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Residential Location Choice and Travel Behavior: Implications for Air Quality

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RESIDENTIAL LOCATION CHOICE AND TRAVEL BEHAVIOR: IMPLICATIONS FOR AIR QUALITY

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TABLE OF CONTENTS

1. INTRODUCTION

The sprawling patterns of land development common to metropolitan areas of the United States have been blamed for high levels of automobile travel, and thus for air quality problems. The defining characteristics of "sprawl" include: low-density development, unlimited outward expansion, and "leapfrog" development (Burchell et al., 2002: 39). Most metropolitan areas in the United States are growing faster in land area than in population. Between 1982 and 1997, urbanized land increased by 47%, while population grew by only 17% (Fulton et al., 2001). This low-density pattern of growth has two important effects on travel, namely longer trip distances and greater reliance on the car. Although the causes of sprawl are complex, public policies have clearly played a role. The development of extensive freeway systems in metropolitan areas, which began in the 1950s, reduced travel costs and enabled suburban growth. Land-use policies, particularly conventional zoning practices, have also contributed to sprawl by requiring the separation of land uses and by restricting the density of development.

In response, "smart growth" programs--designed to counter sprawl--have gained popularity in the United States. "Smart growth" is variously defined. The American Planning Association (2002) defines it as "the planning, design, development and revitalization of cities, towns, suburbs and rural areas in order to create and promote social equity, a sense of place and community, and to preserve natural as well as cultural resources." The U.S. EPA (2002) defines ten smart growth principles:

1. Mix Land Uses
2. Take Advantage of Compact Building Design
3. Create a Range of Housing Opportunities and Choices
4. Create Walkable Neighborhoods
5. Foster Distinctive, Attractive Communities with a Strong Sense of Place
6. Preserve Open Space, Farmland, Natural Beauty, and Critical Environmental Areas
7. Strengthen and Direct Development Towards Existing Communities
8. Provide a Variety of Transportation Choices
9. Make Development Decisions Predictable, Fair, and Cost Effective
10. Encourage Community and Stakeholder Collaboration in Development Decisions

Communities may implement a variety of policies in the form of regulations (such as zoning) and/or financial incentives to achieve these objectives. In general, these policies are designed either to manage the expansion of the community boundary, or to shape the kind of development that occurs within the community boundary; some policies achieve both objectives and the two types of policies are often combined. Policies designed to encourage development within the existing urbanized area aim, in part, to increase the viability of public transit, biking, and walking; more generally, they aim to reduce the distances between activities. Specific land use policies used in smart growth programs include mixed-use zoning, infill development, brownfield development, transit-oriented development, jobs-housing balance, and "Main Street" programs.

With ties to the smart growth movement, the Congress for the New Urbanism (CNU) argues that land use and urban design policies can effectively reduce automobile use and create more livable communities. Authors affiliated with the Congress for the New Urbanism have articulated specific design characteristics to achieve this goal, and claim that by putting the activities of daily living within walking distance and providing an interconnected network of streets, sidewalks, and paths, walking will increase and driving will decrease (e.g. Duany and Plater-Zyberk 1991; Calthorpe 1993; Katz 1994). One of the primary tenets of the New Urbanism is the idea that "communities should be designed for the pedestrian and transit as well as the car" (CNU 2002). The Charter of the New Urbanism states that "Many activities of daily living should occur within walking distance.... Interconnected networks of streets should be designed to encourage walking, reduce the number and length of automobile trips, and conserve energy" (CNU 2002). If so, these characteristics also reduce vehicle emissions.

The EPA now recognizes land-use policies as an effective tool for improving air quality and allows state and local communities to account for the air quality benefits of smart growth strategies in SIPs as a part of the Voluntary Mobile Source Emission Reduction Program (EPA, 2001). However, the estimation of emissions credits for land use policies is based on limited empirical evidence, and little is known about the sensitivity of air quality to changes in land use policy. Studies show that, all else equal, residents of neighborhoods with higher levels of urban density, land-use mix, transit accessibility, and pedestrian friendliness (among other characteristics) drive less than residents of neighborhoods with lower levels of these characteristics. These studies have not shed much light, however, on the underlying direction of causality--in particular, whether neighborhood design influences travel behavior or whether travel preferences influence the choice of neighborhood. The available evidence thus leaves a key question largely unanswered: If cities increase the opportunities for driving less through land use policies, will people drive less, thereby reducing emissions?

This report provides new evidence that helps to answer this question; it aims to provide a stronger basis for assessing the potential for land-use policies to reduce automobile travel, and thus vehicle emissions. The study summarized here uses original data to investigate the relationship between neighborhood characteristics and travel behavior while taking into account the roles of travel preferences and auto ownership in explaining this relationship. Chapter 2 presents a brief review of the literature on this topic. Chapter 3 describes the hypotheses and methodology used in this study. Chapter 4 summarizes the results of a household survey designed to test the hypotheses. Finally, Chapter 5 discusses the implications of the results and outlines questions for further research.

2. Literature Review

If cities increase the opportunities for driving less through land use policies, will people drive less, thereby reducing emissions? Existing research does not provide a clear answer. While a growing body of research points to a significant link between neighborhood design and travel behavior, it also raises important questions that remain unanswered. The relevant studies fall into three categories: studies of the impact of neighborhood design on travel behavior, studies of the role of travel preferences in residential location choice, and studies of the role of automobile ownership in both residential location choice and in travel behavior. Overviews of key studies in each of these categories and their theoretical underpinnings are provided here.

2.1 Impact of Neighborhood Design on Travel Behavior

Mitchell and Rapkin are often given credit for first articulating the connection between land use patterns and travel behavior in their 1954 book *Urban Traffic: A Function of Land Use*. This connection was built into travel demand forecasting models--first developed in the 1950s--to predict travel demand as a function of population and employment distributions. The theoretical basis for studying this connection has evolved considerably. Most notably, the application of a discrete choice framework for understanding travel behavior was first articulated by Domencich and McFadden (1975), later by Ben-Akiva and Lerman (1985) and Train (1986). In this framework, the travel choices made (such as the mode or destination) are determined by the characteristics of the choices available. Each possible choice offers a certain “utility” or value to the individual who seeks to maximize her utility. Maximizing utility generally means minimizing travel time, but other factors can outweigh time. For example, an attractive yet more distant destination may lure travelers, or the value of the exercise one gets while walking can compensate for the longer time it takes to reach the destination Theory thus points to mixed effects on travel for land-use policies: these policies may increase the utility of alternatives to driving, but they also tend to increase the utility of making trips so that reductions in driving from a shift in travel modes may be offset by increases in the overall frequency of trips.

The idea that land use and design policies could be used to influence travel behavior was not widely explored until the 1980s. Early interest focused on the connection between density and transit use. The 1977 study by Pushkarev and Zupan suggests that transit use can be increased through polices that increase densities. A heated debated ensued in the early 1990s over analysis by Newman and Kenworthy on the correlation between densities and gasoline consumption for a sample of international cities (Newman and Kenworthy 1999). In response to the emergence of the smart growth movement and the concept of new urbanism, more recent studies have generally confronted the broader question about the links between travel behavior and the built environment more generally; these studies also aim to test the hypothesis that policies that shape the built environment can be used to reduce automobile travel. Since the early 1990s, such studies have appeared in the literature with increasing frequency. Recent literature reviews document over 70 studies published during the 1990s that have explored and quantified these relationships (e.g. Handy 1996; Boarnet and Crane 2001a; Ewing and Cervero 2001).

These studies fall into three general categories: simulation studies, aggregate studies, and disaggregate studies (Handy 1996). Simulation studies use travel demand forecasting models to estimate the impacts on travel behavior of changes in the built environment. This approach has been most often used to test the impact of the design of the street network on vehicle miles traveled (VMT) (e.g. Kulash, Anglin, and Marks 1990; McNally and Ryan 1993). Aggregate studies use data on average travel characteristics in zones or tracts (or sometimes cities or regions) to test for correlations between travel patterns and characteristics of the built environment, such as density or era of development (e.g. Cervero and Gorham 1995; Friedman, Gordon, and Peers 1992). Disaggregate studies use individual or household-level data to model the relationships between characteristics of the built environment and travel behavior. Most of these studies have focused on the frequency of trips or on the amount of travel by different modes (e.g. Cervero and Kockelman 1997; Boarnet and Crane 2001b; Handy and Clifton 2001). Cutting across these three categories are: differences in the travel characteristic as the dependent variable (e.g. VMT, trip frequency, trip length, mode choice) and the characteristics of the built environment as independent variables (e.g. density, era of development, network characteristics, access to jobs or shopping, etc.). Most studies have focused on travel in general, while some studies have distinguished between work travel and non-work travel.

Sorting out the extent to which socio-economic characteristics and characteristics of the built environment impact travel behavior is a common challenge in these studies. Ewing and Cervero (2001), after one of the most thorough reviews of these studies, come to several important conclusions:

- Trip frequencies appear to be primarily a function of the socio-economic characteristics of travelers, and secondarily a function of the built environment.

- Trip lengths are primarily a function of the built environment and secondarily a function of socioeconomic characteristics.

- Mode choices depend on both socio-economic characteristics and characteristics of the built environment, though probably more the former.

- Characteristics of the built environment are much more significant predictors of VMT, which is the outcome of the combination of trip lengths, trip frequencies, and mode split.

Based on the results of all available studies and original data analysis for available data sets, Ewing and Cervero (2001) estimated elasticities for VMT and vehicle trips. Four measures of the built environment were used: "density," measured as population plus jobs divided by land area; "diversity," a measure of jobs-population balance; "design," a combination of sidewalk completeness, route directness and street network density; and "regional accessibility," an index derived with a gravity model. These estimates were both point elasticities (calculated at the average value of the variable) and partial elasticities, which control for the effects of other variables. The results showed a statistically significant, but rather limited, link between characteristics of the built environment and travel behavior (Table 2-1). A 10% increase in local density, for example, is associated with only a 0.5% decline in vehicle trips and VMT. The highest elasticity is for regional accessibility (a 10% increase in regional accessibility was associated with a 2% decline in VMT), but regional accessibility is also arguably the most difficult characteristic to modify.

Table 2-1. Typical Elasticities of Travel with Respect to the Built Environment

	Vehicle Trips	VMT
Local Density	-0.05	-0.05
Local Diversity	-0.03	-0.05
Local Design	-0.05	-0.03
Regional Accessibility	--	-0.20

Source: Ewing and Cervero 2001

Researchers have also studied the connection between neighborhood design and walking. Saelens, et al. (2002) reviewed and summarized 12 studies from the travel behavior literature. Comparative studies showed significant differences in the frequency of walking for "high-walkable" neighborhoods and "low-walkable" neighborhoods, while correlational studies demonstrated "consistent associations of neighborhood walkability factors with walking and cycling for transport" (Saelens, et al. 2002: 84). However, it is important to note that higher levels of walking do not necessarily mean lower levels of driving. It is possible that walking trips are made in addition to, rather than instead of, driving trips. Handy, et al.(1998) tested this possibility by asking respondents of a household survey to think about the last time they walked to a store and to speculate what they would have done had they not been able to walk that day. The results showed that nearly two-thirds of respondents would have driven to the store instead, suggesting that most walks to the store do in fact replace a driving trip. However, 13 percent of respondents said they would have stayed at home, in which case the walk trip did not replace a driving trip. Further, recreational (rather than destination-oriented) walk trips were not included in this test and presumably would *not* be replacements of car trips.

The debate over the link between neighborhood design and travel behavior now centers on the issue of causality. Almost all of the available studies have used a cross-sectional design that compares travel behavior for different people or places at one point in time. These studies thus reveal correlations between the built environment and travel behavior, but do not prove causality. In other words, it is not possible to say that a 10% increase in local density in a particular neighborhood will lead to a 0.5% decline in vehicle trips and VMT. Researchers generally call this the "self-selection" problem: individuals who would rather not drive may choose to live in neighborhoods conducive to driving less. In other words, the characteristics of the built environment does not cause them to drive less; rather, their desire to drive less causes them to select a neighborhood with those characteristics--the reverse of the presumed causality. As a result, it is not possible to predict the impact on travel of either increasing density in a particular neighborhood or of moving residents from one kind of neighborhood to another…

A few researchers have made some effort to address the self-selection issue. Handy and Clifton (2001) found both quantitative and qualitative evidence that residents of an Austin neighborhood where the average frequency of walking to the store is significantly higher than in other neighborhoods did in fact choose that neighborhood because they like to walk to the store. Bagley and Mokhtarian (2002) undertook a more sophisticated analysis of the relationships between attitudes, neighborhood characteristics, and travel behavior. They concluded that attitudinal variables had the greatest impact on travel behavior among all of the explanatory variables and that neighborhood characteristics had little impact on travel behavior. These findings suggest that "the association commonly observed between land use configuration and travel patterns is not one of direct causality, but due primarily to correlations of each of those variables with others." In other words, observed associations between travel behavior and neighborhood characteristics are largely explained by the self-selection of residents' with certain attitudes into certain kinds of neighborhoods. It is thus important to also consider the role of residential location choice in studying the link between neighborhood design and travel behavior.

2.2 The Role of Residential Location Choice

Travel behavior theory and other behavioral theories point to the importance of relationships between longer-term choices, such as residential location choices, and shorter-term choices, such as daily travel choices. Work by Domencich and McFadden (1975) and others on travel behavior theory recognized that daily choices about travel are related to choices about auto ownership, residential location, and job location. Researchers have sometimes made use of a series of linked choice models to address this issue. Ben-Akiva and Atherton (1977), for example, defined long-range decisions as employment location, residential location, and housing type; medium-range decisions as automobile ownership and mode to work; and short-range decisions as non-work travel (frequency, destination, and mode) (as cited in Ben-Akiva and Lerman 1991). In this model, medium-range decisions are conditional on long-run decisions, and short-range decisions are conditional on medium- and long-range decisions. In addition, expected outcomes of short-range decisions can sometimes influence medium- and long-range decisions; to account for this possibility, attributes of short-term decisions are aggregated and included as composite variables in models of medium-term and long-term decisions. At each level, choices can be modeled using the discrete choice framework.

However, travel behavior theory offers little guidance as to what choices are short-term, medium-term, and long-term and how choices at each level are influenced by choices at other levels. It seems logical that frequent choices (e.g. walk to work today) are conditional on occasional choices (e.g. live close to work), but it is possible that occasional choices (e.g. live close to work) are in fact conditional on preferences for frequent choices (e.g. prefer to walk to work). Although travel behavior theory focuses on choices, in practice, travel behavior research focuses on observed behavior; researchers equate the observable behavior that results from a choice with the choice itself, when in fact the choice may precede the behavior by some amount of time. The separation between thought-process and behavior, suggested by the concept of *intention* in Azjen' Theory of Planned Behavior (1991), is rarely accounted for in the travel behavior field. However, Azjen's theory does not account for the impact of intention with respect to one behavior on other behaviors, for example when the intention to walk impacts the choice of where to live.

The residential location choice literature provides some evidence on a connection between travel preferences and residential location choice. The bid rent model from urban economics says that residential location choice is a trade-off between commute distance and land price: a location near the center of the city means a short commute but high land prices and thus small living spaces; a location near the edge of the city means low land prices large living spaces but a long commute. Evidence suggests that in the U.S., preferences for large living spaces win out over preferences for short commutes, at least for most people. In this model, the residential location decision determines the commute distance, but preferences for commuting influence the residential location decision. Residential location choice has also been analyzed with the use of hedonic pricing models. These empirical models explain housing prices through the characteristics of the house and the characteristics of its location. Haider and Miller (2000), for example, found that being within 1.5 km of a subway line was positively associated with housing price, suggesting that some households make residential location choices based in part on the opportunity to use transit. Such studies provide at least indirect evidence that preferences for certain neighborhood characteristics impact residential location choice. But few of these studies focus on physical characteristics of the neighborhood; instead, most focus on the physical characteristics of the living unit and community characteristics, such as school quality and crime rates.

2.3 The Role of Auto Ownership

Auto ownership has a strong influence on travel behavior, as countless studies show. Most travel demand forecasting models, widely used in regional transportation planning, incorporate auto ownership as a key variable for predicting trip generation and mode split. Even though households that do not own automobiles often rely on the automobiles of others for their daily travel, the correlation between auto ownership and travel by automobile is strong. According to the 2001 National Household Travel Survey (NHTS), households without a vehicle made 34.1% of their trips by auto, 19.1% by transit, and 43.5% by nonmotorized modes; in contrast, households with one vehicle made 81.9% of their trips by automobile and households with 3 or more vehicles made 90.5% of their trips by automobile (Pucher and Renne 2003). A study of cities in the U.S., Australia, Asia, and Europe found that the significant increase in vehicle travel between 1960 and 1990 was a direct result of increased incomes and greater automobile ownership (Cameron, et al. 2004).

The connection between neighborhood design and auto ownership has not been extensively studied. The available evidence suggests that households living in single-family dwellings and/or suburban types of neighborhoods, typically located farther away from large employment centers, tend to own more vehicles (and use them more often) than households living in denser neighborhoods and/or closer to the central business district. (e.g. Lerman, 1979; Sermons and Seredich, 2001; Kitamura et al., 2001; Bagley and Mokhtarian, 2002). Case studies of Chicago, Los Angeles, and San Francisco found that automobile ownership was significantly correlated with neighborhood residential density, after accounting for average per capita income, average family size, and availability of public transit (Holtzclaw, et al. 2000). Similarly, a study of neighborhood design and automobile ownership in Portland, OR found that as land use mix changes from homogeneous to diverse, the probability of owning an automobile decreases by 31 percentage points, after accounting for income and other factors (Hess and Ong 2002). The authors conclude that traditional neighborhoods give households the "opportunity to express their preferences to avoid automobile ownership." In other words, the observed correlations between neighborhood design and auto ownership may be due to the influence of preferences for automobile ownership on residential location choice, rather than the influence of neighborhood design on automobile ownership decisions.

Also of interest is the question of vehicle type: do the types of vehicles owned by residents of different types of neighborhoods vary, and what are the implications for air quality? An analysis of the 1995 Nationwide Personal Transportation Survey (NPTS) by Niemeier and colleagues showed that suburban residents own a disproportionate share of sport utility vehicles (SUVs) and pre-1981 vehicles; both categories produce higher emissions, on average, than a typical passenger vehicle (Niemeier, et al. 1999). In addition, suburban residents have longer average trip lengths than urban residents, thus increasing the gap in emissions between urban and suburban residents. However, it is not clear whether the observed correlations can be attributed to the influence of living in a suburban area on the decision to buy an SUV, or to a correlation between preferences for SUVs and preferences for suburban environments.

2.4 Conclusions

Although existing studies show strong correlations between neighborhood design and travel behavior, as well as automobile ownership, they leave open the question of causality. For example, residents who prefer to walk may be selecting neighborhoods more conducive to walking, and residents who prefer not to drive may be opting for neighborhoods where it is easier to not own a car, or at least to drive less. If so, travel preferences rather than neighborhood design are the primary factors in explaining the different travel behaviors observed in different kinds of neighborhoods. These possibilities suggest that studies focused on articulating the relationships between the built environment and travel behavior must also consider longer-term choices about residential location and auto ownership, and the role that travel preferences play in these choices. In the next chapter we describe the methodology used in this study to address such issues.

3. METHODOLOGY

The literature review summarized in the previous chapter provides strong evidence of correlations between neighborhood design and travel behavior--in neighborhoods that provide opportunities for driving less, residents do in fact drive less. However, the studies uncover important and unanswered questions about the causal relationships between neighborhood design and travel behavior. In particular, few studies have examined the role of preferences; the relationships between short-term choices about travel and longer-term choices about auto ownership and residential location also remain largely unexplored. The methodology used in this study responds to these limitations and aims to offer new evidence on the potential for land-use and design policies to influence travel behavior. This chapter outlines the hypotheses of the study, the research design, the sampling plan, and the administration of the household survey.

3.1 Hypotheses

In exploring the complex relationships between neighborhood design, travel behavior, residential location choice, and automobile ownership, it helps to begin with a simple model and build toward a more complete model of these relationships. We thus offer four hypotheses here, starting with a basic hypothesis and adding new layers to each subsequent hypothesis.

The most basic goal of the study was to examine differences in travel behavior for residents of different kinds of neighborhoods. The first hypothesis is: neighborhoods that offer greater opportunities for driving less are negatively associated with levels of driving (Figure 3-1). In general, "traditional" neighborhoods--characterized by higher densities, greater mix of land uses, better pedestrian infrastructure, and higher levels of transit service--are assumed to offer greater opportunities for driving less than "suburban" neighborhoods. In addition, socio-demographic factors are also expected to influence levels of driving, and must be accounted for in testing the hypothesis: age, income, gender, household structure, education, physical and/or mental limitations, etc.

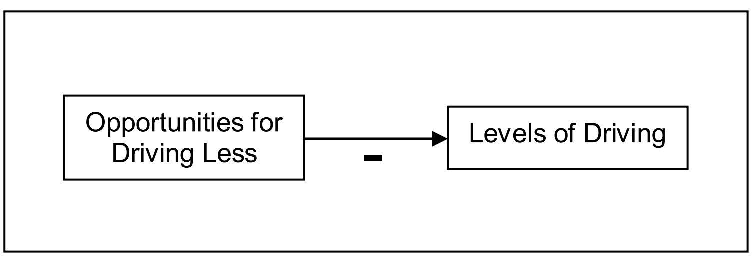

Figure 3-1. Hypothesis 1

Another goal of the study was to explore the question of self-selection: to what degree can differences in travel behavior by neighborhood be explained by differences in residents' preferences by neighborhood? The second hypothesis is that a preference for driving less will be positively associated with living in a neighborhood that offers greater opportunities for driving less; both preferences *and* opportunities for driving less will be negatively associated with levels of driving (Figure 3-2). As in the first hypothesis, socio-demographic factors are also expected to influence levels of driving and must be accounted for.

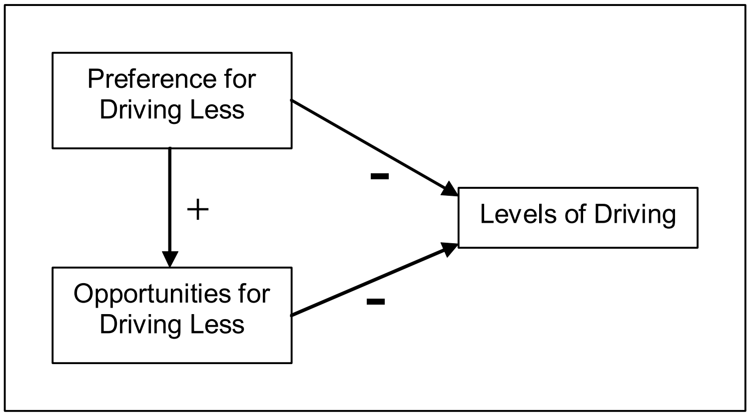

Figure 3-2. Hypothesis 2

Of course, auto ownership may also play an important role. As previous research shows, the lack of access to an automobile is generally associated with lower levels of driving. To complicate matters, auto ownership might be influenced by opportunities for driving less and by preferences for driving less. In other words, these variables may work directly to influence levels of driving and *indirectly* through their influence on automobile ownership (Figure 3). These relationships will be tested using more sophisticated techniques in future analysis.

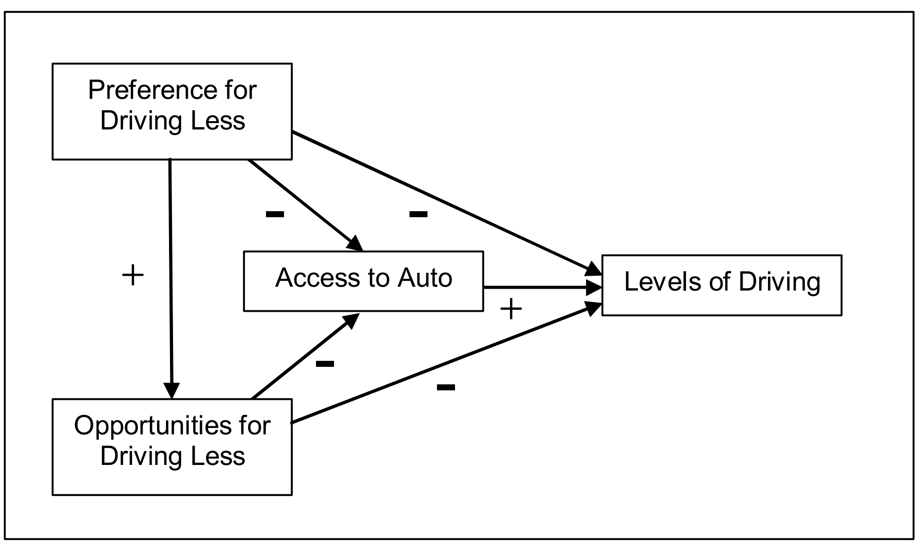

Figure 3-3. Hypothesis 3

In addition, the relationships between all of these variables may be bi-directional, at least over time. For example, living in an environment that offers ample opportunities for driving less might over time increase the preference for driving less or lead to a decline in auto ownership; or, high levels of driving might lead to higher preferences for driving less, and so on (Figure 3-4). These relationships will also be tested using more sophisticated techniques in future analysis.

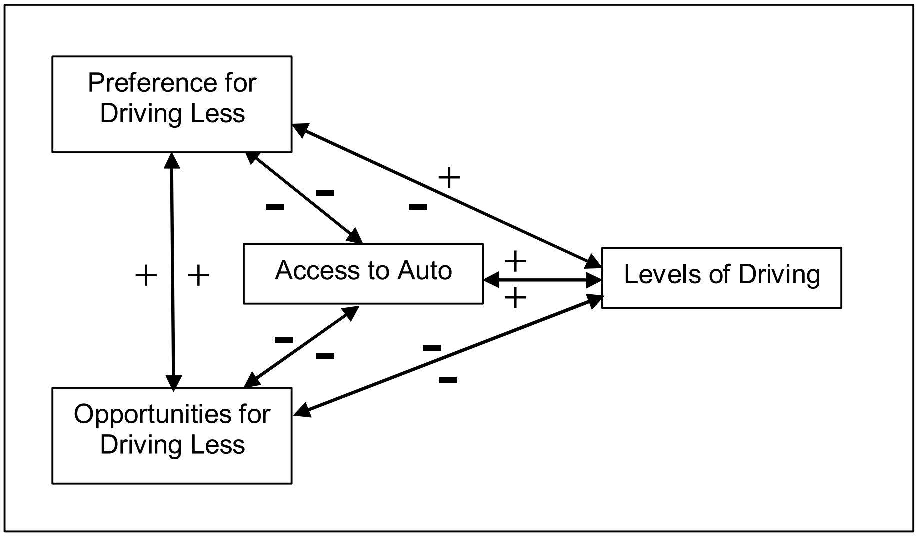

Figure 3-4. Hypothesis 4

3.2 Research Design

If local governments increase the opportunities for driving less through land-use policies, will residents actually drive less? To answer this question, the ideal study would measure travel at one point in time, then at a second point in time following a change in the environment that increases (or decreases) the opportunities for driving less. The study would use a "treatment group" that experienced the increase in opportunities for driving less, along with a "control group" that did not experience the increase. Participants in the study would be randomly assigned to these two groups. This sort of experimental design would provide the strongest possible evidence of causality between neighborhood characteristics and travel behavior (Babbie 1998), but it would also be extremely expensive and generally impractical.

Given financial and practical limitations, most studies rely on cross-sectional designs that compare travel behavior for residents living in neighborhoods with different characteristics. Such studies, as summarized in the previous chapter, show correlations between neighborhood characteristics and travel behavior but do not establish causality. One possibility is that the observed correlations between neighborhood design and travel behavior are explained by travel preferences, namely that travel preferences influence both the choice of neighborhood and travel behavior. One solution is thus to account for travel preferences in cross-sectional studies. This approach would answer the following question: After controlling for the effect of preferences on travel behavior, does neighborhood design further explain variations in travel behavior?

Another approach is to use a quasi-longitudinal design. If it is not feasible to change the physical design of a neighborhood, it is possible at least to observe changes in travel behavior for people who move from one neighborhood to another and who thus effectively experience a change in neighborhood design. Ideally, the study would observe travel behavior before and after the move and test the degree to which changes in neighborhood design explain changes in travel behavior. With limited time and a more restricted budget, researchers can at least identify people who have recently moved and ask about how current travel differs from travel before the move. This approach relies on recall and is unlikely to yield precise measures of changes in travel behavior; however, it can be used to capture the direction of the change and estimate its order of magnitude. This approach would answer the following question: After controlling for the effect of preferences on travel behavior, does change in neighborhood design further explain variations in changes in travel behavior?

The design used in this study enables both cross-sectional and quasi-longitudinal analyses, taking into account travel preferences. As explained in more detail below, we selected eight neighborhoods in Northern California that differ with respect to neighborhood design. In these neighborhoods, we selected a sample of residents who had moved within the last year and residents who had not. We collected data on travel behavior, perceived neighborhood characteristics, preferences for neighborhood characteristics, travel preferences, and socio-demographic characteristics using a mail-out/mail-back household survey.

3.2 Measurement

The variables in our hypotheses were measured using a household survey, the sampling and administration of which are described below. Survey questions were developed from surveys used in previous research projects by the principal investigators and other researchers. The survey was pre-tested on UC Davis students and staff, then on a convenience sample of Davis residents. Participants were asked to first complete the survey, then to discuss the survey questions with the researchers, either in a group meeting or in one-on-one interviews. Based on these pretests, survey questions were modified and refined. The survey instrument is included in Appendix A. Key variables were measured in the following ways (Table 3-1).

Travel behavior was variously measured. A series of questions asked about characteristics of the commute, including frequency of work trip, miles from home to primary place of work, time to get to primary place of work, frequency of stopping on the way home from work, frequency of working at home, and frequency of use of different travel modes. For nonwork travel, respondents were asked to indicate about how frequently they used different modes (driving, public transit, and walking or biking) to get to a selected list of destinations, such as a church, restaurant, or store. For walking, respondents were asked to report how many times in the last 30 days they had walked to a local store and how often they had taken a walk or stroll around the block. Finally, respondents were asked to list vehicles currently available to the household, and to estimate how many miles they drive in a typical week.

Change in travel behavior was measured using a series of general indicators. Because it is difficult for individuals to accurately recall the specifics of their travel behavior from as long as one year ago, respondents were asked to indicate how their travel differs now, from either before they moved (for the sample of respondents who had moved within the last year) or from one year ago (for the sample of respondents who had not recently moved). One question asked about use

Table 3-1. Measurement of Key Variables

Variable	Survey Questions	Notes
Travel Behavior	Commute trip characteristics (Question II.1) Frequency of mode use to non-work destinations (Questions II.2-II.4) Walking frequency (Question II.5) Vehicles available to household (Question III.1) Miles driven per week (Question III.2)	
Opportunities for Driving Less	Perceived neighborhood characteristics - current neighborhood (Question I.9) Accessibility to selected businesses	Reduced to 6 factors using factor analysis Objectively measured using GIS
Preferences for Driving Less	Travel preferences (Question IV) Preferred neighborhood characteristics (Question I.8)	Reduced to 6 factors using factor analysis Reduced to 6 factors using factor analysis
Changes in Travel Behavior	Use of modes for daily travel (Question II.7) Commute trip characteristics (Question II.8) Vehicles available to household before move (Question III.3)	
Changes in Opportunities for Driving Less	Perceived neighborhood characteristics - previous neighborhood (Question I.10)	Reduced to 6 factors using factor analysis; difference between factors for current and previous neighborhood computed
Socio-Demographic Characteristics	Gender and age for respondent and for household members, educational background, driver's license, limiting conditions, owner/renter status, household income (Questions V.1, V.2, V.4-V.8)	
Change in Socio-Demographic Characteristics	Gender and age for previous household members, previous household income (Questions V.3 and V.9)	

of different modes compared to previously; on a five-point scale respondents were asked to choose from “a lot less now” to “a lot more now.” A second question asked about changes in the commute trip, including frequency of the trip to work, frequency of driving to work, and frequency of stopping on the way home from work; again, on a five-point scale respondents chose from “much less often now” to “much more often now,” and on changes in proximity of residence to work, from “much closer now” to “much farther now.”

Opportunities for driving less were measured using perceived neighborhood characteristics. Survey respondents were given a list of 34 items and asked to indicate, on a four-point scale from “not at all true” to “entirely true,” the degree to which the item is true for their current residence and neighborhood. Through factor analysis, these items were reduced to a set of six factors: accessibility, alternatives, safety, socializing, space, and attractiveness (Table 3-2). Factor analysis examines the structure of the relationship among a set of items--in this case the responses on each of the neighborhood characteristics--and is used to identify a smaller number of underlying factors that can be represented by linear combinations of the individual items. The resulting factor scores are dimensionless measures, normalized to a mean of 0 and a variance of 1.

We estimated these factors using principal components analysis with oblique rotation with a threshold for suppression of 0.33 and using a combined database of current neighborhood characteristics, previous neighborhood characteristics, and preferred neighborhood characteristics (these variables are described below). Using a combined database results in consistency in the factors across the three sets of variables and enables direct comparisons of current and previous neighborhood characteristics and of current and preferred neighborhood characteristics. To maximize the sample size, missing values were imputed using the mean score for the neighborhood on that item if a respondent left five or fewer items blank; this process resulted in an increase of 485 respondents across all three variables.

Five items were left out of the analysis because they reflect characteristics of the living unit rather than the neighborhood, and the cul-de-sacs item was reserved as a separate characteristic. The initial solution yielded six factors. One factor (with the items for close to work and close to family) was eliminated because of poor reliability. Another factor combined elements of accessibility and the availability of alternatives; a second factor analysis was performed on the items that loaded on this factor to yield two separate factors. The final solution thus included six factors that showed both statistical and conceptual strength. Only one factor – socializing – has a reliability level as measured by Cronbach’s alpha of less than 0.7, indicating that the factor is uni-dimensional. Only two items, big street trees and good public transit service, loaded on more than one factor (space and attractiveness, and accessibility and alternatives, respectively). For all factors, the items are conceptually related.

Changes in opportunities for driving less, for the quasi-longitudinal analysis, were measured using perceived neighborhood characteristics for the current and the previous neighborhood. Respondents who had moved in the last year were asked to indicate how true each item was for their previous neighborhood. These items were then reduced to six factors, using the process described above, with factor scores separately calculated for perceived characteristics of the

Table 3-2. Factors for Neighborhood Characteristics

Factor	Statement	Loading*
Accessibility	Easy access to a regional shopping mall	0.854
α = .804**	Easy access to downtown	0.830
	Other amenities such as a community center available nearby	0.667
	Shopping areas with walking distance	0.652
	Easy access to the freeway	0.528
	Good public transit service (bus or rail)	0.437
Alternatives	Bike routes beyond the neighborhood	0.882
α = .705	Sidewalks throughout the neighborhood	0.707
	Parks and open spaces nearby	0.637
	Good public transit service (bus or rail)	0.353
Safety	Quiet neighborhood	0.780
α = .864	Low crime rate within neighborhood	0.759
	Low level of car traffic on neighborhood streets	0.752
	Safe neighborhood for walking	0.741
	Safe neighborhood for kids to play outdoors	0.634
	Good street lighting	0.571
Socializing	Diverse neighbors in terms of ethnicity, race, and age	0.789
α = .652	Lots of people out and about within the neighborhood	0.785
	Lots of interaction among neighbors	0.614
	Economic level of neighbors similar to my level	0.476
Space	Large back yards	0.876
α = .737	Large front yards	0.858
	Lots of off-street parking (garages or driveways)	0.562
	Big street trees	0.404
Attractiveness	Attractive appearance of neighborhood	0.780
α = .720	High level of upkeep in neighborhood	0.723
	Variety in housing styles	0.680
	Big street trees	0.451

* Represents the degree of association between the statement and the factor.

** Cronbach's α measures the reliability of the items in the factor based on inter-item correlations; computed based on the items with loadings >0.33 only.

previous neighborhood. The differences between factor scores for the current and previous neighborhoods were calculated as a measure of changes in neighborhood design.

In addition, following the survey, objective measures of accessibility were estimated for each respondent based on distance along the street network from home to a variety of destinations classified as institutional (church, library, post office, bank), maintenance (grocery store, convenience store, pharmacy), eating-out (bakery, pizza, ice cream, take-out), and leisure (health club, bookstore, bar, theater, video rental). The accessibility measures include the number of different types of businesses within specified distances, the number of establishments of each type within specified distances, and the distance to the nearest establishment of each type. Commercial establishments within a distance of 3 miles were identified using YAHOO Yellow Pages (http://yp.yahoo.com). Addresses for businesses and for survey respondents were geo-coded using a geo-coding service in Arc Catalogue with a database of city roads from ESRI (http://www.esri.com/data/download). Addresses that could not be geo-coded using this service were geo-coded by hand, if possible, to achieve a success rate of over 95% for respondents and 90% for businesses in each neighborhood; respondents with post office box addresses could not be geo-coded. The cost-weighted distance function in the spatial analyst component of ArcGIS was then used to calculate network distances between addresses for survey respondents and commercial establishments; a Visual Basic program was developed to facilitate this process for 1623 respondent addresses and 3822 business addresses. Distances from each respondent address to each of the businesses for that neighborhood were formatted using Microsoft Access and Excel and converted to measures of accessibility using SPSS.

Preferences for driving less were measured both directly and indirectly. Travel preferences were measured directly using a question that asked respondents to indicate the degree to which they disagreed or agreed--on a five-point scale from “strongly disagree” to “strongly agree”--with a series of attitudinal statements about travel. These items were reduced to six factors using factor analysis: pro-bike/walk, pro-travel, travel minimizer, pro-transit, driving=safety, and car dependent (Table 3-3). To derive these factors, we used principal components analysis with oblique rotation with a suppression threshold of 0.33 To maximize the sample size, missing values were imputed using the mean score for the neighborhood on that item if a respondent left five or fewer items blank; this process resulted in an increase of 261 respondents. The initial solution included eight factors. The eighth factor was difficult to interpret and was dropped from the analysis. Based on the reliability analysis, the fourth factor seemed to include multiple dimensions and was also dropped from the analysis. The final solution thus included six factors, with four items omitted from the factors .. Two items related to preferences for walking loaded on both the pro-bike/walk factor and the pro-transit factor.

In addition, preferences for neighborhood characteristics that offer opportunities for driving less were measured by asking respondents to indicate the relative importance, on a four-point scale from “not at all important” to “extremely important,” of each of 34 neighborhood characteristics when they were looking for a place to live. These items were reduced to six factors using the procedure described earlier, with factor scores separately calculated for preferred characteristics.

Socio-demographic characteristics measured in the survey included: age and gender of the respondent and of each household member, educational background, driver’s license, physical or anxiety-related conditions that limit driving or use of other modes of transportation, renter/owner status, and total household income. Changes in socio-demographic characteristics were measured for household members and for household income.

Table 3-3. Factors for Travel Preferences

Factor	Statement	Loading*
Pro-Bike/Walk	I like riding a bike	0.880
α=.819**	I prefer to bike rather than drive whenever possible	0.865
	Biking can sometimes be easier for me than driving	0.818
	I prefer to walk rather than drive whenever possible	0.461
	I like walking	0.400
	Walking can sometimes be easier for me than driving	0.339
Pro-Travel	The trip to/from work is a useful transition between home and work	0.683
α=.600	Travel time is generally wasted time	-0.681
	I use my trip to/from work productively	0.616
	The only good thing about traveling is arriving at your destination	-0.563
	I like driving	0.479
Travel Minimizer	Fuel efficiency is an important factor for me in choosing a vehicle	0.679
α=.568	I prefer to organize my errands so that I make as few trips as possible	0.617
	I often use the telephone or the Internet to avoid having to travel somewhere	0.514
	The price of gasoline affects the choices I make about my daily travel	0.513
	I try to limit my driving to help improve air quality	0.458
	Vehicles should be taxed on the basis of the amount of pollution they produce	0.426
	When I need to buy something, I usually prefer to get it at the closest store possible	0.332
Pro-Transit	I like taking transit	0.778
α=.692	I prefer to take transit rather than drive whenever possible	0.771
	Public transit can sometimes be easier for me than driving	0.757
	Walking can sometimes be easier for me than driving	0.344
	I prefer to walk rather than drive whenever possible	0.363
Driving= Safety	Traveling by car is safer overall than walking	0.753
α=.544	Traveling by car is safer overall than taking transit	0.633
	Traveling by car is safer overall than riding a bicycle	0.489
	The region needs to build more highways to reduce traffic congestion	0.444
Car Dependent	I need a car to do many of the things I like to do	0.612
α=.522	Getting to work without a car is a hassle	0.524
	We could manage pretty well with one fewer car than we have (or with no car)	-0.418
	Traveling by car is safer overall than riding a bicycle	0.402
	I like driving	0.356

* Represents the degree of association between the statement and the factor.

** Cronbach's α measures the reliability of the items in the factor based on inter-item correlations; computed based on the items with loadings >0.33 only.

3.3 Sampling

We selected eight neighborhoods in Northern California to include in the study. The neighborhoods were selected to provide sufficient variation in neighborhood type and size of the metropolitan area. Neighborhood type was differentiated as "traditional" for areas built mostly in the pre-World II era, and "suburban" for areas built more recently. This distinction reflects a significant change in design characteristics for residential neighborhoods as the suburban boom took place following World War II. Differences are generally observable in the layout of the street network, the design of houses and their orientation to the street, and in the design and location of neighborhood commercial areas. Additionally, size of the metropolitan area is potentially important in explaining travel behavior because larger regions offer more potential destinations for residents, and may lead to longer and more frequent trips (Handy 1992).

We focused on neighborhoods in Northern California because of their proximity to Davis, making site visits more feasible. Using data from the U.S. Census, we screened potential neighborhoods to ensure that average income and other characteristics were near the average for the region. Four neighborhoods in the Bay Area, including two in the Silicon Valley area and two in Santa Rosa, had been previously studied (Handy 1992). These neighborhoods were included in this study because of our extensive knowledge of these areas, and because they enabled us to compare selected travel characteristics over time. Two neighborhoods from Sacramento and two from Modesto were selected to contrast with Bay Area neighborhoods. These cities are roughly the same distance apart as the Silicon Valley and Santa Rosa, and Modesto is comparable in size to Santa Rosa. Site visits to the Sacramento and Modesto neighborhoods were completed before the neighborhood selections were finalized. This process resulted in a two-by-two matrix of neighborhoods, differentiated by neighborhood type and by size of metropolitan region, with two neighborhoods within each cell (Table 3-4).

Table 3-4. Selection of Neighborhoods

	Traditional Neighborhood	Suburban Neighborhood
Large Metro Area	Silicon Valley - Mountain View	Silicon Valley -Sunnyvale
	Sacramento - Midtown	Sacramento - Natomas
Small City	Santa Rosa - Junior College	Santa Rosa - Rincon Valley
	Modesto - Central	Modesto - Suburban

For each neighborhood, we purchased databases of residents from a commercial provider, New Neighbors Contact Service (www.nncs.com). This service maintains an overall database of names and addresses for residences throughout the U.S. constructed from a variety of public records. Given these sources, the database is presumably restricted to adults. Because this database is largely used for commercial advertisement mailings, the data must be extracted using zip codes or postal carrier routes, rather than census tracts. Thus, we first had to identify the codes for the postal carrier routes that coincided with the selected neighborhoods; in many cases, the routes did not exactly match the boundaries of the selected neighborhoods as we initially defined them; this situation resulted in fuzzier neighborhood boundaries.

We purchased two databases for each neighborhood: a database of "movers" and a database of "nonmovers." The database of "movers" included all current residents of the neighborhood who had moved within the previous year. From this database, we drew a random sample of 500 residents for each neighborhood. It is important to note that the total number of movers in each neighborhood did not exceed 600, so that the sample was nearly a census. The database of "nonmovers" consisted of a random sample of 500 residents not included in the "movers" list for each neighborhood. This sample represented from 1.4% to 4% of the total population of these neighborhoods. The end result was an initial sample of 1000 residents for each neighborhood, 500 movers and 500 nonmovers.

3.4 Survey Administration

The survey was administered using a mail-out, mail-back approach. A limited budget prevented the use of the full set of techniques recommended by Dillman (2000), but we followed his well-respected approach as much as possible. The initial survey, consisting of a cover letter and 11 pages of survey printed in blue ink in 8 ½ by 11 booklet format, was mailed out at the end of September 2004 via third class mail. Included with the survey was a business-reply envelope. Two weeks later, a reminder postcard was mailed to the entire sample using first-class mail. At the beginning of November, a second copy of the survey with a revised cover letter was sent to a shorter list that excluded individuals who had already responded to the survey, and individuals for whom the reminder postcard had been returned to us by the post office. Two weeks later, a second reminder postcard was mailed to this list of residents. As an incentive to complete the survey, respondents were told they would be entered into a drawing to receive one of five $100 cash prizes. The winners were selected at random from the list of respondents and their checks were mailed in mid-December. The survey responses were manually entered into a Microsoft Access database by a team of UC Davis undergraduate students. Each survey was then entered into the database a second time, and the two entries were compared in order to identify data entry errors.

The original database consisted of 8000 addresses. Many of these addresses proved to be incorrect or out-of-date. Based on the postcards returned to us, the original database included 6746 valid addresses. Several weeks after the second mailing of the survey, the number of responses totaled 1682, equivalent to a 24.9% response rate, based on the valid addresses only. This response rate is similar to that achieved by the principal investigators in previous studies and is considered quite good for a survey of this length and complexity, administered to the general population (Sommer and Sommer 1997). However, any response rate less than 100% raises the possibility of non-response bias, or the possibility that the individuals who respond to the survey are systematically different from those who choose not to respond.

Comparing respondent characteristics to the characteristics of the neighborhood's residents as a whole can expose potential biases in the sample. The 2000 U.S. Census provides the only socio-demographic data available for each of these neighborhoods. Given a three-year gap between the survey and the Census, the characteristics cannot be expected to match perfectly, although drastic changes over that period of time are not likely. As shown in Table 3-5, survey respondents tend to be older on average than residents of the neighborhood as a whole; this difference reflects the sampling of adults for the survey. Average household size for survey respondents mirrors the census data for most neighborhoods; in Modesto Central and Santa Rosa Rincon Valley, the average household size for respondents is notably smaller, however. The percent of households with children is significantly lower for respondents, with the exception of the Mountain View and Sunnyvale neighborhoods; this difference is perhaps explained by greater constraints on time for the adults in these households. A greater share of respondents owned homes than in the census data; this difference is consistent across neighborhoods. Finally, amedian household income for survey respondents was consistently higher than the census median, a typical result for voluntary self-administered surveys. These differences suggest the potential for non-response bias to affect the results. However, the biases across neighborhoods appear to be similar, and using multivariate analysis, in which socio-demographic differences are explicitly accounted for, helps to minimize this concern (Babbie 1998).

Table 3-5. Respondent Characteristics vs. Census Characteristics

	Traditional				Suburban			
	Silicon Valley - Mountain View	Santa Rosa - Junior College	Modesto - Central	Sacramento - Midtown	Silicon Valley - Sunnyvale	Santa Rosa - Rincon Valley	Modesto - Suburban	Sacramento - Natomas
Respondent Characteristics								
Number	228	215	184	271	217	165	220	182
Percent female	47.3	54.3	56.3	58.2	46.9	50.9	50.9	54.9
Average auto ownership	1.80	1.63	1.59	1.50	1.79	1.66	1.88	1.68
Average age	43.3	47.0	51.3	43.4	47.1	54.7	53.2	45.6
Average HH size	2.08	2.03	2.13	1.78	2.58	2.19	2.41	2.35
Percent of HHs w/kids	21.1	18.6	21.7	8.9	42.4	24.8	25.5	31.9
Average number of kids	1.60	1.58	1.83	1.58	1.65	1.59	1.98	1.64
Percent home owner	51.1	57.8	75.6	47.0	61.1	68.7	81.0	82.4
Median HH income (k$)	74.3	40.2	42.5	43.8	88.4	49.6	40.2	46.2
Census Characteristics								
Population	5,493	9,886	13,295	7,259	14,973	13,617	19,045	13,295
Average age	36.1	36.3	36.5	42.7	35.9	38.3	38.1	31.7
Average HH size	2.08	2.21	2.46	1.79	2.66	2.48	2.51	2.57
Percent of HHs w/kids	19.3	20.3	32.9	12.4	35.3	35.4	34.2	41.7
Percent home owner	34.3	31.2	58.8	34.3	53.2	63.5	61.4	55.2
Median HH income (k$)	75.1	41.6	43.8	47.5	92.3	51.1	42.1	46.2
Percent of units built after 1960	54.3	37.2	21.4	22.7	79.9	90.3	94.6	90.2

4. Neighborhood Comparisons

The survey produced a rich database that can be analyzed in many different ways. This chapter starts by looking at differences between traditional and suburban neighborhoods--with respect to neighborhood characteristics, respondent characteristics, travel attitudes, and neighborhood preferences--as a step towards understanding differences in travel behavior for traditional and suburban neighborhoods. These analyses show notable differences between the two types of neighborhoods, but also variations among neighborhoods of the same type. Differences by neighborhood type and by neighborhood for each of these categories of variables are presented below and tested for statistical significance using either F-tests (for continuous variables) or chi-square tests (for categorical variables). To better understand the relative contribution of different factors to variations in travel behavior, multivariate analyses are then presented in Chapter 5.

4.1 Neighborhood Characteristics

The eight neighborhoods were chosen in order to reflect a variety of neighborhood characteristics. The four traditional neighborhoods differ in visible ways from the four suburban neighborhoods--the layout of the street network, the age and style of the houses, the location and design of commercial centers. Characteristics of the neighborhood were measured both objectively and as perceived by survey respondents, as noted in Chapter 3.

A selection of the objective accessibility measures, presented in Table 4-1, reveals distinct differences between traditional and suburban neighborhoods. Residents of traditional neighborhoods on average have two to four times more businesses within 400m (about ¼ mile) and 1600m (about 1 mile) from home; they have three times as many types of businesses within 400m and over 35% as many types of businesses within 1600m. In addition, the average distance to the nearest establishment of any type for residents of traditional neighborhoods (247m) is less than half the distance for suburban residents (557m), and residents of traditional neighborhoods are closer to every type of establishment on average than suburban residents. Rincon Valley in Santa Rosa has significantly lower accessibility than any other neighborhood, while Sacramento Midtown has higher accessibility than other neighborhoods on all but one of the measures presented. These differences suggest greater potential for walking more and driving less in traditional neighborhoods but also the potential for more total trips because of closer proximity to more potential destinations. However, it is important to note that these patterns are not entirely consistent across individual neighborhoods. In particular, residents of the Modesto Suburban neighborhood have accessibility levels comparable to those of Modesto Central.

To measure perceived neighborhood characteristics, respondents were asked to indicate how true 34 characteristics are for their current neighborhood, on a four-point scale from 1 ("not at all true") to 4 ("entirely true"), as described in Chapter 3. Scores above 1 thus reflect some degree of truth for that characteristic. The characteristics of these neighborhoods as perceived by survey respondents reflect fundamental differences in neighborhood types. As shown in Table 4-2, the

Table 4-1. Objective Neighborhood Characteristics - Traditional vs. Suburban Neighborhoods

	All Neighborhoods	**Traditional**	Silicon Valley - Mountain View	Santa Rosa - Junior College	Modesto - Central	Sacramento - Midtown	**Suburban**	Silicon Valley - Sunnyvale	Santa Rosa - Rincon Valley	Modesto - Suburban	Sacramento - Natomas	**p-value nbhd type**	p-value neighborhood
No. of business types w/in…													
400m	*1.8*	**2.6**	2.5	2.1	1.2	4.1	**0.8**	1.1	0.8	0.8	0.6	**0.00**	0.00
1600m	*11.4*	**13.0**	13.5	13.4	10.4	14.1	**9.6**	9.1	8.7	10.9	9.4	**0.00**	0.00
No. of institutional businesses w/in…													
400m	*1.0*	**1.5**	1.5	1.2	0.7	2.3	**0.4**	0.4	0.2	0.5	0.3	**0.00**	0.00
1600m	*16.4*	**23.5**	18.8	30.5	10.6	30.6	**8.0**	8.7	5.4	11.1	6.0	**0.00**	0.00
No. of maintenance businesses w/in…													
400m	*0.6*	**0.9**	0.6	0.8	0.4	1.4	**0.2**	0.3	0.3	0.1	0.1	**0.00**	0.00
1600m	*9.0*	**13.0**	10.2	12.6	8.5	18.8	**4.2**	5.2	4.0	5.6	1.6	**0.00**	0.00
No. of eat-out businesses w/in…													
400m	*0.6*	**0.7**	0.6	0.8	0.2	1.5	**0.2**	0.3	0.2	0.2	0.3	**0.00**	0.00
1600m	*9.6*	**12.1**	13.0	13.5	5.2	16.1	**6.0**	5.6	2.7	8.3	8.0	**0.00**	0.00
No. of leisure businesses w/in…													
400m	*0.6*	**0.9**	1.0	0.5	0.2	1.5	**0.3**	0.4	0.3	0.2	0.2	**0.00**	0.00
1600m	*11.5*	**16.6**	18.0	20.7	5.2	20.1	**5.4**	5.8	5.1	6.4	4.2	**0.00**	0.00
Minimum distance in meters to…													
Any business	*389*	**247**	284	235	298	192	**557**	462	581	502	704	**0.00**	0.00
Institutional	*552*	**377**	417	381	427	305	**760**	574	727	683	1087	**0.00**	0.00
Maintenance	*580*	**380**	351	408	478	317	**819**	873	851	663	898	**0.00**	0.00
Eat-out	*646*	**526**	587	438	816	349	**789**	794	955	696	740	**0.00**	0.00
Leisure	*647*	**508**	547	618	654	293	**814**	692	932	799	869	**0.00**	0.00
N	*1623*	**882**	220	208	183	271	**741**	209	155	197	180		

Note: All differences between neighborhood type and neighborhoods are significant at 1% level.

characteristics that residents of traditional neighborhoods perceive as true, to a higher degree than residents of suburban neighborhoods, relate to access and proximity: easy access to downtown , easy access to the freeway, shopping areas within walking distance, close to work, close to friends or family, amenities nearby. In addition, at least some alternatives to driving are perceived as more true in the traditional neighborhoods: shopping areas within walking distance, good public transit service. Residents of traditional neighborhoods, more so than those in suburban neighborhoods, also believe that their neighborhoods have an attractive appearance and a high level of upkeep. The higher scores for streets with large trees and diverse housing styles in the traditional neighborhoods reflect the older age of these neighborhoods, as perhaps do the higher scores for large back yards as well. Residents of traditional neighborhoods also gave higher scores for social activity, both lots of people out and about within the neighborhood and lots of interaction among neighbors.

Perceived characteristics of suburban neighborhoods are fairly predictable; for example, suburban residents perceive their neighborhoods as offering high quality schools, low crime rates, quiet neighborhood, low levels of car traffic, and safe for kids to play outdoors. Suburban residents also perceive their neighborhoods as offering affordable housing units and good investment potential. Physical differences include abundant off-street parking and good street lighting, perhaps reflecting stricter standards for these characteristics at the time these areas were developed. Suburban residents gave higher scores for large front yards, living on a cul-de-sac, and relatively new living unit than residents of traditional neighborhoods, though these characteristics were true for less than half of the respondents in the suburbs and on average not true even in the suburbs. Interestingly, suburban residents give high scores to their neighbors having similar economic levels and to neighborhood diversity, in terms of ethnicity, race, and age; this finding supports the notion that although the economic segregation typical of suburban areas persists, the ethnic and racial make-up of California’s suburbs increasingly reflects the diversity of the population of the state as a whole.

The list of perceived characteristics that did not differ between residents of traditional and suburban residents was also interesting and includes several characteristics that may influence travel behavior. Both groups on average said they have sidewalks throughout the neighborhood; the neighborhood is safe for walking; parks and open spaces are nearby; and there are bike routes beyond the neighborhood. These characteristics are related to opportunities for walking and biking, although more clearly related to the use of these modes for recreation than for transportation. Both groups also said they have easy access to a regional shopping mall, a characteristic that might lead to relatively equal amounts of driving associated with trips to the mall. Finally, the two groups gave equal scores for high quality living units.

Perceived neighborhood characteristics also sometimes differ significantly across neighborhoods of the same type. Within traditional neighborhoods, Modesto Central stands out as having a lower average score on easy access to the freeway, shopping areas within walking distance, and other amenities nearby, but a higher average score on large front yards compared to other traditional neighborhoods. Sacramento Midtown has a lower score for high quality schools and abundant off-street parking, consistent with its more urban character. Within the suburban neighborhoods, Sacramento Natomas stands out as having a higher average score for easy access to downtown, having other amenities nearby, and diverse neighbors, but lower average scores for

Table 4-2. Perceived Neighborhood Characteristics - Traditional vs. Suburban Neighborhoods*

	All Neighborhoods	**Traditional**	Silicon Valley - Mountain View	Santa Rosa - Junior College	Modesto - Central	Sacramento - Midtown	**Suburban**	Silicon Valley - Sunnyvale	Santa Rosa - Rincon Valley	Modesto - Suburban	Sacramento - Natomas	**p-value nbhd type**	p-value neighborhood
More true for Traditional…													
Easy access to downtown	*3.4*	**3.7**	3.8	3.7	3.5	3.8	**3.0**	2.9	2.9	2.8	3.5	**0.00**	0.00
Easy access to the freeway	*3.4*	**3.5**	3.7	3.4	2.9	3.8	**3.3**	3.7	2.7	3.0	3.8	**0.00**	0.00
Big street trees	*3.2*	**3.5**	3.1	3.4	3.8	3.7	**2.9**	2.8	2.7	3.3	2.9	**0.00**	0.00
Variety in housing styles	*3.1*	**3.4**	3.2	3.4	3.3	3.5	**2.7**	2.6	2.6	2.9	2.7	**0.00**	0.00
Attractive appearance of neighborhood	*3.3*	**3.3**	3.2	3.2	3.4	3.5	**3.2**	3.2	3.2	3.2	3.0	**0.00**	0.00
Shopping areas with walking distance	*3.2*	**3.2**	3.3	3.3	2.8	3.4	**3.1**	3.1	2.9	3.1	3.2	**0.00**	0.00
Good public transit service (bus or rail)	*3.1*	**3.2**	3.4	3.0	3.0	3.4	**3.0**	2.7	3.0	3.0	3.1	**0.00**	0.00
High level of upkeep in neighborhood	*3.1*	**3.2**	3.1	3.0	3.3	3.2	**3.0**	3.1	3.0	3.2	2.8	**0.00**	0.00
Lots of people out and about within the neighborhood	*2.9*	**3.1**	3.1	3.0	2.8	3.3	**2.7**	2.7	2.7	2.8	2.7	**0.00**	0.00
Close to where I work	*3.0*	**3.1**	3.1	2.9	3.0	3.2	**2.9**	3.0	2.6	2.8	3.0	**0.00**	0.00
Close to friends or family	*2.8*	**2.9**	2.8	2.8	3.0	3.0	**2.7**	2.8	2.5	2.8	2.6	**0.00**	0.00
Other amenities such as a community center available nearby	*2.8*	**2.9**	3.3	2.8	2.2	3.1	**2.7**	2.9	2.3	2.4	3.3	**0.01**	0.00
Lots of interaction among neighbors	*2.6*	**2.7**	2.7	2.7	2.6	2.8	**2.4**	2.3	2.5	2.5	2.4	**0.00**	0.00
Large back yards	*2.5*	**2.6**	2.3	2.7	3.3	2.2	**2.5**	2.3	2.4	2.7	2.4	**0.07**	0.00
More true for Suburban…													
High quality K-12 schools	*3.1*	**2.9**	2.9	3.0	3.2	2.3	**3.3**	3.4	3.4	3.3	2.9	**0.00**	0.00
Low crime rate within neighborhood	*3.1*	**3.1**	3.3	3.0	3.1	2.9	**3.2**	3.5	3.4	3.2	2.7	**0.00**	0.09
Safe neighborhood for kids to play outdoors	*3.1*	**3.0**	3.2	3.0	3.2	2.8	**3.2**	3.3	3.2	3.2	2.9	**0.01**	0.00
Quiet neighborhood	*3.0*	**2.9**	3.0	2.8	3.2	2.7	**3.1**	3.2	3.1	3.2	3.0	**0.00**	0.00
Lots of off-street parking (garages or driveways)	*2.9*	**2.8**	2.9	2.8	3.3	2.4	**3.1**	3.1	3.1	3.2	3.1	**0.00**	0.00
Good street lighting	*3.0*	**2.9**	3.0	2.9	3.0	2.7	**3.1**	3.2	3.1	3.1	2.9	**0.00**	0.00
Diverse neighbors in terms of ethnicity, race, and age	*3.0*	**3.0**	3.2	2.9	2.7	3.0	**3.1**	3.3	2.5	2.9	3.5	**0.00**	0.00
Good investment potential	*3.0*	**2.9**	2.7	3.0	3.2	2.7	**3.1**	2.8	2.9	3.2	3.2	**0.00**	0.00
Affordable living unit	*3.0*	**2.9**	2.7	2.8	3.3	3.0	**3.0**	2.7	3.0	3.3	3.2	**0.00**	0.00
Economic level of neighbors similar to my level	*2.9*	**2.8**	2.8	2.8	2.9	2.8	**3.0**	3.1	2.9	2.9	3.0	**0.00**	0.00
Low level of car traffic on neighborhood streets	*2.6*	**2.5**	2.7	2.4	2.8	2.2	**2.7**	2.8	2.6	2.7	2.5	**0.00**	0.00
Large front yards	*2.3*	**2.3**	2.1	2.3	2.9	1.9	**2.4**	2.2	2.3	2.6	2.4	**0.03**	0.00
Living unit on cul-de-sac rather than through street	*1.7*	**1.4**	1.5	1.4	1.6	1.3	**2.1**	2.0	2.3	1.9	2.0	**0.00**	0.00
New Living Unit	*1.7*	**1.5**	1.7	1.5	1.3	1.5	**1.9**	1.7	2.2	1.9	1.9	**0.00**	0.00

*How true statement is for neighborhood, on a scale from 1 (not at all true) to 4 (entirely true).

Table 4-2. Perceived Neighborhood Characteristics - Traditional vs. Suburban Neighborhoods*

	All Neighborhoods	**Traditional**	Silicon Valley - Mountain View	Santa Rosa - Junior College	Modesto - Central	Sacramento - Midtown	**Suburban**	Silicon Valley - Sunnyvale	Santa Rosa - Rincon Valley	Modesto - Suburban	Sacramento - Natomas	**p-value nbhd type**	p-value neighborhood
No differences…													
Sidewalks throughout the neighborhood	*3.6*	**3.6**	3.8	3.6	2.9	3.8	**3.6**	3.6	3.3	3.7	3.7	**0.85**	0.00
Parks and open spaces nearby	*3.5*	**3.49**	3.6	3.3	3.5	3.5	**3.45**	3.5	3.5	3.4	3.4	**0.36**	0.00
Safe neighborhood for walking	*3.4*	**3.4**	3.5	3.4	3.4	3.3	**3.3**	3.5	3.4	3.3	3.0	**0.17**	0.00
Bike routes beyond the neighborhood	*3.1*	**3.1**	3.4	2.7	2.8	3.4	**3.1**	3.0	3.0	3.0	3.3	**0.30**	0.00
Easy access to a regional shopping mall	*3.1*	**3.0**	2.9	3.5	2.6	3.1	**3.1**	3.2	2.9	3.1	3.1	**0.28**	0.00
High quality living unit	*3.0*	**3.0**	2.9	3.0	3.0	3.1	**3.0**	2.9	3.0	3.1	2.8	**0.19**	0.09

*How true statement is for neighborhood, on a scale from 1 (not at all true) to 4 (entirely true).

Table 4-3. Perceived Neighborhood Factors - Traditional vs. Suburban Neighborhoods

	Traditional	Silicon Valley - Mountain View	Santa Rosa - Junior College	Modesto - Central	Sacramento - Midtown	**Suburban**	Silicon Valley - Sunnyvale	Santa Rosa - Rincon Valley	Modesto - Suburban	Sacramento - Natomas	**p-value nbhd type**	p-value neighborhood
Accessibility	**0.15**	0.30	0.25	-0.41	0.32	**-0.18**	-0.07	-0.52	-0.36	0.23	**0.00**	0.00
Alternatives	**0.01**	0.35	-0.29	-0.40	0.25	**-0.01**	-0.02	-0.14	-0.02	0.10	**0.45**	0.00
Safety	**-0.14**	0.12	-0.20	0.07	-0.46	**0.16**	0.46	0.27	0.14	-0.25	**0.00**	0.00
Socializing	**0.09**	0.21	0.03	-0.15	0.21	**-0.12**	-0.05	-0.37	-0.14	0.06	**0.00**	0.00
Space	**0.00**	-0.21	0.06	0.74	-0.37	**-0.01**	-0.19	-0.16	0.25	0.03	**0.82**	0.00
Attractiveness	**0.28**	0.01	0.17	0.32	0.57	**-0.33**	-0.39	-0.33	-0.07	-0.56	**0.00**	0.00
N	**888**	227	214	182	265	**762**	211	161	212	178		

Note: Scores normalized to a mean value of 0 and variance of 1.

high quality schools, low crime rate, safe for kids to play, and safe for walking. Rincon Valley has lower scores for sidewalks throughout, and Modesto Suburban scores higher on big street trees, and both have lower scores for easy access to the freeway than the other two suburban neighborhoods.

The average factor scores for the traditional and suburban neighborhoods differ in potentially important ways (Table 4-3). Residents of traditional neighborhoods gave higher scores on average to accessibility, socializing, and attractiveness. Residents of suburban neighborhoods gave higher scores on average to safety. The differences in scores for the alternatives and space factors were not significant. The difference on accessibility suggests that residents of traditional neighborhoods perceive greater opportunities for driving less than residents of suburban neighborhoods, and higher scores on the socializing and attractiveness factors might imply a better walking environment. However, the higher score for suburban neighborhoods for safety and the lack of difference on the alternatives and space factors suggest that the differences in walking environment between suburban and traditional neighborhoods is not simply defined. The differences by neighborhood also warn against a simple classification: only for attractiveness do the average scores by neighborhood follow the overall pattern for suburban and traditional neighborhoods.

4.2 Respondent Characteristics

Not surprisingly, the average respondent in traditional neighborhoods differs from the average respondent in suburban neighborhoods in notable ways: more likely to be female, owner of fewer vehicles, younger, living in a smaller household, less likely to live with any children, more likely to work full or part time, less likely to be a home owner, and living on a lower household income (Table 4-4). The number of children in the household, for those households with children, did not differ significantly between suburban and traditional neighborhoods. Given the stratified sampling approach, the higher share of recent movers in traditional neighborhoods indicates a greater response rate for the recent movers surveyed, rather than a difference in the share of residents who had recently moved: recent movers in traditional neighborhoods were more likely to respond to the survey than were those in suburban neighborhoods, and were less likely to respond to the survey than nonmovers in both types of neighborhoods.

The variations between neighborhoods are also interesting. In the two Silicon Valley neighborhoods, Sunnyvale and Mountain View, average household incomes are significantly higher than in the other neighborhoods, a difference that reflects the higher cost of living and higher housing prices in these areas. Interestingly, the share of respondents who are female is lower for these two neighborhoods, perhaps reflecting the high-tech orientation of the economy in this area. Not surprisingly, average household size, presence of children, and average number of autos owned are lowest in Sacramento Midtown, the most urban of the traditional neighborhoods; home ownership is also lowest in this neighborhood.

Table 4-4. Respondent Characteristics - Traditional vs. Suburban Neighborhoods

	All Neighborhoods	**Traditional**	Silicon Valley - Mountain View	Santa Rosa - Junior College	Modesto - Central	Sacramento - Midtown	**Suburban**	Silicon Valley - Sunnyvale	Santa Rosa - Rincon Valley	Modesto - Suburban	Sacramento - Natomas	**p-value nbhd type**	p-value neighborhood
Number	*1682*	**894**	228	215	184	271	**778**	217	165	220	182		
Percent movers	*40.9*	**43.7**	45.6	46	39.1	43.2	**37.8**	40.1	40.6	34.1	36.8	**0.01**	0.15
Percent female	*51.1*	**54.1**	47.3	54.3	56.3	58.2	**50.7**	46.9	50.9	50.9	54.9	**0.01**	0.14
Percent workers	*79.9*	**82.4**	84.1	83.9	73.7	85.8	**77.0**	78.3	64.2	74.1	90.4	**0.01**	0.00
Avg autos owned	*1.69*	**1.62**	1.80	1.63	1.59	1.50	**1.76**	1.79	1.66	1.88	1.68	**0.00**	0.00
Average age	*47.8*	**45.9**	43.3	47.0	51.3	43.4	**50.1**	47.1	54.7	53.2	45.6	**0.00**	0.00
Average HH size	*2.18*	**1.99**	2.08	2.03	2.13	1.78	**2.40**	2.58	2.19	2.41	2.35	**0.00**	0.00
Pct of HHs w/kids	*23.7*	**16.9**	21.1	18.6	21.7	8.9	**31.5**	42.4	24.8	25.5	31.9	**0.00**	0.00
Avg no. of kids	*1.69*	**1.65**	1.60	1.58	1.83	1.58	**1.71**	1.65	1.59	1.98	1.64	**0.46**	0.11
Pct home owner	*63.3*	**56.4**	51.1	57.8	75.6	47.0	**73.3**	61.1	68.7	81.0	82.4	**0.00**	0.00
Avg HH income ($k)	*67.6*	**70.0**	89.5	63.5	60.0	65.4	**65.3**	82.4	56.7	58.9	60.6	**0.01**	0.00

4.3 Travel Attitudes

To measure preferences regarding travel, the survey asked respondents whether they agreed or disagreed with a series of 32 statements on a 5-point scale from 1 (“strongly disagree”) to 5 (“strongly agree”), as described in Chapter 3. A “3” thus represents a neutral position--neither agree nor disagree. The results show distinctive, and potentially important, differences by neighborhood type (Table 4-5).

For both types of neighborhoods, respondents agreed on average with the statements “I like walking” and “I like riding a bike” but disagreed on average with the statement “I like taking transit.” However, residents of traditional neighborhoods expressed stronger agreement (or less disagreement) with statements having to do with a preference for walking, biking, and using transit. Residents of traditional neighborhoods also expressed greater agreement with statements related to limiting or taxing driving for the sake of the environment, which suggests a greater willingness to support such policies; they disagreed less with the statement that they could manage pretty well without a car. Residents of suburban neighborhoods, in contrast, expressed stronger agreement (or less disagreement) with statements having to do with the need for a car, the safety of driving, and the enjoyment of driving. There were no differences, however, on several statements related to the effort respondents put into trying to minimize travel, and both groups agreed equally that air quality is a major problem in the region. Both groups disagreed slightly on average that their households spend too much on owning and driving their cars.

Travel preferences also differed in some interesting instances across neighborhoods of the same type. Within the traditional neighborhoods, residents of Modesto Central agreed less strongly that walking can sometimes be easier than driving and that they prefer to walk, and residents of both Modesto Central and Junior College disagreed more strongly on statements having to do with preferences for transit, perhaps reflecting more limited transit service in these smaller metropolitan areas. Residents of the two traditional neighborhoods in large metro areas--Mountain View and Sacramento Midtown--on average disagreed somewhat that their regions need more highways, while the residents of the two traditional neighborhoods in small metro areas on average agreed somewhat. Fewer differences stand out for the suburban neighborhoods. Sunnyvale residents disagreed that the region needs to build more highways, while residents of the other suburban neighborhoods agreed on average. Agreement on the statement “air quality is a major problem in this region” mirrored the actual severity of the air quality problem in the different metro areas: highest in the four Sacramento and Modesto neighborhoods, and lowest in the two Santa Rosa neighborhoods.

These attitudinal statements were reduced to six factors using the procedure described in Chapter 3. Differences between traditional and suburban neighborhoods in the average scores for these factors are significant for four of the six factors (Table 4-6). Residents of traditional neighborhoods had higher scores on average for pro-bike/walk and pro-transit. Residents of suburban neighborhoods had higher scores on average for driving=safety and car dependent. These differences suggest a strong connection between travel preferences and neighborhood choice, although they do not reveal the direction of the connection. The two groups showed no difference on average for the pro-travel and travel minimizer factors. This result suggests that

Table 4-5. Travel Preferences - Traditional vs. Suburban Neighborhoods*

	All Neighborhoods	**Traditional**	Silicon Valley - Mountain View	Santa Rosa - Junior College	Modesto -Central	Sacramento - Midtown	**Suburban**	Silicon Valley - Sunnyvale	Santa Rosa - Rincon Valley	Modesto - Suburban	Sacramento - Natomas	**p-value nbhd type**	p-value neighborhood
Higher for Traditional…													
Walking can sometimes be easier for me than driving	*2.9*	**4.2**	3.6	3.0	2.6	3.7	**3.9**	2.7	2.5	2.4	2.4	**0.0**	0.0
I like walking	*4.0*	**4.2**	4.2	4.2	3.9	4.3	**3.9**	4.0	3.9	3.8	3.9	**0.0**	0.0
Vehicles should be taxed on the basis of the amount of pollution they produce	*3.4*	**3.6**	3.8	3.6	3.3	3.5	**3.2**	3.4	3.3	3.0	3.0	**0.0**	0.0
I like riding a bike	*3.4*	**3.5**	3.6	3.6	3.3	3.6	**3.2**	3.2	3.1	3.0	3.3	**0.0**	0.0
I prefer to walk rather than drive whenever possible	*3.1*	**3.3**	3.4	3.2	2.8	3.6	**2.9**	3.0	2.8	2.6	3.0	**0.0**	0.0
I try to limit my driving to help improve air quality	*3.0*	**3.1**	3.0	3.1	3.0	3.2	**3.0**	2.9	3.0	3.0	3.2	**0.0**	0.0
I am willing to pay a toll or a tax to pay for new highways	*2.9*	**3.0**	3.0	3.0	3.0	3.0	**2.8**	3.0	2.9	2.7	2.7	**0.0**	0.0
I prefer to bike rather than drive whenever possible	*2.5*	**2.7**	2.7	2.7	2.3	2.9	**2.4**	2.4	2.5	2.1	2.5	**0.0**	0.0
Biking can sometimes be easier for me than driving	*2.5*	**2.7**	2.7	2.6	2.3	2.9	**2.2**	2.3	2.2	2.1	2.3	**0.0**	0.0
I like taking transit	*2.3*	**2.5**	2.7	2.3	2.0	2.7	**2.1**	2.3	2.0	1.9	2.3	**0.0**	0.0
We could manage pretty well with one fewer car than we have (or with no car)	*2.2*	**2.3**	2.3	2.2	2.2	2.4	**2.1**	2.0	2.1	2.1	2.1	**0.0**	0.0
Public transit can sometimes be easier for me than driving	*2.2*	**2.3**	2.5	2.0	1.9	2.5	**2.1**	2.2	1.9	2.0	2.2	**0.0**	0.0
I prefer to take transit rather than drive whenever possible	*2.1*	**2.2**	2.5	2.0	1.9	2.4	**1.9**	2.2	1.8	1.7	2.1	**0.0**	0.0
Higher for Suburban…													
I need a car to do many of the things I like to do	*4.2*	**4.1**	4.1	4.0	4.2	3.9	**4.3**	4.4	4.3	4.3	4.3	**0.0**	0.0
Getting to work without a car is a hassle	*4.0*	**3.9**	3.9	3.9	4.0	3.6	**4.2**	4.3	4.1	4.4	4.0	**0.0**	0.0
Traveling by car is safer overall than riding a bicycle	*3.6*	**3.5**	3.6	3.6	3.5	3.4	**3.8**	3.9	3.8	3.8	3.6	**0.0**	0.0
I like driving	*3.6*	**3.5**	3.4	3.5	3.7	3.4	**3.8**	3.7	3.7	3.9	3.7	**0.0**	0.0
The region needs to build more highways to reduce traffic congestion	*3.0*	**2.9**	2.6	3.1	3.1	2.7	**3.2**	2.8	3.3	3.5	3.3	**0.0**	0.0
The price of gasoline affects the choices I make about my daily travel	*3.0*	**2.8**	2.7	2.9	3.0	2.7	**3.1**	2.8	3.1	3.2	3.4	**0.0**	0.0
Traveling by car is safer overall than taking transit	*2.8*	**2.6**	2.6	2.7	2.8	2.6	**2.9**	2.8	2.9	3.0	3.0	**0.0**	0.0

* Average agreement with statement on a 5-point scale from 1 ("strongly disagree") to 5 ("strongly agree")

Table 4-5. Travel Preferences - Traditional vs. Suburban Neighborhoods - Continued

	All Neighborhood	**Traditional**	Silicon Valley - Mountain View	Santa Rosa - Junior College	Modesto - Central	Sacramento - Midtown	**Suburban**	Silicon Valley - Sunnyvale	Santa Rosa - Rincon Valley	Modesto - Suburban	Sacramento - Natomas	**p-value nbhd type**	p-value neighborhood
Higher for Suburban (continued)…													
Traveling by car is safer overall than walking	*2.7*	**2.5**	2.4	2.4	2.8	2.5	**3.0**	2.8	3.0	3.1	3.1	**0.0**	0.0
The only good thing about traveling is arriving at your destination	*2.6*	**2.6**	2.7	2.5	2.5	2.5	**2.8**	2.8	2.6	2.7	2.8	**0.0**	0.0
We would like to own at least one more car	*1.9*	**1.8**	1.8	1.8	2.0	1.8	**2.0**	2.2	1.7	2.0	2.1	**0.0**	0.0
No difference…													
Travel time is generally wasted time	*4.2*	**4.2**	4.2	4.2	4.1	4.2	**4.2**	4.1	4.3	4.2	4.3	**0.7**	0.2
I use my trip to/from work productively	*3.9*	**3.9**	3.9	4.0	3.9	3.9	**3.9**	3.8	3.9	3.8	4.1	**0.3**	0.1
Air quality is a major problem in this region	*3.6*	**3.6**	3.9	3.6	3.4	3.6	**3.6**	3.6	3.6	3.5	3.6	**0.2**	0.0
I prefer to organize my errands so that I make as few trips as possible	*3.5*	**3.6**	3.6	3.5	3.5	3.6	**3.6**	3.6	3.5	3.5	3.9	**0.5**	0.0
The trip to/from work is a useful transition between home and work	*3.4*	**3.5**	3.2	2.5	4.0	4.1	**3.4**	3.2	2.6	3.9	3.8	**0.3**	0.0
Fuel efficiency is an important factor for me in choosing a vehicle	*3.2*	**3.2**	3.1	3.3	3.2	3.3	**3.3**	3.2	3.3	3.3	3.5	**0.1**	0.1
I often use the telephone or the Internet to avoid having to travel somewhere	*2.9*	**3.0**	2.9	3.0	2.9	3.0	**3.0**	3.0	2.8	2.9	3.3	**0.4**	0.0
When I need to buy something, I usually prefer to get it at the closest store possible	*2.8*	**2.9**	3.0	3.0	2.7	2.9	**2.8**	3.0	2.9	2.6	2.8	**0.2**	0.0
My household spends too much money on owning and driving our cars	*2.7*	**2.8**	2.9	2.7	2.8	2.7	**2.8**	2.7	2.9	2.8	2.9	**0.2**	0.1

* Average agreement with statement on a 5-point scale from 1 ("strongly disagree") to 5 ("strongly agree")

Table 4-6. Travel Preference Factors - Traditional vs. Suburban Neighborhoods

	Traditional	Silicon Valley - Mountain View	Santa Rosa - Junior College	Modesto - Central	Sacramento - Midtown	**Suburban**	Silicon Valley - Sunnyvale	Santa Rosa - Rincon Valley	Modesto - Suburban	Sacramento - Natomas	**p-value nbhd type**	p-value neighborhood
Pro-bike/walk	**0.20**	0.21	0.19	-0.14	0.42	**-0.23**	-0.17	-0.22	-0.41	-0.10	**0.00**	0.00
Pro-travel	**-0.03**	-0.19	0.02	0.08	0.00	**0.03**	-0.13	0.00	0.10	0.17	**0.27**	0.00
Travel-minimizer	**0.01**	0.06	0.08	-0.11	-0.01	**-0.01**	-0.08	0.00	-0.12	0.19	**0.69**	0.00
Pro-transit	**0.15**	0.42	-0.07	-0.28	0.38	**-0.17**	0.07	-0.31	-0.38	-0.09	**0.00**	0.00
Driving=safety	**-0.27**	-0.40	-0.25	0.01	-0.36	**0.31**	0.04	0.24	0.48	0.50	**0.00**	0.00
Car dependent	**-0.06**	0.08	-0.02	-0.10	-0.19	**0.07**	0.28	0.09	0.07	-0.19	**0.01**	0.00

the difference in travel preference between neighborhood types has more to do with modes of travels than travel itself and point to a strong connection between neighborhood choice and attitudes about travel modes but not attitudes about travel. The differences by neighborhood are not always consistent with this pattern. For example, residents of Modesto Central have lower scores than average on the pro-bike/walk factor and a higher score ton the driving=safety factor than other traditional neighborhoods, while residents of Mountain View are higher than average on the car dependent factor. Sunnyvale is lower on the pro-travel factor and higher on the pro-transit factor than other suburban neighborhoods, and Sacramento Natomas is considerably lower on the car dependent factor.

4.4 Neighborhood Preferences

Preferences for neighborhood characteristics provide an indication of the degree to which respondents prefer neighborhoods that offer greater opportunities for driving less and offer an indirect measure of preferences for driving less. Preferences for neighborhood characteristics were measured by asking respondents to indicate the relative importance, on a four-point scale from “not at all important” to “extremely important,” of each of 34 neighborhood characteristics when they were looking for a place to live. An average score of 2.5 thus represents a neutral position.

Although the relative ranking of preferred characteristics was similar for residents of traditional and suburban neighborhoods, the importance they placed on these characteristics differed in important ways (Table 4-7). Residents of traditional neighborhoods put higher importance on average to several measures related to proximity: being close to work, having easy access to downtown, having shopping areas within walking distance. They also rated bicycle routes and public transit as more important than suburban residents. These results suggest a greater preference for opportunities for driving less on the part of residents of traditional neighborhoods. Additional characteristics on which they put higher importance than did suburban residents included big street trees, variety in housing styles, lots of people out and about, and diverse neighbors, all characteristics commonly assumed to be more prevalent in traditional neighborhoods and that potentially create a more appealing walking environment. However, the

Table 4-7. Preferred Neighborhood Characteristics - Traditional vs. Suburban Neighborhoods*

	Neighborhoods	**Traditional**	Silicon Valley - Mountain View	Santa Rosa - Junior College	Modesto - Central	Sacramento - Midtown	**Suburban**	Silicon Valley - Sunnyvale	Santa Rosa - Rincon Valley	Modesto - Suburban	Sacramento - Natomas	**p-value nbhd type**	p-value neighborhood
More important for Traditional…													
Close to where I work	**2.9**	**3.0**	3.2	3.0	2.7	3.0	**2.8**	3.0	2.6	2.7	3.1	**0.00**	0.00
Big street trees	**2.8**	**3.0**	2.7	2.8	3.2	3.2	**2.7**	2.5	2.6	2.8	2.7	**0.00**	0.00
Easy access to downtown	**2.7**	**2.9**	3.1	2.8	2.6	3.1	**2.5**	2.3	2.4	2.4	2.9	**0.00**	0.00
Variety in housing styles	**2.7**	**2.8**	2.5	2.8	2.9	2.9	**2.6**	2.4	2.5	2.9	2.8	**0.00**	0.00
Shopping areas with walking distance	**2.7**	**2.8**	2.9	2.8	2.4	3.0	**2.6**	2.5	2.4	2.7	2.7	**0.00**	0.00
Lots of people out and about within the neighborhood	**2.7**	**2.8**	2.7	2.7	2.6	2.9	**2.6**	2.5	2.5	2.7	2.7	**0.00**	0.00
Bike routes beyond the neighborhood	**2.6**	**2.7**	2.7	2.6	2.5	2.8	**2.5**	2.4	2.3	2.6	2.8	**0.03**	0.00
Diverse neighbors in terms of ethnicity, race, and age	**2.5**	**2.6**	2.6	2.7	2.3	2.8	**2.4**	2.4	2.2	2.4	2.7	**0.00**	0.00
Good public transit service (bus or rail)	**2.4**	**2.5**	2.6	2.4	2.3	2.7	**2.4**	2.2	2.3	2.4	2.6	**0.02**	0.00
More important for Suburban…													
Low crime rate within neighborhood	**3.6**	**3.5**	3.5	3.5	3.7	3.5	**3.7**	3.8	3.7	3.7	3.7	**0.00**	0.00
Safe neighborhood for walking	**3.6**	**3.55**	3.6	3.6	3.6	3.5	**3.64**	3.7	3.6	3.7	3.6	**0.00**	0.03
Affordable living unit	**3.6**	**3.5**	3.4	3.6	3.6	3.5	**3.6**	3.5	3.6	3.6	3.7	**0.01**	0.00
Quiet neighborhood	**3.3**	**3.2**	3.3	3.3	3.4	3.0	**3.5**	3.5	3.5	3.5	3.5	**0.00**	0.00
Attractive appearance of neighborhood	**3.4**	**3.3**	3.2	3.3	3.5	3.4	**3.4**	3.3	3.4	3.5	3.4	**0.05**	0.00
High level of upkeep in neighborhood	**3.3**	**3.2**	3.2	3.1	3.4	3.2	**3.3**	3.2	3.4	3.4	3.5	**0.01**	0.00
Safe neighborhood for kids to play outdoors	**3.1**	**3.0**	2.9	3.1	3.2	2.8	**3.3**	3.4	3.2	3.4	3.3	**0.00**	0.00
Good street lighting	**3.1**	**3.0**	2.8	2.9	3.2	3.0	**3.3**	3.1	3.2	3.4	3.4	**0.00**	0.00
Low level of car traffic on neighborhood streets	**3.2**	**3.1**	3.0	3.2	3.2	2.9	**3.3**	3.2	3.3	3.3	3.3	**0.00**	0.00
Lots of off-street parking (garages or driveways)	**2.9**	**2.9**	2.8	2.9	3.1	2.7	**3.0**	2.9	2.9	3.1	3.1	**0.00**	0.00
Good investment potential	**2.8**	**2.7**	2.5	2.7	3.0	2.5	**3.0**	2.8	2.8	3.1	3.2	**0.00**	0.00
Easy access to the freeway	**2.8**	**2.7**	2.9	2.5	2.5	2.9	**3.0**	3.1	2.5	2.8	3.4	**0.00**	0.00
Economic level of neighbors similar to my level	**2.5**	**2.4**	2.3	2.4	2.5	2.4	**2.7**	2.6	2.5	2.8	2.8	**0.00**	0.00
Large back yards	**2.6**	**2.5**	2.5	2.5	2.8	2.3	**2.6**	2.6	2.6	2.7	2.7	**0.01**	0.00
Relatively new living unit	**2.2**	**1.8**	2.0	1.9	1.8	1.7	**2.5**	2.4	2.5	2.6	2.7	**0.00**	0.00
High quality K-12 schools	**2.3**	**2.1**	2.2	2.1	2.3	1.8	**2.5**	2.8	2.2	2.5	2.4	**0.00**	0.00
Easy access to a regional shopping mall	**2.3**	**2.2**	2.2	2.3	2.1	2.2	**2.5**	2.4	2.3	2.5	2.6	**0.00**	0.00
Large front yards	**2.2**	**2.1**	2.1	2.2	2.5	2.0	**2.3**	2.2	2.2	2.4	2.5	**0.00**	0.00
Living unit on cul-de-sac rather than through street	**2.0**	**1.7**	1.8	1.7	2.0	1.5	**2.3**	2.3	2.2	2.4	2.3	**0.00**	0.00

*How important statement is in choice of neighborhood, on a scale from 1 (not at all important) to 4 (extremely important).

Table 4-7. Preferred Neighborhood Characteristics - Traditional vs. Suburban Neighborhoods*

	Neighborhoods	**Traditional**	Silicon Valley - Mountain View	Santa Rosa - Junior College	Modesto - Central	Sacramento - Midtown	**Suburban**	Silicon Valley - Sunnyvale	Santa Rosa - Rincon Valley	Modesto - Suburban	Sacramento - Natomas	**p-value nbhd type**	p-value neighborhood
No differences…													
High quality living unit	**3.3**	**3.3**	3.3	3.3	3.3	3.3	**3.4**	3.3	3.3	3.5	3.4	**0.10**	0.12
Parks and open spaces nearby	**3.1**	**3.1**	3.2	2.9	2.9	3.2	**3.1**	3.1	3.0	2.9	3.2	**0.60**	0.00
Sidewalks throughout the neighborhood	**3.0**	**3.0**	2.9	3.1	2.8	3.2	**3.1**	2.9	2.9	3.3	3.3	**0.15**	0.00
Close to friends or family	**2.8**	**2.8**	2.8	2.8	2.8	2.8	**2.8**	2.8	2.7	2.8	2.6	**0.35**	0.52
Lots of interaction among neighbors	**2.7**	**2.7**	2.6	2.6	2.7	2.7	**2.6**	2.5	2.6	2.7	2.7	**0.60**	0.30
Other amenities such as a community center available nearby	**2.2**	**2.1**	2.4	2.2	1.8	2.1	**2.2**	2.2	2.1	2.1	2.4	**0.35**	0.00

*How important statement is in choice of neighborhood, on a scale from 1 (not at all important) to 4 (extremely important).

characteristics that residents of traditional neighborhoods rated as more important than did suburban residents were generally not the characteristics with the highest importance ratings.

The characteristics with the highest importance to residents of both types of neighborhoods were low crime rate, safe for walking, affordable living unit, quiet neighborhood, attractive appearance of neighborhood, high level of upkeep, safe for kids to play outdoors, good street lighting, and low levels of car traffic. With the exception of the affordability of the living unit, all of these characteristics potentially increase the appeal of walking, suggesting that residents of both types of neighborhoods prefer a walkable environment. On all of these characteristics, suburban residents gave somewhat higher importance scores than residents of traditional neighborhoods. The fact that the top importance scores are generally lower for residents of traditional neighborhoods suggests that their preferences for specific characteristics are not as strong and that they may be more flexible in their choice of neighborhoods.

Factors that were less unimportant to suburban residents than residents of traditional neighborhoods included large front yards and living on a cul-de-sac. Characteristics that were equally important to residents of both types of neighborhoods included high quality living unit, parks and open spaces nearby, sidewalks throughout the neighborhood, close to friends or family, and lots of interaction among neighbors. Having other amenities available nearby, such as a community center, was not important to residents of either type of neighborhood on average.

Neighborhood characteristics were reduced to six factors using the procedure described in Chapter 3. These neighborhood preference factors also differ significantly by neighborhood type (Table 4-8). Suburban residents have higher scores on average for safety and for space, while residents of traditional neighborhoods have higher scores on average for socializing and attractiveness. The scores for accessibility and alternatives were not significantly different, however. Again, it is important to note that the scores across neighborhoods do not perfectly follow the patterns for neighborhood type; only for preferences for safety are the average scores for all traditional neighborhoods lower than the average scores for all suburban neighborhoods. Residents of Mountain View and Sacramento Midtown have higher scores on accessibility and alternatives than residents of the other two traditional neighborhoods. Among the suburban neighborhoods, Sacramento Natomas stands out as having higher scores on accessibility and alternatives, and Rincon Valley has a lower score on socializing. Interestingly, the four Central Valley neighborhoods have higher scores on space and attractiveness than the four Bay Area neighborhoods, suggesting potential regional differences in neighborhood preferences.

By comparing scores on preferences (Table 4-8) to scores on perceived neighborhood characteristics (Table 4-3) it is possible to get some sense of the degree to which residents get what they want. Residents of traditional neighborhoods have higher preferences for and perceptions of attractiveness and socializing, but while their preferences for accessibility are only slightly higher, their perceived accessibility is significantly higher. Suburban residents have higher preferences for and perceptions of safety, but while they have higher preferences for space, the perceived differences for this characteristic are not statistically significant. Differences in preferences for and perceptions of alternatives are statistically significant. These results thus provide mixed evidence on the possibility of self-selection: residents of traditional neighborhoods want and get two factors that might lead to more walking (attractiveness and socializing) and get one factor that they didn't necessarily want that might also lead to more walking and to less driving (accessibility). At the same time, residents of suburban neighborhoods also get one factor that might lead to more walking (safety).

Table 4-8. Preferred Neighborhood Factors - Traditional vs. Suburban Neighborhoods

	Traditional	Silicon Valley - Mountain View	Santa Rosa - Junior College	Modesto - Central	Sacramento - Midtown	**Suburban**	Silicon Valley - Sunnyvale	Santa Rosa - Rincon Valley	Modesto - Suburban	Sacramento - Natomas	**p-value nbhd type**	p-value neighborhood
Accessibility	**0.03**	0.22	-0.01	-0.33	0.16	**-0.04**	-0.13	-0.25	-0.08	0.32	**0.14**	0.00
Alternatives	**0.01**	0.03	-0.09	-0.25	0.25	**-0.02**	-0.13	-0.23	0.00	0.28	**0.60**	0.00
Safety	**-0.18**	-0.18	-0.14	0.07	-0.39	**0.21**	0.26	0.16	0.23	0.17	**0.00**	0.00
Socializing	**0.05**	-0.05	0.04	-0.08	0.24	**-0.05**	0.66	-0.28	0.07	0.16	**0.05**	0.00
Space	**-0.05**	-0.15	-0.01	0.33	-0.26	**0.06**	-0.08	-0.02	0.16	0.17	**0.02**	0.00
Attractiveness	**0.04**	-0.16	-0.12	0.26	0.19	**-0.05**	-0.29	-0.06	0.12	0.05	**0.04**	0.00
N	**870**	225	207	178	260	**751**	210	155	209	177		

4.5 Travel Behavior

Travel behavior was measured in various ways, as described in Chapter 3, and additional measures were derived from the direct measures included in the survey. For vehicle miles driven per week, six respondents reported more than 1000 miles per week; these values were treated as outliers and recoded to 1000 miles. Work VMD per week was estimated by multiplying the number of work trips by week by the reported miles to work (doubled to get round-trip distance), and the share of commute trips by single-occupant vehicle. Included in this estimate were carpool trips, where the respondents could be either the driver or the passenger. Non-work VMD per week was then estimated by subtracting estimated work VMD from total reported VMD. Using this approach, 268 respondents had estimated non-work VMD of less than 0; these values were recoded to 0. Although the estimates of nonwork VMD are unlikely to be accurate, they should provide a reasonable indicator of the relative level of driving.

A simple comparison of various travel behavior measures by neighborhood type and by individual neighborhood reveals significant differences (Table 4-9). The bottom line is that total vehicle miles driven by the respondent per week is 18% higher for residents of suburban neighborhoods than for residents of traditional neighborhoods. This pattern holds true across individual neighborhoods: the highest level of driving for traditional neighborhoods (161 miles per week in Modesto Central) is still lower than the lowest level of driving for suburban neighborhoods (166 miles in Rincon Valley). This difference appears to come from differences in both work travel and nonwork travel.

The average estimated work VMD for residents of traditional neighborhoods who work was just 73% of the average estimated VMD for residents of suburban neighborhoods who work. This difference can be attributed to both the shorter distance to work and the lower share of commute trips by car for residents of traditional neighborhoods; the number of work trips per week was the same for both groups. Of course, a greater share of respondents in the traditional neighborhoods work either full or part time (see Table 4-4), so that difference in the total amount of work driving between residents of traditional and suburban neighborhoods is somewhat less.

Nonwork travel also apparently contributes to the difference in total driving. The average estimated nonwork VMD for residents of traditional neighborhoods was just 86% of the estimated nonwork VMD for residents of suburban neighborhoods. This difference may be attributable to the greater access in these neighborhoods, as indicated by the factor score for perceived neighborhood characteristics and by the objective measures of accessibility, described in Section 4.1. Note that residents of traditional neighborhoods walk to the store more than twice as often on average as residents of suburban neighborhoods. Interestingly, despite the differences in miles driven, car ownership (measured as cars per adult of driving age in the household) is essentially the same across all neighborhoods, exceeding 1 in Mountain View and Modesto Suburban and dropping below 0.95 only in Sacramento Midtown, the most urban of the neighborhoods.

Table 4-9. Travel Behavior by Neighborhood Type and Neighborhood

	Traditional	Silicon Valley - Mountain View	Santa Rosa - Junior College	Modesto - Central	Sacramento - Midtown	**Suburban**	Silicon Valley - Sunnyvale	Santa Rosa - Rincon Valley	Modesto - Suburban	Sacramento - Natomas	**p-value nbhd type**	p-value neighborhood
Vehicle Miles Driven (VMD) per Week	**148**	146	148	161	142	**175**	169	166	180	187	**0.00**	0.04
Estimated Work VMD per Week for Workers	**87.8**	87.6	84.9	117.6	73.0	**121.0**	98.2	118.5	151.0	115.6	**0.00**	0.00
Work Trips per Week	**9.5**	9.7	9.5	9.4	9.5	**9.6**	9.8	9.2	9.2	9.9	**0.68**	0.00
Miles to Work	**10.5**	10.4	10.85	13.67	8.6	**14.8**	10.8	13.3	19.5	15.2	**0.00**	0.00
Share of Commute Trips by Car	**0.84**	0.84	0.9	0.93	0.75	**0.95**	0.98	0.93	0.96	0.91	**0.00**	0.00
Estimated Nonwork VMD per Week	**84.2**	79.5	87.0	86.7	84.4	**98.1**	102.5	100.6	88.6	102.1	**0.02**	0.40
Walks to Store per Month	**5.0**	5.3	5.2	2.5	6.3	**1.8**	2.0	1.4	1.8	2.1	**0.00**	0.00
Cars per Adult (16-85 yrs)	**0.98**	1.06	0.98	0.96	0.94	**1.00**	0.98	0.98	1.06	1.00	**0.46**	0.06
N	**848**	219	205	171	253	**741**	205	158	205	173		

5. MULTIVARIATE ANALYSIS

To better understand the relative contribution of different factors to variations in travel behavior, multivariate analyses were undertaken. These analyses provide initial tests of the hypotheses outlined in Chapter 3 and suggest that both neighborhood characteristics and preferences and attitudes play a role in explaining travel behavior. The analyses are of two types: cross-sectional and quasi-longitudinal. The cross-sectional analyses relate socio-demographic characteristics, travel preferences, and neighborhood characteristics to measures of travel at one point in time; models were estimated for vehicle miles driven, frequency of walks to the store, and number of automobiles. The quasi-longitudinal analyses produced models of changes in travel behavior, including driving, walking, and number of automobiles, using the same set of independent variables as well as changes in socio-demographic characteristics and changes in perceived neighborhood characteristics for respondents who had moved in the last year.

5.1 Cross-Sectional

In developing cross-sectional models, we first considered socio-demographic characteristics, then added travel preferences and neighborhood preferences, then added neighborhood characteristics, both perceived measures and measures of accessibility. This approach, hierarchical step-wise regression, is designed to determine the marginal contribution of each additional set of variables to the variation in travel behavior, after accounting for the previous sets of variables. At each step, all variables in that category were entered into the model, then the model was re-estimated with only those variables that were significant at the 1% level. Because the dependent variables differ in their nature, different techniques are used to estimate each model: ordinary least squares regression was used to estimate the model for the natural log of vehicle-miles driven, negative binomial regression was used to estimate the model for the frequency of walks to the store, and an ordered probit model was estimated for automobile ownership.

Driving

Because of the skewed distribution of VMD, the natural log of VMD was used as the dependent variable (Table 5-1). The final model included 10 significant independent variables and explained 16% of the overall variation in VMD. Perhaps not surprisingly, the variable with the highest standardized coefficient was the factor for car dependent attitude. This factor reflects a perceived need for a car, which may or may not reflect the actual availability of alternatives to driving. Other attitudes were also significant: pro-bike/walk and pro-transit attitudes were negatively associated with driving, and driving=safety attitude was positively associated with driving. In the final model, no measures of the built environment – either accessibility measures or perceived characteristics – were significant. As a result, it appears that the bivariate associations between neighborhood type and levels of driving are better explained by attitudes

Table 5-1 Regression Model for ln(VMT)

Variable	Coefficient	Standardized Coefficient	t-statistic	p-value
Constant	3.646		11.317	0.000
Female	-0.282	-0.140	-5.650	0.000
Working	0.298	0.112	4.034	0.000
Age	-0.006	-0.094	-3.296	0.001
Driver's license	1.050	0.086	3.519	0.000
Cars per adult	0.170	0.069	2.852	0.004
Pro-bike/walk attitude	-0.055	-0.054	-1.973	0.049
Pro-transit attitude	-0.048	-0.046	-1.784	0.075
Driving=safe attitude	0.060	0.058	2.255	0.024
Car dependent attitude	0.271	0.260	10.566	0.000
Space preference	0.054	0.052	2.110	0.035
N	1466			
R-square	0.16			
Adjusted R-square	0.154			

towards transportation than by the built environment itself. This finding does not support the hypothesis that the built environment has a causal relationship with travel behavior.

Walking

Because the frequency of walking to the store followed a Poisson distribution rather than a normal distribution, a negative binomial regression model was estimated for this variable (using the Limdep 8.0 statistical package). In the initial model, eight socio-demographic characteristics explained less than 6% of the variation in the frequency of walking to the store. The addition of eight attitudinal variables reduced the number of significant socio-demographic characteristics to five – limits on walking, number of children under 18, age, worker, and rent - but increased the share of variation explained to 26%. The addition of perceived and objective neighborhood characteristics in the final model eliminated just one attitudinal variable – socializing preference; two socio-demographic characteristics dropped out of the model (children under 18 and rent) and one additional socio-demographic entered the model (number of autos). The final model included three perceived neighborhood characteristics (safety, attractiveness, and stores within walking distance) as well as two objective characteristics (minimum distance to a grocery store and the number of types of businesses within 800 meters) (Table 5-2). This model explained nearly 32% of the variation in frequency of walking to the store, a strong result for a model of individual travel behavior.

The model yields interesting insights into walking behavior. Among socio-demographic characteristics, having limits on the ability to walk and being a worker have the largest marginal effects, negative in both cases. Among attitudes, a pro-bike/walk attitude has the largest marginal effect, with a pro-transit attitude also positively associated with walking frequency and a driving=safety attitude negatively associated. The significance of preferences for neighborhood characteristics is also notable. Respondents expressing a preferences for alternatives to driving and for having stores within walking distance walk to the store more frequently, all else equal, suggesting a self-selection effect. Respondents with preferences for safety and for cul-de-sacs walk less frequently, all else equal; these variables are likely associated with a preference for suburban neighborhoods, again pointing to self-selection. However, neighborhood characteristics are significant even after accounting for these attitudes and preferences, suggesting the possibility that the built environment has a direct causal effect on walking behavior. Not surprisingly, the distance to potential destinations, both objective and perceived, plays an important role.

Table 5-2 Negative Binomial Regression for Walking to the Store Frequency

Variable	Coefficient	t-statistic	p-value	Marginal Effect
Constant	0.4645	1.979	0.048	1.732
Limits on walking	-0.4135	-2.323	0.020	-1.542
Age	-0.0096	-3.64	0.000	-0.036
Number of autos	-0.0795	-1.907	0.057	-0.296
Worker	-0.3251	-3.448	0.001	-1.212
Pro-alternatives attitude	0.3144	8.246	0.000	1.172
Pro-transit attitude	0.2253	5.846	0.000	0.840
Driving=safety attitude	-0.1239	-3.185	0.001	-0.462
Alternatives preferred	0.1163	2.927	0.003	0.434
Safety preferred	-0.1245	-2.682	0.007	-0.464
Stores within walking distance preferred	0.1797	4.607	0.000	0.670
Cul-de-sac preferred	-0.0639	-1.734	0.083	-0.238
Safety perception	-0.0741	-2.12	0.034	-0.276
Attractiveness perception	0.0851	2.128	0.033	0.317
Stores w/in walking distance perception	0.2565	7.249	0.000	0.956
Min. dist. to nearest grocery store (m)	-0.0002	-3.797	0.000	-0.001
No. of types of businesses w/in 800m	0.0512	4.728	0.000	0.191
N	1480			
R-square	0.32			

Auto Ownership

Auto ownership affects levels of driving to some degree, as shown in the model presented in Table 5-1. If the built environment affects auto ownership, then it also has an indirect effect on driving. In the ordered probit models for auto ownership (developed using the Limdep 8.0 statistical package), household size, the number of household members within driving age (16-85), and the number of workers in the household increases the probability of owning more vehicles (Table 5-3). The model also shows that individuals who are lower-income are likely to own fewer vehicles, as expected. Those having constraints on driving are inclined to own fewer vehicles while individuals who are limited or prevented from using transit are likely to own more vehicles. Home renters are likely to own fewer vehicles, even after controlling for income and household size, suggesting that being a renter could serve as an indicator for other factors, such as a transitional life stage or a philosophy of accumulating fewer material possessions (cars as well as homes). Female respondents tend to live in households owning fewer vehicles.

The model also includes travel attitudes: those who think their daily activities are dependent on vehicles and have safety concerns regarding the use of alternative modes are likely to own more vehicles. Preferences for the neighborhood factors for space and accessibility are also significant: those with higher preferences for accessibility are likely to own fewer vehicles, while those with higher preferences for space are likely to own more vehicles. However, a comparison of standardized parameter estimates shows that socio-demographic characteristics are the most important determinants of auto ownership level even after incorporating attitudinal factors in the model; each attitudinal factor alone has only a marginal effect on the decisions of auto ownership. On the other hand, the extensive presence of residential preferences and travel attitudes in the model implies that attitudes may collectively play an important role in individuals' auto ownership behavior. With attitudinal variables in the model, no neighborhood characteristics – perceived or objective – are significant. This finding also does not support the hypothesis that the built environment has a causal effect on travel behavior.

Table 5-3 Ordered Probit Model for Auto Ownership			
	Coefficient	Standardized Coefficient	p-value
Constant	0.653	2.538	<0.001
Female	-0.195	-0.1	0.002
Household income ($k)	-0.00817	0.295	<0.001
Household size	0.0786	0.0932	0.023
Number of household members of driving age (16-85)	0.617	0.472	<0.001
Number of workers in household	0.136	0.115	0.001
Driving disability	-1.192	-0.147	<0.001
Transit disability	0.323	0.0482	0.085
Renter	-0.269	-0.129	<0.001
Car dependent attitude	0.0977	0.0967	0.002
Driving=safety attitude	0.098	0.0974	0.004
Accessibility preference	-0.102	-0.0954	0.004
Space preference	0.08711	0.08	0.015
Threshold parameter - 1	2.29	2.29	<0.001
Threshold parameter - 2	4	4	<0.001
Number of observations		1495	
Degrees of freedom		12	
% correctly classified		50.20%	
Log-likelihood at constant		-1639.722	
Log-likelihood at convergence		-1292.06	
Pseudo-R square		0.212	
Adjusted Pseudo-R square		0.205	
a. Dependent variable was not standardized.			

5.2 Quasi-Longitudinal Analysis

A more direct test of a causal relationship between the built environment and travel behavior is an analysis of the association between a change in the built environment and a change in travel behavior. As noted above, this study measured change in travel behavior through indicator variables for changes in driving, using public transit, walking in the neighborhood, and riding a bike. Changes in the built environment were measured for the sample of movers by taking the difference between perceived characteristics of the current and previous neighborhoods. A simple bivariate analysis of these variables shows several significant associations (Table 5-4). In general, changes in neighborhood characteristics have the strongest association with changes in walking and, to a lesser extent, riding a bike. Changes in the accessibility factor are the most consistently important built environment changes, with increases in accessibility associated with decreases in driving and increases in using transit, walking, and riding a bike. This finding is interesting given that accessibility may have two opposite effects on driving: 1. higher accessibility reduces the cost of driving and may increase levels of driving as a result, 2. higher accessibility reduces the cost of walking and may lead to a substitution of walking for driving. These results suggest that the latter effect outweighs the former.

Of course, the changes in behavior are not always consistent: 47.6 percent of respondents who experienced an increase in accessibility reported driving less, but 23.9 percent reported driving more. This discrepancy may be partly explained by differences in attitudes. Indeed, average scores on transportation attitudes in many cases differ significantly for those who increased and those who decreased use of one of the four modes (Table 5-5). For example, those who decreased driving scored well above the mean on the pro-walk/pro-bike factor, while those who increased driving scored somewhat below. Similarly, those who increased use of transit, walking, or riding a bike scored above the mean on the pro-bike/walk factor, while those who decreased use of these modes scored below the mean. The connection between attitudes and changes in travel behavior might be partly explained by a connection between attitudes and changes in neighborhood characteristics. For example, those who experienced an increase in the alternatives factor as a result of a move scored higher than the mean on the pro-bike/walk factor and on the pro-transit factor (Table 5-5).

Change in Driving

The relationships between changes in the built environment and changes in travel behavior while controlling for attitudes were estimated using an ordered probit model. This technique is appropriate for an ordinal dependent variable, and its model structure is parsimonious. In developing these models, the following sets of variables were tested: current socio-demographic characteristics, changes in socio-demographic characteristics, objective accessibility measures, perceived current neighborhood characteristics, changes in perceived neighborhood characteristics, travel attitudes, and neighborhood characteristic preferences. The resulting equation can be interpreted as representing the propensity of an individual to be in a higher change category – either less of a decrease or more of an increase in the use of that mode. A statistically significant association between a change in the built environment and change in travel behavior provides evidence of a causal relationship.

Table 5-4 Percent of Respondents by Change in Travel Behavior vs. Change in Neighborhood Characteristics

Travel Beh	Characteristic	Decr in Characteristic		Incr in Characteristic		
		Incr in Beh	Decr in Beh	Incr in Beh	Decr in Beh	p-value
Driving	*Accessibility*	*31.0*	*28.3*	*23.9*	*47.6*	*0.000*
	Alternatives	28.3	38.3	24.7	44.2	0.343
	Safety	30.3	41.0	23.2	42.6	0.107
	Socializing	28.7	38.6	24.2	44.1	0.314
	Space	24.4	44.6	27.4	39.6	0.420
	Attractiveness	26.3	40.3	25.8	43.0	0.770
Transit	*Accessibility*	*4.5*	*29.9*	*12.2*	*21.5*	*0.004*
	Alternatives	*7.0*	*29.9*	*11.6*	*20.7*	*0.016*
	Safety	9.5	27.8	10.3	21.4	0.195
	Socializing	7.6	26.7	11.5	22.2	0.183
	Space	10.8	24.0	9.3	23.8	0.811
	Attractiveness	10.7	23.6	9.6	24.2	0.912
Walking	*Accessibility*	*37.4*	*27.8*	*55.9*	*16.7*	*0.000*
	Alternatives	*35.4*	*28.8*	*58.9*	*15.1*	*0.000*
	Safety	*44.8*	*28.0*	*54.2*	*14.9*	*0.000*
	Socializing	*38.9*	*27.8*	*58.0*	*14.9*	*0.000*
	Space	50.6	22.4	50.4	17.7	0.211
	Attractiveness	*35.7*	*31.9*	*59.0*	*13.1*	*0.000*
Biking	Accessibility	19.7	27.7	25.8	20.6	0.095
	Alternatives	*13.8*	*31.4*	*29.6*	*17.9*	*0.000*
	Safety	*26.6*	*29.1*	*22.3*	*18.4*	*0.001*
	Socializing	*18.2*	*28.1*	*27.7*	*19.2*	*0.006*
	Space	25.9	24.1	22.4	21.5	0.322
	Attractiveness	22.1	24.3	25.2	21.7	0.609

Note: Italics indicates significant at 1% level.

Table 5-5 Attitudes by Change in Travel Behavior and Change in Neighborhood Characteristics

	Pro-bike/walk	Pro-travel	Travel minimizer	Pro-transit	driving=safe	car dependent
Change in driving						
Decrease	0.15	-0.03	0.16	0.14	-0.14	-0.14
Increase	-0.02	-0.11	0.08	-0.03	0.03	0.18
p-value	0.000	0.045	0.000	0.001	0.001	0.000
Change in transit						
Decrease	-0.13	-0.02	0.04	0.06	0.17	-0.22
Increase	0.43	0.11	0.12	1.33	-0.33	-0.43
p-value	0.000	0.494	0.219	0.000	0.000	0.000
Change in walking						
Decrease	-0.31	-0.02	-0.06	-0.10	0.26	-0.03
Increase	0.21	0.00	0.12	0.09	-0.19	0.04
p-value	0.000	0.923	0.003	0.018	0.000	0.576
Change in biking						
Decrease	-0.14	-0.11	0.02	0.04	0.20	-0.10
Increase	0.90	0.02	0.09	0.11	-0.30	-0.05
p-value	0.000	0.123	0.156	0.017	0.000	0.006
Change in Accessibility						
Decrease	-0.09	0.04	-0.11	-0.08	0.02	0.04
Increase	0.09	-0.01	0.03	0.05	-0.17	0.06
p-value	0.050	0.801	0.265	0.283	0.000	0.302
Change in Alternatives						
Decrease	-0.12	-0.05	0.01	-0.15	0.01	-0.01
Increase	0.12	0.04	-0.02	0.10	-0.19	0.09
p-value	0.007	0.567	0.902	0.009	0.000	0.149
Change in Safety						
Decrease	0.11	-0.09	-0.05	0.07	-0.18	-0.01
Increase	-0.01	0.06	0.00	-0.03	-0.10	0.10
p-value	0.130	0.177	0.705	0.409	0.000	0.000
Change in Socializing						
Decrease	0.01	-0.06	-0.12	-0.03	-0.04	-0.03
Increase	0.06	0.05	0.05	0.03	-0.18	0.12
p-value	0.295	0.394	0.108	0.685	0.000	0.036
Change in Space						
Decrease	0.08	-0.02	-0.01	0.06	-0.05	-0.01
Increase	0.01	0.03	-0.03	-0.05	-0.20	0.12
p-value	0.259	0.789	0.808	0.387	0.000	0.055
Change in Attractiveness						
Decrease	-0.01	-0.01	-0.04	0.01	-0.07	0.06
Increase	0.07	0.02	-0.01	0.00	-0.16	0.06
p-value	0.234	0.914	0.768	0.944	0.000	0.228

Note: Values for no change in behavior or neighborhood characteristics are not shown.

The results are presented for changes in driving (Table 5-6) and changes in walking (Table 5-7). Change in the accessibility factor was the most important factor in explaining changes in driving, as indicated by the standardized coefficients, with an increase in accessibility associated with either a smaller increase or a larger decrease in driving. Change in the safety factor was also significant, with an increase in safety associated with either a smaller increase or a larger decrease in driving. Three objective measures were also significant: number of grocery stores and number of pharmacies within 1600m and number of theaters within 400m (why theaters is significant is not entirely clear, although theaters may be an indicator of a particular type of commercial district). Note that objective accessibility was measured for the current neighborhood only, rather than as the change in accessibility; however, a high current level of accessibility is more likely to be associated with an increase in accessibility than a decrease as a result of a move. In all of these cases, an increase in accessibility is associated with a higher propensity to drive less. Two travel attitudes were also significant: car dependent, with a positive effect on the propensity to drive more, and pro-bike/walk, with a negative effect on the propensity to drive more. These results support the hypothesis that changes in the built environment are associated with changes in driving and point to increases in accessibility as the factor having the greatest negative effect on driving.

Change in Walking

For change in walking, change in the attractiveness factor had the highest standardized coefficient: an increase in the attractiveness factor is associated with either a smaller decrease in walking or a larger increase. Changes in other factors also had a positive impact on the propensity to be in a higher category: accessibility, alternatives, safety, and socializing. Three objective measures were also significant: minimum distance to a bank, number of banks within 800m, and number of types of businesses within 1600m; again, although these variables are measured for the current neighborhood, a high current level of these factors is more likely to be associated with an increase rather than a decrease in their levels as a result of a move. The space factor for the current neighborhood was also significant, with an increase in the factor associated with either a larger decrease or a smaller increase in walking. Only one attitudinal variable was significant: the pro-bike/walk factor, with an increase in this factor associated with either a smaller decrease or a larger increase in walking. These results also support the hypothesis that changes in the built environment are associated with changes in walking and point to increases in accessibility, alternatives to driving, safety, socializing interactions, and attractiveness as having positive effects on walking.

Change in Autos Owned

Change in autos owned was estimated for movers by taking the difference between the current number of autos owned and the reported number of autos owned just prior to the move (non-movers were not asked about the number of autos owned one year earlier). To model changes in autos owned for movers, we used a static-score model that expresses the changes in auto ownership as a function of prior auto ownership and prior and current values of explanatory

Table 5-5 Ordered Probit Model for Change in Driving

	Coefficient	Standardized Coefficient*	p-value
Constant*	1.508	1.147	0.000
Current age	-0.006	-0.084	0.014
Currently working	0.155	0.059	0.065
Current # kids<18 years	0.070	0.057	0.051
Limits on driving	-0.678	-0.074	0.000
Change in income	0.000	0.155	0.000
# groceries within 1600m	-0.014	-0.066	0.048
# pharmacies within 1600m	-0.028	-0.069	0.041
# theaters within 400m	-0.703	-0.057	0.055
Change in accessibility factor	-0.269	-0.226	0.000
Change in safety factor	-0.088	-0.086	0.000
Car dependent	0.115	0.111	0.000
Pro-bike/walk	-0.070	-0.070	0.020
Threshold parameter - 1	0.543	0.543	0.000
Threshold parameter - 2	2.142	2.142	0.000
Threshold parameter - 3	2.589	2.589	0.000
N	1490		
Log-likelihood at 0	-2378.038		
Log-likelihood at constant	-1954.785		
Log-likelihood at convergence	-1869.302		
Pseudo-R square	0.214		
Adjusted Pseudo-R square	0.209		

*All independent variables standardized and model re-estimated; constant not standardized.

Table 5-6 Ordered Probit Model for Change in Walking

	Coefficient	Standardized Coefficient	p-value
Constant	1.139	1.681	0.000
Current age			
Current income			
Limits on walking			
Change in income	0.000	-0.064	0.015
Change in #kids<5 yrs	0.269	-0.077	0.004
Min dist to bank	0.000	0.082	0.035
#Banks within 800m	0.050	0.091	0.005
#Types of businesses within 1600m	0.028	0.073	0.040
Current space factor	-0.068	-0.064	0.030
Change in accessibility factor	0.123	0.103	0.000
Change in alternatives factor	0.124	0.103	0.000
Change in safety factor	0.153	0.150	0.000
Change in socializing factor	0.174	0.140	0.000
Change in attractiveness factor	0.194	0.200	0.000
Pro-bike/walk	0.153	0.152	0.000
Threshold parameter - 1	0.645	0.645	0.000
Threshold parameter - 2	2.160	2.160	0.000
Threshold parameter - 3	2.877	2.877	0.000
N	1550		
Log-likelihood at 0	-2735.015		
Log-likelihood at constant	-2059.568		
Log-likelihood at convergence	-1883.789		
Pseudo-R square	0.311		
Adjusted Pseudo-R square	0.206		

*All independent variables standardized and model re-estimated; constant not standardized.

variables as well as the changes between them. We estimated the static-score model using ordinary least squares regression. Table 5-8 presents the model for changes in auto ownership for respondents who moved in the previous year.

Among various categories of determinants of auto ownership, socio-demographic characteristics are the most important based on their extensive presence in the model and their large standardized coefficients. In particular, an increase in household income is associated with an increase in the number vehicles a household has, and the higher the household income before moving, the more they are likely to increase auto ownership. Increases in the number of household members of driving age have a positive impact on changes in auto ownership, and the more driving-age members of the household, the more likely that the household's vehicles increase. Older people and individuals with personal constraints on driving tend to reduce their number of vehicles. These findings reinforce the argument that socio-demographics are fundamental determinants of auto ownership and that the built environment acts as a facilitator of or a constraint on auto ownership. It is worth noting that the variable for auto ownership before residential relocation shoulders a large proportion of explanatory power for the variation in changes in auto ownership. Removing this variable from the model reduces the share of the variation explained from 55% to just below 20%. Logically enough, the more vehicles a households own, the more inclined they are to reduce the number of vehicles and vice versa.

Neighborhood preferences and travel attitudes also affect changes in auto ownership. Those preferring large yards and off-street parking tend to reduce their auto ownership, probably because they have owned a large number of vehicles before moving. And car-dependent individuals tend to increase their auto ownership. However, the effects of these two variables on changes in auto ownership are less important. The relative absence of attitudinal factors indicates that this panel model is effective at controlling for some individual permanent effects resulting from unchanging explanatory variables.

After controlling for socio-demographic characteristics and attitudes, neighborhood characteristics are significant. Changes in perceived space are positively related to changes in auto ownership. In addition, individuals living in areas with a diversity of business types within close proximity tend to reduce their auto ownership, presumably because they are more likely to be able to conduct their daily activities with one fewer vehicle. Since the changes in auto ownership were measured after residential relocation, we can more confidently conclude that there is a *causal* effect from built environment characteristics to auto ownership. However, these effects are marginal in terms of the size of standardized coefficients.

Table 5-8 Static-Score Model for Changes in Auto Ownership (Movers only)

Variable	Coefficient	Standardized Coefficient	p-value
Constant	0.536		<0.001
Changes			
Change in household income ($k)	0.004	0.114	<0.001
Change in no. of household members of driving age (16-85)	0.081	0.086	0.008
Change in space perceived	0.050	0.088	0.002
At current time			
Number of household members of driving age (16-85)	0.341	0.291	<0.001
Age	-0.007	-0.113	<0.001
Driving disability	-0.384	-0.068	0.019
Number of business types w/in 400m	-0.018	-0.058	0.042
Space preference	-0.049	-0.054	0.062
Car dependent attitude	0.050	0.061	0.034
At previous time			
Household income ($k) before move	0.003	0.107	0.001
Number of autos before move	-0.654	-0.687	<0.001
Number of observations		614	
R^2		0.548	
Adjusted R^2		0.540	

6. CONCLUSIONS

One lesson that emerges from this study is that different types of analyses yield different answers to the question, does the built environment have a causal relationship with travel behavior? A simple comparison of neighborhoods of different types shows significant differences in a variety of measures of travel behavior. However, a multivariate analysis of cross-sectional data shows that these differences are largely explained by attitudes and that the effect of the built environment mostly disappears when attitudes and socio-demographic factors have been accounted for. Then, a quasi-longitudinal analysis of changes in travel behavior and changes in the built environment shows significant associations, even when attitudes have been accounted for, providing support for a causal relationship. Of course, these analyses are still not definitive, nor do they clarify the nature of the causal relationship. More sophisticated analyses of these data, such as simultaneous equations modeling, will help to establish the strength and direction of the relationships between attitudes, changes in the built environment, changes in travel behavior, and other factors. Future studies that adopt research designs that more closely resemble a true experimental design will provide more definitive evidence yet. Only with such evidence can we be sure that by increasing opportunities for driving less through land use policies, cities will help to reduce driving and thus emissions.

In the meantime, the results presented here provide some encouragement that land-use policies designed to increase the opportunities to drive less will actually lead to less driving. In particular, it appears that an increase in accessibility may lead to a decrease in driving, all else equal. Policies that could increase accessibility in new areas include mixed-use zoning that allows for retail and other commercial within close proximity to residential areas and street connectivity ordinances that ensure more direct routes between residential and commercial areas. Policies that could increase accessibility in existing areas include Main Street programs designed to enhance and revitalize traditional neighborhood shopping areas, incentives for infill development and redevelopment of underutilized shopping centers, and the like. In addition, it appears that policies to increase land use mix and reduce residential lot sizes may help to reduce automobile ownership, which then helps to decrease driving. However, the results presented here also suggest that changes in neighborhood characteristics will have a greater impact on walking than driving – good news for public health officials interested in increasing overall levels of physical activity but not necessarily helpful in efforts to reduce emissions. Increases in accessibility, as well as enhancements to alternatives to driving, improvements in safety, and an increase in socializing in the neighborhood may lead to increases in walking. Efforts on the part of the city to fill gaps in the sidewalk network and slow traffic through neighborhoods could lead to increases in walking, as could programs run by community groups to increase interactions among neighbors. Although this study does not definitively prove that land use policies can reduce driving and increase walking, it provides new evidence that supports the adoption of such policies.

Other possibilities also argue for policies that increase opportunities to drive less. First, exposure to opportunities to drive less may, over time, lead to changes in travel preferences that would then lead to decreases in driving. Our study does not test this possibility, nor do other available studies. Second, providing more opportunities to drive less might satisfy an unmet demand for driving less. In other words, there may be more people who prefer to drive less than there are available housing units in neighborhoods that offer the opportunity to drive less. Indeed, Levine,et al. (2002) found evidence of unmet demand in the form of a mismatch between preferences for neighborhood environments and the neighborhood environments in which residents live. In our study, the survey asked respondents to indicate their satisfaction with their current neighborhood. While respondents in both traditional and suburban neighborhoods on average felt that the character of their current neighborhood meets their needs, suburban residents were somewhat less satisfied on average, suggesting the possibility of an unmet demand for the characteristics that traditional neighborhoods have to offer (Table 6-1). Combined, these three effects – a direct causal effect of the built environment on driving, an indirect effect through the impact over time of the built environment on attitudes and preferences for driving, and the effect of facilitating the satisfaction of preferences for driving less – may add up to a significant impact. With little downside to land use policies that improve the alternatives to driving, the likelihood of the combined effects appears sufficient to support the adoption of smart growth policies as a strategy for reducing automobile use and emissions.

Table 6-1. Satisfaction with Residence and Location*

	All Neighborhoods	**Traditional**	Silicon Valley - Mountain View	Santa Rosa - Junior College	Modesto - Central	Sacramento - Midtown	**Suburban**	Silicon Valley - Sunnyvale	Santa Rosa - Rincon Valley	Modesto - Suburban	Sacramento - Natomas	**p-value nbhd type**	p-value neighborhood
Location in Region	*4.4*	**4.5**	4.5	4.5	4.5	4.6	**4.3**	4.4	4.1	4.3	4.2	**0.00**	0.00
Character of Neighborhood	*4.1*	**4.2**	4.2	4.1	4.2	4.4	**3.9**	4.2	3.9	4.0	3.6	**0.00**	0.00
Location in Neighborhood	*4.2*	**4.2**	4.2	4.1	4.3	4.3	**4.1**	4.2	4.1	4.2	4.0	**0.04**	0.00
Characteristics of Residence	*4.0*	**3.9**	3.8	3.9	4.1	4.0	**4.0**	4.1	3.9	4.0	3.9	**0.67**	0.02

* How well current residence and location meets current needs of household, on 5-point scale from 1 ("very poorly") to 5 ("very well")

References

American Planning Association. 2002. Planning for Smart Growth: 2002 State of the States. Chicago, IL, February. Available: http://www.planning.org/growingsmart/pdf/states2002.pdf. Accessed: 11/1/02.

Ajzen, I. 1991. The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes* 50: 179-211.

Babbie, E. 1998. *The Practice of Social Research*. 8th Edition. Stamford, CT: Wadsworth Publishing Company.

Bagley, M. N. and P. L. Mokhtarian. 2002. The Impact of Residential Neighborhood Type on Travel Behavior: A Structural Equations Modeling Approach. *Annals of Regional Science* 36(2): 279-297.

Bandura, A. 1986. *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ, Prentice-Hall, Inc.

Ben-Akiva, M. and T. Atherton. 1977. Methdology for Short-Range Travel Demand Predictions. *Journal of Transportation Economics and Policy* 11: 224-261.

Ben-Akiva, M. and S. R. Lerman. 1991. *Discrete Choice Analysis: Theory and Application to Travel Demand*. Cambridge, MA: The MIT Press.

Boarnet, M.G. and R. Crane. 2001a. *Travel by Design: The Influence of Urban Form on Travel*. New York: Oxford University Press.

Boarnet, M.G. and R. Crane. 2001b. The Influence of Land Use on Travel Behavior: Empirical Strategies. *Transportation Research A* 35: 823-845.

Burchell, Robert W., George Lowenstien, William R. Dolphin, Catherin C. Galley, Anthony Downs, Samuel Seskin, Katherine Gray Still, Terry Moore. 2002. Costs of Sprawl – 2000. TCRP Report 74, Transit Cooperative Research Program, Transportation Research Board, Washington, DC.

Calthorpe, P. 1993. *The Next American Metropolis: Ecology, Community and the American Dream*. New York: Princeton Architectural Press.

Cameron, I., T. J. Lyons, J.R. Kenworthy. 2004. Trends in Vehicle Kilometres of Travel in World Cities, 1960-1990: Underlying Drivers and Policy Responses. *Transport Policy* 11: 287-298.

Cervero, R. and K. Kockelman. 1997. Travel Demand and the 3Ds: Density, Diversity, and Design. *Transportation Research D* 3: 199-219.

Congress for the New Urbanism (CNU). 2002. Charter of the New Urbanism. Available:http://www.cnu.org/aboutcnu/index.cfm?formaction=charter&CFID=1778105&CFTOKEN=35528783. Accessed 4/25/02.

Dillman, Don A. 2000. *Mail and Internet Surveys: The Tailored Design Method*. Second Edition. New York: John Wiley & Sons.

Domencich, T. A. and D. McFadden (1975). *Urban Travel Demand: A Behavioral Analysis*. New York, American Elsevier Publishing Company.

Duany, A. and E. Plater-Zyberk. 1991. *Towns and Town-Making Principles*. New York: Rizzoli.

EPA (Environmental Protection Agency) (2001a). *Our Built and Natural Environments: A Technical Review of the Interactions between Land Use, Transportation, and Environmental Quality*. EPA 231-R-01-002, Development, Community, and Environmental Division, January.

Environmental Protection Agency (EPA). 2001. EPA Guidance: Improving Air Quality Through Land Use Activities. EPA420-R-01-001, Transportation and Regional Programs Division, Office of Transportation and Air Quality, January.

Environmental Protection Agency (EPA). 2002. About Smart Growth. Available: http://www.epa.gov/smartgrowth/about_sg.htm. Accessed: 11/1/02.

Ewing, Reid (1997). Is Los Angeles style sprawl desirable? *Journal of the American Planning Association*, **63**(1).

Ewing, R. and R. Cervero. 2001. Travel and the Built Environment. *Transportation Research Record* 1780: 87-114.

Friedman, B., S. P. Gordon, and J.B. Peers. 1992. The Effect of Neotraditional Design on Travel Characteristics. In *Compendium of Technical Papers*, Institute of Transportation Engineers 1992 District 6 Annual Meeting, 195-208.

Fulton, William, Rolf Pendall, Mai Nguyen, and Alicia Harrison. 2001. "Who Sprawls Most? How Growth Patterns Differ Across the U.S." The Brookings Institute, Center on Urban and Metropolitan Policy, July.

Handy, S. 1992. Regional versus Local Accessibility: Variations in Suburban Form and the Effects on Nonwork Travel. Unpublished dissertation, University of California Berkeley, November.

Handy, S. 1996. Methodologies for Exploring the Link Between Urban Form and Travel Behavior. *Transportation Research D* 1: 151-165.

Handy, S.L. and K.J. Clifton. 2001. Local Shopping as a Strategy for Reducing Automobile Travel. *Transportation* 28: 317-346.

Hansen, W.G. 1959. How Accessibility Shapes Land Use. *Journal of the American Institute of Planners* 25: 73-76.

Haider, M. and E. J. Miller. 2000. Effects of Transportation Infrastructure and Location on Residential Real Estate Values: Application of Spatial Autoregressive Techniques. *Transportation Research Record* 1722: 1-8.

Hess, Daniel Baldwin and Paul M. Ong. 2002. Traditional Neighborhoods and Automobile Ownership. *Transportation Research Record* 1805: 35-44.

Holtzclaw, Johan, Robert Clear, Hank Dittmar, David Goldstein, and Peter Haas. 2000. Location Efficiency: Neighborhood and Socio-Economic Characteristics Determine Auto Onwership and Use – Studies in Chicago, Los Angeles, and San Francisco. *Transportation Planning and* Technology 25: 1-27.

Katz, P. 1994. *The New Urbanism: Toward an Architecture of Community*. New York: McGraw-Hill.

Kitamura, R., P.L. Mokhtarian, and L. Laidet. 1997. A Micro-Analysis of Land Use and Travel in Five Neighborhoods in the San Francisco Bay Area. *Transportation* 24: 125-158.

Kitamura, Ryuichi, Takamasa Akiyama, Toshiyuki Yamamoto, and Thomas F. Golob. 2001. Accessibility in a metropolis: Towards a better understanding a land use and travel. *Transportation Research Record* **1780**: 64-75.

Krizek, K. 2003. Residential Relocation and Changes in Urban Travel: Does Neighborhood-Scale Urban Form Matter? *Journal of the American Planning Association* 69: 265-281.

Kulash, W., J. Anglin, and D. Marks. 1990. Traditional Neighborhood Development: Will the Traffic Work? *Development* 21: 21-24.

Lerman, Steven R. 1979. Neighborhood Choice and Transportation Services. In *The Economics of Neighborhood.* Segal, David (Ed.) New York: Academic Press.

Levine, J., A. Inam, R. Werbel, and W. Torng. 2002. *Land Use and Transportation Alternatives: Constraint or Expansion of Household Choice?* MTI Report 01-19, Mineta Transportation Institute, San Jose State University, San Jose, California, June.

Mitchell, R.B. and C. Rapkin. 1954. *Urban Traffic: A Function of Land Use*. New York: Columbia University Press.

Nelson, Arthur C. and James B. Duncan. 1995. *Growth Management Principles and Practices*. Chicago: American Planning Association.

Newman, P. and J. Kenworthy. 1999. *Sustainability and Cities: Overcoming Automobile Dependence*. Washington, DC: Island Press.

Niemeier, Deb, Lorien Redmond, Jennifer Morey, Jamie Hicks, Patricia Hendren, Jie Lin, Erin Foresman, Yi Zheng. 1999. Redefining Conventional Wisdom: Exploration of Automobile Ownership and Travel Behavior in the United States. *TRB Transportation Research Circular E-C026 – Personal Travel: The Long and Short of It*, Washington, DC.

Pucher, John and John L. Renne. 2003. Socioeconomics of Urban Travel: Evidence from the 2001 NHTS. *Transportation Quarterly* 57, 3: 49-77.

Sermons, William and Natalya Seredich. 2001. Assessing traveler responsiveness to land and location based accessibility and mobility solutions. *Transportation Research D*, **6**: 417-428.

Sommer, B. and Sommer, R. 1997. *A Practical Guide to Behavioral Research: Tools and Techniques*. 4th Edition. Oxford and New York: Oxford University Press.

Song, Jumin, Jayanthi Rajamanji, Juchul Jung, Susan Handy, Robert Paterson, Chandra Bhat, and Kara Kockelman. 2002. Techniques for Mitigating Urban Sprawl. Research Report 4420-1, Texas Department of Transportation, Center for Transportation Research, University of Texas at Austin, August.