way acquisition and potential population displacement and destruction to neighborhoods due to a new facility construction
- Impacts on community cohesion
- Impacts on land Use
- Impacts on safety
- Noise impacts

- Air quality impacts, especially for the populations living close to the highways (Harvey, 1996).

In addition, HOV-to-HOT specific concerns include the following potential negative effects:

- Congestion increase for the current highway users
- Forcing some of the HOV-2 vehicles off the lane as the carpool requirement is raised to 3+ persons for free access

In addressing the typical externalities associated with highway projects, no new Right-of-way would be required for this project. Noise impacts have not been extensively studied in regards to a conversion of an HOV facility to an HOT facility; however, given that the HOV lanes are located in the middle of the highway on the I-85 corridor, it is likely that the potential effect on overall noise pollution would be negligible. In relation to the air quality impacts, Georgia Tech modeling of future emissions from the I-85 HOT lane in Atlanta using MOBILE 6 and a newly created MOBILE-Matrix tool showed a very slight increase in the emissions of NO_x, carbon monoxide, $PM_{2.5}$, and PM_{10}, coupled with a small decrease in mass emissions for hydrocarbons (Kall, 2008). The increase in some of the criteria pollutants emissions are due to an increase in VMT on the corridor; however, the magnitude of the projected increase falls within the margin of error of currently used models and would likely not affect the region's clean air standards attainment status (Kall, 2008).

In regards to increased congestion on the general purpose lanes, studies of HOT facilities implemented in the U.S. have shown a negative or a negligible effect on the regular lane congestion, apart from annual increases in congestion that are due to the general year-to-year VMT increase trends in. For example, the I-394 HOT lanes in Minneapolis now carry 33 percent of the corridor peak period volume, as compared with 9 percent before, which resulted in increase of speeds in the general-purpose lanes of up to 15 percent during peak period (K.T. Analytics, Inc. and Cambridge Systematics, Inc., 2008).

In regards to current legitimate HOV lane users, we can separate them into Xpress bus users (traveling from the suburbs to Atlanta CBD), and carpoolers. Carpoolers can be actual formed carpools with a co-worker, or an acquaintance, for convenience, as well as fampools (carpools where multiple family members, often a parent and a non-driving age child, travel together). While the treatment of fampools as legitimate carpools is an debatable issue, brought up by some of the Atlanta Congestion Pricing Response focus group participants, this issue is outside the scope of this paper. The benefits to the Xpress Bus riders should be very clear, as the HOV-to-HOT conversion would ensure free-flow speeds not currently guaranteed on the corridor, and investment of $30 million into additional Xpress buses and improvements to the park-n-ride lots should result in better travel options for the current Xpress bus riders. Impact on the existing 2-person carpools will be further investigated in Chapter 3 (Demographic Analysis) and Chapter 4 (Focus Groups). It should be noted here, however, that converting an HOV-2 lane to an HOT-3 lane (where only three-person carpools receive a free ride) is actually two separate decisions. An HOV-2 lane could easily be converted to an HOT-2 lane, in which case the added enforcement might actually free up some room by shifting off the free riders who are SOVs currently breaking the law and driving in the HOV lane illegally. However, it is also likely that even with added enforcement, an HOV-2 or an HOT-2 lane currently does not have enough capacity to operate efficiently during the peak periods, as the peak flow is limited to 1500 vehicles per lane per hour (Guin, et al., 2008). Several of the Atlanta Congestion Pricing Response focus groups participants mentioned the fact that the I-85

HOV lane gets congested at certain times and does not always save them time. If increasing the HOV-2 requirement to three persons or more is an operational necessity, the equity issue of affecting the HOV-2 carpools is less apparent. However, it might appear to the public that the carpool requirement was raised specifically to “free up some space” to SOVs willing to pay the toll, which would likely have negative consequences. Special attention would have to be paid to separating the two issues in the public mind (HOV-2 to HOV-3 conversion, and HOV-3 to HOT-3 conversion).

To summarize the literature sources reviewed in relationship to equity issues in HOV-to-HOT conversion, there is a consensus in the transportation and environmental justice community that congestion pricing and tolling projects should be considered carefully, to avoid disproportionate impact on the disadvantaged populations. Ungemah (2007) recognizes the following three factors as indicators that the congestion pricing project will ultimately benefit all users, rather than disadvantaging the lower-income and the minority groups:

- Positive spillover effect for all users is created, by tolling a specific facility (i.e. parallel routes would feel a decrease in congestion)
- When the toll charge is lower than the value of time for lower-income drivers (such as when single parents are in danger of being late to a daycare facility)
- When new mobility options are created, without compromising the existing mobility options

It appears that in the situation given (I-85 corridor HOV-to-HOT conversion), typical highway project externalities would not be an issue. While there are potential equity issues associated with carpool occupancy requirement increase to HOV-3+, the carpool requirement standard is more of a matter of engineering judgment, based on providing a guaranteed travel speed of 45-55 miles per hour. Without a guaranteed speed, the very purpose of the HOV lane is diminished as it can no longer provide adequate service for the Xpress buses or carpools of any size. Some of the equity questions that arise in this situation are whether it would be fair that higher-income single-occupancy drivers would be able to buy their way in more often than lower-income single-occupancy drivers and two-person carpools, and whether it is fair to spend such a large sum of capital investment funds on improving the transportation infrastructure for the population groups (both general-purpose lane commuters and HOV lane users) which are already likely better off than some of the transportation disadvantaged residents of Metropolitan Atlanta.

In considering the potential impacts on the current HOV lane users, and the importance of public opinion, the next chapter will analyze the current socio-demographic profiles of HOV lane users, as compared with general highway users and general population in Metro Atlanta. Chapter 4 will then address the existing Metropolitan Atlanta highway users' perception of fairness and equity issues as they pertain to the HOT lanes, as evidenced by the Congestion Pricing Response focus groups conducted during 2008.

CHAPTER 3

METRO ATLANTA I-85 CORRIDOR COMMUTER DEMOGRAPHICS

Defining the Reference Population in Environmental Justice Analysis

Research by Most, et al. (2004) and Sheppard, et al. (1999), as cited in Hartell (2007), suggests that defining the reference area for a project is a very strong factor in determining the outcome of an environmental justice assessment of a transportation project. Hartell (2007) indicates that procedures for determining the reference population for environmental justice analysis are not specified in the EO2898 or other USDOT guidelines. For the purpose of this paper, current users of the I-85 interstate corridor were the considered to be the primary affected population, with general Metropolitan Atlanta population being the larger affected group. As previously mentioned, a full-spectrum transportation equity analysis for the entire metro Atlanta was outside of the scope of this project. Corridor-specific geographic and income equity implications were considered in analyzing the demographics of I-85 typical commuters.

Prior Context of Commuting in Atlanta

Given that the I-85 HOV to HOT conversion project is geared towards easing AM peak and PM peak period congestion, commute to work trips are the primary likely source of congestion during those times. Most non-incident related congestion occurs in the morning and evening due to vehicular travel coincident with typical daytime business opening and closing hours. Peak direction morning and evening commuters would be most affected by congestion pricing activities. Some of the background context for analyzing I-85 peak period commuters in metro Atlanta can be summarized as follows:

- In 2000, 77% of commuters in Atlanta MSA drove alone to work (U.S. DOT FHWA, 2003). 13.6% of commuters carpooled to work, 3.7% took transit, 3.5% worked from home, and the remaining 2.2% walked, biked, or used other means of getting to work (U.S. DOT FHWA, 2003). As extrapolated from ARC travel behavior studies, at least 60% of vehicular trips taken at peak hour are commute-related, either home to work or home to school trips. (Nelson, et al., 2008)
- 53% of Atlanta MSA workers commute to work from a suburban residence to a suburban job location; only 20% of Atlanta MSA workers commute from a suburban location to a central city job location (U.S. DOT FHWA, 2003).
- In 2000, there were, on average, 1.32 vehicles per worker, 1.37 workers per household and 1.8 vehicles per household in the Atlanta MSA (U.S. DOT FHWA, 2003). 7.3% of all households had zero vehicles (U.S. DOT FHWA, 2003).
- Mean travel time to work in Atlanta MSA in 2000 was at 31 minutes, up from 26 minutes in 1990 (U.S. DOT FHWA, 2003).
- Roadway capacity is related to vehicle trips, rather than person trips.
- Only about 60% of highway funding in the U.S. comes from user fees, with the following break-down by type:
    - 34.8% from gasoline tax
    - 19.7% from vehicle taxes/fees
    - 4.4% from tolls (Wachs, 2003).

  The remainder of highway funding is obtained from the general fund, bonds, property taxes, and several other sources (Wachs, 2003).

- Roadway congestion imposes significant costs upon society at large. In 2005 highway congestion resulted in 4.2 billion hours of delay and 2.9 billion gallons of additional fuel used, at a cost of $78 billion to highway users (TTI, 2007, as cited in Congress of the U.S. Congressional Budget Office, 2009).
- A number of methods can increase infrastructure efficiency. Managing transportation demand is more cost-effective, and is a very attractive option as building highway capacity is becoming less feasible (Congress of the U.S. Congressional Budget Office, 2009).
- Removing even a small percentage, such as 5% of cars, off the highways during peak congestion, allows a more efficient operation of the facility, where more cars can flow per lane per hour than under the previous peak congestion conditions (U.S. DOT FHWA, 2006).
- Increasing travel speeds from congested speeds is likely to reduce overall emissions, provide a more reliable trip, and may reduce incidents (related to constant stop-and-go traffic).
- Congestion pricing, as intended to be implemented along I-85, provides incentive to increase vehicle occupancy and will allow faster and more reliable travel times. It will also raise toll revenue sufficient for operating costs, including additional HERO units on the corridor (Vu, 2009).
- Traffic congestion has been an issue in Metropolitan Atlanta for years, and significantly affects the quality of life and business productivity in the region. As of 2005, an additional 96 million gallons of fuel were consumed in Atlanta Metro per year due to congestion, which also accounted for 132 million person-hours of delay per year, and resulted in an estimated $2.58 billion worth of economic losses (TTI, 2007)

- Most of the traffic congestion occurs at peak hours due to the highly directional flow of work place commuters. The demographic and geographic commuter profiles were analyzed for potential effect on equity, as well as potential pricing structure recommendations.

Data Collection Process

Between June and August of 2007, researchers at Georgia Institute of Technology collected license plate data and performed classification counts of vehicles traveling during the morning and evening peaks at key locations along the Interstate 85 corridor in Metropolitan Atlanta. From vantage points atop highway overpasses, the research team recorded license plates for potential commuter vehicles (e.g. cars, light trucks, and small vans) using spotting scopes and voice recorders. For reasons of safety, geographic coverage, and potential longitudinal comparison to previous data collection efforts, the following I-85 overpasses were chosen as observation sites: Beaver Ruin Road, Northcrest Road, Chamblee-Tucker Road, 5th Street, Fair Drive, and Flat Shoals Road. Figure 3.1 depicts the six observation locations.

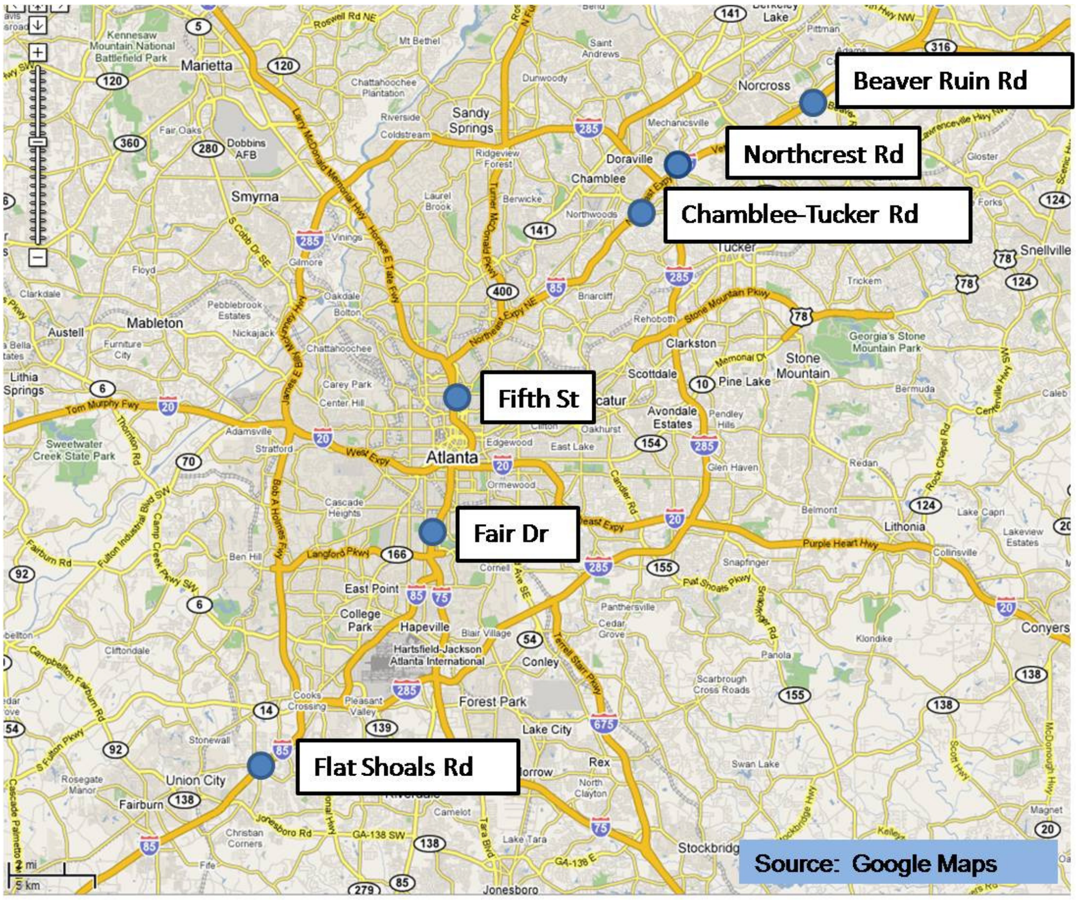

Figure 3.1 I-85 Observation Sites in Metropolitan Atlanta

Over the course of the summer, researchers spent one week at each overpass collecting information for two hours in the morning (7:00 to 9:00 AM) and two hours in the afternoon (4:30 to 6:30 PM) on Monday, Wednesday, and Friday, which corresponds to the peak commute periods during weekdays. During the observation periods, the first hour of analysis was dedicated to the peak direction. For the second hour of analysis during each observation period, researchers switched to the other side of the overpass to record volumes in the reverse direction. The peak direction was defined as the inbound direction, relative to the Atlanta Central Business District (CBD). At 5th Street, where less directionality was observed in terms of traffic volume, AM Northbound and PM Southbound traffic movements were chosen to comprise the peak direction.

At each site, the license plates of vehicles in the high occupancy vehicle (HOV) travel lanes and half of the remaining general purpose lanes were recorded simultaneously. Typically, three travel lanes were recorded at once, with the exception of the Flat Shoals Road and 5th Street locations. I-85 at Flat Shoals Road site has no HOV lane (the only one among the six sites chosen), and so only general purpose lane data were collected for that site. Vehicle classification counts were performed for all of the HOV and continuous (non-weaving) general purpose lanes.

Data collectors were paired in two-person teams and each team was assigned to monitor either the HOV lane or two adjacent general purpose lanes. On each team, one person was tasked with verbally recording the license characters of vehicles in a single lane while the other used a JAMAR count board to classify vehicle types in both lanes observed (only one lane for those assigned to HOVs). The recorders switched lanes halfway through each observation hour to ensure random sampling across the general purpose lanes. Personnel switched roles every 10 minutes to prevent mental fatigue. After each field session, voice recordings of license plates were transcribed to spreadsheets along with classification count data.

Video cameras recorded each session as a quality control measure so that the vehicle classification counts could be repeated in a laboratory setting. Overall, the researchers collected license plate data on approximately 25% – 30 % of passing vehicles compared to the total volumes derived from the count boards. While high vehicular counts made 100% license plate sampling unnecessary, variations in vehicle volume and speed visually obscured some tags, and other vehicles were ignored if they were potentially classified as heavy trucks, airport limousines, or were registered out of state.

Sample Size

A total of 122,348 randomly selected license plates were recorded across all six sites and 110,684 (90.5%) of these were matched to Georgia August 2007 vehicle registration data. While some license plates belonged to out-of-state vehicles or were recorded or transcribed incorrectly, this match rate was significantly higher than that achieved in previous similar efforts (Nelson, et al., 2008) due to the use of higher quality sound recorders and the use of word-based coding for alphabetic characters (e.g., Bravo = B) to record license plate characters in the field.

Repeat observations of some of the license plate numbers were noticed during the study because of same-day occurrences (morning and evening peak) and longitudinal consistency, meaning that drivers had similar departure times and routes for everyday travel. It was also possible for a vehicle to pass under multiple observation points for a trip during the analysis period. Of the matched plates, 90,317 (81.4%, or 73.8% of the overall total) were unique, although there was less duplication at the individual site level. Table 3.1 below indicates the total and unique sample size, by site.

Table 3.1 Original Sample Size, by Site and Lane Type

Observation Site	All Lanes			General Purpose Lanes			HOV Lanes		
	Total	Matched (% of total)	Unique % of total)	Total	Matched (% of total)	Unique % of total)	Total	Matched (% of total)	Unique % of total)
Beaver Ruin Road	24,933	23,160 (92.9%)	20,518 (82.3%)	8,680	17,524 (93.8%)	5,759 (84.4%)	,253	5,636 (90.1%)	5,036 (80.5%)
Northcrest Road	20,266	18,605 (91.8%)	16,472 (81.3%)	5,330	14,052 (91.7%)	2,614 (82.3%)	,936	4,553 (92.2%)	4,056 (82.7%)
Chamblee-Tucker Road	20,281	18,308 (90.3%)	16,262 (80.2%)	5,911	14,426 (90.7%)	2,988 (81.6%)	4,370	3,882 (88.8%)	3,455 (79.1%)
Fifth Street	26,811	23,783 (88.7%)	21,598 (80.6%)	0,487	18,212 (88.9%)	6,706 (81.6%)	6,324	5,567 (88.0%)	5,137 (81.2%)
Fair Drive	15,279	13,664 (89.4%)	12,255 (80.2%)	1,944	10,721 (89.8%)	9,698 (81.2%)	3,335	2,943 (88.2%)	2,671 (80.1%)
Flat Shoals Road	14,778	13,164 (89.1%)	11,772 (79.7%)	4,778	13,164 (89.1%)	11,772 (79.7%)		-	-
Site Specific Total	122,348	110,680 (90.5%)	98,877 (80.8%)	7,130	88,099 (90.7%)	79,537 (81.9%)	25,218	22,581 (89.5%)	20,355 (80.7%)
Non-Site Specific Total		-	90,315 (73.8%)		-	73,524 (75.7%)		-	18,904 (75.0%)

The sum of unique tags observed in HOV lanes and unique tags observed in general purpose lanes does not equal unique tags observed in "all lanes" because some vehicles (1000+) were observed in multiple lane types. This indicates that either multi-person vehicles are using general purpose lanes, or that the occupancy of a given vehicle changed on a day-to-day basis while maintaining the same approximate commute pattern.

Overview of the Analytical Procedures

Vehicle registration addresses associated with each matched license plate observation were geocoded to obtain latitudinal and longitudinal coordinates. These coordinates were then spatially joined to census block groups and associated US census data, assuming that vehicle owners and observed vehicle drivers are the same or otherwise share a household. Census 2000 SF3 data were used for demographic analysis due to SF3 files containing the highest sample rate of all recent Census data collection efforts, and the lowest internal margin of error. More recent data would be preferable due to the socioeconomic and geographic changes that Metropolitan Atlanta has undergone over the last decade; however, these data are not available at the block group geography with a reasonable degree of accuracy.

A number of statistical and spatial procedures were used to quantify and visualize the demographic and geographic characteristics of peak period I-85 users. The demographic characteristics evaluated include the census categories of household income, travel time to work, and travel mode to work at a block group level. As the primary means of analysis, a Chi-Square test is used to compare the demographics of block groups with a certain frequency of vehicle registration address observations to the overall un-weighted block group characteristics. In other words, this paper analyzes what is observed versus what is expected, and whether there is any significant difference between them.

The vehicle registration address coordinates serve as a proxy for the trip origins of observed vehicles. According to Granell (2002), at least two-thirds of vehicles originate from the address at which they are registered, with lower-density residential parcels having higher percentages of vehicles coming from these addresses. Reasons that vehicles would be registered in one location while being primarily used at another include: company-owned vehicles are driven by employees between various starting and ending points, in-state college students live on campus but maintain their home address when registering their vehicles, vehicle registrations have not been updated to reflect recent household moves, vehicle owners intentionally register vehicles in locations with lower insurance rates due to territorial pricing, and travel related to personal relationships. Within ArcGIS, Network Analyst and measurement tools are used to determine how far vehicles have hypothetically driven prior to being observed, and to depict the overall geographic distribution of likely commuter households in relation to the metro area and I-85 corridor. The methodology for both analyses was developed by Nelson, et al. (2008). Statistics and analyses are presented, by site, for peak direction travel in both general purpose and HOV lanes.

Methodology: Selecting the Analysis Geography for Each Observation Site

When mapping all geocoded home registration addresses of observed license plates, almost every county in Georgia was represented. Researchers used a multi-tier approach to narrow down the appropriate analysis geography for each site.

Limiting the Initial Geographic Scope to 73 North Georgia Counties

The primary intent of the research was to define the characteristics of typical commutes in Atlanta and demographic characteristics of I-85 corridor commuters. To accommodate this, the geography was restricted to only those areas in North Georgia, as defined by all the census block groups within the 73 counties north of the Columbus, Macon, and Augusta MSAs. License plates registered to Columbus, Macon and Augusta MSAs and counties south of them likely belonged to drivers passing through Atlanta, rather than living and working there due to the distance between these locations. A total of 86,569 unique registration addresses were located in the 73 northern counties.

Using Block Groups as the Primary Unit of Demographic Data

Census block groups were selected as the unit of demographic data analysis, because certain demographic elements of the Census long form data are available at the block group level for Census 2000, but not always at the block level (due to privacy concerns). Block groups typically contain between 600 and 3000 households and do not cross state or county boundaries. A given block group belongs to one, and only one, census tract. While Census 2000 data are somewhat outdated for the Metropolitan Atlanta region, especially considering the fast rate of population growth in many of the counties, American Community Survey data do not currently exist at the block group level and sampling method concerns make the data less reliable for the analyses conducted in this research. Therefore, Census 2000 SF3 data at the block group level were the best source of demographic data available at the time of this analysis.

Ranking the Block Groups by Unique License Plates per Household Observed for Each Site (Peak Direction)

Within the 73 Northern counties selected, a further narrowing of geography (i.e. the commutershed) applicable to each site, for peak direction, was based on rank order analysis by ratio of unique tags observed to the number of households in each block group. The researchers debated between using total observations per block group and unique observations as a proportion of households per block group (based on 2000 Census) as the ranking criteria. When a Spearman Rho test was performed, a high correlation coefficient (0.887) was observed between rankings of block groups using the two distinct methods (See Table 2 below). The ratio of unique observations to number of households per block group was chosen to be the ranking criteria for this analysis so that the data would not be biased towards block groups with larger populations.

Table 3.2 Results of Spearman's Rho Correlation Analysis for Block Group Order by Total Observed License Plates and by Unique License Plates Observed per Number of Households.

Spearman's Rho Analysis	
Correlation between rank by unique tags observed per number of households in a BG and rank by total unique tags observed in a BG	0.887*
Number of ranked BG's	2748
Significance (2-tailed)	0.000
*significant at the 0.01 level (two-tailed)	

Excluding the Block Groups with Zero Households

Three block groups with observed vehicle tags were not usable in the rank order analysis and subsequent demographic analysis because they did not contain any households, according to the 2000 census. Two block groups were located in Clayton County near the airport, and the third was in Fulton County encompassing parts of the Georgia Tech campus and Midtown Atlanta west of West Peachtree Street. Rental vehicles most likely comprise the observations registered in the Clayton block groups. The Fulton County block group was recently developed and likely had very different demographic characteristics at the time of 2000 Census. Midtown Atlanta has undergone a significant influx of investment over the past ten years, with many previously blighted areas now including new office and residential buildings. It was concluded that the Fulton County block group in question simply had no residences in 2000 outside of university dormitories, for which demographic data by household are not recorded in the Census long form. A total of 667 vehicle observations (corresponding to 627 unique tags out of 98,877 unique tags matched to valid addresses) were taken out of the sample, which corresponds to 0.63% of unique matched tags. Figure 3.2 below illustrates the location of the three block groups that were excluded from the demographic analysis due to the absence of recorded households as of 2000 Census.

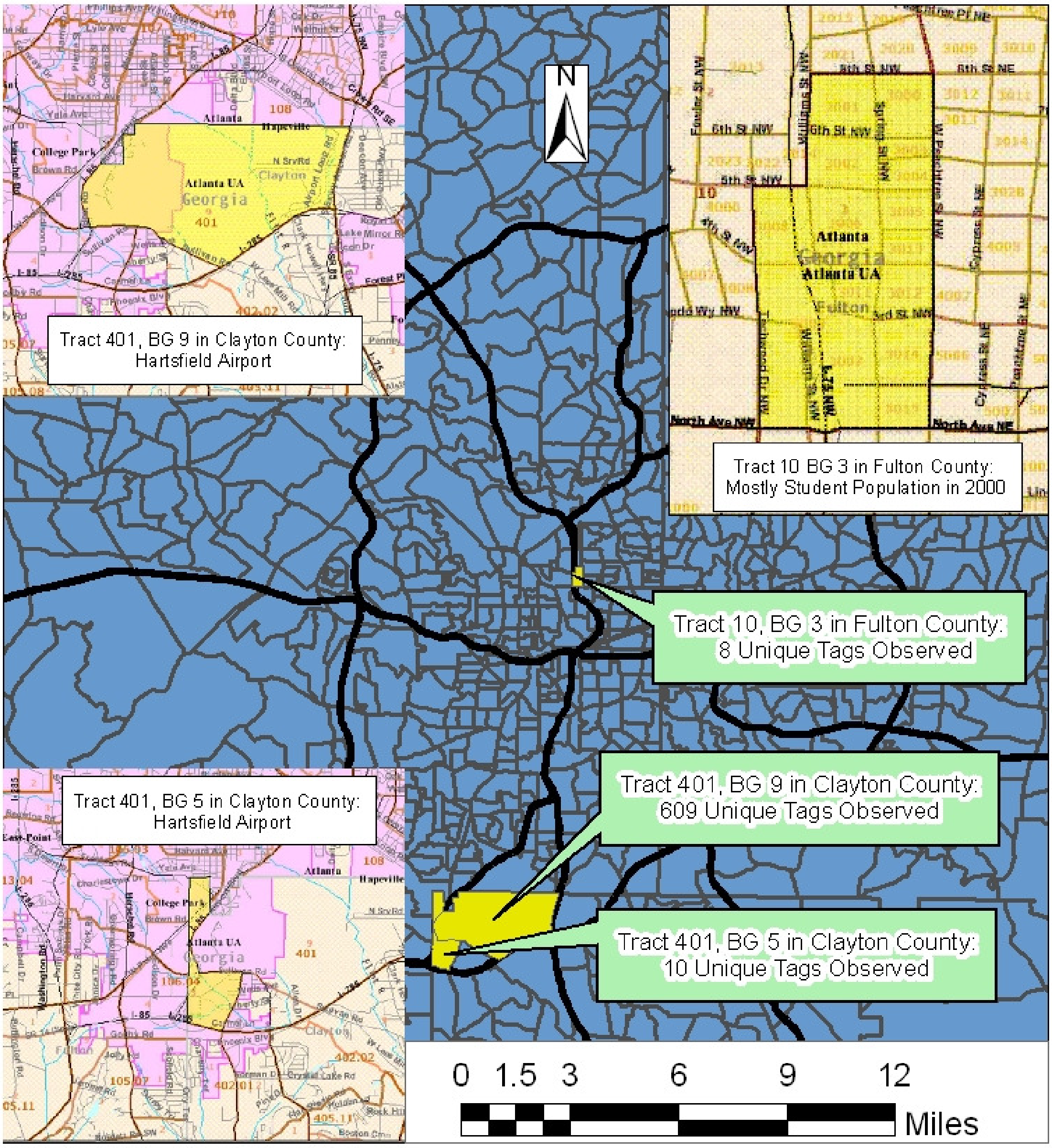

Figure 3.2 Map of Three Block Groups Excluded from Rank Order Analysis

Selecting the Base Geography Block Groups Using ESRI ArcGIS 75th Percentile Directional Distribution Ellipse for Each Site, Peak Direction

In selecting the geography for the analytical work, the total license plates observed by block group for each observation site, in the peak direction only, were mapped to census block group. This resulted in the creation of six datasets (one for each site), internally ranked by the ratio of block group observations to the number of households within that block group. The weighting ensures that small nearby census blocks from which a large percentage of vehicles were observed are not displaced in the analysis by larger, remote census block (e.g. Macon, GA) from which more total vehicles may have been observed simply because these vehicles remain registered in that remote block group. The demographic characteristics of these remote regions do not really represent the commutershed. Applying cumulative percentages, the top 75% of observed block groups in each data set (75% by total observations, after ranking the block groups by observations per number of households) were designated as the basis of further spatial analysis applied in ArcGIS to select a relatively contiguous "commuter" and base geography.

A Directional Distribution Ellipse, also called Standard Deviational Ellipse, is drawn around the mean center of a group of selected features, such as the top 75% of block group observations. Within ArcGIS, "the (Standard Deviational Ellipse) method calculates the standard deviation of the x coordinates and y coordinates from the mean center to define the axes of the ellipse" and the elongation direction of the ellipse is informed by the distribution of the features (ESRI, 2008). One of the goals of the Ellipses process was to select the block groups with a high percentage of vehicles observed for the block group size. Figure 3.3 below illustrates the cumulative distribution of peak direction block group observations for each site, with the 75th percentile block group ranking cutoff chosen based on the shape of the curve, where it was starting to flatten out. Selecting the 75% value dictated the shape of the directional distribution ellipse, thereby eliminating what some might term "geographic outliers." For all sites except Fifth Street, approximately 300 block groups comprised 75% of tag observations. The Fifth Street site serves a larger commutershed; multiple highways feed into the Fifth Street observation site.

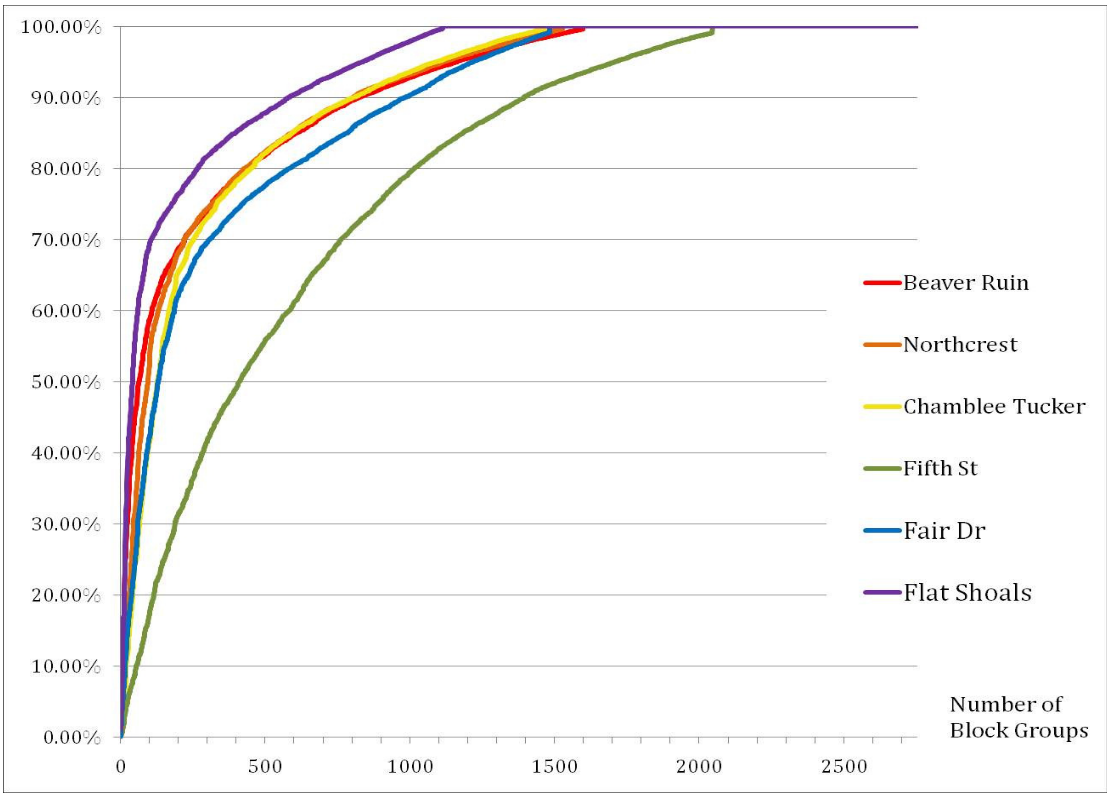

Figure 3.3 Cumulative Distributions of Block Group Observations, By Site

As detailed in Appendix A**,** ellipses encompassing the census block groups that form the main body of the commutershed were created for each site. As described earlier, the data set used in the ellipse analysis included only 75% of the original observed data. The first cut was made to remove data representing vehicles that are used in the commutershed, but registered elsewhere in the state, outside of the 73 Northern Georgia counties selected as the likely counties of origin for work trips to metropolitan Atlanta area (following the logic described in Granell, 2002). The ellipse methodology then identifies the elliptical area encompassing one standard deviation around the mean center of spatial distribution of all the block groups, weighted by total observations in each census block group.

Weighting each block group by observation frequency allows comparisons to be made between the base geography demographics and typical I-85 user demographics for a specific site and type of lane. Once an ellipse for each site was created in ArcGIS, all the block groups with centers falling within the ellipse, where at least one tag observed at the specific site during peak direction travel, were selected to constitute the selected base commutershed geography for each site. The final sample sizes used in analysis are shown in Tables 2 and 3. As previously mentioned, 650+ observations were removed because the block groups where certain observed vehicles were registered to contained no households. A total of 40,126 observation records were used as the basis for the remaining analysis in this study (as compared with 110,680 total matched tags, observed in both peak and reverse directions.)

Table 3.3 Number of License Tags Matched to an Address within the Representative Commuter Geography, and Corresponding Census Block Group Characteristics

Observation Site	All Matched Observations			Reduced Geography	Census 2000 Composition		
	Total	Peak (% of total)	Reverse (% of total)	Peak (% of matched peak)	BG	# HH	Total Pop
Beaver Ruin Road	23,068	13,899 (60.3%)	9,169 (39.7%)	8,692 (62.5%)	195	213,208	617,628
Northcrest Road	18,516	12,321 (66.5%)	6,195 (33.5%)	7,696 (62.5%)	218	218,071	620,652
Chamblee-Tucker Road	18,225	10,661 (58.5%)	7,564 (41.5%)	6,585 (68.1%)	232	234,997	662,766
Fifth Street	23,577	12,322 (52.3%)	11,255 (47.7%)	7,233 (58.7%)	928	725,083	1,891,993
Fair Drive	13,527	8,381 (62.0%)	5,146 (38.0%)	5,121 (61.1%)	409	310,697	856,631
Flat Shoals Road	13,100	7,867 (60.1%)	5,233 (39.9%)	4,799 (61.0%)	113	101,068	282,815
TOTAL	110,013	65,451 (59.5%)	44,562 (40.5%)	40,126 (61.3%)	-	-	-

Table 3.4 Number of License Tags within Representative Commuter Geography by Lane Type

Observation Site	Total Number of Peak Direction Observations	General Purpose (% of total)	HOV (% of total)
Beaver Ruin Road	8,692	6,302 (72.5%)	2,390 (27.5%)
Northcrest Road	7,696	5,442 (70.7%)	2,254 (29.3%)
Chamblee-Tucker Road	6,585	4,962 (75.4%)	1,623 (24.6%)
Fifth Street	7,233	5,624 (77.8%)	1,609 (22.3%)
Fair Drive	5,121	3,792 (74.0%)	1,329 (26.0%)
Flat Shoals Road	4,799	4,799 (100.0%)	-
TOTAL	40,126	30,921 (77.1%)	9,205 (22.9%)

Results of Demographic Analysis

Once the base geography was selected in ArcGIS, the selected block groups were linked with U.S. Census 2000 Long Form (SF3) data to perform demographic analysis on typical demographic characteristics of I-85 commuters. Chi-square tests were performed to measure the probability that the differences between the demographic characteristics of the selected base geography, weighted by the number of observations per block group, compared with average values for the block groups within base geography, occurred by chance. A 95% confidence level was employed in the analysis.

A number of limitations exist in using Census data at the block group level: limitations due to age of Census Data (as many of Atlanta's metropolitan area counties experienced high growth rates over the past decade, many variables might have changed); limitations due to inferring a link between the block group U.S. Census demographic attributes and the commuter household demographic attributes; inaccuracies in vehicle registration data; changes in congestion levels over the past decade; and changes in commuters' mode share over the past decade. With these limitations in mind, the researchers proceeded to analyze the selected base geography demographic data, accounting for HOV lanes and general purpose lanes separately (except for I-85 at Flat Shoals Road, where no HOV lane currently exists).

Results for the Entire I-85 Corridor (All Six Sites): Household Income

When comparing the demographics of I-85 peak period peak direction commuters with the expected demographics of an average resident within the selected base commutershed geography, interstate users do exhibit a significant difference in income. As shown in Figures 3.4 and 3.5 below, the I-85 general-purpose lane and HOV lane users have a higher representation among the block groups with median annual household income in the $50K to $200K range than would be expected for a typical resident of the selected base geography. The lower household income categories (less than $25K and between $25K and $49.9K per year) are less well represented among the I-85 interstate users (both HOV and General-purpose lanes) than would be expected for typical residents of the selected base geography. When analyzing the results for peak period peak direction observations and associated demographic profile for combined data from all six sites, no statistically significant differences emerge between income levels of General-purpose lane drivers and HOV lane users (see Figure 3.6).

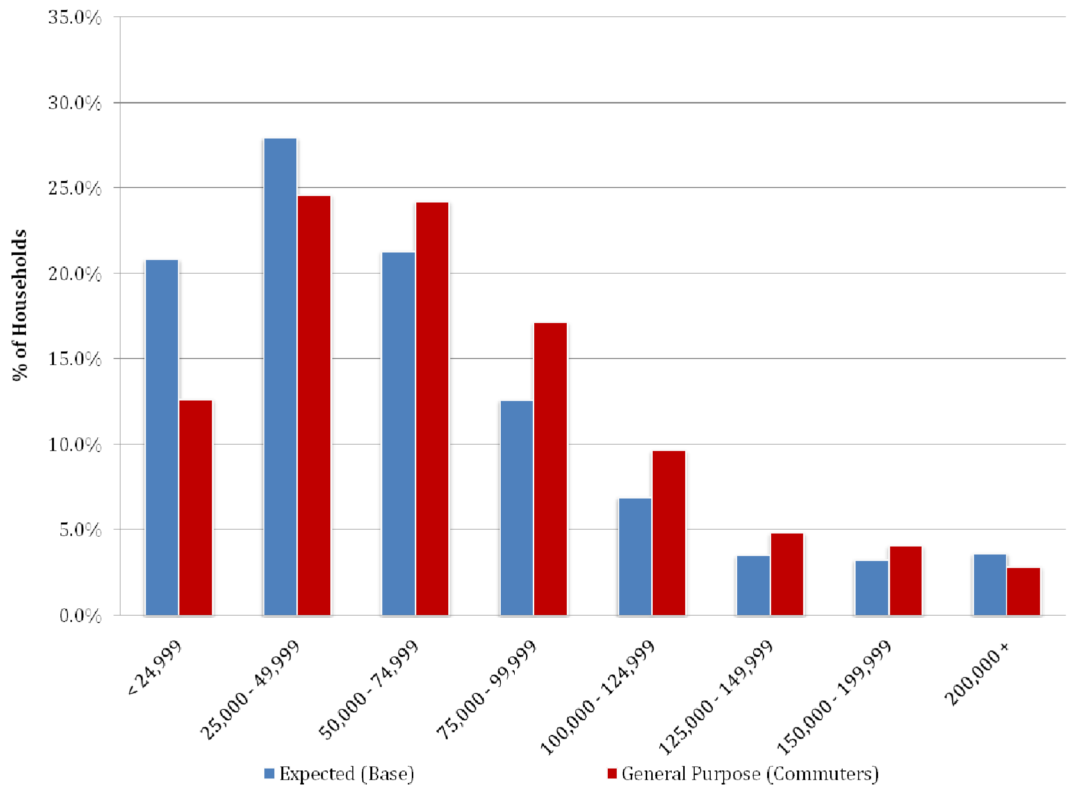

Figure 3.4 Expected versus General Purpose Lanes Observed Household Income Distribution for Peak Period/Direction Observations, All Sites (GP Count = 30,921)

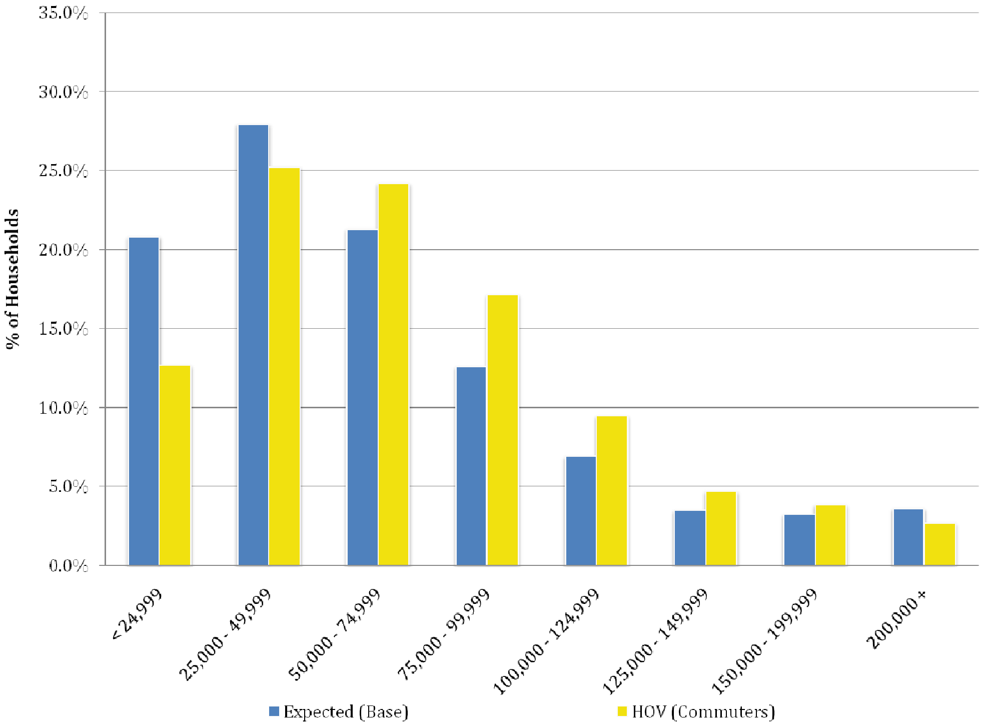

Figure 3.5 Expected versus HOV Lane Observed Household Income Distribution for Peak Period/Direction Observations, Five Sites* (HOV Count =9,205; *no HOV lane at Flat Shoals Site)

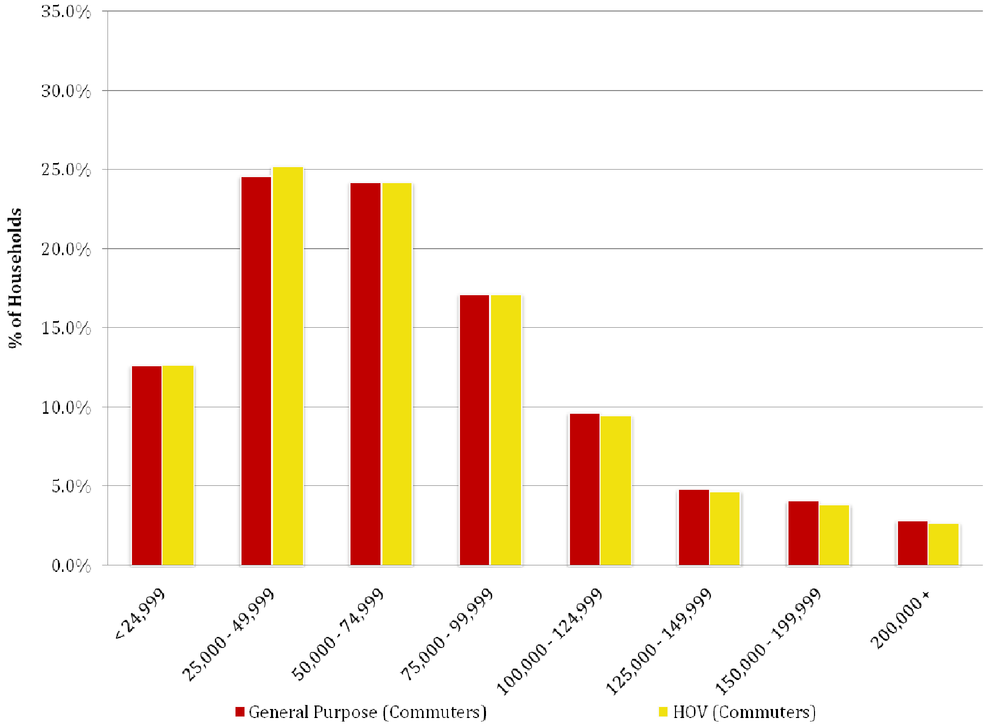

Figure 3.6 General Purpose and HOV Lane Observed Household Income Distribution for Peak Period/Direction Observations, All Sites (GP Count = 30,921 and HOV Count =9,205)

Figure 3.7 below displays the combined results of expected base geography income distribution, general purpose lane peak period peak direction income distribution, and HOV lane peak period peak direction distribution. It can be noted that where present, the difference between the general purpose lane users and the HOV lane users is much smaller than the respective difference between all highway users and expected base geography income distribution.

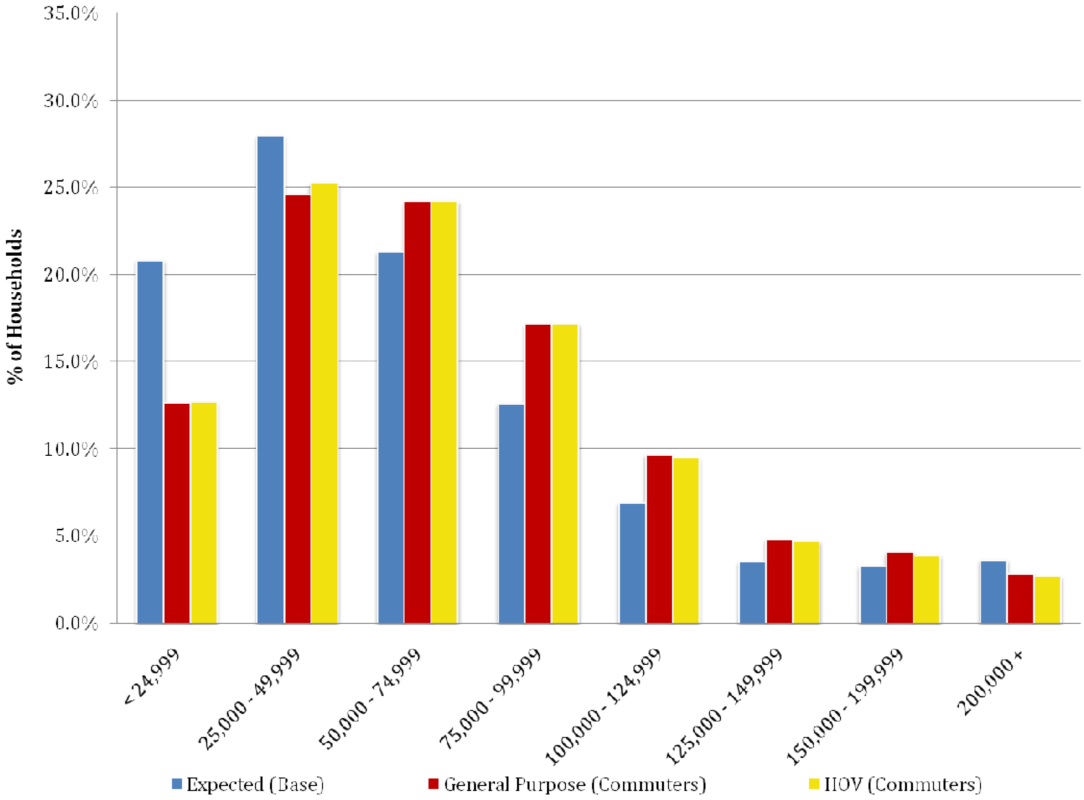

Figure 3.7 Expected versus Observed Household Income Distribution for Peak Period/Direction Observations, All Sites (GP Count = 30,921 and HOV Count =9,205)

Table 3.4 below further illustrates the income differences between the expected demographics and the observed I-85 commuter demographics. Both the General-purpose lane users and HOV lane users exhibit higher than expected representation among the income bins starting at $50K per annum, and lower than expected representation among the income bins below $50K per annum. The Chi-squared test proved the difference from expected income values significant for both the General-purpose commuters and HOV lane commuters.

Table 3.5 Expected versus Observed Income Distribution for Peak Period Observations, All Sites

Census 2000 Data		General Purpose (n = 38,177)			HOV (n = 11,409)		
Income Bin	**Midpoint**	**Expected**	**Observed**	**% diff**	**Expected**	**Observed**	**% diff**
<10,000	5000	2203	1379	-37.4%	658	407	-61.7%
10,000 - 14,999	12500	1278	922	-27.9%	382	278	-37.6%
15,000 - 19,999	17500	1537	1151	-25.1%	459	344	-33.6%
20,000 - 24,999	22500	1868	1459	-21.9%	558	442	-26.3%
25,000 - 29,999	27500	2046	1643	-19.7%	612	505	-21.2%
30,000 - 34,999	32500	2204	1851	-16.0%	659	570	-15.6%
35,000 - 39,999	37500	2186	1906	-12.8%	653	589	-11.0%
40,000 - 44,999	42500	2171	2027	-6.7%	649	621	-4.5%
45,000 - 49,999	47500	1953	1925	-1.5%	584	577	-1.1%
50,000 - 59,999	55000	3747	3835	2.4%	1120	1151	2.7%
60,000 - 74,999	67500	4656	5333	14.5%	1392	1589	12.4%
75,000 - 99,999	87500	5136	6438	25.3%	1535	1919	20.0%
100,000 - 124,999	112500	2901	3668	26.4%	867	1078	19.5%
125,000 - 149,999	137500	1506	1860	23.5%	450	542	16.9%
150,000 - 199,999	175000	1379	1586	15.0%	412	455	9.4%
200,000 +	300000*	1404	1196	-14.9%	420	344	-22.2%
Mean	-	69,590	75,031	7.82%	69,590	74,208	6.64%
Median	-	54,381	62,786	15.46%	54,381	62,093	14.18%
P(Chi-Squared)	-	-	0.0000	-	-	0.0000	-

*The median HH income for the $200,000+ bin was estimated to be $300,000, due to lack of additional census data. This estimate affects the grouped mean value only.

When further examining the difference in income between General-purpose lane users and HOV lane users, the HOV lane users do tend to have slightly higher representation among within the under $25K income bin and within the $25 to $50K income bin, as compared with general-purpose lane users (see Table 3.5 below.) While the percentage difference might indicate that the HOV lane users have slightly lower incomes than the general-purpose lane users, this difference is not statistically significant, as indicated by the chi-squared test at the 95% confidence level.

Table 3.5 Difference in Annual Household Income between General-purpose lane and HOV Lane Users for all Peak Period Observations, All Sites

Income Bin	General Purpose	HOV	Difference, GP over HOV
< 24,999	12.86%	12.89%	-0.03%
25,000 - 49,999	24.50%	25.08%	-0.58%
50,000 - 74,999	24.01%	24.02%	0.00%
75,000 - 99,999	16.86%	16.82%	0.04%
100,000 - 124,999	9.61%	9.45%	0.16%
125,000 - 149,999	4.87%	4.75%	0.12%
150,000 - 199,999	4.15%	3.99%	0.17%
200,000 +	3.13%	3.01%	0.12%
Probability of Observed Difference (Chi-squared)	0.8299		

Results for the Entire Corridor: Travel Time to Work

When analyzing the travel time as of 2000 U.S. Census, both the general-purpose lane and the HOV lane I-85 commuters exhibit higher than normal representation among the group that works from home, and among the commuters who report spending 40 to 90 minutes to commute to work one way. On the other hand, I-85 commuters are under-represented among the group of commuters that report 10 to 40 minutes times for travel to work. Figure 3.8 below illustrates the travel time differences. This finding appears reasonable, given that commuters who take less than 40 minutes to get to work are less likely to use the Interstate, or may only use the interstate for a small portion of their journey. On the other hand, employees with longer commutes are more likely to have to use the interstate for a significant portion of their trips. Higher incomes often allow greater flexibility in work schedule which would explain a higher percentage of those working from home among block groups with more I-85 commuters. For example, an average of 47.9% of engineers and managerial workers in the U.S. have a flexible work schedule, as compared with 11% of machine operators, 19.% of construction labor, and 24% of administrative support personnel (Golden, 2001). Although the HOV lane users appear to experience a slightly higher percentage of commutes in the 40 to 90 minutes category than the general-purpose lane users, the difference between travel time for general-purpose lane commuters and HOV lane commuters is not statistically significant based on chi-squared probability result of 0.677. This is not surprising, given that the HOV users must coordinate ridesharing with passenger pick-ups and drop-offs and given that the HOV lane on the I-85 is often becomes congested and breaks down during peak periods (Guin, 2008). The percentage of extreme commuters (those with travel times over 90 minutes) is fairly small among both the HOV lane commuters and general-purpose lane commuters, at around 3%. Extreme commuters proportion observed among the highway users is slightly smaller than would be expected (although the difference is not statistically significant), which echoes the previously-discussed findings in the literature that extreme commuting is a constrained choice, negatively correlated with an increase in income (Marion and Horner, 2007).

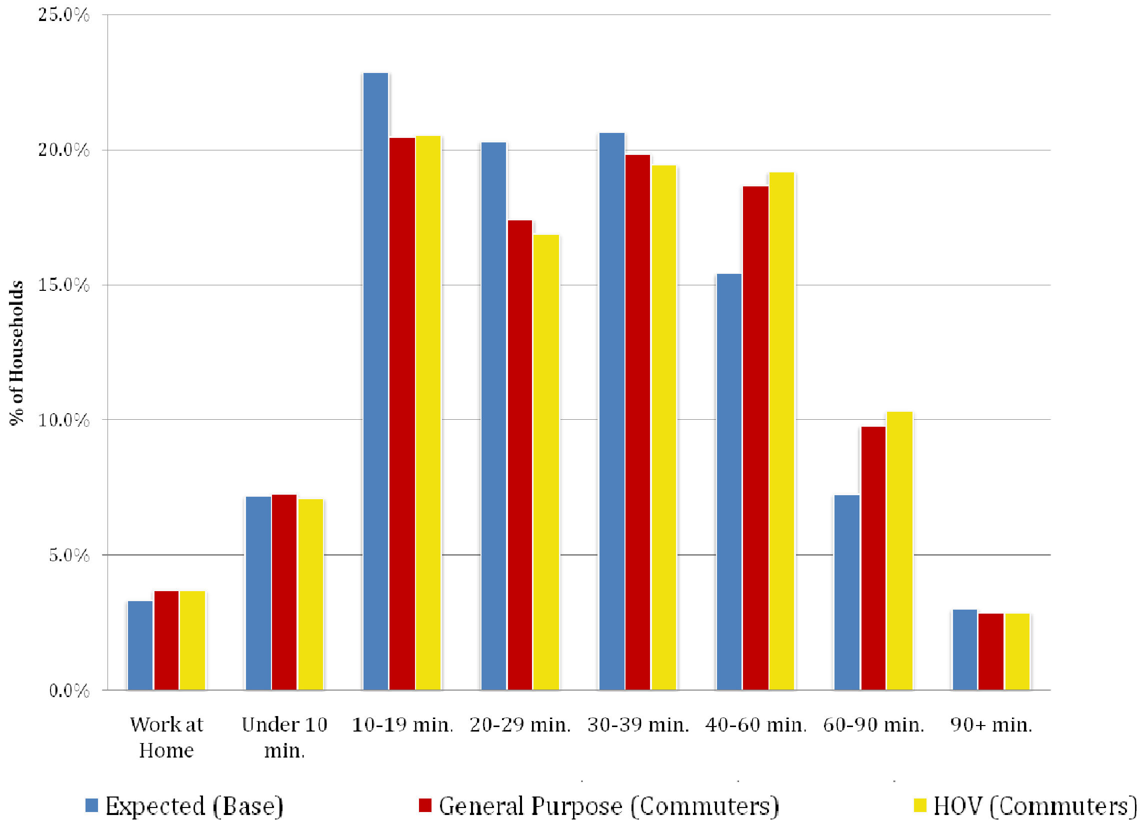

Figure 3.8 Travel Time to Work for Peak Period Observations, All Sites
(GP Count = 30,921 and HOV Count =9,205)

Results for the Entire Corridor: Commute Mode

When analyzing the I-85 commuter license plate-linked U.S. Census data for travel mode, it appears that carpooling is slightly underrepresented among both the peak hour general-purpose lane users and the HOV lane users, as compared with the general population. As seen in Figure 3.9 below, public transit and non-motorized vehicle use are also under-represented among the I-85 corridor commuters.

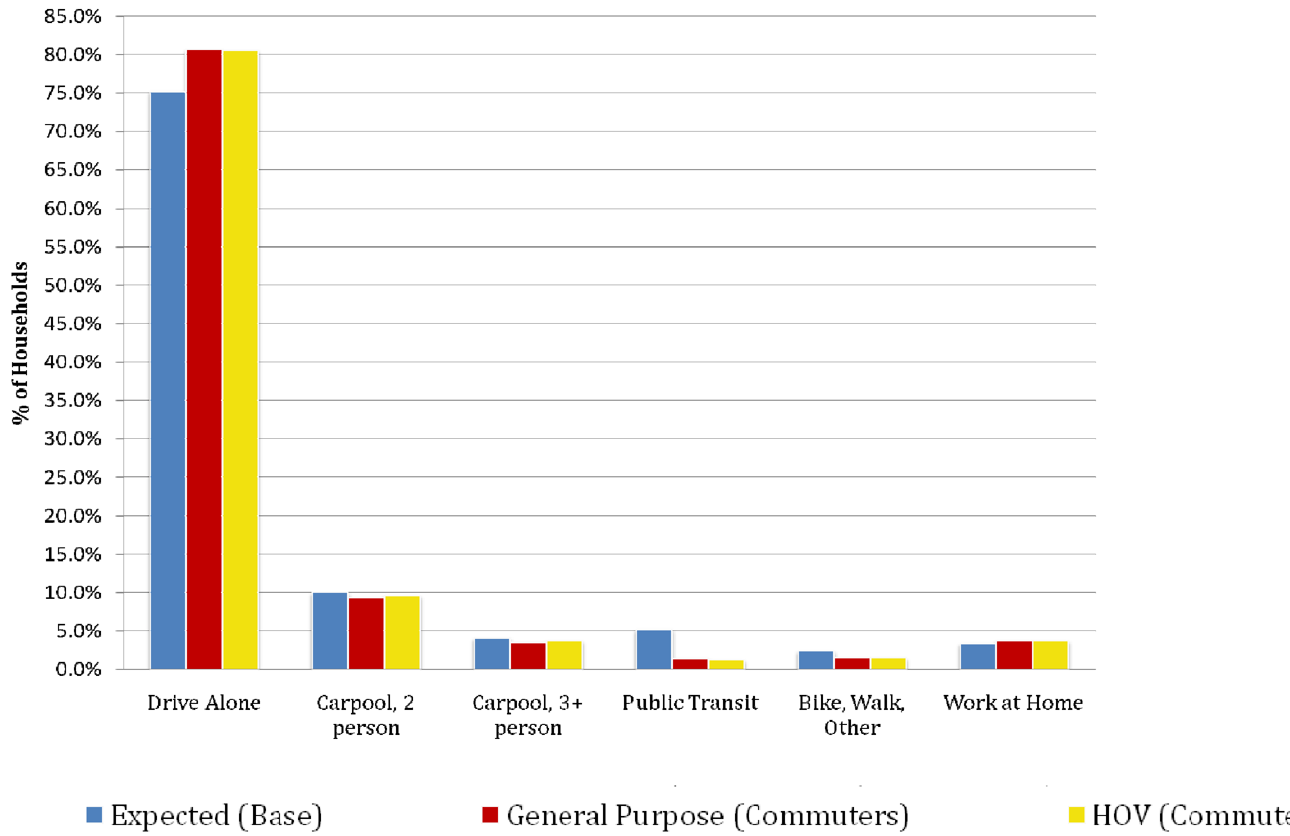

Figure 3.9 Non-Single Occupancy Vehicle Modal Use for Peak Period Observation, All Sites (GP = 38,177 and HOV = 11,409)

Differences between Individual Sites by Household Income

When breaking down the demographic analysis by site, the overall findings were also generally true for each specific site. Statistically significant differences exist between all I-85 peak period peak direction users and typical residents of selected base geography for income, travel time and mode choice. Figure 3.10 below illustrates the Beaver Ruin Road site observed income differences from expected values for general-purpose lane users, HOV lane users, and combined.

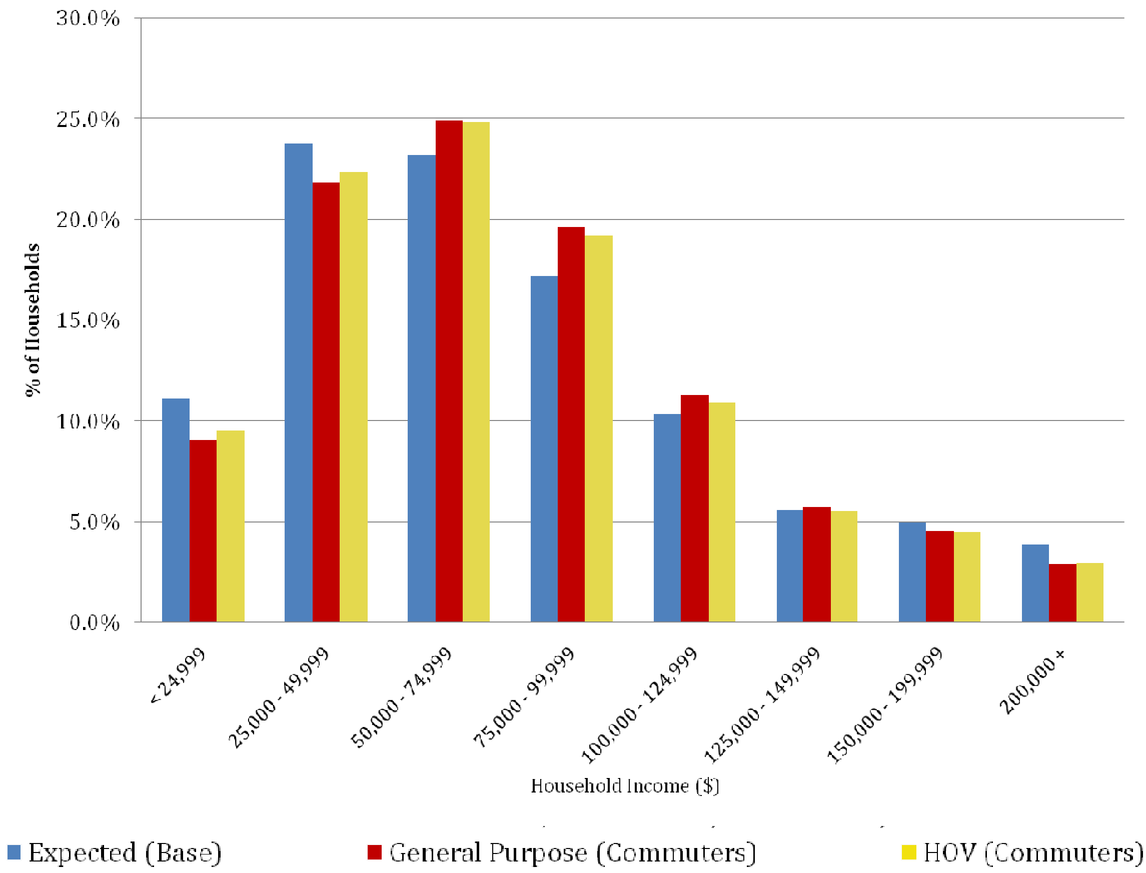

Figure 3.10 Beaver Ruin Expected versus Observed Household Income Distribution for Peak Period/Direction Observations (GP=6,302; HOV=2,390)

When comparing the income distribution across six different sites, the three northern sites display very similar characteristics. Fifth Street and Fair Drive exhibit similar characteristics (due to selection of AM Northbound and PM Southbound as peak directions for Fifth Street), which are somewhat different from the three northern sites; and Flat Shoals site is similar to the three northern sites, and very different from the Fifth Street and Fair Drive sites in income distribution. As you can see in Figure 3.11 below, the general-purpose lane commuters at the three northern sites tend to exhibit higher incomes than the general-purpose lane commuters at Fifth Street and Fair Drive sites. Flat Shoals general-purpose lane commuters are more similar to the three northern sites in their income characteristics.

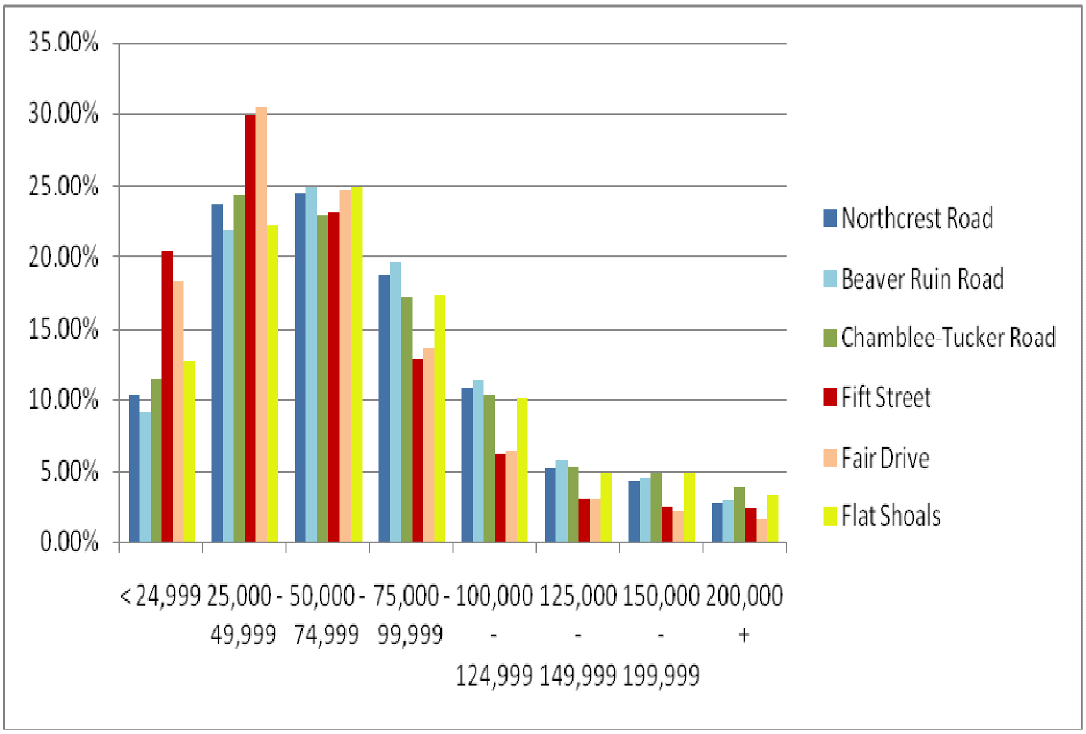

Figure 3.11 Comparison of Income Bins for General-Purpose Lane Commuters Across Six Sites

Figure 3.12 below groups the three northern-most sites together, and groups Fifth Street and Fair Drive together, to highlight the similarities between the three northern sites and Flat Shoals, and the differences between Fifth Street-Fair Drive grouping and the other sites, in terms of income distribution of the general-purpose lane drivers.

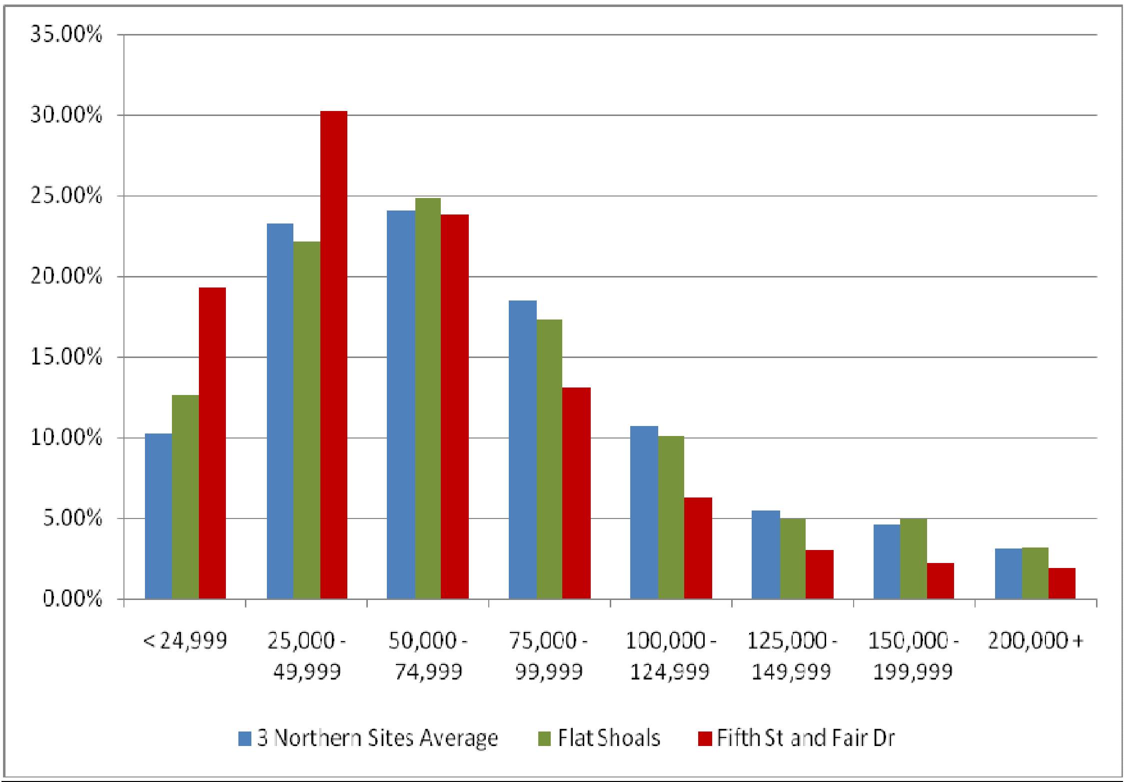

Figure 3.12 Comparison of Income Bins for General-Purpose Lane Commuters across Six Sites, Grouped

Regarding the income distribution of HOV lane commuters, the three northernmost sites again emerge as a separate category from Fifth Street and Fair Drive, with the northern sites overrepresented in the income categories above $50K per annum, and with the two sites catching the northbound AM Peak Period trips (Fifth Street and Fair Drive sites) underrepresented in the income categories above $50K per annum. Of all the sites with HOV lanes, HOV lane users detected at Fifth Street site had the highest presence of households living in block groups with median income below $25K per year. Fair Drive site had the second highest presence of HOV lane users coming from block groups with under $25K per year median income, and had the highest percengate among five sites of HOV lane users coming from block groups with median income in the $25K-50K range.

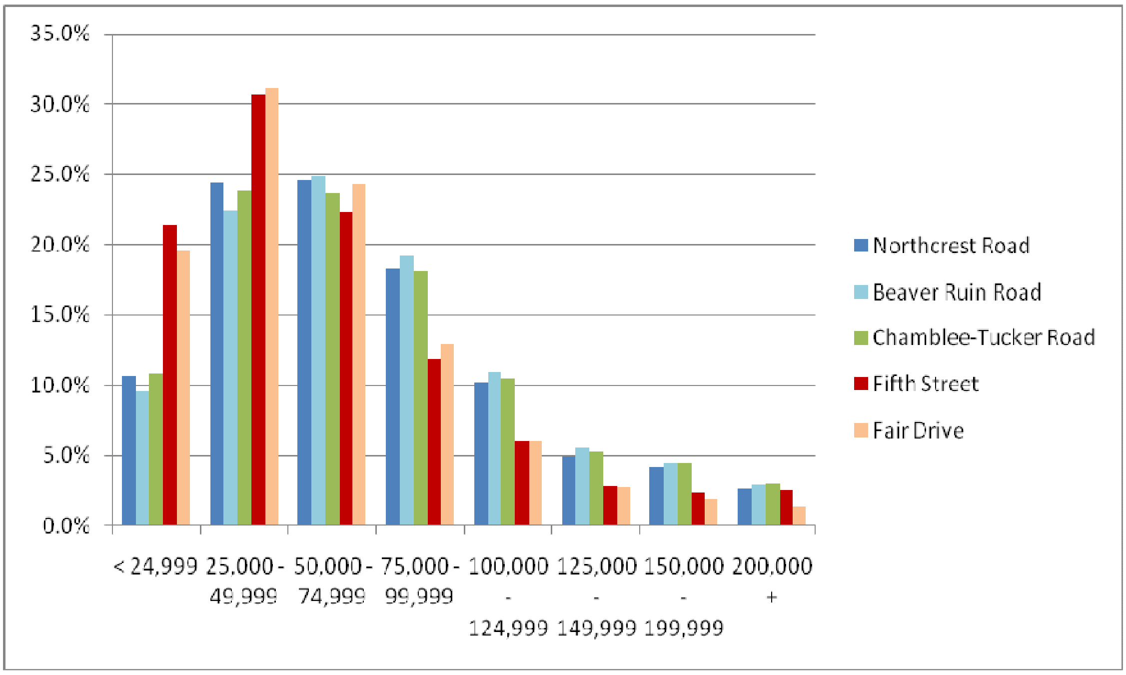

Figure 3.13 Comparison of Income Bins Representation for HOV Lane Commuters Across Five Sites

As can be observed in Figure 3.14 below, when general purpose lane commuters and HOV lane commuters from the three northern sites are grouped, while the general purpose lane commuters and HOV lane commuters from Fifth Street and Fair Drive sites are also grouped, it becomes more obvious that there are more significant differences between highway commuters coming from different parts of Atlanta (northern suburbs vs. southern suburbs), and less significant differences between HOV lane commuters and general purpose lane commuters when looking at the sub-group of highway commuters coming either from the northern suburbs, or from the southern suburbs of Atlanta. The northern suburbs-originating commuters emerge as representing wealthier block groups overall, as compared with the southern suburbs-originating commuters, whether commuting in the general purpose lanes or in the HOV lanes. That is, I-85 commuters coming from the areas south of Fifth Street are predominantly coming from block groups with a more dominant presence of households in the below 50K per year income category than those I-85 commuters coming from the areas north of Fifth Street. I-85 commuters coming from areas north of Fifth Street are more likely to come from block groups with median household incomes above 75K than I-85 commuters coming from areas south of Fifth Street.

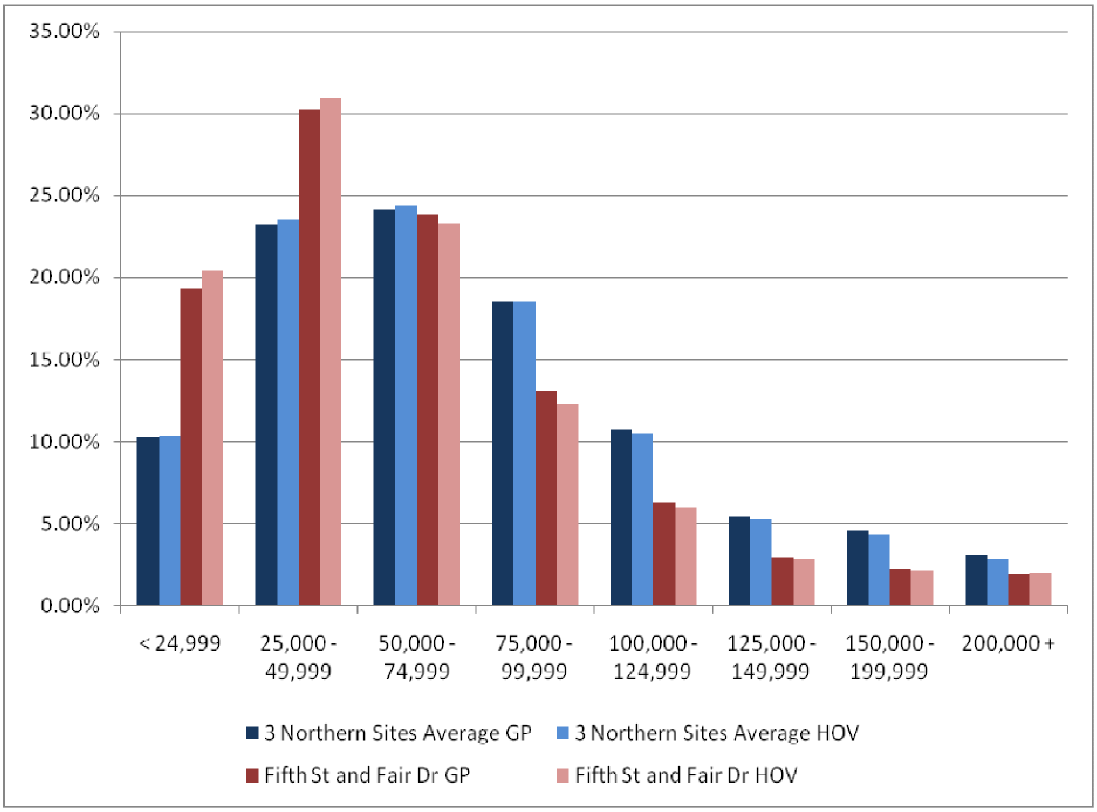

Figure 3.14 Comparison of Income Bins Representation for HOV Lane Commuters and GP Lane Commuters, Grouped into Northern and Southern Sites (Except Flat Shoals)

I-85 Commuter Demographic Study Limitations

The following were some of the limitations inherent in the I-85 Commuter Demographics Analysis undertaken:

- The demographic data analysis was subject to drawbacks due to the date of U.S. Census data used and fast-paced demographic changes that have been taking place in the Atlanta Metropolitan region over the past decade

- There could have been possible errors in the vehicle registration database
- It was not possible to separate visitors from out-of-town from regular commuters, except for based on reasonable driving distance
- Not all vehicles are properly registered at the locations where the primary driver lives at the moment (for example, a college students coming to Atlanta for studies might live in Atlanta but keep her vehicle registered at her parents' home location in Macon)
- Analysis of demographic data tied to home registration addresses for license plate numbers collected on the interstate does not give researchers any insight into the type of people likely to use Xpress buses; nor can we capture the information on the transportation-disadvantaged segments of the population living along the corridor who cannot currently use it due to the absence of reliable vehicle, or due to a physical, income or another type of transportation limitation.

Analysis of I-85 Commuter Demographics Conclusions

After collecting over 100,000 license plates of passenger vehicles traveling on I-85 corridor during the weekday peak periods in the summer of 2007, a data analysis process was undertaken to compare the block group income and commute characteristics of I-85 HOV lane users, general-purpose highway lane commuters, and typical residents of the catchment area. Taking into account the study and data limitations, the following are some of the conclusions:

- For the I-85 corridor overall, no statistically significant differences were found between the census block group incomes for General-purpose lane users and HOV lane users

- Both General-purpose lane users and HOV lane users commuting along I-85 were found to have higher incomes than a typical resident of the block groups linked with the commuters' vehicle registration address, with $50K per year household income being the breaking point above which I-85 corridor commuters are over-represented (consistent with the findings of Nelson, et al. (2008))
- I-85 Corridor peak period commuters (both General-purpose and HOV lane users) were more likely to have commutes to work reported to take between 40 and 90 minutes, compared with a typical resident of the selected base geography; I-85 commuters were more likely than a typical resident to have shorter commutes, with time length under 40 minutes [confusing text here]
- In comparing differences across sites, commuters at the three northern sites and Flat Shoals site (the southernmost site) display similar income characteristics, different from the characteristics of morning peak northbound commuters at Fifth Street and Fair Drive
- The morning peak northbound commuters (both general-purpose and HOV lane users), as documented by data collected at Fifth Street and Fair Drive sites, tend to have lower incomes than commuters at the other four sites; this suggests that commuters (both general-purpose and HOV lane users) from the close-in southern suburbs tend to come from lower median-income block groups, as compared with commuters coming from the northern suburbs and from the suburbs further out to the south (such as suburbs in Fayette County.)

Given the higher incomes of current HOV lane users, as compared with general population, it is not clear whether switching from and HOV-2 to an HOT-3 facility requirement will disproportionately affect the lower-income population groups. It appears from the study that a typical general-purpose lane user is similar in socio-economic status to a typical HOV lane user. Most HOV-2 carpools would likely have similar means and ability to pay as a typical general-purpose lane commuter on the I-85 corridor. The demographic analysis of current I-85 corridor commuters suggests that there might be less of a real equity issue inherent in displacing some of the current HOV lane users out of the HOT lane than expected. However, it does not negate the possibility that only the higher-income current highway commuters (from both current HOV lane users and current general-purpose lane users) would self-select to use the HOT lane after the HOV-2 to HOT-3 conversion, given that they might have a higher value of time. There are also some equity implications inherent in the finding that the highway users, on average, belong to higher income categories than the typical resident of the baseline geography. In addition, it appears that the highway users coming from northern suburbs tend to be wealthier than the highway users coming from the closer-in southern suburbs. There likely exists an inequitable distribution of mobility and accessibility benefits of the current interstate highway corridors in the Metropolitan Atlanta region, where not all metropolitan area residents are able to access the benefits provided by interstate highway travel in equal measure. These equity implications point to the need a larger, metro-wide transportation equity analysis that could be undertaken as the region considers local sales taxes for transportation projects, and the use of the revenues from such taxes.

CHAPTER 4

ATLANTA CONGESTION PRICING FOCUS GROUP RESULTS

Focus Group Set-Up and Participants

Ultimately, the public opinion about what is fair for a given place and time, and not the abstract concepts of equity, influence the decision-makers and become the litmus test for congestion pricing legitimacy, as noted by Ungemah (2007). Considering the importance of public perception to the success of a congestion pricing project, the results of 19 focus groups held in metro Atlanta during 2008 can be analyzed for potential key points of concern. The 19 focus groups of seven to 12 participants were recruited from the Metropolitan Atlanta area, and participated in a moderated discussion focused on managed lanes and the HOT lane option. Several images of HOT facilities were shown to the participants, and the key concepts were carefully explained, before asking the focus group specific questions about the types of managed lanes they liked the most, and the type of payment or enforcement mechanism they would prefer. The participants also filled out before and after surveys, where they indicated their typical commute patterns and their willingness to pay for an HOT lane with a guaranteed speed of 45-55 miles per hour. Table 4.1 below indicates the commuter type (carpoolers, general commuters, Xpress bus users) and household income for the 19 focus groups.

Table 4.1 Atlanta Congestion Pricing Focus Group Characteristics

Group Number	Number of Participants in Group	Commute Corridor (Home to Work)	Commuter Type	HH Income (Low: under 50k, Medium: 50-100K; High: Over 100k; Mixed)
1	11	I-85 corridor north of I-285	General Commuters	Over 100k
2	12	I-85 corridor north of I-285	General Commuters	50-100k
3	10	I-85 corridor north of I-285	General Commuters	Under 50k
4	8	I-85 corridor north of I-285	Carpoolers (3+ times a week)	Mixed
5	8	I-75 corridor north of I-285	General Commuters	Mixed
6	11	I-75 corridor north of I-285	General Commuters	Mixed
7	8	GA 400 corridor	GA 400 Cruise Card Users	Mixed
8	8	GA 400 corridor	GA 400 Cruise Card Users	Mixed (no low income)
9	11	GA 400 corridor	GA 400 Cash Toll users	Mixed
10	12	GRTA Xpress bus ridership shed (Cobb, Gwinnett, Clayton)	Xpress bus riders (all GRTA routes)	Mixed
11	11	I-20 corridor east of I-285	General Commuters	Mixed
12	9	I-20 corridor east of I-285	General Commuters	Mixed
13	7	I-75 corridor south of I-285	General Commuters	50-100k
14	11	I-75 corridor south of I-285	General Commuters	Under 50k
15	8	I-75 corridor south of I-285	General Commuters	Over 100k
16	11	Gwinnett County I-85 corridor north of I-285	Xpress bus riders (coming from Gwinnett Co)	Mixed
17	9	I-85 corridor north of I-285	General Commuters	Under 50k
18	9	I-85 corridor north of I-285	General Commuters	Over 100k
19	8	I-85 corridor north of I-285	General Commuters	50-100k

Figure 4.1 below illustrates the commute shed corridors from which the focus group participants were recruited. Inner-city Atlanta residents not using those travel corridors were not targeted in the focus groups; future research should probably compare potential differences of opinion with regards to HOT lanes between suburban residents and inner-city residents

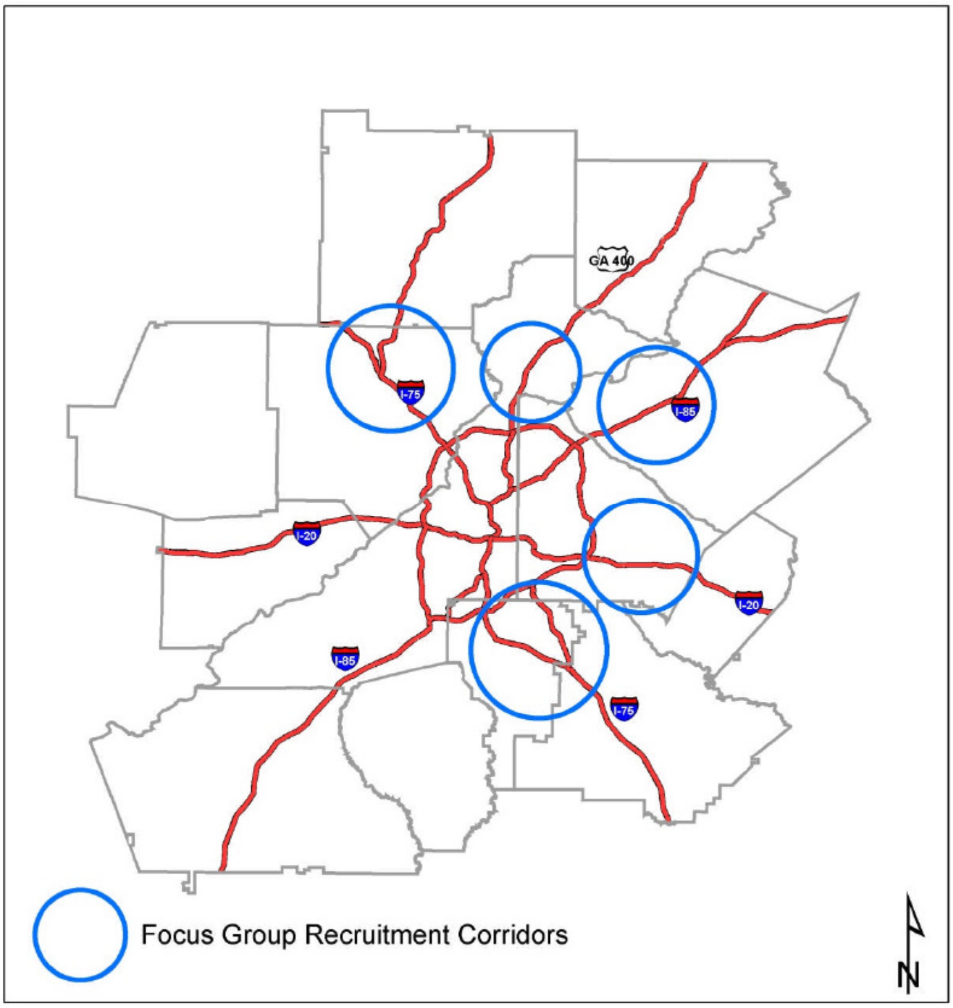

Figure 4.1 Focus Group Recruitment Corridors.
Source: Ross, Barringer, et al., 2009

Three main income groups were represented by the focus group participants: under $50,000 per year household income, $50-99,000 per year household income, and over $100,000 per year household income. However, no specific effort was made to target those with income under $25,000 per year. Access to a vehicle was an unspoken requirement for participation in the group, given the location of the focus groups (off Buford Highway).

African-Americans were well represented by the focus group participants, but Hispanics and Asians were underrepresented.

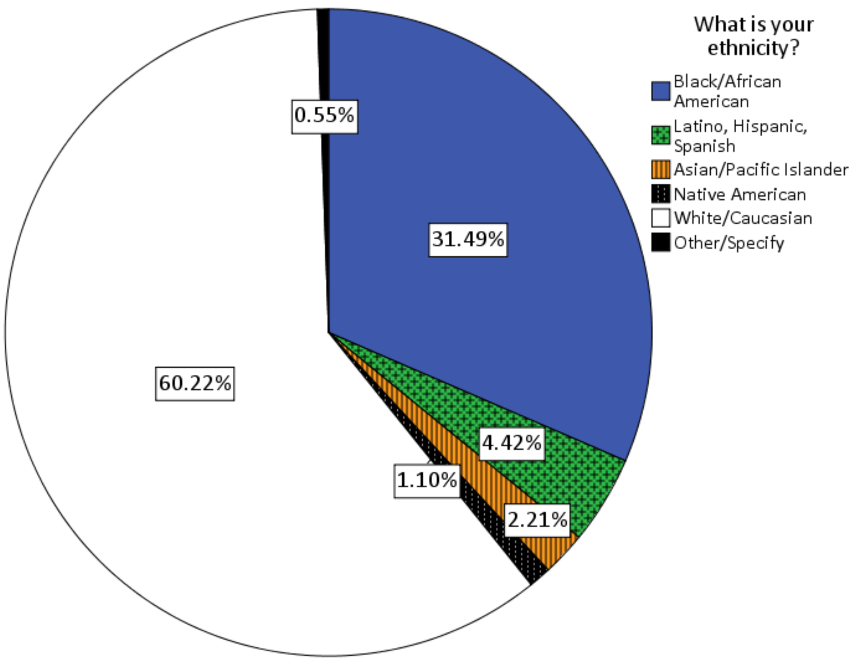

Figure 4.2 Focus Group Participants by Racial/Ethnic Category

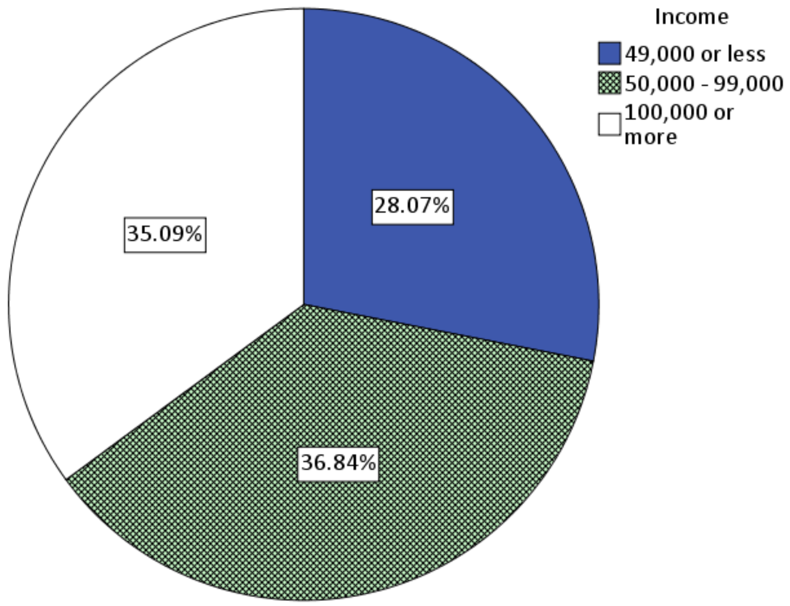

Figure 4.3 Focus Group Participants by Income

Access to a vehicle was an unspoken participant requirement due to the Focus Group Location on Buford Highway, although access by MARTA bus #39 would have been theoretically possible. 60% of focus group participants had a College degree or higher education level, which makes them better educated that Metropolitan Atlanta population on the average. By comparison, City of Atlanta and Metro Atlanta average higher education attainment figures are as follows:

- 41.2% of the City of Atlanta population over the age of 25 had at least a Bachelor's degree during the period of 2005-2007 (U.S. Census, 2007, A.)

- 33.5% of the Atlanta-Sandy Springs MSA population had at least a Bachelor's degree during the period of 2005-2007 (U.S. Census, 2007, B.)

Given the suburban home locations of most respondents in the focus groups, it is not surprising that only slightly less than 22% of them have a transit stop within a five-minute walk (see Figure 4.4 below). This means that the majority of suburban residents are forced to have a vehicle to be able to commute to work, regardless of their income. As discussed in the literature review, 86% of Xpress Bus riders in the metro Atlanta area currently access transit by driving to a stop (either Xpress Bus park-and-ride lot, or a MARTA rail stop). The HOV-to-HOT conversion will likely improve the options for the portion of suburban population with sufficient vehicles per driver available to them. Additional funding for the Xpress Bus system would also create better transit options. However, for the population residing in the suburbs without access to a vehicle, transit accessibility is likely problematic. The vehicle-disadvantaged population is also less likely to commute on the highways for work. The users already taking advantage of the highway for their travel to work will likely benefit from this project, whereas the users currently not using the highway due to a lack of sufficient income or a vehicle, are not likely to benefit from the improvements to the facility because the first link (driving to the nearest Park-and-ride lot to catch an Xpress bus or join a casual carpool) is not easily available to them.

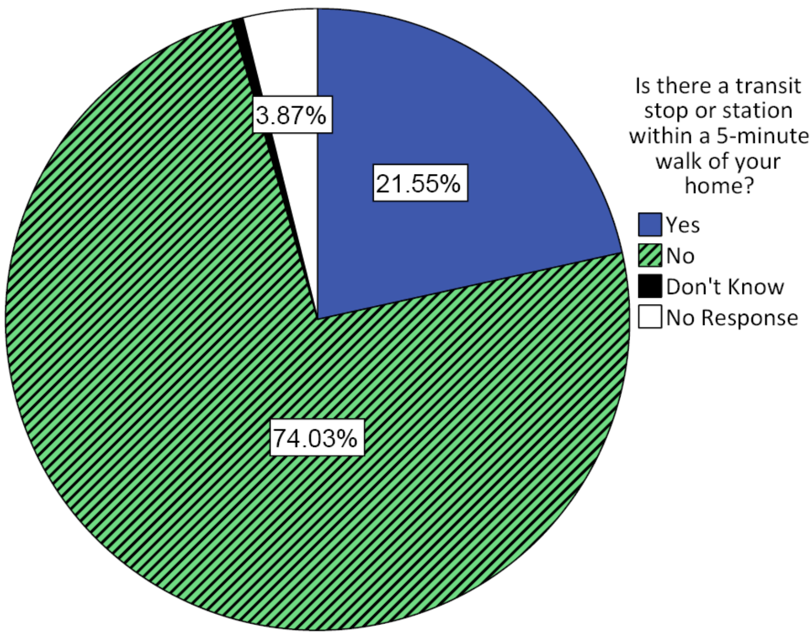

Figure 4.4 Focus Group Participants' Availability of Transit Accessible by Walking

Willingness-to-Pay

On average, willingness-to-pay was very similar across different participant types. The mean willingness to pay for all focus group participants who answered that question was $1.38 for a one-way trip, if a speed of 55 miles per hour was guaranteed (see Figure 4.5 below), with responses ranging from zero up to $5.25 for a one-way trip.

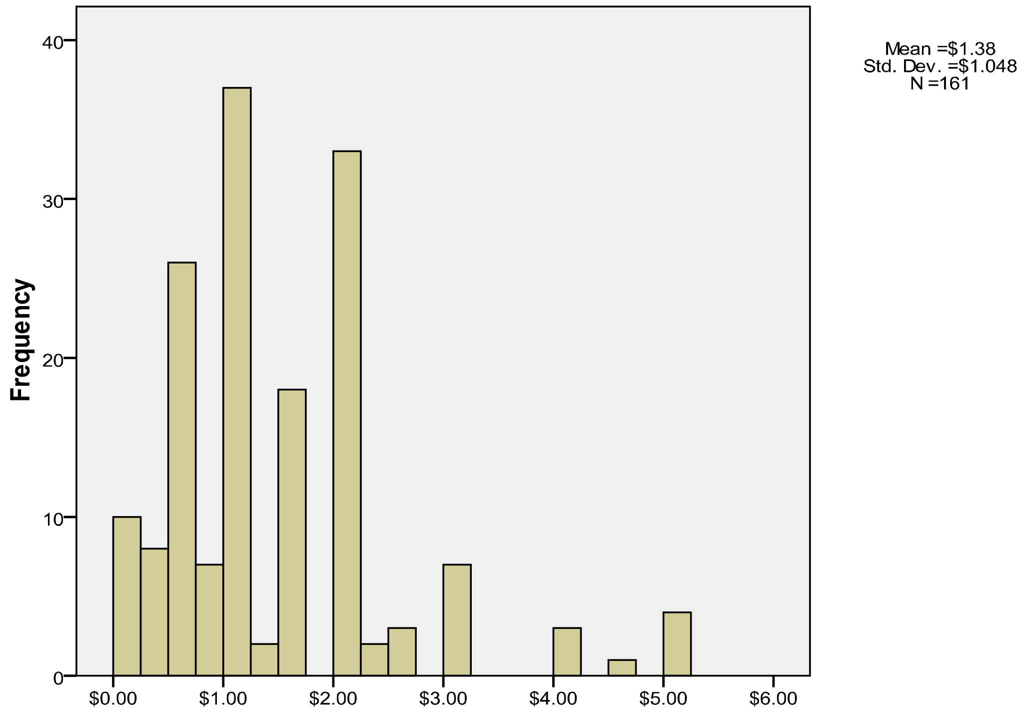

Figure 4.5 Willingness to Pay for 55 MPH Speed on the HOT Lane, 95% Confidence Interval

Participants from all three income categories (low, medium and high income households) were very similar in their expressed willingness to pay for an HOT lane trip if a speed of 55 mph was guaranteed (see Figure 4.6 below). The median willingness to pay converged on about $1.40 for all three income groups. When analyzing willingness-to-pay by racial and ethnic category, only white and African American populations were represented in sufficient numbers. African American participants displayed a slightly higher willingness-to-pay than white focus group participants (see Figure 4.7 below).

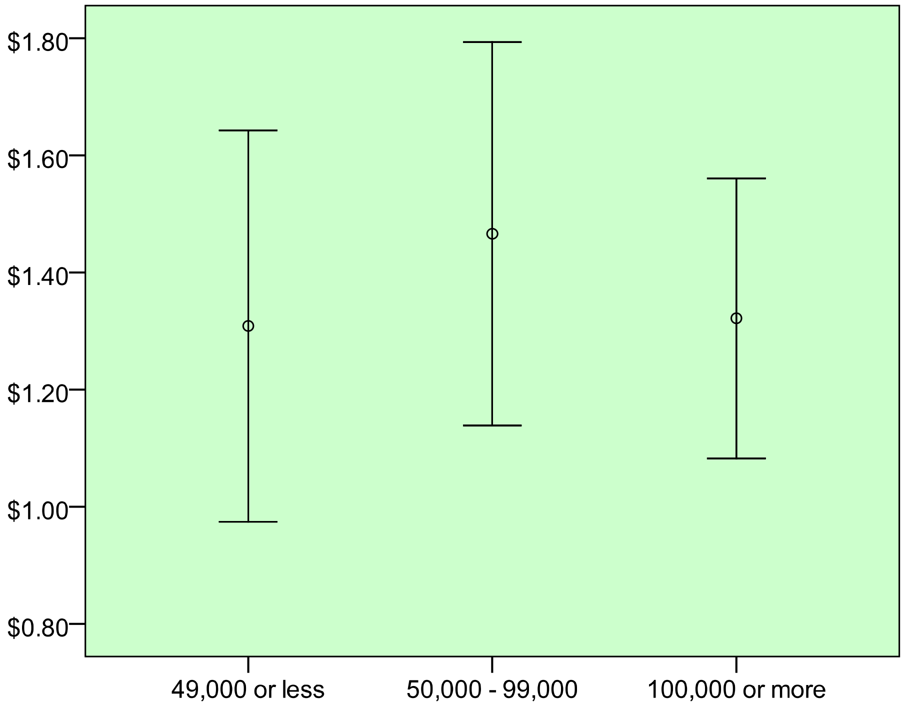

Figure 4.6 Willingness to Pay for 55 MPH Speed on the HOT Lane by Income, 95% Confidence Interval

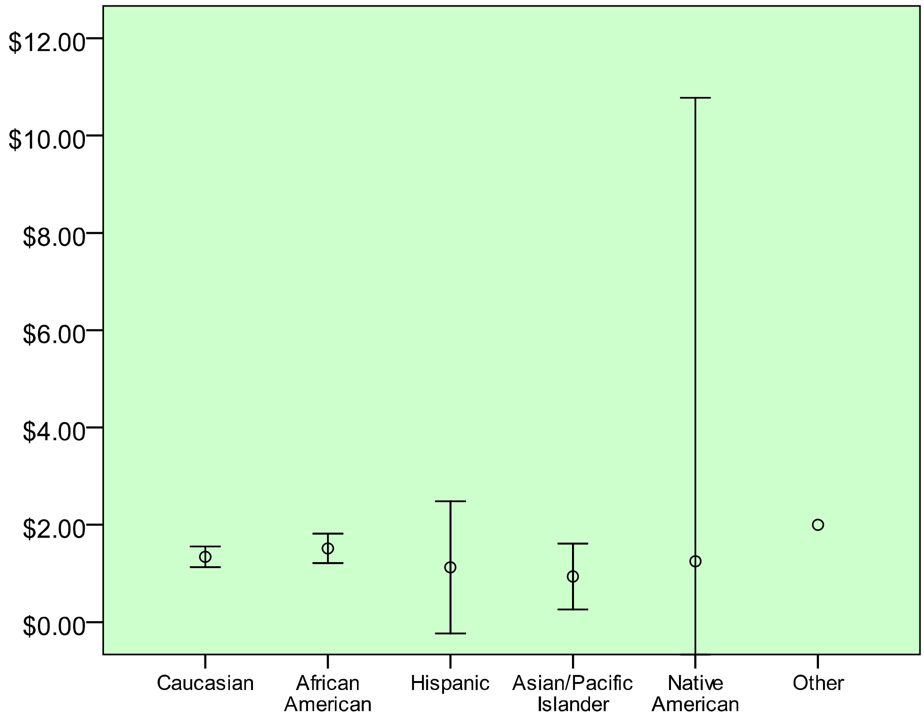

Figure 4.7. Willingness to Pay for 55 MPH Speed on the HOT Lane by Racial/Ethnic Category, 95% Confidence Interval
(*Only 1 to 4 Responses Present for Each Category Other than White and African American)

Surprisingly, people with a post-graduate degree were less willing than people with a Bachelor's degree to pay for the HOT lane use (see Figure 4.8), possibly due to having more flexibility in work schedules and more teleworking options. Men and women displayed no difference in their reported willingness-to-pay for uncongested travel on the HOT lanes (see Figure 4.9 below).

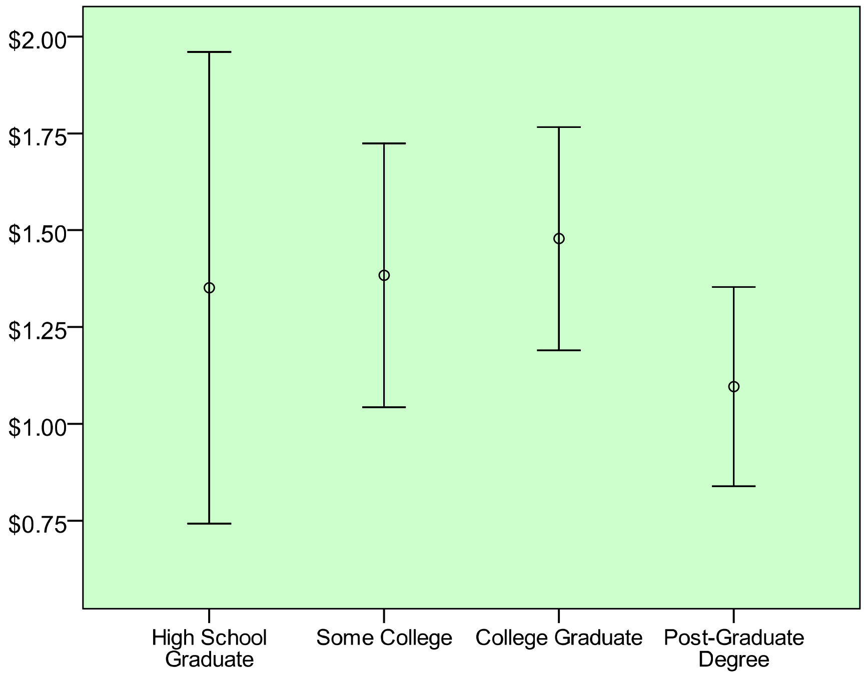

Figure 4.8 Willingness to Pay for 55 MPH Speed on the HOT Lane by Level of Education, 95% Confidence Interval

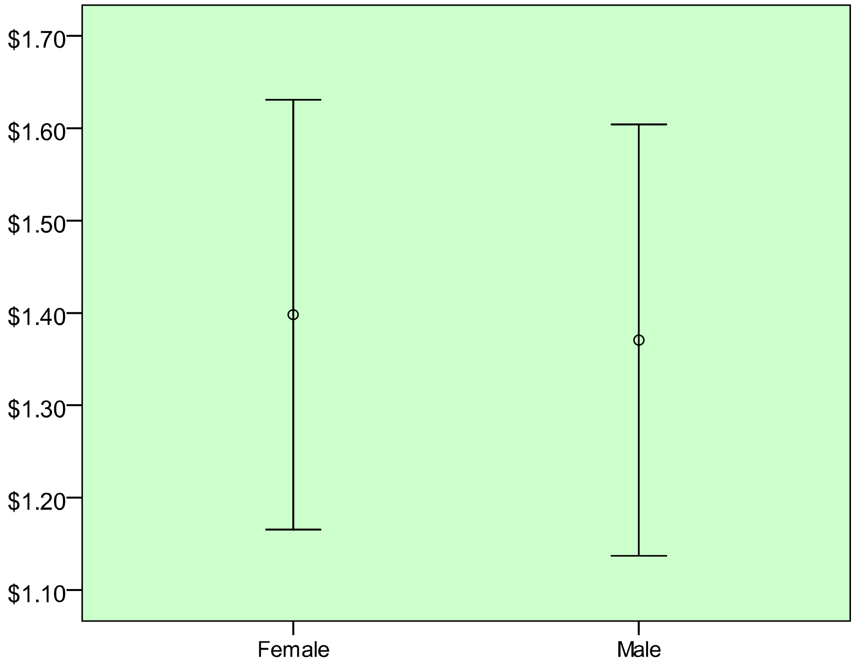

Figure 4.9 Willingness to Pay for 55 MPH Speed on the HOT Lane by Gender, 95% Confidence Interval

Current carpoolers displayed a lower willingness-to-pay for uncongested travel on the HOT lane than those not currently carpooling (see Figure 4.10 below).

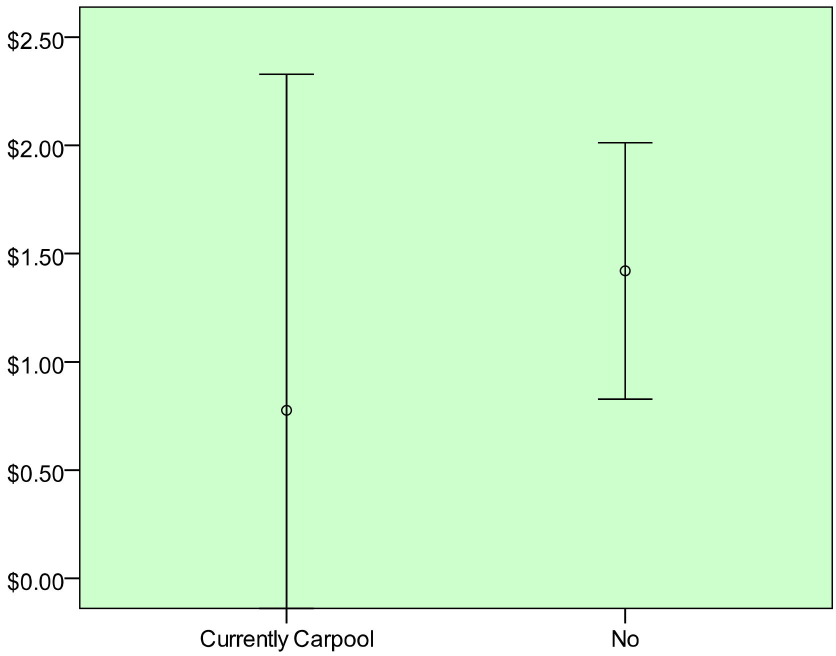

Figure 4.10 Willingness to Pay for 55 MPH Speed on the HOT Lane by Current Carpool Status, 95% Confidence Interval

Construction, manufacturing and maintenance workers tended to have a higher willingness-to-pay for an uncongested trip on the HOT lanes than a professional, managerial or technical employee (see Figure 4.11 below). Analogous with the lower willingness-to-pay displayed by people with a graduate degree, as compared with those with a Bachelor's degree, this could indicate that professional and managerial employees tend to have more flexibility in their work schedule. This is supported by some of the flexible work schedule rates by occupation, cited in the literature (Golden, 2001): 47.9% of managers and engineers had a flexible schedule as of 2001, while only 30.4 percent of construction and trades workers had flexible work schedules, and only 21.2% of cleaning and building services workers had a flexible schedule. In addition, construction and maintenance workers might have to travel more on the highway during the work day, to access the client's location, and thus they might value that travel time at a premium.

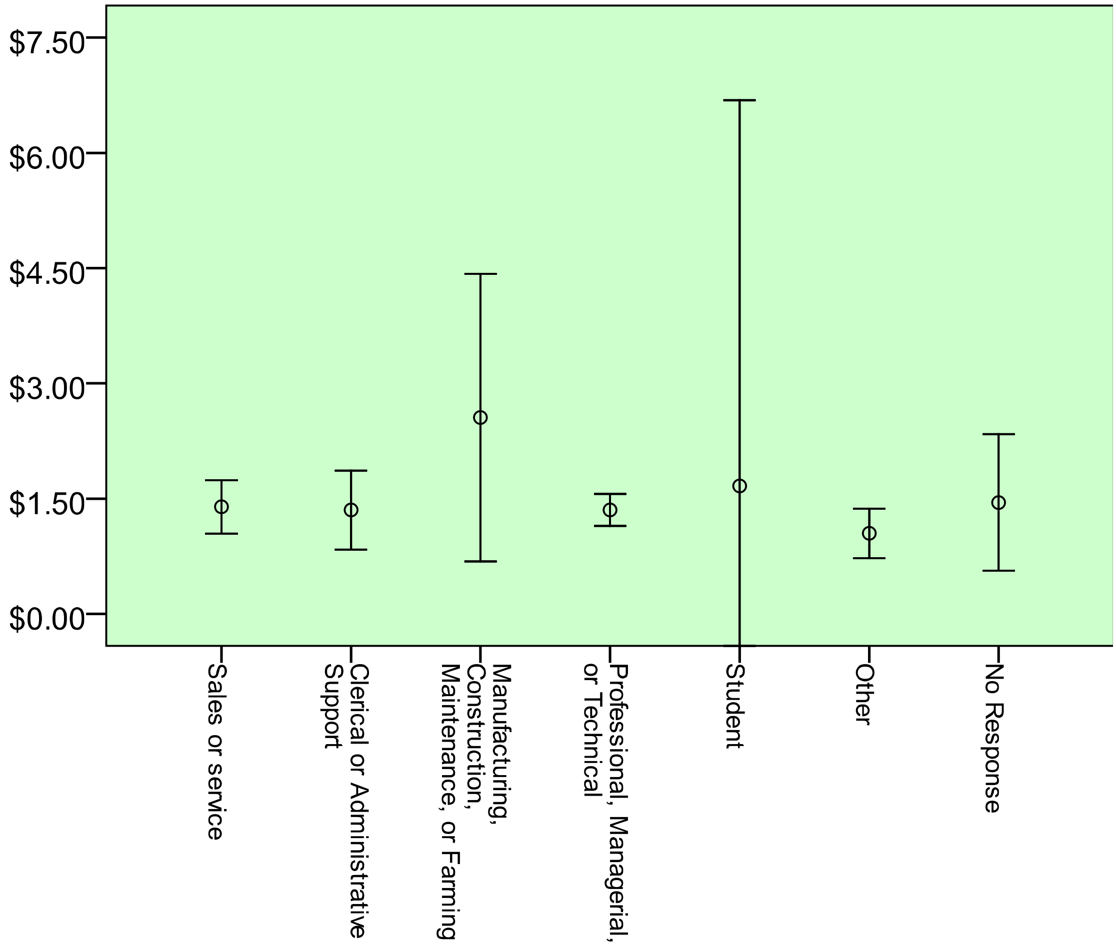

Figure 4.11 Willingness to Pay for 55 MPH Speed on the HOT Lane by Current Occupation, 95% Confidence Interval

Other Considerations Voiced in Focus Groups

As previously presented in a TRB Poster session (Guensler, 2009), some additional considerations expressed by the focus group participants were as follows:

- Low income drivers generally cannot afford to spend $4-8 in one direction to pay for HOT lanes
- When tolls are low (around $1.50) or under emergency situations, low income focus group participants indicated that they would be willing to pay to use the HOT lanes
- Low income focus group participants are generally in favor of managed lanes

- Upper income focus groups are more often against converting general purpose lanes to HOT lanes (some on principle, and some out of expressed concern for fairness towards the lower income drivers)
- Participants in all focus groups like the idea of having an additional transportation option that the HOT lanes provide
- Current carpoolers participating in Atlanta groups are strong supporters of converting HOV lanes to HOT lanes, possibly because the carpoolers indicate that the HOV lanes are often congested and are becoming more congested
- Some current carpoolers indicated that, in the absence of another convincing reason to form a carpool, they would be unlikely to form a carpool for the purpose of taking advantage of the HOT lane for free or at a discounted toll rate
- Some focus group participants indicated that they are in carpools of temporary convenience (such as with a co-worker), and might not see it as a long-term solution

Focus Groups Study Limitations

The 19 focus groups conducted during 2008 were representative of suburban residents of Metropolitan Atlanta who currently use the interstate highways for typical travel, in various income brackets (under $50,000 per year, $50,000-99,000 per year, and $100,000 and over per year household income categories). However, there was no differentiation between the under $25,000 per year income group and the $25,000-49,000 income group, which could be important to make if the research was targeting the working poor as a separate group. It is likely that very few to none of the focus group participants were in the under $25,000 per year household income category. African-Americans were well-represented in the focus groups, while Hispanics and Asians were under-represented in the focus group. There were no wheelchair-bound persons, or persons having difficulty understanding English participating in the groups, or people living in households with zero vehicles available to them. The location of the focus group and pre-selection questions for the focus groups likely discouraged participants without reliable access to a vehicle. The recruitment corridors selected for the focus groups made it unlikely that any of the potential reverse commuters would be captured (where potential reverse commuters would be those with home location inside the Central Atlanta and inner-ring suburbs to the south, commuting to jobs in the northern suburbs). In addition, the focus group participants tended to be better educated, than metro Atlanta residents, on average. As a result, there are some questions as to whether the focus group participants represent Metropolitan Atlanta population sufficiently, or even the Metropolitan Atlanta suburban population. However, the participants did represent the interstate highway users fairly well, in that carpoolers, single-occupancy drivers and Xpress bus riders participated.

Focus Groups Conclusions

The focus groups were generally in favor of Managed Lanes, and even the low-income groups perceived HOT lanes as fair. People across different income groups tended to place a similar value on time savings from the HOT lane flowing at 55 mph. Low-income groups appeared to be less likely to use the HOT lanes as often. Multiple participants mentioned that the HOT lanes currently break down during peak periods. If public acceptance was the main criteria of equity used for the HOV-to-HOT conversion, it appears that the public currently using the interstate highways is generally accepting of the idea. However, we know very little about the transportation-disadvantaged population and their perception of the HOV-to-HOT conversion, and how it might impact them.

In future similar focus group studies, to get a better representation of the Metropolitan Atlanta population, it would be advantageous to recruit participants from the under $25,000 per year household income group, as well as participants who do not speak English well, persons who use a wheelchair, and persons who do not have access to a private vehicle, to fully represent the various population groups in Metropolitan Atlanta. In addition, it might be beneficial to recruit potential reverse Xpress bus commuters, living in inner-city Atlanta or in the southern inner suburbs of Atlanta, and seeking access to entry-level jobs in the northern suburbs. Such efforts would allow input from the people who are less likely to be currently using the I-85 North corridor, but might be able to use it with certain improvements to the public transit system.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Limitations of the Equity Analysis of I-85 HOV-to-HOT Conversion Presented in this Thesis

Equity in transportation is a very complex issue, where such analyses can be considered within different timeframes, different geographical scopes, and for different population categories. Given the available time and data, the equity analysis results presented in this thesis are subject to the following constraints:

- When incremental equity analysis is conducted corridor-by-corridor, the bigger picture issues associated with equity may be overlooked in the analysis. That is, more meaningful equity analysis may need to be done at the regional level, and include all relevant transportation projects, for which the region receives federal and state monies, considering that funds used in one corridor become unavailable for use in other corridors and to serve other transportation needs, and thus carry an opportunity cost apart from the direct negative impacts on the populations affected by the project. Unfortunately, such an analysis was outside of the scope of this project, but is relevant to discussions related to the HOV-to-HOT conversion
- While metropolitan-level equity analysis is preferable for transportation, only corridor-specific highway commuter demographic data were available; public opinion of the HOT lanes and willingness-to-pay data were only available for commuters residing in the suburbs (who were the focus group participants)

- As part of the demographic analysis conducted, we might know the average block group-level household demographic characteristics of those traveling on the interstate in Metropolitan Atlanta, but we do not know the actual household characteristics of the individual travelers using the Interstate system, and we do not know the actual household characteristics of the individual travelers that do not use the Interstate system
- The household demographic characteristics for the I-85 commuters were derived from Census 2000 data, whereas many socio-economic changes have taken place within the Metropolitan Atlanta region in the 2000-2007 period
- The focus groups did not specifically capture the interests of persons in below 25K per year income group (which comprise 18.6% of Atlanta MSA population, according to U.S. Census, 2007 (C)), handicapped persons, non-drivers, inner-city residents, reverse commuters, zero-vehicle households and non-English speakers

Conclusions of the I-85 North HOV-to-HOT Conversion Equity Analysis

The findings of this thesis tend to suggest equity issues might be present in the I-85 HOV-to-HOT conversion, but more in-depth and metropolitan area-wide analysis would be necessary to fully determine the equity impacts of the project. Some of the more specific findings of the study, based on the literature reviewed, the demographics analysis of the I-85 corridor commuter demographics, and based on the Atlanta Congestion Pricing focus group results, are as follows:

- The users of the HOV lane along the I-85 North corridor tend to come from neighborhoods with very similar demographics as neighborhoods where the SOV I-85 North corridor commuters originate; the slight tendency of HOV lane users to come from lower income census block groups was not found to be statistically significant

- There appear to be significant differences between the income characteristics of I-85 Metropolitan Atlanta commuters and expected income characteristics for the block groups contained within the base geography, such that I-85 commuters (both general purpose lane users and HOV lane users) tend to come from block groups with higher median incomes than would be typical for an average block group in the base geography. This could be pointing to a potential opportunity equity issue between the current interstate highway users (of all modes, including Xpress bus riders and carpoolers) and interstate highway non-users (who are likely to be economically and transportation disadvantaged for a variety of reasons)
- There appear to be differences between the I-85 commuters commuting south from the northern suburbs, and those commuting north from the areas south of Fifth Street site; the northern suburbs-originating commuters tend to come from block groups with higher median incomes than typical for block groups represented by the commuters coming from the closer-in southern suburbs; northbound commuters captured at Flat Shoals site, south of I-285, tended to represent higher-income block groups, similar to commuters captured at the three northern sites, and dissimilar from northbound commuters captured at Fifth Street and Fair Drive sites
- I-85 corridor commuters tend to come from block groups with higher than average presence of commuters that take 40 to 90 minutes to travel to work; block groups with average travel time to work under 40 minutes or over 90 minutes are under-represented among the I-85 commuters

- Based on the Atlanta focus groups, current interstate highway commuters of different modes (SOVs, Xpress bus riders, and carpoolers) living in the suburbs of the Atlanta region tend to view the HOV-to-HOT conversion favorably; commuters in the under $50K household income group tend to value the travel time savings from an HOT lane similarly to commuters in other income groups, but are less likely to pay the fee to use the HOT lane as often as commuters in the higher-income groups

Factors suggesting that there might be more negative equity impacts than anticipated, and thus warranting further equity analysis, are as follows:

- A corridor-level equity analysis is likely to not be sufficient given that the moneys invested in the corridor come at the expense of moneys invested in other corridors. Given that this facility is already used by population with higher incomes, this comes with an opportunity cost of not being able to provide transportation improvements in areas or on facilities used by transportation and income-disadvantaged populations
- Committing a portion of the funds invested in the project to improving the Xpress bus system will not automatically make the project more equitable, in that 83% of Xpress bus users tend to come from households with more vehicles than drivers available (GRTA, 2009 (D)); improving the network of feeder buses and improving the reverse commute options would be more helpful toward improving the transportation options for those households who are currently transportation- and economically-disadvantaged
- Even if the absolute mobility and accessibility are not affected by this project for those people not typically traveling on the interstate highways, improving the mobility and accessibility options for the other members of the society

decreases their relative mobility and accessibility, which carries potential social exclusion impacts

Some potential solutions for mitigating the inequitable impacts of the I-85 HOV-to-HOT conversion could include the following:

- To offset this impact of “relative disadvantage in terms of mobility and accessibility”, the transportation-disadvantaged population could be compensated, not through improvements to Xpress bus service, although useful, but through improving the local feeder bus service, reverse commute transit options, and alternative options such as possibly subsidized taxi vouchers for doctors’ visits, grocery store trips, and other necessary services. However, there is a limit to how much society is willing to pay for providing such services, thus raising the need for a better nationally-defined, quantifiable, transportation access minimum standard
- Given that the 14-mile pilot project is not projected to generate enough operating revenue to cover other transportation projects except for possibly additional HERO units (Vu, 2009), another way to compensate the disadvantaged populations could be found through the regional transportation planning process (keeping in mind that transportation funding is a zero sum game); possibly, there will be more flexibility for Metro areas transportation funding with the upcoming Transportation Reauthorization Bill, that would allow such compensation
- Even if compensation of the transportation-disadvantaged population is not currently possible at the regional level, in direct proportion to the partial disadvantage resulting on them from this project, a conversation should be going on in the region about where the priorities are, and how the needs of

the transportation-disadvantaged population could be best met. However, quantifying the impact on the transportation-disadvantaged population from any transportation project would first be necessary

Recommendations for Future Studies

Based on the literature review and the limitations inherent in the data analysis, the following suggestions can be made for future research related to the topic of equity in congestion pricing projects for Metropolitan Atlanta region:

- When the pilot I-85 HOV-to-HOT conversion takes place, it would be beneficial to analyze the impacts of the conversion on the current carpoolers on the corridor, to see how they are affected by raising the occupancy requirement to HOV-3+, and how they further adopt to the HOT conversion. A control group of carpoolers currently traveling on another major interstate corridor in Atlanta (such as I-75) should be used, to control for naturally occurring turnover and variability in typical carpool behavior. Surveys of the carpoolers participating in the study should be used to help identify the reasons for behavioral shifts, if any identified. Special efforts should be made to quantify the income distribution of carpoolers and ensure random sampling that includes carpoolers from various income groups, including the below 25K per year household income category.
- A more comprehensive metropolitan region-level equity analysis of converting the full currently existing HOV lane network to HOT lanes, within the context of the current RTP, should be undertaken. Such an analysis might reveal much more pronounced discrepancies between the HOV lane users and the general-purpose lane users on the current HOV facilities other

than the I-85 North corridor. Such an analysis might also reveal high discrepancies in regional transportation funding by mode.

- A study of potential demand for more frequent Xpress bus reverse routes along the I-85 corridor and other corridors would be beneficial (i.e. serving trips from CBD to the malls in the suburbs), to detect if investment in improving such services would be advantageous and would improve the mobility and accessibility for some of the currently economically and transportation-disadvantaged population groups.
- A study of potential demand for improved bus networks serving the Xpress bus park-n-ride lots should be undertaken, given that the majority of current Xpress bus users come from household with more vehicles than drivers, and thus investment in improving the Xpress bus service without providing Xpress bus access to the zero-vehicle households potentially exacerbates equity issues.
- Future research needs to be undertaken to have a better idea or what is a socially and culturally-appropriate, quantifiable “transportation minimum”, or a “minimally-acceptable mobility standard” which would be mobility and accessibility that each person should have the right to, and whether such standard would differ significantly between those living within an urbanized area and the populations living within a rural area.

APPENDIX A

DIRECTIONAL DISTRIBUTION ELLIPSE ANSLYSIS

The purpose of this appendix is to further discuss the ESRI ArcGIS Directional Distribution Ellipse-based method chosen to select the base geography used for I-85 peak period commuter demographics analysis, which was one of the necessary steps for the commuter demographic analysis covered in Chapter 2 of the thesis.

As previously mentioned, 75th percentile was chosen as the primary selection factor for prioritizing block groups into the base geography selection for each site. A further step was needed to select those block groups that fell within the geographically-appropriate proximity to the observation site, so that the block groups located more than an hour and a half away from the observation site would not be included in the analysis, even if showing strong enough representation to fall within the 75th percentile. To demonstrate the difficulty of such seemingly easy task, the example of Rabun County can be taken into consideration. See Figure A.1 and Figure A.2 below for an illustration of block group #132419701001, within Rabun County, which fell within the 90th percentile for the Fifth Street 1 due to five tags being observed in peak direction at Fifth Street (over the course of three different observation periods.) According to Google Maps, the driving distance from Clayton, Georgia (at the southern tip of the block group in question) to I-85 Fifth Street overpass is estimated at 105 miles, which amounts to 1 hour 51 minutes of driving time (Google Maps, 2008). Rabun County Convention and Business Bureau site (2008) indicates that Rabun County is “nestled in the southern tip of the scenic Blue Ridge Mountains” and “a convenient drive from the major metro areas of Atlanta, Asheville, Greenville and Chattanooga.”

Block Group 1, Census Tract 9701, Rabun County, Georgia

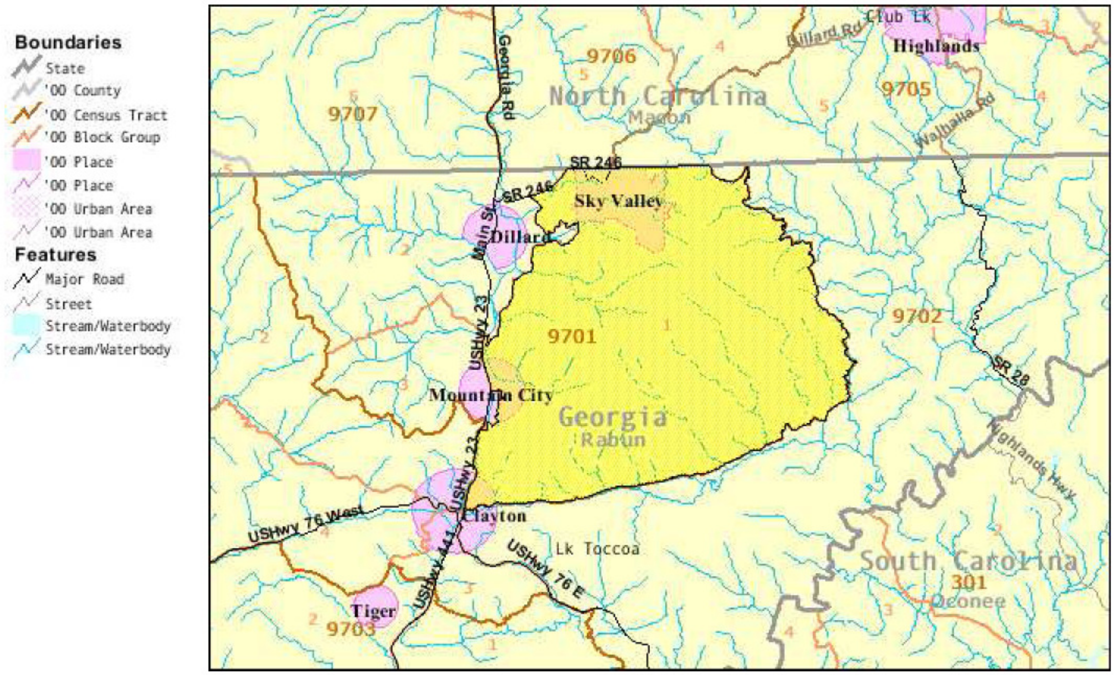

Figure A.1 Map of Block Group #1324197010001 in Rabun Co.

Source: U.S. Census, 2008.

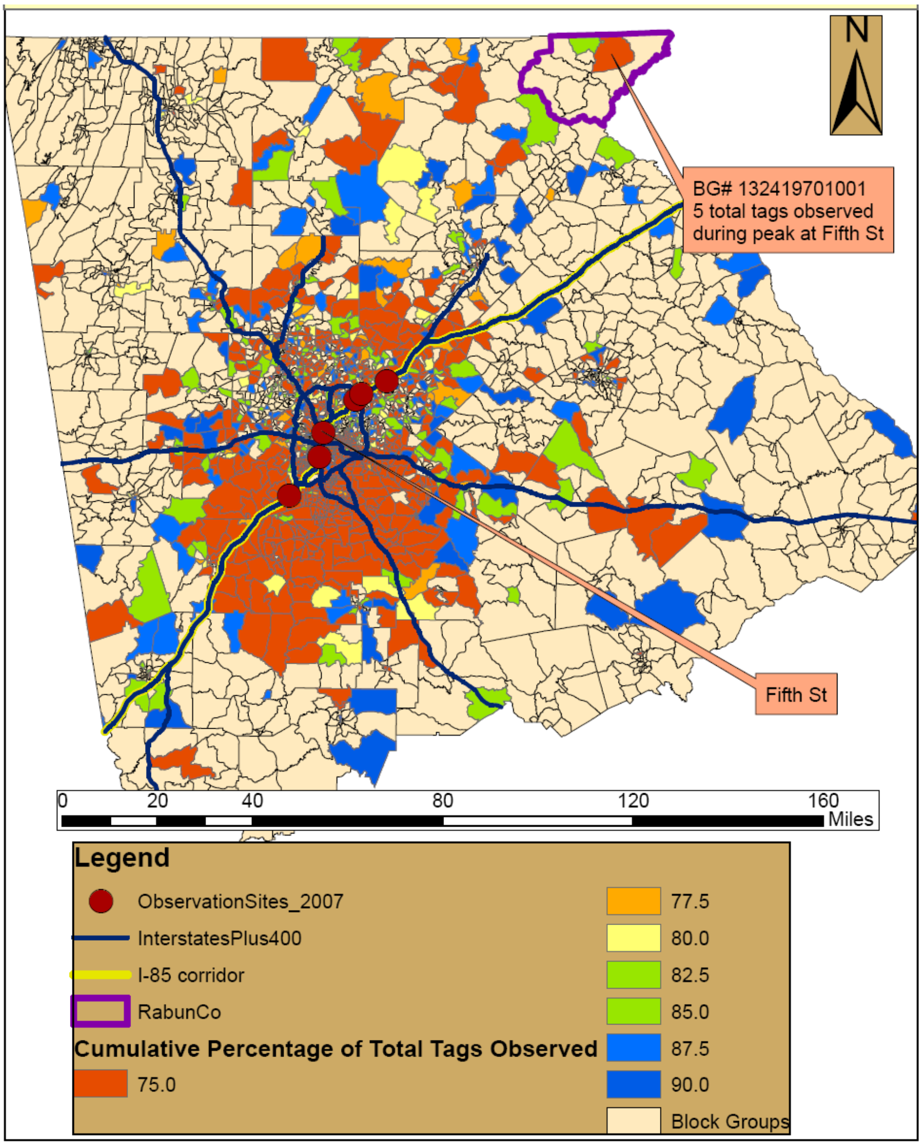

Figure A.2 Rabun Co. Block Group #1324197010001, in Relation to the Fifth Street Observation Site.

In order to insulate the base geography from the "Rabun County Anomaly" and select the core commuter shed without including the two-hour drive block groups, a tool within ESRI ArcGIS called *Directional Distribution Ellipse* was chosen. A Directional Distribution Ellipse, also called Standard Deviational Ellipse, is drawn around the mean center of all the points or polygons selected. One, two or three standard deviations can be chosen to draw a wider or a smaller ellipse. ArcGIS help files indicate that "the method (Standard Deviational Ellipse) calculates the standard deviation of the x coordinates and y coordinates from the mean center to define the axes of the ellipse" and the elongation direction of the ellipse is informed by the distribution of the features (ESRI, 2008).

The research team chose to create the directional distribution ellipses for each of the six sites, using only the block groups that fell within the 75th percentile category for peak direction for each site. The ellipses were created for each site based on the one standard deviation around the mean center of spatial distribution of all the block groups that fell in the 75th percentile category for the peak direction observations at a given site. In addition, the ellipses were weighted by total observations. Once an ellipse for each site was created in ArcGIS, all the block groups with their centers within the ellipse, that had at least one tag observed at the specific site during peak direction travel, were selected.

All the selected block groups with at least one observation constituted the base geography for the given site, whereas weighting the selected block groups by observations would allow the research team to make comparisons between the base geography demographics and typical I-85 user demographics for a specific site and type of lane.

Figure A.3 below demonstrates the 75th percentile directional distribution ellipses created for the Fair Drive peak direction observations. The three ellipses differ in their weighting factor: the largest ellipse is not weighted, the smallest ellipse is weighted by total observations, and the middle ellipse is weighted by unique tags per households. The ellipse chosen was the 75th percentile ellipse weighted by total observations (with the 75th percentile calculated based on the ranking of block groups by unique tags to households ratio). No significant difference emerges when selecting the block groups by 75th percentile ellipse weighted by total observations vs. selecting by 75th percentile ellipse weighted by unique tags per number of households.

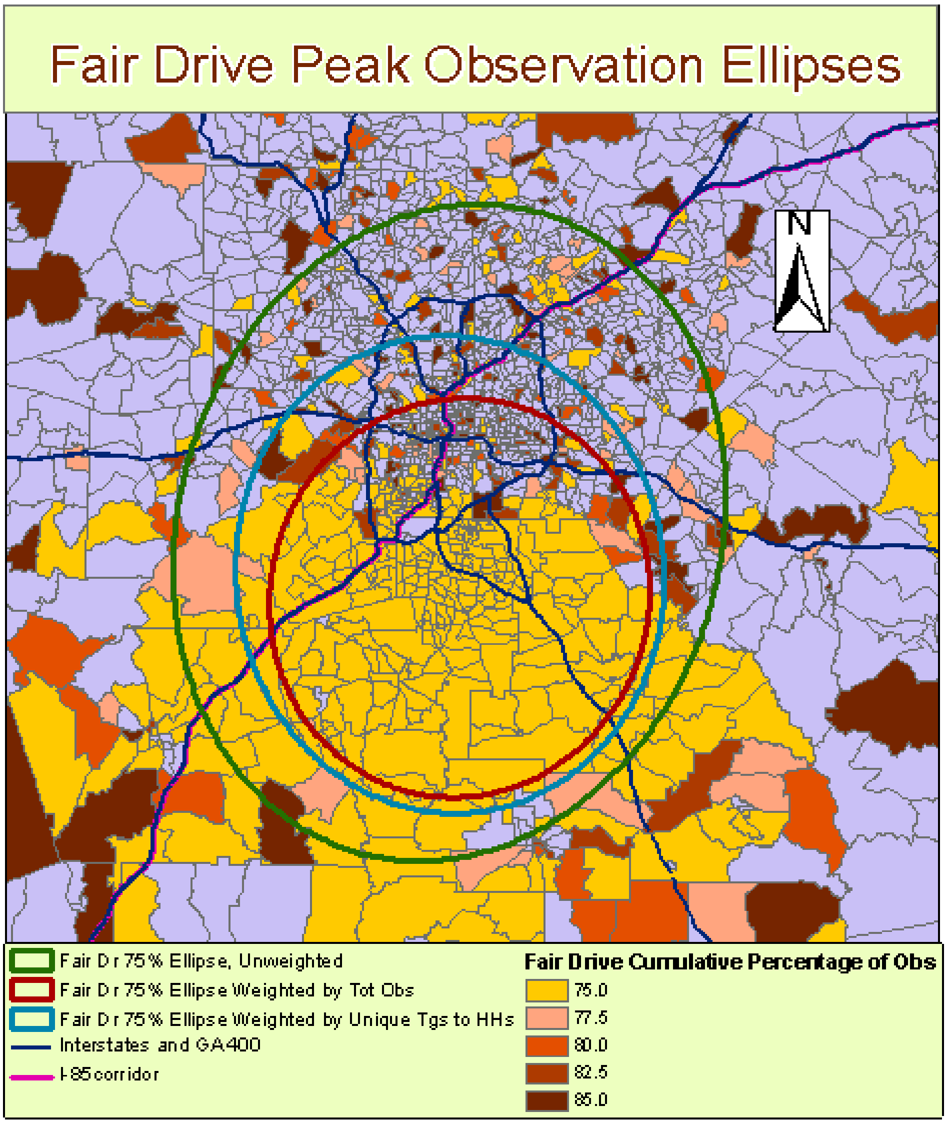

Figure A.3 Demonstration of Three Different Types of Directional Distribution Ellipses for Fair Drive Site.

Base Geography for Site 1, Fifth Street

For Fifth Street, this selection process resulted in 930 block groups out of 2,891 total block groups within 73 North Georgia counties being selected, representing 7,348 license plates out of total 11,876 peak direction license tags observed at Fifth Street

(Site 1), which amounts to 61.87%. Findings of Nelson, et al. (2009) research suggest that around 60 percent of all observed vehicles on Metropolitan Atlanta interstates can be reasonably expected to be commuters. Therefore, our capture rate of around 62 % using the directional distribution ellipse method should be adequate to capture the bulk of true commuters at the site.

Base Geography for Fair Drive

For Fair Drive site, selecting base geography by 75th percentile Directional Distribution Ellipse weighted by total observations resulted in 411 block groups being selected, which represented 5,194 total peak direction tags observed, or 64.65% of the recorded 8,034 license plates observed at Fair Drive in peak direction, for which registration addresses fell within the 73 North Georgia counties.

The block groups were selected by ellipse and based on at least one observed license plate make up the base geography for each site. Given the base geography and weight factors (by total tags observed per block group), further analysis could proceed linking the selected block groups with U.S. Census 2000 demographic data.

Figure A.4 below illustrates the 75th percentile ellipse and the resulting selected base geography block groups for peak direction at Site 2, Fair Drive.

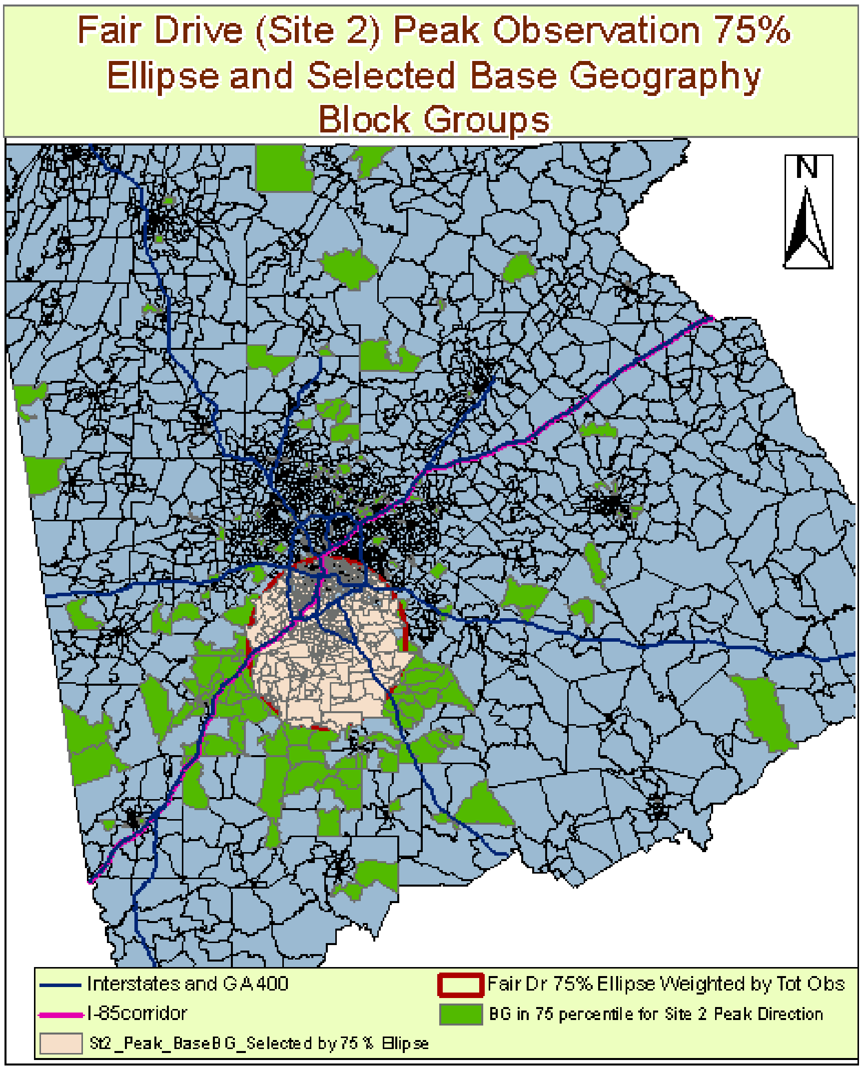

Figure A.4 Fair Drive Directional Distribution Ellipse and Selected Peak Direction Base Geography

Base Geography for Chamblee Tucker Site

For Chamblee Tucker site, the selected block groups accounted for 6,585 total observations in peak direction, which accounts for 63.19% of 10,421 total tags observed at that site in peak direction that were registered within the 73 North Georgia counties.

See Figure A.5 below for a map of the selected base geography for the Chamblee-Tucker site.

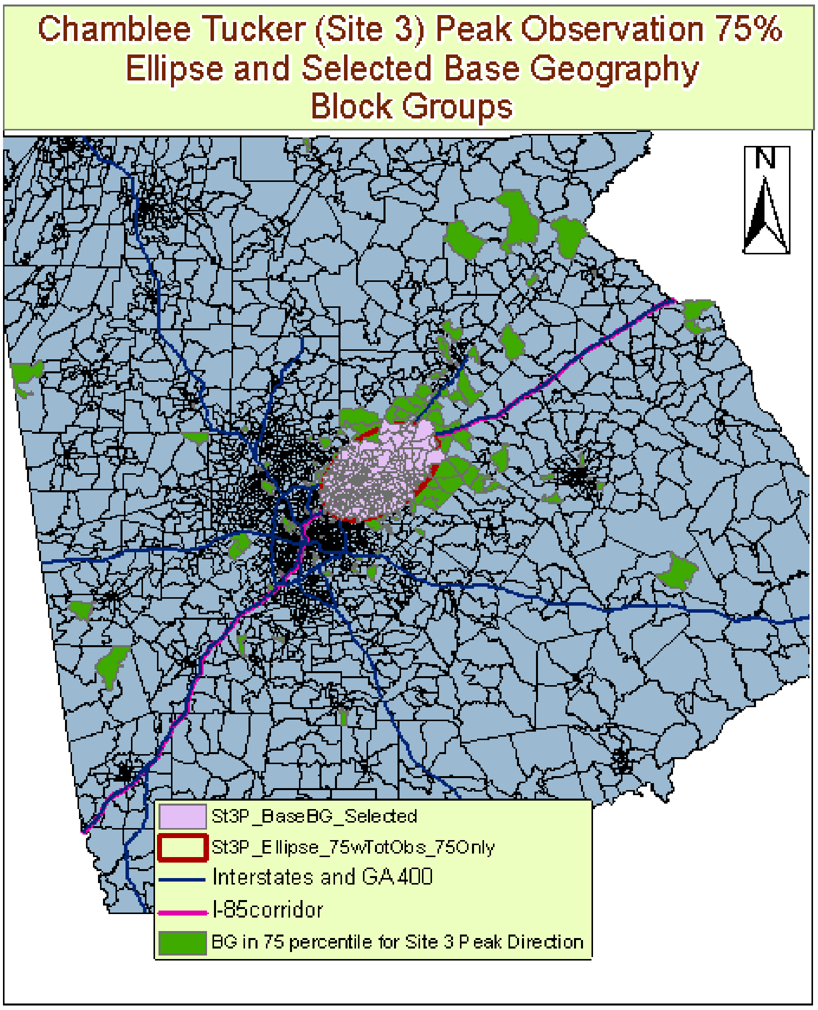

Figure A.5. Chamblee Tucker Directional Distribution Ellipse and Selected Peak Direction Base Geography

Base Geography for Site 4, Beaver Ruin Road

The Beaver Ruin Road site block groups selected for the base geography using the 75th percentile directional distribution ellipse accounted for 64.15% of all tags observed in peak direction out of all the tags observed at the site in peak direction that were registered within the 73 North Georgia counties (8,692 tags of 13,550 total tags). See Figure A.6 below for a map of the selected geography for Site 4.

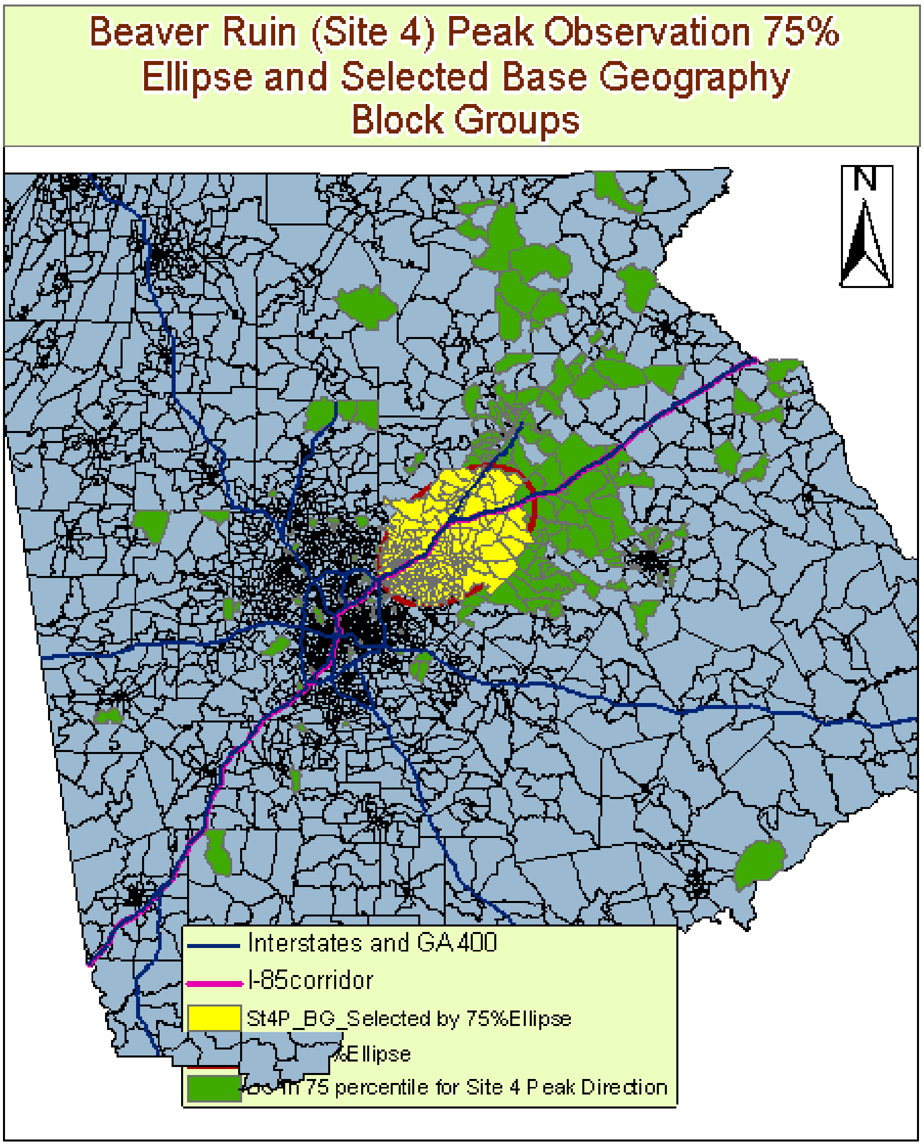

Figure A.6 Beaver Ruin Road Directional Distribution Ellipse and Selected Peak Direction Base Geography

Base Geography for Site 5, Northcrest Road

The block groups selected using the 75th percentile Directional Distribution Ellipse for Northcrest Road site represented 64.21% of total peak direction observations at that site that were attributable to registration addresses within the 73 North Georgia counties (7,696 observations out of a total of 11,985 observations.) Figure A.7 below illustrates the 75% Ellipse and the selected block groups for Northcrest Road site.

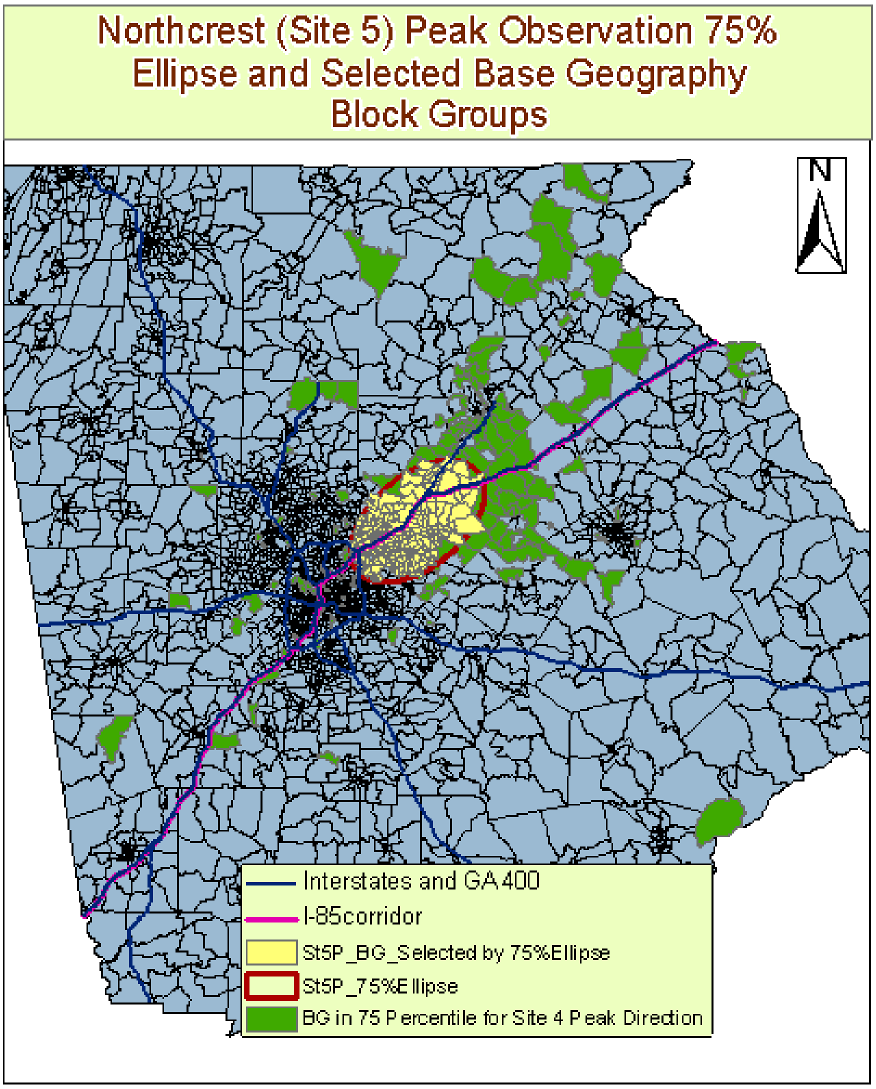

Figure A.7 Northcrest Road Directional Distribution Ellipse and Selected Peak Direction Base Geography

Base Geography for Site 6, Flat Shoals Road

Flat Shoals site block groups selected for the base geography accounted for 7499 total observations in peak direction, which represented 63.27% of all tags observed at the site in peak direction that were registered within the 73 North Georgia counties. Figure

A.8 below illustrates the map of selected base geography block groups for Flat Shoals site.

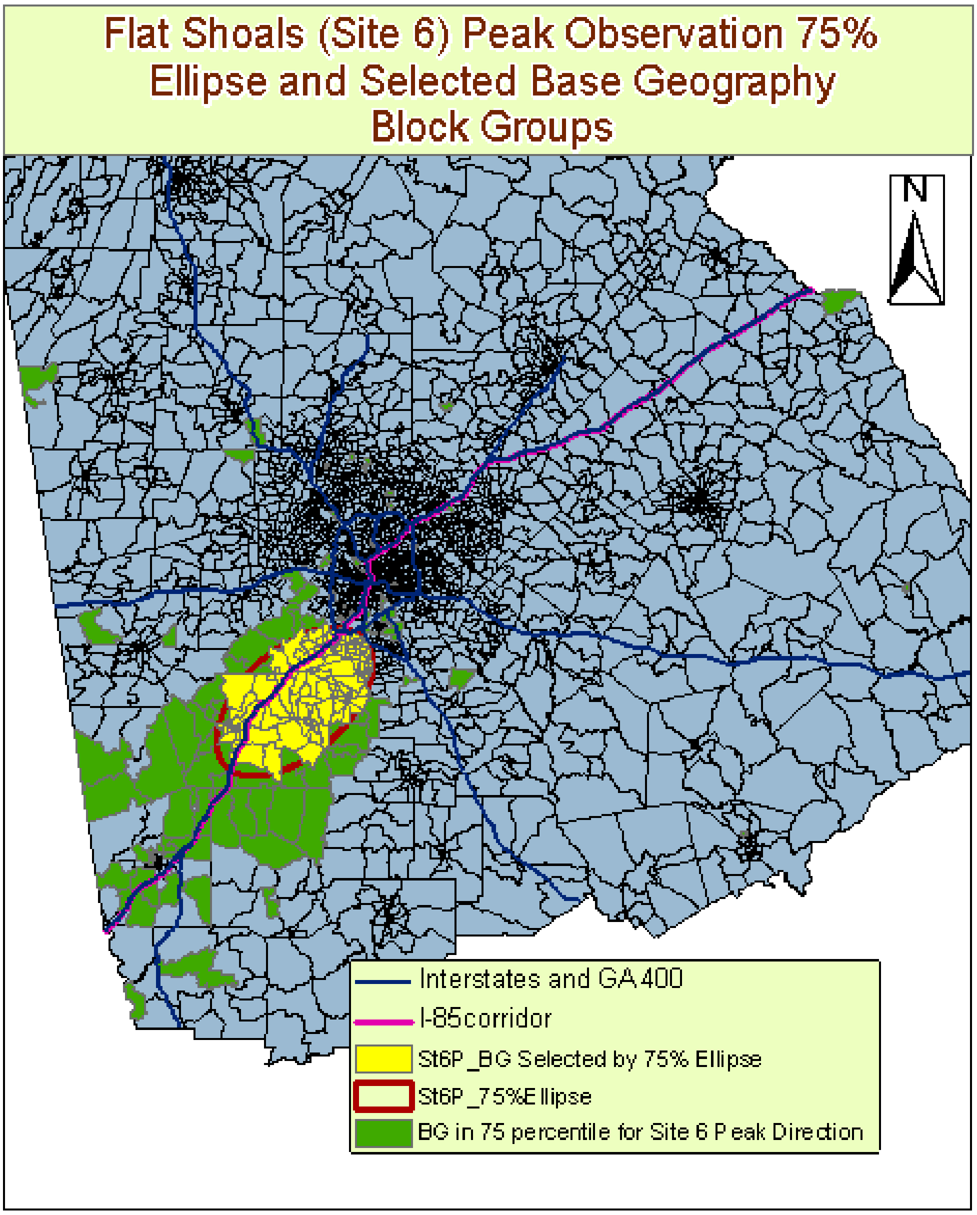

Figure A.8 Flat Shoals Site Directional Distribution Ellipse and Selected Peak Direction Base Geography

Once a base geography for each site was selected, the combined base geography for Metropolitan Atlanta I-85 corridor commuters was compiled from the six sub-geographies. As you can see from Figure A.9 below, the resulting selected base geography for each site falls within the 20 ARC 8-hour ozone non-attainment counties (ARC 18 transportation planning counties plus Carroll county and Hall county.)

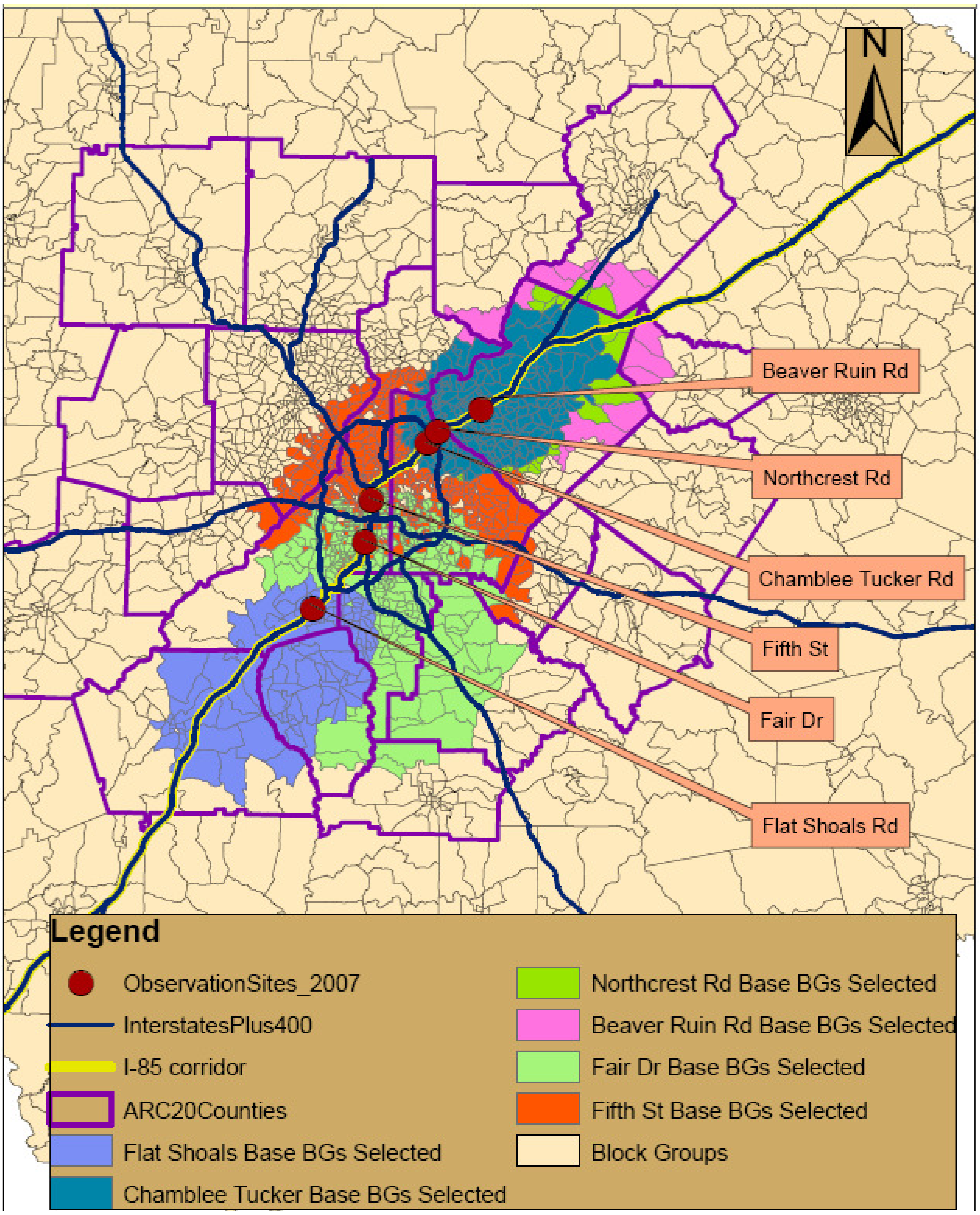

Figure A.9 Base Geography for All Six Sites, Selected Using Directional Distribution Ellipse Method in ESRI ArcGIS.

APPENDIX B

COMMUTERSHEDS FOR SUMMER 2007 LICENSE PLATE STUDY OBSERVATION SITES

The purpose of this appendix is to present the results of commutershed analysis for the three southern observation sites of the Summer 2007 License Plate study. This is an addition to the I-85 Commuter Demographics analysis presented in Chapter 2.

When considering the geographic distribution of commuter home locations, a significant percentage of "extreme commuters" with commutes approaching two hours were observed, either due to inaccuracies in vehicle registration database, or due to a high number of out-of-town trips taken on the I-85 corridor. Commutersheds were mapped for the observed corridor, as well as for each individual site.

For the purpose of this report, a commutershed denotes the driver home address catchment area for a specific observation site and specific observation direction, based on observed license plates' registration addresses. Commutershed is applied to all types of travelers on the corridor with vehicles registered within the state of Georgia. U.S. Census Bureau refers to home location catchment areas as labor sheds, when tied to a specific employment destination. Commutersheds in this report differ from labor sheds in that they do not necessarily indicate people driving within the Metropolitan Atlanta I-85 corridor for work purpose only.

The research team used the peak direction observed license plates that were registered in Georgia and matched them to the Vehicle Registration database home addresses. The home addresses were then geocoded to display the location on the map. When generating the commutersheds for peak direction observations at each observation site, the home addresses were generally dispersed throughout the state of

Georgia. The licence plates registered to states other than Georgia were not linked to addresses or geocoded.

Figure B.1 below illustrates the commutershed for the peak direction observations along the I-85 corridor (i.e. for all six observation sites combined). This commutershed represents all the unique tags observed in peak direction, registered within the state of Georgia, and is larger than the combined selected base geography chosen to analyze the demographics of I-85 commuters. Out-of-town travelers and those who have recently relocated to Metropolitan Atlanta area and have not yet changed their registration address likely affect this commutershed and account for a quarter to a third of all the dots on the map. As to be expected, Gwinnett County, Dekalb County, north Fulton County, City of Atlanta, South Fulton County, Clayton County and Coweta County are well represented. Cobb County and the southern tip of Cherokee County are surprisingly well-represented, given their primary reliance on the I-75 corridor north of the Connector for travel towards the Atlanta CBD.

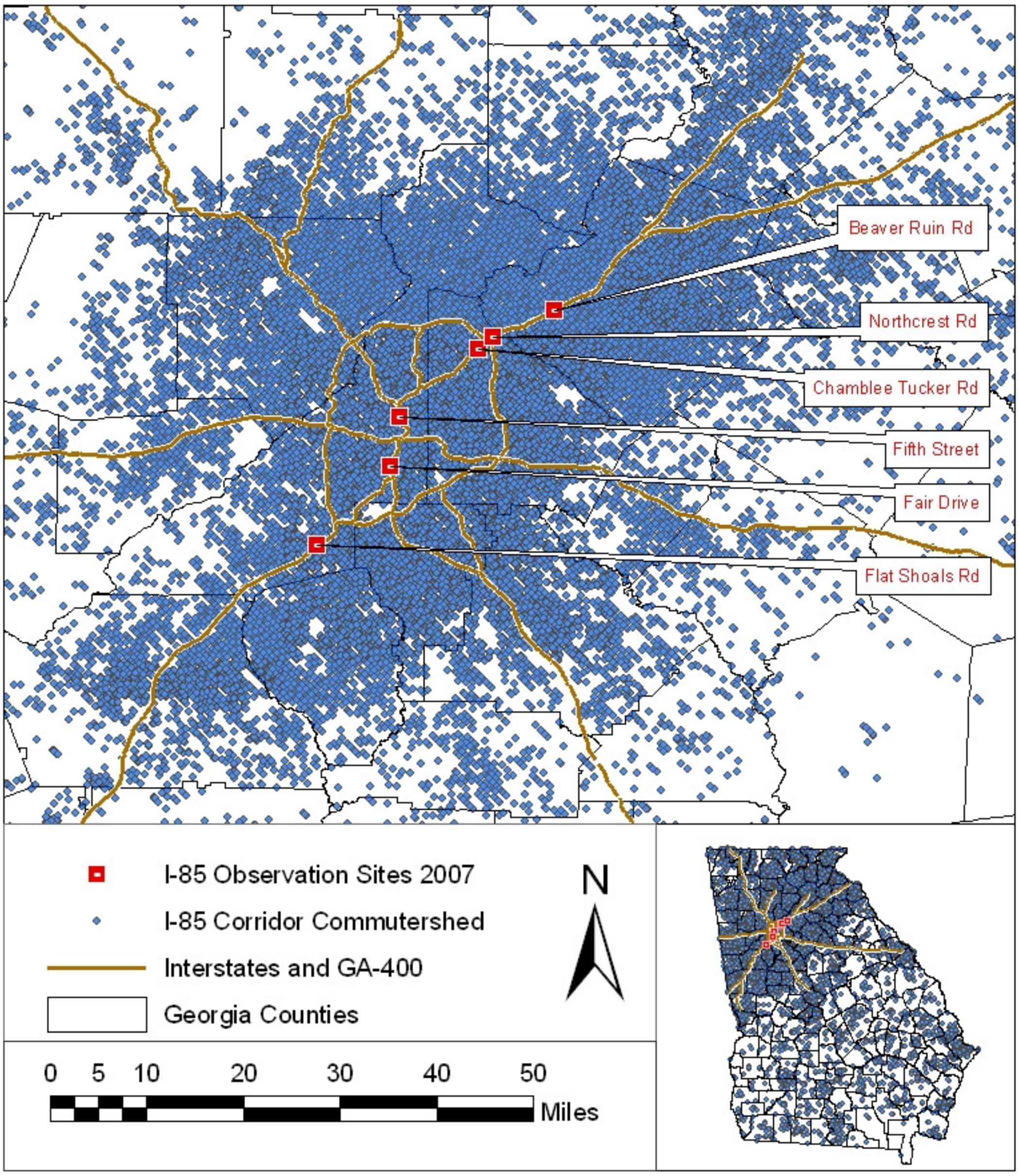

Figure B.1 Commutershed for I-85 Corridor Six Observation Sites Combined, Peak Direction.

Figure B.2 below indicates the commutershed for the peak direction observations at Beaver Ruin Road location along I-85. This was the northernmost location used in the Summer 2007 license plate observation study. The commutershed at Beaver Ruin Road heavily favors northern portion of Dekalb County and Gwinnett County, with northern part of Fulton County, southern section of Hall County and Cobb County also being heavily represented. The heavy presence of Cobb County-registered vehicles at this location might be indicative of a high percentage of commute trips taking place along the northern arch between Cobb, north Fulton and Gwinnett Counties, rather than being radially directed towards Atlanta downtown.

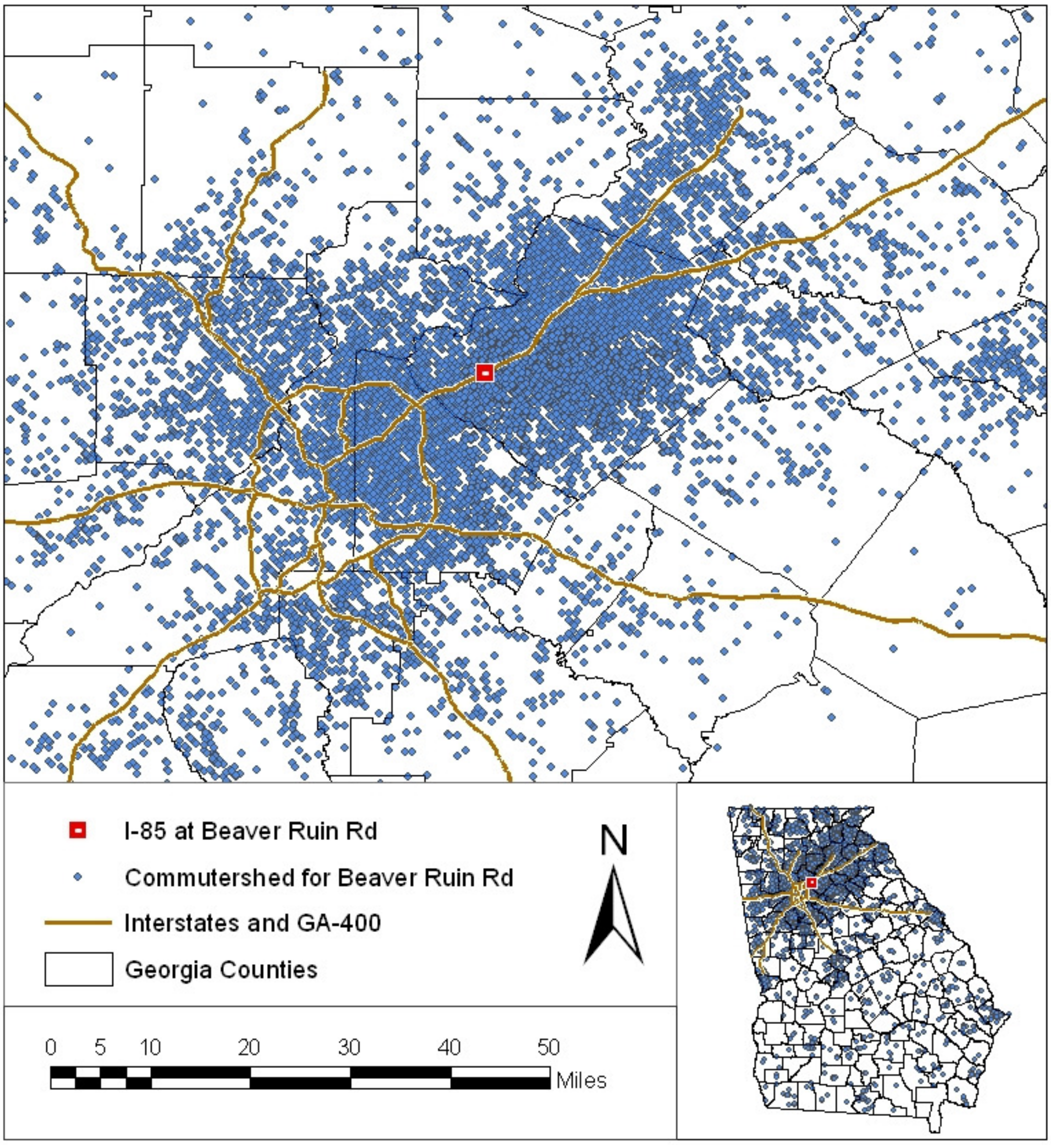

Figure B.2 Commutershed for I-85 Corridor Peak Direction Observed at Beaver Ruin Road

See Figure B.3 below for a representation of Northcrest Road peak direction commutershed. Being the second northernmost site within the 2007 I-85 corridor study, this site is fairly similar to Beaver Ruin Road in commutershed representation. However, Cobb County is less well represented, perhaps due to the proximity to I-285.

The peak direction chosen was southbound in the morning peak period, and northbound during the evening peak period. Commuters coming from Cobb County, traveling to locations south of Northcrest Road off I-85, would likely have an easier time taking I-285 east towards the I-85 corridor and then continuing south, rather than making the east-to-west arch movement north of I-285 prior to getting on I-85 southbound.

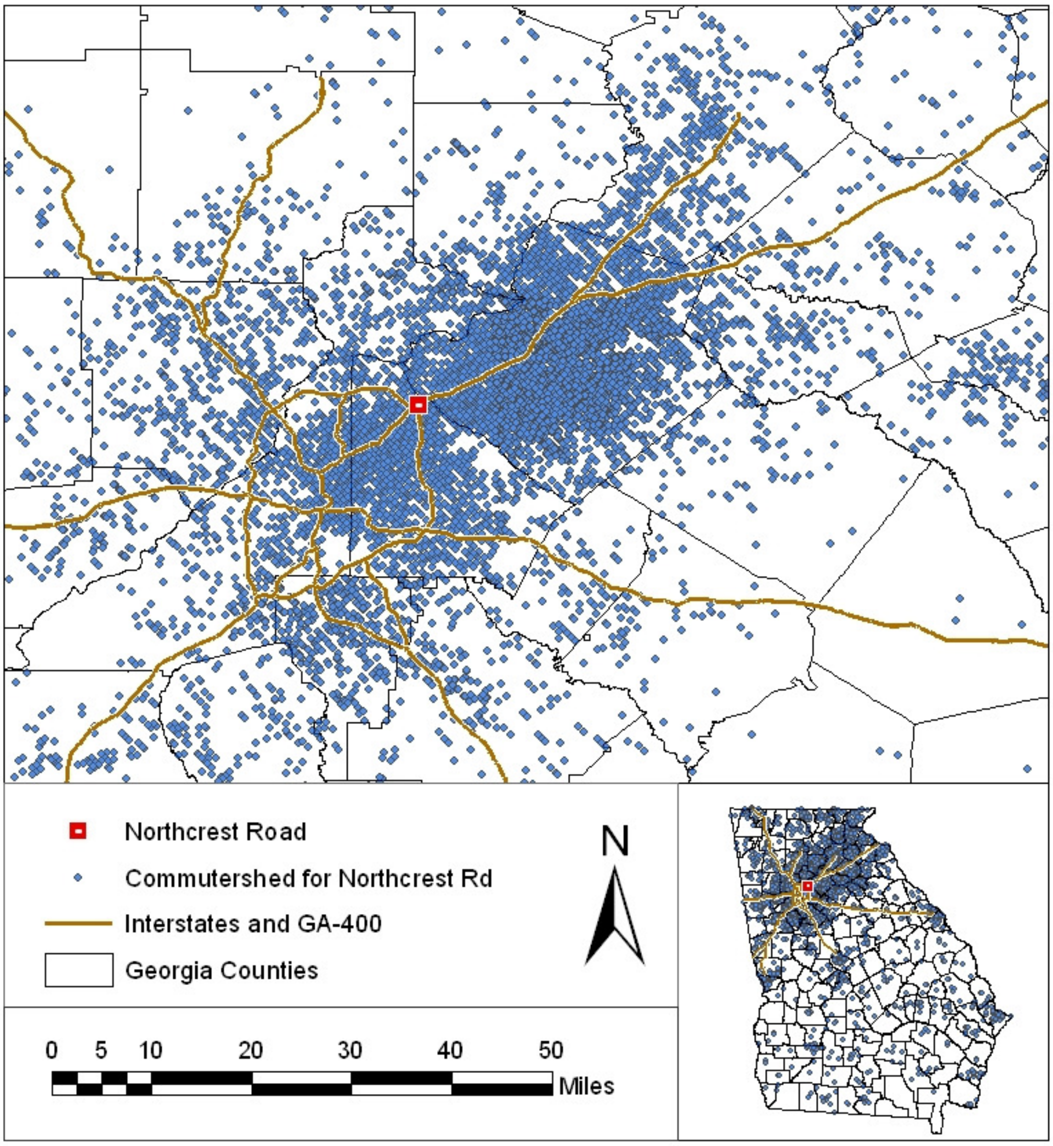

Figure B.3 Commutershed for I-85 Corridor Peak Direction Observed at Northcrest

Figure B.4 below illustrates the commutershed for the peak direction observations at Chamblee Tucker Road location along I-85. Chamblee Tucker observation location falls within the perimeter, being just inside I-285. Commutershed characteristics at this location are very similar both to Northcrest Road location and Beaver Ruin Road location.

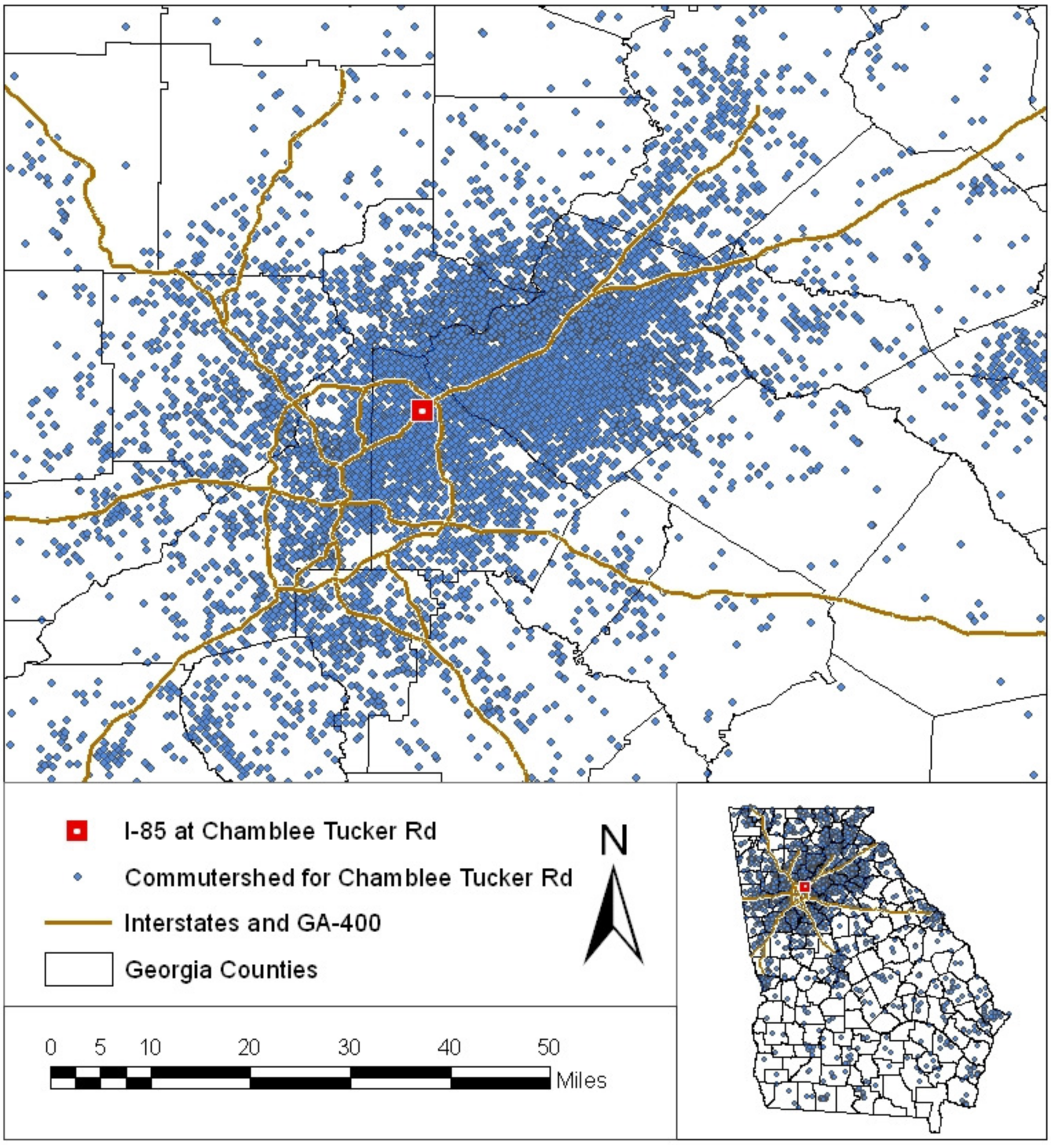

Figure B.4 Commutershed for I-85 Corridor Peak Direction Observed at Chamblee Tucker Road

Moving further south along the I-85 corridor, Fifth Street site receives peak traffic for both directions. For the purpose of this study, at Fifth Street location A.M. northbound and P.M. southbound directions were chosen as the peak directions. While the peak traffic distribution is fairly equal in both directions, travelers going south on I-85 to traverse the Fifth Street location would most likely be already represented by the observations at the three northern sites (Beaver Ruin Road, Chamblee-Tucker Road, and Northcrest Road.) Figure B.5 below illustrates the commutershed for the peak direction observations at Fifth Street site on I-85. You can see that the Fifth Street commuter shed is not very different from the combined I-85 corridor commuter shed, although slightly less dense and fades faster.

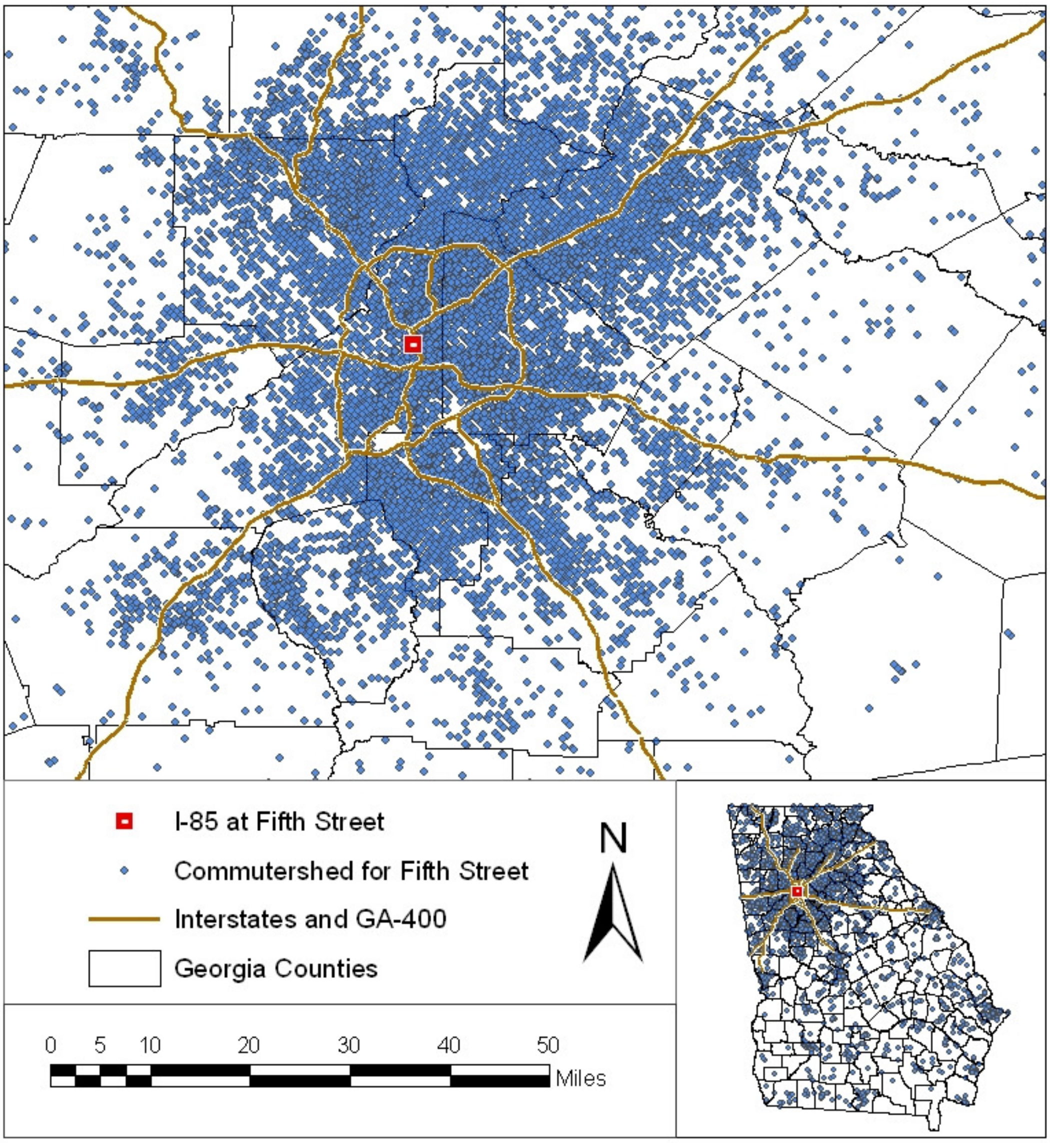

Figure B.5 Commutershed for I-85 Corridor Peak Direction Observed at Fifth Street

Figure B.6 below illustrates the commutershed for Fair Drive peak direction observations. Fair Drive is located slightly to the north of I-85 and I-75 split south of the Connector, which results in that site drawing from both I-85 and I-75 corridor commuters south of Atlanta.

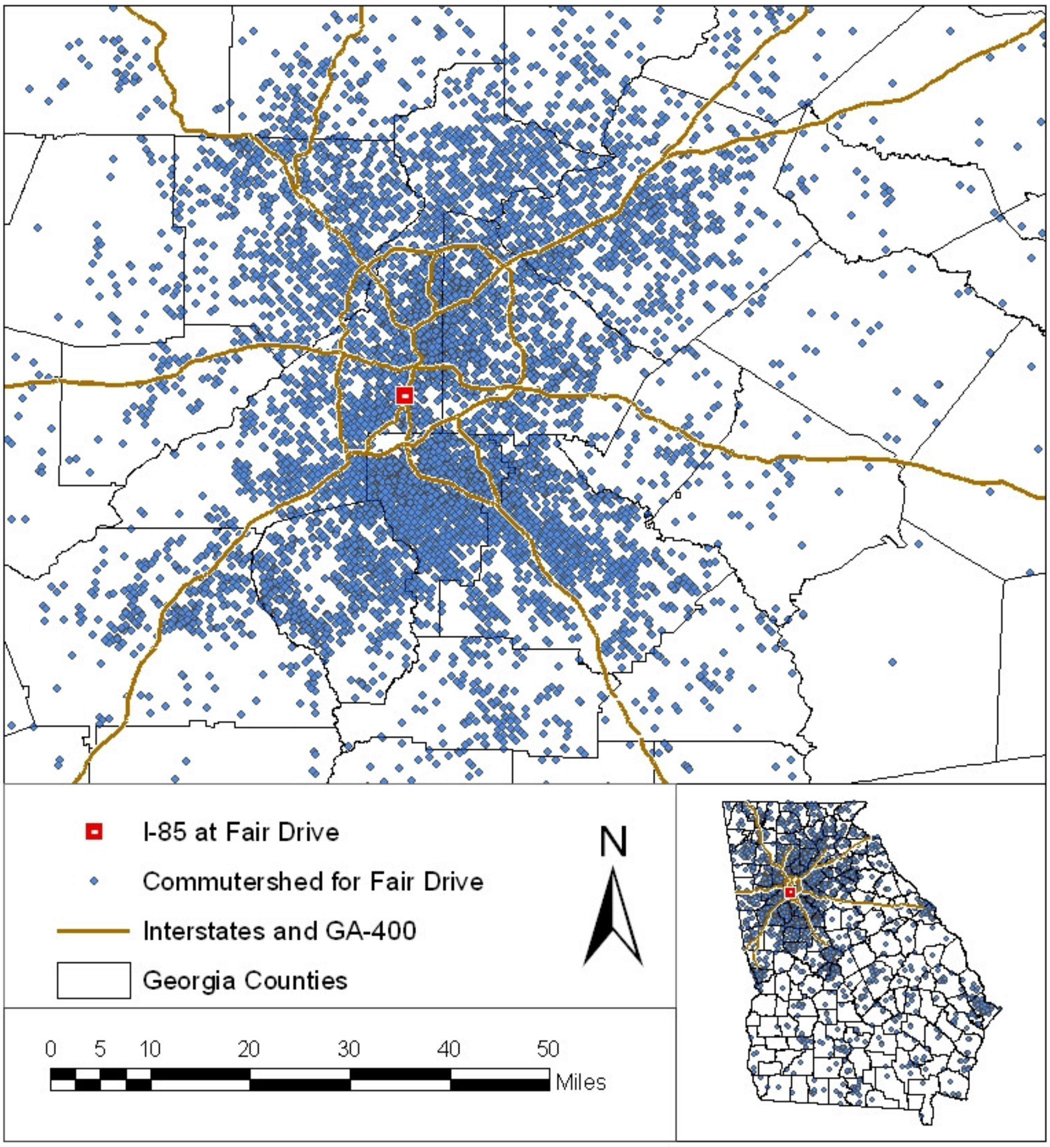

Figure B.6 Commutershed for I-85 Corridor Peak Direction Observed at Fair Drive

Figure B.7 below shows the commutershed for Flat Shoals observation site, peak direction traffic. Fayette County, Coweta County and South Fulton County are more heavily represented at Flat Shoals site than at Fair Drive location.

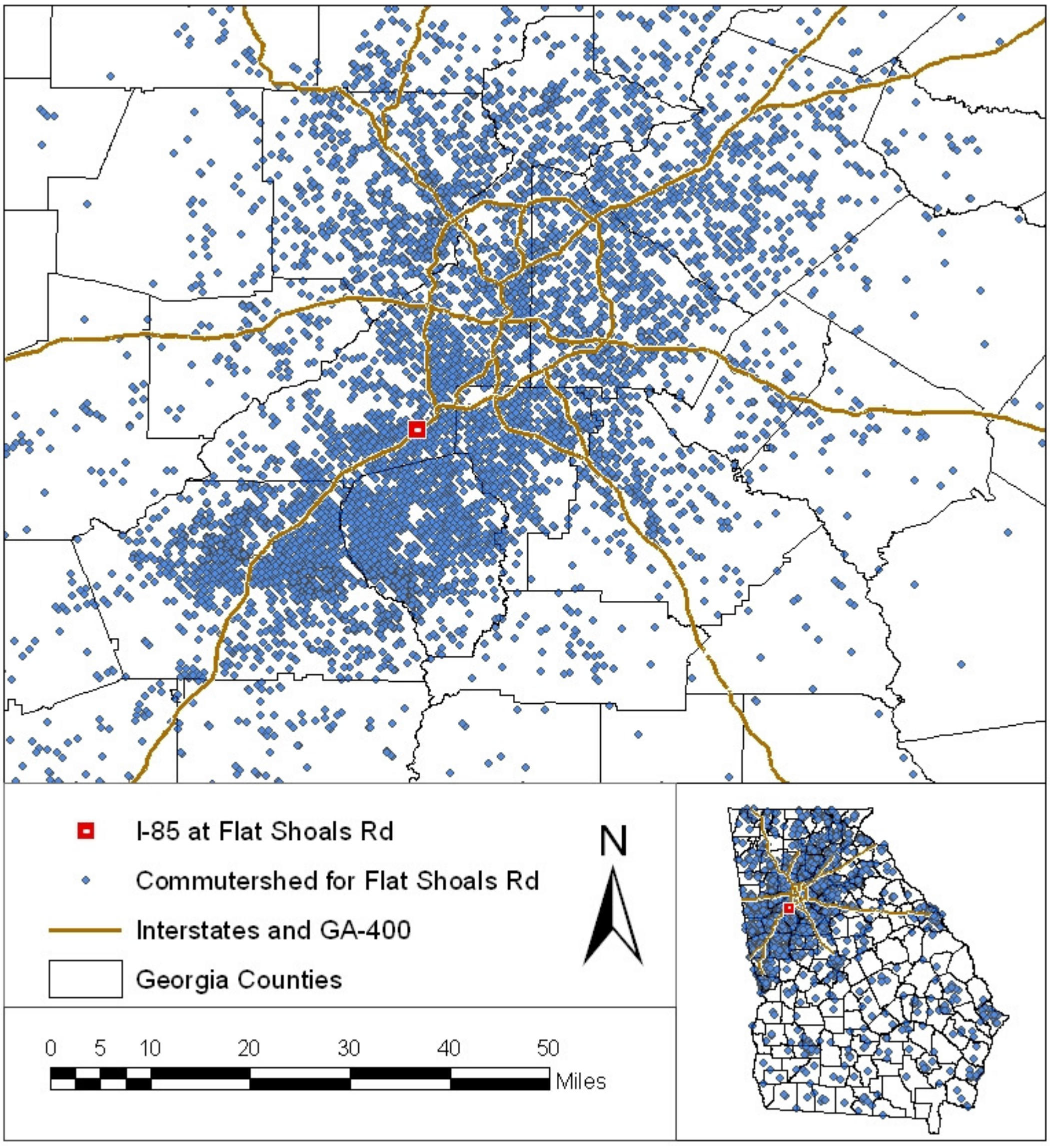

Figure B.7 Commutershed for I-85 Corridor Peak Direction Observed at Flat Shoals

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