AN ANALYSIS OF WALKING AND BICYCLING BEHAVIOR IN SUBURBAN MULTIFAMILY HOUSING: A CASE STUDY IN EUGENE, OREGON

by

KEVIN M. BELANGER

A THESIS

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Nico Larco, Chair of the Examining Committee

____

Date

Committee in Charge: Nico Larco, Chair
Dr. Marc Schlossberg
Dr. Kathryn A. Lynch

Accepted by:

____

Dean of the Graduate School

An Abstract of the Thesis of

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Nico Larco

Walking, bicycling, and other modes of active transportation can be utilitarian modes of personal transport, but barriers exist that limit the ability of groups of people to use these modes. This research looks at the walking and bicycling behaviors and attitudes of residents of suburban multifamily housing, a housing type identified in previous literature as needing research. Particularly, the roles of pedestrian route distance and directness as well as physical route characteristics are explored in their effects on walking and bicycling behavior. Results show that both the pedestrian network distance and major arterials are significantly correlated with a person's mode choice. Recommendations include increasing density around suburban commercial centers and encouraging pedestrian and bicycle connections between developments to limit arterial interaction.

CURRICULUM VITAE

NAME OF AUTHOR: Kevin M. Belanger

GRADUATE AND UNDERGRADUATE SCHOOLS ATTENDED:

University of Oregon
University of Maryland, College Park

DEGREES AWARDED:

Master of Science, Environmental Studies, 2010, University of Oregon
Master of Community and Regional Planning, 2010, University of Oregon
Bachelor of Science, Geography, 2007, University of Maryland

AREAS OF SPECIAL INTEREST:

Transportation Planning
Alternative Modes of Transportation

PROFESSIONAL EXPERIENCE:

Transportation Planning Intern, City of Gresham, Gresham, Oregon, 2010

Graduate Teaching Fellow, University of Oregon, Eugene, Oregon, 2008-2010

GRANTS, AWARDS AND HONORS:

Harper Award for Writing in Geography, University of Maryland, 2006

Phi Beta Kappa Honors Fraternity, University of Maryland, 2006

PUBLICATIONS:

Belanger, K. (2008). Ecotourism and its effects on native populations. Ed. Prabha Shastri Renate. *Ecotourism: Focus on Wildlife and Local Communities*. (170-184). ICFAI University Press, Hyderabad, India.

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To my parents, whose desire for a better life for my sister and me has helped us accomplish our goals.

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CHAPTER I

INTRODUCTION

A nexus of environmental, social, and health problems has been developing in the past several decades, with suburbanization and its subsequent automobile-oriented lifestyle consistently labeled as the main culprits. A warming earth with erratic weather patterns is attributed partially to emissions from automobiles (Gonzalez, 2005). Suburban residents report a lack of communication and trust between neighbors due to isolation in single-family houses in enclave developments, and the young, the old, the low-income, and the disabled, our most vulnerable citizens, are forced to compete with automobiles to have the freedom of mobility they deserve (Freeman, 2001; Frank et al., 2003; Newman and Kenworthy, 1999). The increasingly sedentary lifestyle associated with living in the suburbs also creates generations of Americans growing more obese than the ones preceding them, while automobile pollutants exacerbate asthma rates and other health problems (Frank et al., 2003). These are not the only problems associated with the suburban, automobile-centric culture, nor are they entirely the fault of this lifestyle, but one can discern a great deal of information from these ails of suburbanization.

Suburban development in America began in 1820 when people began building on the “borderlands” of cities, though the suburbs that many Americans now associate with were introduced around 1940 (Hayden, 2003). The boom of the modern suburb coincided with rise of the automobile as a popular method of transportation for average citizens, predating the subsequent construction of the interstate highway system which was authorized under President Eisenhower by the Federal-Aid Highway Act of 1956. People sought out suburbs for a respite from the noise, the pollution, and the overcrowding that were present in the city, and the design of the suburb reflects these desires. Suburban single-family homes are typically built along meandering streets and dead-end cul-de-sacs, forcing their residents to drive out to a major street to get access out of their development. Typically, houses are a uniform size and distance apart from each other, each with separate lawns and regimented private space, an obvious departure from life in the city. Suburban life often requires automobile ownership since residences are often so clearly and purposefully separated from anywhere people would like to go, making the use of other modes of transportation, such as walking, bicycling, and public transit, difficult or impossible for everyday use (Hayden, 2003).

While suburban development is undeniably interlaced with automobile travel, residents do walk and bicycle in the suburbs and a variety of factors play into a person's travel decisions. The effects of socioeconomic, environmental, and urban form factors are strong and difficult to extract from one another. For example, gender plays a role in active transportation behavior as women are less likely to walk and bicycle for utilitarian purposes than men for reasons of safety, family, and employment (Garrard et al., 2008; Dill, 2009). Likewise, economic factors certainly play into those decisions depending on the location of the workplace, work shifts, and housing types and location (Jara-Diaz and Videla, 1989). However, I choose to look at the role of urban form on active transportation behavior in this research because it seems to be an integral part of the solution to increase active transportation behavior, one that planners, developers, and policymakers can readily utilize.

Not all suburban development is the same. Multifamily housing, an often disparaged housing type in the suburbs, often offers residents the unique condition of being close to local commercial areas with everyday amenities such as banks, grocery stores, and cafes (Larco, 2010). Not all multifamily housing is located near commercial areas, but among those that are, it is possible for these residents to use active transportation for everyday trips to stores and nearby amenities. However, I hypothesize that there is a latent demand for walking and bicycling that is limited because of inadequate facilities and indirect routes. By making access to active transportation a priority in these developments, there is the potential to reduce automobile trips, increase activity levels, and increase social equity for the spectrum of residents of suburban multifamily housing (Larco et al., 2010; Freeman, 2001; Handy et al., 2002).

This research focuses on the role of the built environment on walking and bicycling behavior in suburban multifamily housing, based on surveys sent to residents of fourteen multifamily housing developments on the suburban fringe of Eugene, Oregon. Through analyzing the responses to the survey using Geographic Information Systems (GIS), I determined positive and negative indicators of active transportation to answer the following questions about the effect of three route features on walking and bicycling behavior:

Research Questions

1. What is the effect of the distance along the pedestrian network between origins and destinations on walking and bicycling behavior?
2. What is the effect of pedestrian route directness on walking and bicycling behavior?
3. What is the effect of other route characteristics (such as walking along major arterials, crossing major arterials, large parking lots, and inconvenient crosswalks) on walking and bicycling behavior?

I hypothesize that people who live closer to destinations will choose to walk or bicycle more often, that people will not walk or bicycle if the most efficient pedestrian route is significantly longer than the straight line distance to the desired destination, and that all four of the characteristics mentioned in the third questions will have negative impacts on active transportation behavior. I will use the answers to these questions to extrapolate information on designing for connectivity in suburban multifamily housing and will make policy recommendations to encourage greater active transportation.

CHAPTER II

LITERATURE REVIEW

In this section, I explore the wide breadth of literature on the topic of transportation by researching several ways to view the expanding base of research on active transportation, a term used to replace the automobile-centric term “alternative transportation”.

Travel Demand

An important introduction to the field of transportation research is the concept of travel demand. Cervero and Kockelman (1997, 200) define travel demand as “a ‘derived’ demand in the sense that trips are made and distributed on the basis of the desire to reach places, whether office buildings, ballparks, or shopping centers.” This derived demand assumes that travel is derived from the demand for activities (Handy et al., 2002, 68). Cao et al. (2009) focused on aspects of travel that are not a derived demand for activities but rather a demand for pleasure and exercise, but the authors mention that it is difficult to understand these trips and even harder to gather concrete information on them.

Cervero and Kockelman (1997) are the foremost authors on travel demand and its effect on mode choice through their paper on the 3 D’s of travel demand: density, diversity, and design. The authors note that the effect of **density** on demand and mode choice has been acknowledged for decades. High-density and compact neighborhoods “can degenerate vehicle trips and encourage non-motorized travel” by making driving more cumbersome and active transportation more attractive (Cervero and Kockelman, 1997, 200). Having access to a **diversity** of destination options within walking and bicycling distance allows a person to exercise transportation choices more often, making more trips to nearby destinations and using a variety of modes while doing so. The effect of **design** on transportation demand and choice had not been studied much before their research, though the authors recognize that "the effect of design treatments, like aligning shade trees along sidewalks and siting parking lots in the rear of stores, on travel demand are thought to parallel influences on density and diversity" (Cervero and Kockelman, 1997, 201).

The travel demand for work trips compared to non-work trips has gathered attention as well. For longer distance work-related trips, driving is often more convenient because it is typically faster. People generally have more flexible time for non-work trips and their destination choices can be more flexible as well with more options that can be closer to home, allowing them to choose a variety of travel modes for these non-work trips. Because people have more time and are able to make other choices, design is likely to have a greater effect on the travel demand and mode choice of non-work trips (Cervero and Kockelman, 1997).

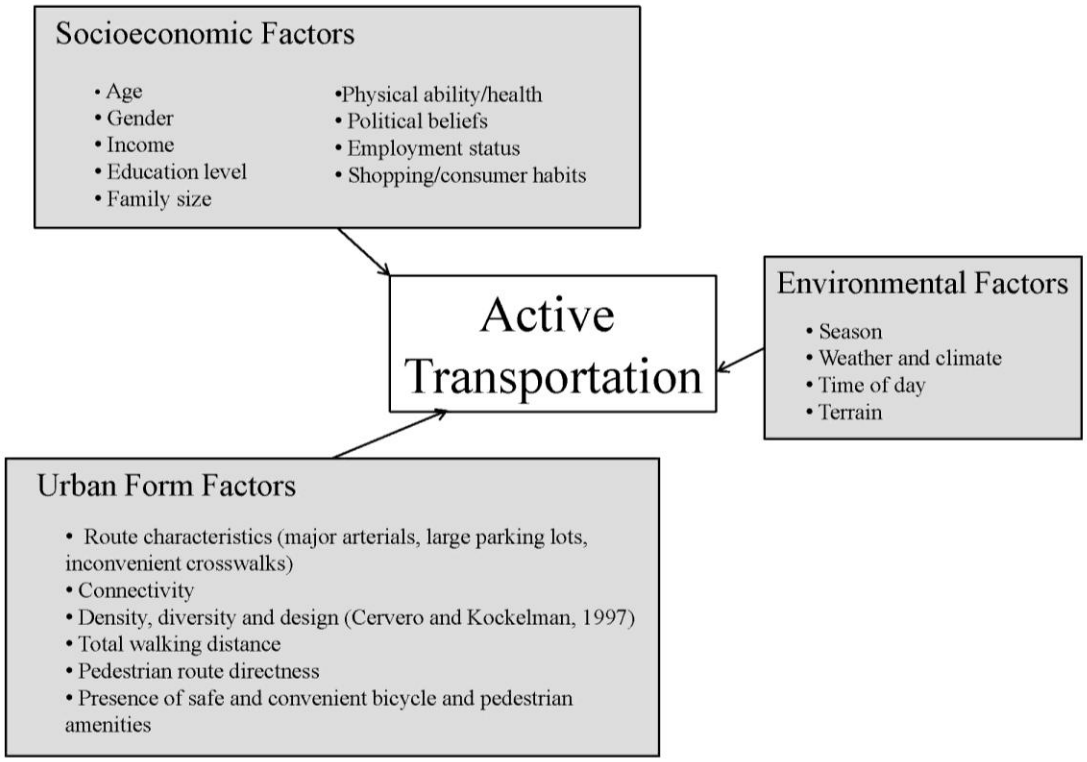
Lee and Moudon (2006) expand upon Cervero and Kockleman's 3D's by adding "route" to the list of density, diversity, and design as effects on travel demand. Particularly, the authors note three spatial elements associated with travel demand, mode choice, and routes: "the 'origin and destination' of trips, the 'area' characteristics around the origin and destination, and the characteristics of the 'route' connecting the origin and destination" (Lee and Moudon, 2006, 205). The research described in this thesis pays particular attention to Lee and Moudon's route characteristics as major influences on mode choice, though the role of Cervero and Kockelman's 3 D's provide a lens through which to frame the study of travel demand and mode choice.

The Role of Urban Form on Active Transportation

Travel research has predominantly focused on vehicular transportation. While active transportation research is not necessarily a new field, it has largely been scattered around disciplines and based on recreation rather than transportation; researchers have long noted the need for a more comprehensive focus in the study of active transportation (Handy et al., 2002). A wealth of studies has come forth in the past decade that expands the research.

Research on active transportation has identified three main factors in a person's transportation mode choices: socioeconomic factors, environmental factors, and urban form factors. While there is some disagreement between which of these factors has a greater influence on active transportation behavior, all factors seem to have an important impact on these decisions (see Figure 1, below). My research here focuses on the third factor, urban form, and ways to discover how the urban form affects active transportation behavior. From a planning perspective, urban form is important to explore as it is a logical way for planners to approach the issue of active transportation.

Figure 1: Influences on Active Transportation Behavior



Neighborhood Street Pattern

Whether a neighborhood was constructed in a traditional manner (with a street grid and dense development) or a more conventional manner (with meandering streets and development that is spread out) is one way that the literature has attempted to classify the types of urban form and their relative effect on active transportation. Lund (2003) explores this link by using a neighborhood's age as a proxy for its street pattern. She acknowledges that neighborhoods constructed before the 1950s would be considered "traditional" with better connections, and housing constructed in the past several decades would follow a more suburban style pattern. Using this method, Lund found that the local access found in traditional neighborhood street patterns "contributes to increased levels of pedestrian travel" (Lund, 2003, 426). Through travel diaries and GIS data, previous research by Crane and Crepeau (1998) find that both traditional and conventional neighborhood street patterns in San Diego show no evidence of affecting short or long non-work mode choices.

Land Use Patterns

A common hypothesis that land use has an effect on transportation decisions is well-stated in Lund (2003, 414), "placing amenities within walking distance of homes will increase pedestrian travel and social interaction among neighborhood residents." Other research also recognizes the effect of land use on transportation mode choice (Leslie et al., 2005; Handy et al., 2002; Saelens et al., 2003). The idea that strategically integrating land uses, particularly shopping among residential areas, can help stimulate pedestrian activity is explored in Handy and Clifton (2001). While the authors believe that providing local shopping opportunities may encourage residents to drive less by giving them options, they ultimately find that residents choose distant stores frequently enough and choose to drive frequently enough that encouraging land use mixes is a noble but potentially ineffective effort. However, this study did not equalize the pedestrian magnets available in each neighborhood, and the difference between trips to boutique stores and larger stores and the impacts on transportation behavior is not explored. Crane and Crepeau (1998) argue that land use has a very limited role in explaining travel behavior and that travel choice is primarily a decision based on personal beliefs.

Distance

Southworth (2005, 249) makes the clear statement that "distance to destinations is the single factor that most affects whether or not people decide to walk or to take the car." Handy and Clifton (2001) find similar results in a study to two Austin, Texas neighborhoods, showing that 42% of residents living within a half-mile of a local commercial area reported walking there frequently, while only 15% of residents living farther away than a half-mile reported the same.

However, Dill (2004) found that there was little research available that makes the claim that longer walking distance to destinations result in fewer walking and bicycling trips. Giles-Corti and Donovan (2002) assert that distance does not play a factor in travel choice through a study on the effect of distance between origins and destinations on whether residents get an appropriate amount of exercise weekly. They find that the "influence of individual and social environment determinants outweighed the role played by physical environment determinants of exercising as recommended" (Giles-Corti and Donovan, 2002, 1804), though as stated before, demand for exercise is not necessarily directly comparable to demand for utilitarian trips.

Connectivity

The concept of connectivity is a popular metric of urban form used to explore travel behavior. A variety of definitions of connectivity appear in the literature to help explain the results of studies that look at the role of urban form on behavior. Saelens et al. (2003, 81) defines connectivity as the "directness or ease of travel between two points that is directly related to the characteristics of street design." It is hypothesized in several studies (Hess, 1997; Randall and Baetz, 2001; Larco et al., 2010) that places with greater connectivity are better places for active transportation and should see greater incidences of walking and bicycling among residents.

The list below identifies connectivity criteria in two studies that focus primarily on the concept of connectivity as it relates to active transportation. Dill (2004) determined nine general connectivity criteria, while Larco et al. (2010) determined nine connectivity criteria specific to multifamily housing developments. Overlap exists between the two lists, though the multifamily housing connectivity characteristics are more specific to that housing type and elaborate upon the general connectivity criteria.

General Connectivity (Dill, 2004)

- Block length
- Block size
- Block density
- Intersection density
- Link-node ratio
- Grid pattern
- Pedestrian route directness
- Connected node ratio
- Street density

Multifamily Connectivity (Larco et al., 2010)

- Internal pedestrian network (building to building AND internal network to egress points)
- Pedestrian network node density
- Pedestrian route directness
- Pedestrian friendliness of the automobile realm
- Access point distribution
- External route directness
- Presence of protected pedestrian paths
- External street type

One similar criterion between the two authors is pedestrian route directness (PRD), which is a measurement of connectivity shared by many researchers (Randall and Baetz, 2001; Dill, 2004; Frank et al., 2005; Larco et al., 2010). PRD is a measure of (1) the difference between the straight line, geodetic, or “as the crow flies” distance between an origin and a destination and (2) the distance using the pedestrian network between the origin and destination. Randall and Baetz (2001, 3) believe that “a more efficient neighborhood, from a pedestrian’s point of view, would be one in which the route distance was as close to the geodetic distance as possible”. Larco et al. (2010) implicitly state that PRD is a requirement for a development to be considered well-connected. In looking at PRD for urban and suburban environments, Hess (1997) found that routes in communities near Toronto, Ontario are more direct in urban areas (with a PRD of 1.2, meaning that routes are 20% longer than the straight line distance) than in suburban areas (with a PRD of 1.7). It is surprising, however, that given the attention to pedestrian route directness in defining connectivity criteria, literature is sparse that explores the specific link between PRD and mode choice to determine if route directness has a major influence on pedestrian behavior.

Aesthetics/Other Route Characteristics

Handy and Clifton (2001) recognize the importance of comfort and other physical route characteristics on pedestrian and bicycle behavior. While distance is the main factor in transportation decisions according to their research, Handy and Clifton (2001, 337) note the importance of "the quality of the connection between residential and commercial areas, in particular whether residents would have to cross a busy arterial to reach the store." In a similar study, Handy et al. (2002) come to a similar conclusion that aesthetics might influence walking and bicycle behavior, but they note that this link has not been studied enough to accurately make that statement.

On the contrary, several researchers have found that visual interest and aesthetics have no significant impact on walking and bicycling behavior (Humpel et al., 2004; Sallis et al., 2007). Craig et al. (2002) bridges the gap in the debate by recognizing that qualitative research suggests this link, but no quantitative studies have yet to make this link.

The metrics of urban form in the research on the role of urban form on travel behavior are not entirely agreed upon, and terms are used in different ways, leading to different results. However, these different results lead to a richer discussion of active transportation. The next section focuses on how research has used these metrics in exploring active transportation in the suburbs.

Social Influences and Active Transportation

The intersection of active transportation and social influences has received significant attention through its interdisciplinary links in psychology and sociology. Findings by Giles-Corti and Donovan (2002) show that education and income levels are positively associated with active transportation behavior. Others see the converse, that transportation patterns have effects on social ties. Freeman (2001) published a study exploring the links between social relationships and sprawl, particularly the transportation impacts of suburbanization. Through surveys, he found that "every 1% increase in proportion of individuals driving to work is associated with a 73% decrease in the odds of an individual having a neighborhood social tie" (Freeman, 2001, 74). Leydon (2003) found similar results in Galway, Ireland, finding that people in walkable neighborhoods were more likely to be socially and politically involved in their communities.

Song and Quercia (2008) researched the effects of active transportation on economics by studying how neighborhood design features are manifested in housing prices in three kinds of neighborhoods: traditional (urban core, grid street pattern), neo-traditional (higher density, newer, built on greenfields), and suburban (meandering streets, low density) neighborhoods. Using sales data on single-family homes sold in 2000, Song and Quercia found that homebuyers across all neighborhood types value automobile accessibility to minor roads and maintaining a comfortable distance from major roads. Residents of conventional single-family suburban developments did not value pedestrian access to commercial areas. However, residents of neo-traditional neighborhoods (where multifamily housing is often located) valued pedestrian connectivity highly.

Active Transportation in the Suburbs

The suburbs have been a central subject in the literature on active transportation. Freeman (2001, 70) finds it ironic "that the low densities associated with sprawl should come under attack… because it was the higher densities associated with urbanization" that led to suburbanization in the first place. Influential authors such as Jacobs (1961) and Jackson (1987) wrote about the growth of the American suburb and have influenced a generation of academics and professionals to continue to explore the consequences of suburban development. Lund (2003, 415) was particularly affected by their work in her discussion of how the loss of street activity at a neighborhood level in the suburbs "resulted in a loss of cohesiveness and perceived safety in our neighborhoods and the privatization and isolation of life in automobile-dependent suburbs."

Residents of suburban environments have relied on automobiles for transportation for decades, often the result of long distances between destinations, indirect routes, and the lack of bicycle and pedestrian amenities (Randall and Baetz, 2001). Handy et al. (2005a) found that vehicle miles traveled (VMT) is 18 percent higher for suburban residents than it is for urban residents, and they also found a difference of opinion about the perceived safety of transportation modes. Suburban residents prefer the safety of the automobile and the openness of driving in the suburbs, while urban residents find the automobile to be the least safe mode of transportation.

This argument raises the idea of self-selection, that people live in walkable neighborhoods because they value walkability and that people choose conventional suburbs because they appreciate the choice and convenience of driving and do not value walking and bicycling. Handy et al. (2005a) and others believe this idea to be true, asserting that trying to make existing neighborhoods walkable is not a good use of effort because people living there are unlikely to use it anyway. Lund (2003) disagrees, saying that researchers can not know how individuals feel about transportation choices because people make their choices based on their surroundings. She hypothesizes that suburban residents make the choice to drive more often because of the auto-dominant landscape in which they live and other options are unknown to them. Continuing this logic, urban residents choose to walk and bike more often because their landscape encourages this, and it is unclear if such residents would choose the same behavior if they moved to the suburbs.

Though the majority of suburban transportation trips are made by the automobile, walking and bicycling can also be transportation options in the suburbs. Active transportation emits no environmental pollutants, the lessening of which is a goal of many government agencies and non-profits (Crane and Crepeau, 1998). The federal livability initiative, sponsored by the Department of Transportation, the Office of Housing and Urban Development, and the Environmental Protection Agency, includes active transportation as an important mode choice to increase livability across the country

(Osbourne, 2010). Handy et al. (2005) also note the importance of the role of walking and bicycling for short trips to nearby commercial areas in reducing automobile dependence and congestion.

While active transportation trips are a small percentage of all trips, walking and bicycling are inexpensive and time-efficient modes for short trips. People use walking paths to get to nearby stores and parks and to visit friends and relatives. Public bicycle and pedestrian amenities are important, but the suburbs also have a hidden network of private walkways. Hess (1997) found that twelve miles of private walkways in apartment complexes and commercial areas existed in a Seattle suburb. While he found evidence that people used these paths on a regular basis, he noted that the system was not well-connected, meaning that people inside these developments with private sidewalks had to travel far out of their way to reach destinations. Private sidewalks are important in transportation planning because though they are not part of the public network, people are likely to use them if they help the pedestrian reach his or her destination more safely and efficiently (Hess, 1997).

Multifamily Housing

Research focusing on particular housing types in the suburbs is limited, though the different types have implications on the travel patterns of their residents. Suburban multifamily housing is an important and growing housing type with a variety of residents. Hess et al. (1999, 17) note that "the sheer quantity of people living in these neighborhoods (typically in multifamily developments) also calls for further research on the potential of these areas to contribute to a balanced transportation program."

Larco (2010) has been a central researcher on suburban multifamily housing. In his research, he provides a detailed description of the physical design of typical multifamily housing as well as a report of the residential demographics contained therein. Larco notes that suburban multifamily housing is the fastest growing segment of the housing market, with one in four housing units in suburbia belonging to multifamily housing.

In his research, Larco (2010) describes suburban multifamily housing and its unique physical layout. Typically, each development consists of several buildings two to three stories in height, usually without elevators. Each unit often has its own exterior entry, and units are connected through exterior and interior hallways. The layout of the buildings within the development often has a focus on parking, where there is a large parking lot in the center of the buildings or each building has its own parking lanes or pods.

Figure 2: Typical Suburban Multifamily Housing, Heron Meadows, Eugene, OR

Larco (2010) also describes the typical residential demographics of multifamily housing. Residents are often single, divorced, or widowed. In addition, they often have fewer children than residents of single-family housing. An aging population living in these developments needs access to medical facilities and commercial locations nearby and travel options once the personal automobile is no longer a viable option for them. The relative lack of children in these developments allows their residents to have greater mobility. There is a large number of younger heads of household as well, since these young professionals do not need a lot of space and have not yet reached their earning potential.

Multifamily housing also has had a negative stigma as a development type that attracts undesirable low-income residents. Larco (2010) notes that this sentiment is not universally true; while many residents are low-income, they can often be the young professional working class or older residents with limited incomes, not the “chronically poor.” Multifamily housing has been excluded from many locations or is zoned in undesirable spaces between commercial areas, industrial uses, and single-family homes, “largely based on a perception by planners and the general public that multifamily housing reduces adjacent property values and creates service burdens for local jurisdictions” (Larco, 2010).

However, Larco et al. (2010) suggests that the placement of multifamily housing between commercial areas and single family housing that is already happening in suburbs across the country holds a unique opportunity for resident’s use of active transportation. By locating this dense housing near commercial areas, trips to local commercial areas are inherently shorter and could be made by walking and bicycling. Given this opportunity, and if the built environment does affect mode choice, it would then be important that planning and engineering projects “capitalize on a potentially new suburban model that is embodied in suburban multifamily housing” and focus on making walking and bicycling easier and more efficient (Larco, 2010).

Literature Summary and Missing Links in the Research

In summary, the literature indicates that mode choice is made by a variety of factors, and no one specific factor can determine why a person chooses one mode of transportation over another to reach their destination. However, research on reasons why people choose to walk and bicycle has increased in the last decade. While there are noted disagreements between the role of the physical environment compared to the role of personal preferences on transportation choices, the literature generally agrees that suburbs offer fewer pedestrian and bicycle amenities and that driving is often the default for many suburban residents because of travel distances and the physical environment. Researchers have found that distance between destinations and the diversity of land uses are two of the main factors influencing transportation decisions. Within the realm of suburban housing types, multifamily housing is the fastest growing type with a wide variety of residents. The potential for active transportation in multifamily housing is large because residents often live closer to nearby commercial areas, which could make them walk or bicycle more often.

There are several missing links in the literature that I explore in this thesis. First, while there has been a focus on the concept of pedestrian route directness as a measurement of pedestrian connectivity, the link between pedestrian route directness and behavior has not yet been explored. Also, though research studies have explored a variety of physical route characteristics such as high-volume arterials, none have looked at multiple characteristics and their effects on travel choice. Finally, given the nature of multifamily housing and its residents, it is important to fill the gap of exploring the general effect of the transportation network on multifamily housing resident mode choice.

CHAPTER III

METHODS

A variety of methods have been used in studies about pedestrian travel behavior and urban form, including quantitative analyses (through surveys and GPS tracking of travel behavior) and qualitative analyses (involving focus groups and anecdotal evidence). Clifton and Handy (2001) reviewed a variety of qualitative methods in travel behavior research and determined that Likert scales (asking respondents to rate their opinions on certain statements on a scale, usually 1-5) were the most commonly used to gather travel opinions and behavior. Other studies, such as Frank et al. (2005), asked subjects to wear ankle collars with GPS units attached for two days to show their daily travel patterns. A common method for gathering travel information in many active transportation studies is through personal surveys.

The research described in this thesis used travel surveys to quantify pedestrian behavior and opinions in suburban multifamily housing. While the housing type and resident group studied within this research are unique, using similar survey methods allows for a comparison of travel behavior with previous travel research.

Background

This research was initiated as part of a larger study led by Professor Nico Larco in the Department of Architecture at the University of Oregon. Larco's research on suburban multifamily housing focuses on two questions. First, do increased physical connections between suburban multifamily housing developments and adjacent uses, especially commercial uses, lead to a significant increase in non-motorized travel? Second, if increased connections do lead to increased non-motorized travel, how can existing developments be retrofitted to increase connections, and what changes need to happen at a code and policy level to increase connections in new suburban multifamily housing developments? This thesis aims to provide evidence to help answer the first question, particularly in determining what amenities are most important for pedestrians and bicyclists in suburban multifamily housing.

Selecting Case Study Developments

The data for this research are obtained from a survey received by residents of fourteen multifamily housing developments in Eugene, Oregon. This survey was administered by Larco and the Community Planning Workshop at the University of Oregon in March 2009. The survey was a part of larger study on connectivity in suburban multifamily housing, including housing code reviews, the development of connectivity criteria for suburban multifamily housing, and focus groups with residents, planners, and housing developers. Eugene was chosen as the location for this study based on its proximity to the researchers, the availability of local data, and the presence of a variety of suburban-style multifamily housing.

The fourteen developments were narrowed down from all multifamily developments in Eugene based on several criteria. First, developments with fewer than thirty units were eliminated based on the limited potential sample size. Of the developments that remained, developments were eliminated if they were not within a quarter mile of a ‘local commercial area’. This distance was chosen based on previous research stating that the majority of pedestrians were willing to walk up to a quarter mile to visit commercial areas (Southworth, 2005). Other research has shown that this distance is underestimated and that pedestrians are willing to walk a half mile or more to reach desired destinations (Agrawal et al., 2008; Handy and Clifton, 2001; Hess et al., 1999).

The ‘local commercial areas’ used in this study included typical suburban strip development with a variety of commercial choices located within. In all of sites, the commercial areas were anchored by supermarkets with smaller establishments located within, such as restaurants, hair salons, and cafes. To standardize the potential commercial options that pedestrians had available to them, only local commercial areas with a large supermarket (namely national chains with a variety of sections including produce, prepared goods, and other household items) were included in this study. Handy and Clifton (2001) document evidence to support the use of supermarkets as a common destination, finding that residents reported that of all commercial areas near their homes, they visited supermarkets most frequently.

After removing all developments that did not fit these criteria, the research team chose fourteen developments based on creating an even distribution around Eugene. The fourteen developments were then divided into two categories (well-connected and less-connected) using a set of connectivity criteria developed with the Community Planning Workshop team (see Larco et al., 2010 for a greater discussion of these connectivity criteria). Six of the developments were determined to be well connected for pedestrian access, and nine were determined to be less-connected for pedestrians.

Surveys

Of the 1,493 surveys that were sent to the fourteen developments, a total of 229 surveys were returned, representing a 15.3% response rate (130 out of 848 returned from well-connected sites and 99 out of 645 from less-connected sites). While this response rate is not sufficiently high to make conclusions that would apply to the general population, the responses provide insight into multifamily resident travel habits and perceptions. After conducting preliminary analysis, the data were cleaned by removing the results from residents who do not own a car as they do not have a choice to drive, leaving 198 respondents.

The Community Planning Workshop team, of which I was a member, used standardized survey distribution strategies to ensure the highest return rate possible. These methods included an introductory postcard about the project, a survey mailing, a follow-up postcard, and a second survey mailing to assure the greatest response rate (Dillman 2000). Incentives were offered to respondents and gift cards worth $25 each were given to eight respondents at random after the analysis was complete.

All study sites were surveyed simultaneously in March 2009 to avoid differences in weather, fuel costs, and day length. The survey period had an even mix of sun and rain with daytime temperatures typically ranging between the mid 50’s and mid 70’s. In general, this area of Oregon has mild but wet winters, variable dry/wet springs and falls, and mild and dry summers. Walking and bicycling is feasible throughout the year, though many people report a desire to not walk and bicycle during the rainy period.

The survey consisted of twenty-seven questions on six pages, including sections about transportation modes and frequency, transportation choices, ease of walking and bicycling, housing choices, personal information, and a mapping exercise. We compared the social questions that were asked in the survey with the reported transportation behaviors and found that only gender was significantly correlated with active transportation behavior (men reported walking and bicycling more often than women). I use these survey responses to explore the trip and route information described in the survey maps, explained below. A copy of the survey is included in Appendix B.

Survey Maps

The last page of each survey included an aerial image tailored to each development with directions asking respondents to outline how they walk or bicycle from their developments to their local commercial areas. The specific development was outlined on the map and each destination within the set walking distance was labeled (see Appendix for an example survey map). Respondents were asked to place an “x” over their apartment building, circle any places that they visit in their local commercial area, and, if they ever walked or bicycled to a destination, to draw a line showing their exact walking or bicycling route to each of the destinations. If they never walked or bicycled to these destinations, they were instructed to not draw a line and leave that route blank. As we were only interested in knowing the routes that pedestrians took to reach their destinations, we did not ask questions about the frequency with which they visit these destinations. This is left for future research where researchers can monitor specific pedestrians' travel habits.

The mapping exercise was used to understand the routes that residents of multifamily housing take to get to their desired destinations. A mapping exercise leaves a margin for error in the part of the survey taker in understanding the directions or exaggerating their transportation habits. There can also be error in the part of the survey analyst in understanding the intent of the respondent if their response did not accurately follow the instructions.

An initial analysis of the survey maps was completed to gather a preliminary understanding of travel patterns and visual evidence on the avoidance of obstacles, pedestrians crossing streets without a crosswalk (mid-block crossings), and shortcuts that are not apparent using aerial imagery. My role in this project was to conduct a more thorough analysis of the survey map results. I established methods using Geographic Information Systems (GIS) to gather more specific knowledge from these survey results.

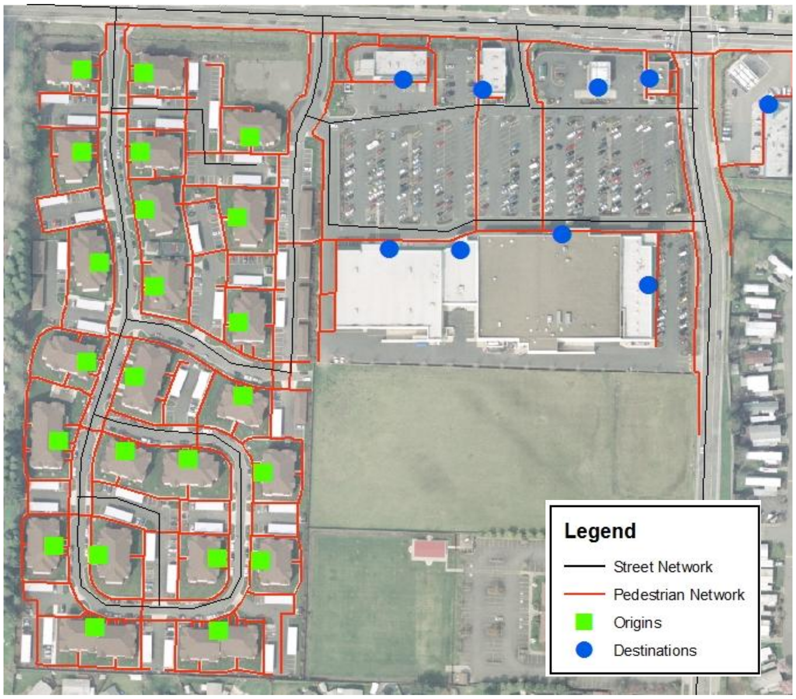
GIS Analysis

Using GIS to analyze pedestrian routes is uncommon in the field of transportation research. GIS is often used to analyze automobile travel, with functions such as Network Analyst that have specific auto-oriented elements. Network Analyst can be used to model the most efficient driving routes, trip costs, signal timing, and other data not specific to pedestrians. While using GIS allowed me to get the most accurate information about travel routes, the specific transportation functions in ArcGIS are built for automobile analysis; using these tools for pedestrian analysis presented particular difficulties as pedestrians and bicyclists have a wider variety of route options that are not allowed in a typical GIS network analysis.

For this research, I first created points in the GIS database for all origins (respondents' apartment buildings) and destinations (commercial buildings) indentified in the survey maps. For ease of analysis, clusters of destinations were grouped together within each local commercial area. I used these points to determine the straight line distance between each origin and destination to use as a comparison later in the study.

While street network data exist in local government databases, a comprehensive pedestrian network is not readily available in a GIS-accessible format in Eugene. To create a full network, I digitized and coded all of the pedestrian paths for each of the fourteen developments that were part of this study. Digitizing the pedestrian network involved importing aerial images of each of the developments and tracing lines for each of the pedestrian paths to create a path network to work from. Chin et al. (2007) followed similar methods in order to incorporate the pedestrian network into the already existing street network. However, they did not include shopping centers and schools in their networks "due to limited temporal access and issues of safety and walking comfort" (Chin et al., 2007, 42). Because this research is specifically interested in access to local commercial areas and the issue of pedestrian comfort, the pedestrian network through shopping centers was included. While some pedestrians are likely to go out of their way to avoid paths through shopping centers to reach their destinations, our survey map results showed that many would choose to walk through the center if choosing that path makes the route more direct. Understanding the barriers to pedestrian activity in shopping centers is important, especially in the suburbs where shopping centers are ubiquitous.

Figure 3: Pedestrian Network Compared to the Street Network

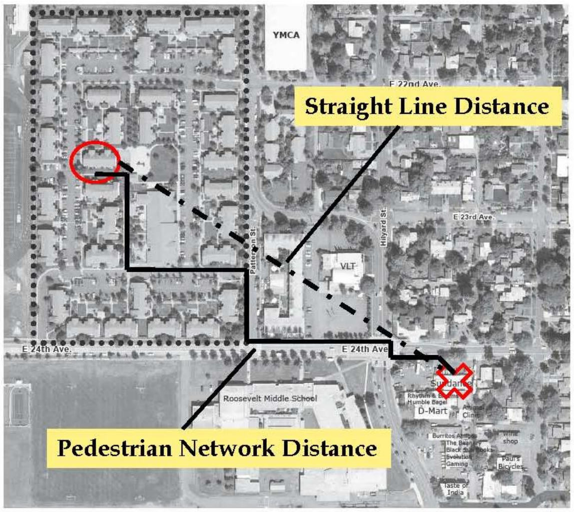


After drawing in the pedestrian network (shown in Figure 1, above, comparing the greater route options in the pedestrian network compared to the street network), I was able to determine the pedestrian network distance between each origin and destination. This analysis used the Origin-Destination Cost Matrix (OD Cost Matrix) function in the Network Analyst tool of ArcGIS to find this distance. While originally intended for automobile use, the OD Cost Matrix tool is a simple method to find the most efficient route between two points, what I call the "most efficient network distance" or MEND. In this analysis, the MEND route is the assumed pedestrian route between each origin and destination. This study focuses on the effect of these route characteristics on the aggregated group of residents in specific multifamily housing developments; a future study could look more closely at individual behavior and its correlation with these route characteristics.

The analysis in this thesis focuses on the most efficient network distance as determined by the GIS software. In an ideal pedestrian environment, this route would be the default route. While it is unlikely that all respondents followed the most efficient route on their trips to nearby destinations, analyzing these routes can tell us general trends in the travel environment in each development. Comparing survey map responses to the routes I chose as the most efficient network routes, I noticed many people followed those routes which gives some credibility to the routes I chose.

I then compared the straight line distances and the most efficient network distances to determine how much farther the routes are on the pedestrian network compared to the straight line distance, using the pedestrian route directness ratio (or PRD) that Randall and Baetz (2001) establish (see Figure 2, next page). This ratio can be used to determine how far pedestrians need to walk out of the way to reach destinations I will also use this term in this study for comparison purposes.

Figure 4: Pedestrian Route Directness Ratio



Pedestrian Route Directness =

Pedestrian Network Distance / Straight Line Distance

Example:
•Network Distance = 1050 feet
• Straight Line Distance = 650 feet

PRD = 1.62

Using the MEND length and PRD ratio for each origin-destination link, I then calculated the median number for both factors in each development. These numbers can provide an accessible comparison for characteristics of each development and their relationship with active transportation behavior. Comparing between developments can give information on the aggregated effect of the built environment on the behavior of all residents within each development, rather than exploring the behavior of individual residents which can introduce complicating demographic factors.

For the second part of the analysis, I gathered data on other route characteristics to determine the effect of certain barriers to pedestrian travel. The barriers analyzed in this study include:

- Travel along high-volume, high-speed arterial streets,
- Crossing high-volume, high-speed arterial streets,
- Large parking lots, and
- Inconvenient crosswalks.

To determine the effect of these barriers, I visually compared the maps from each of the developments to find patterns. For the most efficient network route between each origin and destination the respondents reported travelling between, I marked if any or all of these barriers were present. Because the OD Cost Matrix function does not provide a visual of the most efficient network route, this part of the analysis required using certain visual assumptions to determine what this route would be.

Final Analysis

For quality control and ease of comparison, only developments with ten or more respondents were included in the final analysis to account for distorted results from developments with fewer respondents. Four well-connected developments and three less-connected developments were included in the final analysis for a total of seven developments. These seven developments had 162 respondents, with a total of 959 trips analyzed in this study (approximately 5.9 trips per person).

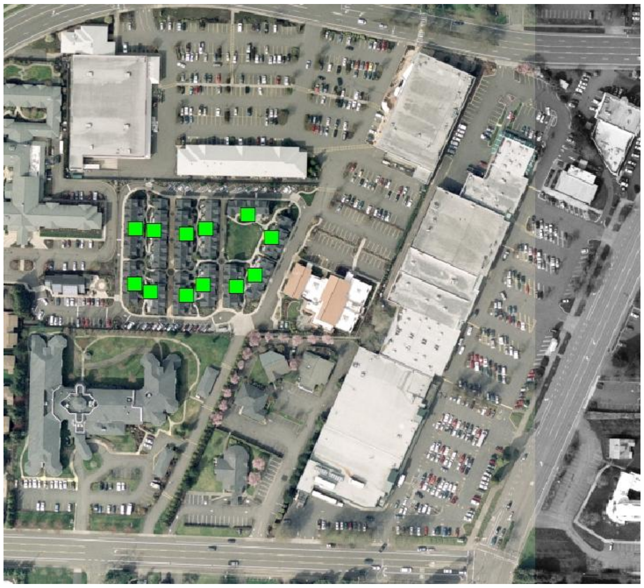
Finally, I used statistical analysis software to run a regression analysis on each of the relationships explored in the research. These numbers were used to determine the statistical significance of the relationships between distance, route directness, and other route characteristics on pedestrian and bicycle behavior.

Figure 5: Oak Meadow, Oak Lane, and Firwood (left to right), Aerial Image

Figure 6: Heron Meadows, Aerial Image

Figure 7: Crossings and Parkside (left to right), Aerial Image

Figure 8: Sheldon Village, Aerial Image



Methods Discussion

Using the automobile-focused GIS tools for pedestrians and bicycles is difficult because they have a greater variety of route options than automobiles, including crossing streets where they desire and cutting through parking lots and landscaped areas that are not included in the pedestrian network. I attempted to digitize all route options and chose the most logical routes where too many options existed (i.e. through parking lots, etc.). Another difficulty in using the OD Cost Matrix function for this analysis is that the output does not present which route was chosen as the most efficient; rather, a simple distance (in feet) is given. Not having a visual of the specific most efficient network routes that the GIS chose did not allow me to compare the MEND with the actual routes taken by respondents, but the results can still be applicable to the role of physical environment characteristics on pedestrian and bicycle behavior on a larger level. Future research should explore how to add these varied route options into a GIS-based analysis.

Rather than simply using the street network to determine walking and bicycling distances, this study looks more specifically at the entire pedestrian network because pedestrians often do not follow the street network precisely to get to destinations. Using street networks as the sole pedestrian option is not ideal because “pedestrian networks can incorporate informal and formal paths, including sidewalks, laneways, pedestrian bridges, and parks paths” (Chin et al., 2007, 42). Also, because the street network is usually used to look at longer distances, using the street network for pedestrian studies ignores the significance of distances in crossing streets and the potential lack of pedestrian amenities. While it was time-consuming to digitize pedestrian routes for all fourteen developments by hand, the results of a study using the true pedestrian network are more accurate to the reality of how pedestrians travel in these areas.

CHAPTER IV

RESULTS

An analysis of responses to the Multifamily Housing Travel Survey in 2009 yields several key results about the nature of active transportation in suburban multifamily housing. I use the results of the survey, published in a report by Larco et al. (2010).

Effect of Pedestrian Network Distance on Behavior

In order to determine a comparable number for the network distance for each development, I took the median length of the most efficient network routes for all trips (walking/bicycling and driving) reported on the respondents' survey maps. Comparing the median network distance travelled by respondents mitigated extreme outliers in the data set ($p<.05$). As a result, network distance shows a clear relationship with active transportation behavior (see Table 1, next page). Developments with shorter median walking distances have higher percentages of people that report ever walking or bicycling to their local commercial area, which is highly significant in this data set. Also significant is the correlation between network distance and the mean percent of trips taken using active transportation to the local commercial area. The correlation between network distance and mean trips to the local commercial area (meaning that people who live within closer walking distance to their local commercial area tend to take more trips to the shopping center) is also significant, though not as significant as the other two factors.

Table 1: Effect of Pedestrian Network Distance on Walking/Bicycling

Development	**Median MEND** (in feet)	**Larco et al. (2010)** % of respondents reporting ever walking/ bicycling**	Mean % trips walking/ bicycling***	Mean # trips to LCA*
Sheldon Village[a]	833.21	**90%**	**72%**	**7.7**
Heron Meadows[a]	1202.01	**85%**	**56.3%**	**5.6**
Crossings[a]	1688.79	**76.2%**	**42.5%**	**5.7**
Firwood	1865.51	50%	32.4%	4.1
Parkside[a]	2204.24	63.4%	33.7%	4.3
Oak Lane	2223.48	47.1%	17.6%	5.4
Oak Meadow	2354.65	40%	15.6%	3.9

[a] Well connected
[*] P<.05
[**] P<.01
[***] P<.001

Effect of Pedestrian Route Directness on Behavior

Pedestrian route directness (PRD) is a measurement of the difference between the straight line distance between origins and destinations and the distance using the pedestrian network. Using the survey map analysis, the correlation between PRD and the behavior of residents of suburban multifamily housing is not significant (see Table 2, next page). Contrary to the hypothesis that indirect routes would be correlated with lower rates of reported walking and bicycling, a clear distinction does not exist, though the data visually show a general trend that the two developments that report the most walking and bicycling have lower PRD ratios.

Table 2: Effect of Pedestrian Route Directness on Walking/Bicycling

Development	Added Distance	PRD Ratio	Larco et al. (2010)		
			% of respondents reporting ever walking/bicycling[**]	**Mean % trips walking/ bicycling**[*]	**Mean # trips to LCA**[**]
Heron Meadows[a]	353.83	1.42	**85%**	**56.3%**	**5.6**
Sheldon Village[a]	250.89	1.43	**90%**	**72%**	**7.7**
Oak Lane	733.73	1.49	47.1%	17.6%	5.4
Parkside[a]	779.90	1.54	63.4%	33.7%	4.3
Oak Meadow	958.58	1.68	40%	15.6%	3.9
Crossings[a]	702.54	1.71	**76.2%**	**42.5%**	**5.7**
Firwood	1044.99	2.27	50%	32.4%	4.1

[a] Well Connected
[*]P<.05 (for added distance, not PRD ratio)
[**]P<.01 (for added distance, not PRD ratio)

Pedestrian route directness is not a perfect measurement, however, because the effect of smaller increases in distance for developments with shorter network distances is given greater weight compared to developments with longer network distances. For example, Sheldon Village has the shortest median network distance at 833.21 feet, and its PRD ratio is 1.43 with an added distance between the straight line route and the most efficient network route being 250.89 feet. In comparison, Oak Lane, a development with one of the longest median network distances (2223.48 feet) and an added distance of about 733 feet, has a similar PRD ratio to Sheldon Village. This shows the skewed nature of the PRD ratio and supports the significant relationship of network distance to active transportation behavior. While the PRD ratio was not correlated with walking and bicycling, the added distance between the straight line and most efficient network distances does show a significant relationship.

Effect of Other Route Characteristics on Behavior

In analyzing the relationship between physical route characteristics other than network distance on transportation behavior, it was determined that only the relationships between pedestrian interaction with major arterials and active transportation behavior is significant. The relationship of large parking lots was not correlated with active transportation behavior in this study.

Along Arterials

Developments with a lower percentage of routes involving walking along high-volume, high-traffic arterials have a greater percentage of walking and bicycling (see Table 3, below). All seven developments were located within close proximity to a major arterial (as is the case in many suburban multifamily housing developments). Table 3 shows that when routes to local commercial areas do not necessitate walking along these major arterials, a greater percentage of people seem to choose to use active transportation. The relationship is significant between walking along major arterials and the percent of residents who report ever walking and bicycling to their local commercial area as well as the mean percent of trips taken to the local commercial areas using active transportation.

Table 3: Effect of Walking along Major Arterials on Walking/Bicycling

Development	**% Routes Along Arterial**	**Larco et al. (2010)**		
		% of respondents reporting ever walking/ bicycling* **	**Mean % trips walking/ bicycling*** **	**Mean # trips to LCA**
Sheldon Village[a]	4.9%	**90.0%**	**72.0%**	**7.7**
Heron Meadows[a]	12.6%	**85.0%**	**56.3%**	**5.6**
Parkside[a]	43.1%	63.4%	33.7%	4.3
Crossings[a]	47.1%	**76.2%**	**42.5%**	**5.7**
Firwood	68.9%	50.0%	32.4%	4.1
Oak Meadow	77.4%	40.0%	15.6%	3.9
Oak Lane	81.5%	47.1%	17.6%	5.4

[a] Well connected
*** P<.001

Crossing Arterials

The relationship between active transportation and the necessity to cross major arterials to reach a local commercial area is also significant. Table 4 (below) shows that there is a trend that developments with a greater percentage of routes crossing major arterials have lower percentages of walking and bicycling. Crossing arterials is highly correlated with the percent of people who report ever walking or bicycling to their local commercial area, and it is also correlated with the mean percent of trips using active transportation that residents report. The relationship between crossing arterials and mean number of trips to the local commercial area is also significant, though less than the other two elements.

Table 4: Effect of Crossing Major Arterials on Walking/Bicycling

Development	**% Routes Crossing Arterial**	**Larco et al. (2010)**		
		% of respondents reporting ever walking/ bicycling* **	**Mean % trips walking/ bicycling** **	**Mean # trips to LCA***
Sheldon Village[a]	4.9%	**90.0%**	**72.0%**	**7.7**
Heron Meadows[a]	12.6%	**85.0%**	**56.3%**	**5.6**
Parkside[a]	32.3%	63.4%	33.7%	4.3
Crossings[a]	36.8%	**76.2%**	**42.5%**	**5.7**
Oak Lane	65.1%	47.1%	17.6%	5.4
Oak Meadow	66.7%	40.0%	15.6%	3.9
Firwood	68.9%	50.0%	32.4%	4.1

[a] Well connected
[*] P<.05
[**] P<.01
[***] P<.001

Large Parking Lots

Contrary to the hypothesis, the relationship between active transportation and walking through large parking lots is not significant. For this study, routes that were determined to have large parking lots were those where a pedestrian had no clear, convenient option to reach the destination without interacting with a parking lot that had more than approximately five spaces.

There is a slight correlation between the mean number of trips to the local commercial area and large parking lots, but the other two factors are not correlated (see Table 5, next page). The slight correlation with number of trips to the shopping center could potentially be explained because the mean number of trips includes all modes of transportation, not just walking and bicycling. It could be true that residents reporting greater trips to their local commercial area in a week often drive if there are larger parking lots and more open parking spaces.

Table 5: Effect of Large Parking Lots on Walking/Bicycling

Development	% Routes w/ Large Parking Lots	Larco et al. (2010)		
		% of respondents reporting ever walking/ bicycling	Mean % trips walking/ bicycling	Mean # trips to LCA*
Sheldon Village[a]	0.0%	**90.0%**	**72.0%**	**7.7**
Heron Meadows[a]	15.2%	**85.0%**	**56.3%**	**5.6**
Oak Meadow	34.5%	40.0%	15.6%	3.9
Oak Lane	35.4%	47.1%	17.6%	5.4
Parkside[a]	47.8%	63.4%	33.7%	4.3
Crossings[a]	50.0%	**76.2%**	**42.5%**	**5.7**
Firwood	57.8%	50.0%	32.4%	4.1

[a] Well connected

* $P<.05$

Limitations

The results of the survey present limitations to the greater applicability of the conclusions. First, contrary to the composition of the general population, over 70 percent of the respondents were women. While this is not necessarily a surprising return for a mail survey, men and women vary in their comfort level with walking and bicycling, and a higher proportion of women in the survey responses can lead to biased results. Clifton and Dill (2005) recognize that women are more hesitant to walk and bicycle in neighborhoods where they feel unsafe or other barriers exist. The authors found that while men tended to walk and bicycle more than women in all kinds of neighborhoods, women showed a marked increase in walking and bicycling behavior in neighborhoods where amenities were provided to make it feel safer and more efficient. Walking and bicycling may be skewed negatively in less-connected developments and positively in well-connected developments with the high percentage of women responding to this survey; however, planning for the most vulnerable users is an important tenet in planning, so having a high sample rate of women who tend to be more apprehensive to walking and bicycling is not necessarily negative.

Likewise, the possibility existed for respondents to exaggerate their walking and bicycling behavior in a survey such as the one analyzed in this report. Active transportation may be perceived to be more virtuous than driving, and respondents may have felt the need to indicate that they walk or bicycle more often. The possibility also existed that respondents accidentally overstated their active transportation behavior because of confusion in the survey map methods. Future surveys of this kind should be more explicit in their directions that ask respondents to answer questions using methods with which they may not be familiar.

CHAPTER V

IMPLICATIONS

The network distance between origins and destinations and interactions with major arterials have the clearest relationships with a person's decision on whether to use active transportation or drive to nearby commercial areas. This study sampled seven multifamily housing developments that were within a quarter-mile of a local commercial area. The results show that a greater percentage of people who live closer to destinations via the pedestrian network use active transportation, take a greater percent of their trips via walking and bicycling, and visit local commercial areas more often.

While this study did not look into the greatest average walking distance, a general rule in the findings of this study appears to state that minimizing the total distance between origins and destinations through direct routes can help increase walking and bicycling rates. The effect of pedestrian accessible pathways that decrease total walking distance should not be understated. In the preliminary GIS analysis of this data, a key link between Sheldon Village and its local commercial area that allows its residents to access the shopping center from behind was missing. Including this link decreased the median travel distance by over 50%. Sheldon Village is also the development with the greatest percentages of reported walking and bicycling, so this link to the local commercial area appears to be an important piece of the pedestrian infrastructure.

Pedestrian route directness does not appear to have a correlation with active transportation in suburban multifamily housing as was hypothesized. Though pedestrian route directness highlights the greater distance pedestrians need to walk using the pedestrian network, route directness may play a more psychological role in determining whether someone will drive or use active transportation. It appears that small distances between origins and destinations in closer developments plays the largest role in the high percentages of residents reporting the use of active transportation in those developments. However, pedestrian route directness may play a greater role in the travel behavior of residents of developments that are already farther away from destinations by making routes along the pedestrian network appear to be even longer than they are. Walking distances in the Oak Lane development in Eugene are only 49% longer using the pedestrian network; however, because residences in Oak Lane are already, on average, the farthest away from destinations, adding even a relatively small amount of indirectness to the route could play a major role in deciding if a person will drive or walk.

Parking lots are curious in this study because they do not have a correlation with decreased walking and bicycling behavior and only have a small correlation with total trips to a local commercial area. This finding is surprising because with the high volume of automobiles, the dangerous turning movements, and the general lack of pedestrian-dedicated infrastructure, it seems intuitive that parking lots are not pedestrian-friendly environments. However, it could be true that destinations that a greater percentage of people want to patronize generally have larger parking lots, which makes them a non-issue if the desire to visit the establishment is strong enough. It could also be true that suburban residents have become desensitized to the dangers of large parking lots, weaving and angling their way through parking aisles to reach their destinations in a more efficient manner while remaining aware of automobile behavior around them.

The results of this study have important implications on the environmental, social, and health aspects of transportation for residents of suburban multifamily housing. Since shorter distances along the pedestrian network tend to increase walking and bicycling behavior, focusing on reducing trip distance and making the routes for those trips more amenable to active transportation could help reduce local traffic as well as the carbon emissions and other pollutants that are associated with automobile use. Transforming automobile trips that would be taken to farther destinations into active transportation trips to local commercial areas could also increase the amount of physical activity that residents of suburban multifamily housing engage in each week. With the increasing obesity epidemic and other health issues related to driving and a sedentary lifestyle, even a small increase in an individual's physical activity can play a large role in their health.

Though it is difficult to assert that increasing active transportation in suburban multifamily housing will make residents happier and more socially aware, research has shown these assertions to be true in other locations (Freeman, 2001; Leydon, 2003). Hess et al. (1997) also found that there were many young pedestrians in suburban areas. Though fewer children live in multifamily housing than in single family housing in the suburbs, the youth that do live in these developments deserve a better, more adequate system as a matter of safety and social equity. Youth, the elderly, and those with different physical abilities are truly the most vulnerable road users and should be the common denominator for which we plan.

This study also has implications for the future use of GIS in active transportation travel studies. GIS proved to be a useful tool in this research. Because a significant quantity of the pedestrian network around suburban multifamily housing is typically located in disconnected private developments, using GIS allowed for the creation of layers of pedestrian network data that are more specific than the ones that exist in many local databases. Creating these layers was time consuming, though it is time well-spent as the layers are useful for a range of active transportation travel studies. However, using GIS for pedestrian and bicycling travel behavior studies is also imperfect as pedestrians and bicycles can travel in a variety of routes that are difficult to create in the linear structure of GIS. I was able to use a combination of my experience as a pedestrian and examples from the survey maps to determine what might be logical pedestrian paths through areas with many route options, and a brief overview of several survey maps showed that the routes I showed were generally the routes people chose.

CHAPTER VI

POLICY RECOMMENDATIONS

The results of this study show the importance of providing connections for active transportation that link suburban multifamily housing to local commercial areas. Making these kinds of connections should be prioritized to make active transportation more accessible to a population that can be located closer to desired destinations.

This research leads to nine policy recommendations that should be explored by municipalities interested in increasing the utilization of active transportation by residents in suburban multifamily housing:

- Encourage zoning that increases density around suburban commercial centers to increase the number of residents within walking and bicycling distance to everyday amenities.
- Create off-street connections that give pedestrians and bicyclists options to reach nearby destinations without requiring them to interact with arterial roads.
- Foster partnerships between adjacent developments to increase connections.
- Explore a requirement that all streets, even those within private developments, connect directly to the greater street grid to create greater transportation efficiency (i.e. eliminate or restrict cul-de-sacs, etc.).
- Improve the pedestrian environment along major arterials with widened sidewalks and buffers between sidewalks and vehicle travel lanes. Improve crosswalks with

bulb-outs, pedestrian refuge islands, and crosswalk countdown signals so that pedestrians feel safer when crossing these arterials. These improvements are especially important in areas where pedestrians are required to walk along or cross arterials to reach destinations.

- Complete all sidewalk segments to ensure a fully-connected pedestrian network. Complete sidewalk networks should be a requirement of all public and private development to increase equity for vulnerable road users and assert the local municipality's belief that walking and bicycling are important modes of transportation.
- All cities should have multifamily housing standards that ensure proper design and transportation connections. The cities of Eugene and Gresham in Oregon have recently created multifamily housing standards that are good models for other communities.
- Incorporate distance between origins and destinations into walkability assessments. A local municipality can give development points or leniency in other requirements for developments that increase density around commercial centers and provide above adequate active transportation amenities.
- Network distance should be used for future studies and any municipalities that would like to use pedestrian distances for development codes. Straight line distance between origins and destinations is not an adequate measure for future travel studies of this nature. All developments in this study had their center point

within a quarter-mile of a commercial area, but the average pedestrian network distance ranged from .2 miles to .44 miles.

These recommendations should be used in conjunction with “programs to promote the health benefits of walking and convince the public that walking is time well spent” to have the greatest positive effect (Handy et al., 2002, 72). The results are also not necessarily limited to multifamily housing residents. Nearby single-family housing residents as well as other patrons of the local commercial area who wish to get around more easily on foot to other nearby establishments could benefit from these links.

Future research can expand on these findings in several ways. While this study focused on walking and bicycling, the results of the study appear more applicable to walking. Bicyclists are able to travel farther than pedestrians, can share the road with automobiles to travel, and are more shielded from negative conditions such as personal safety. Future studies should look specifically at the bicycle infrastructure in multifamily housing and suburbs in general to determine the effect of route directness and other characteristics on bicycling behavior. Also, the effect of age and other demographic characteristics on people’s perception of certain barriers should be explored in greater detail. Targeting investments to the needs of the population is important, and understanding how different age groups perceive the danger of walking along major arterials, for example, can help determine what proper investments would be.

APPENDIX A

EXAMPLE SURVEY MAP

APPENDIX B

EXAMPLE SURVEY

UNIVERSITY OF OREGON

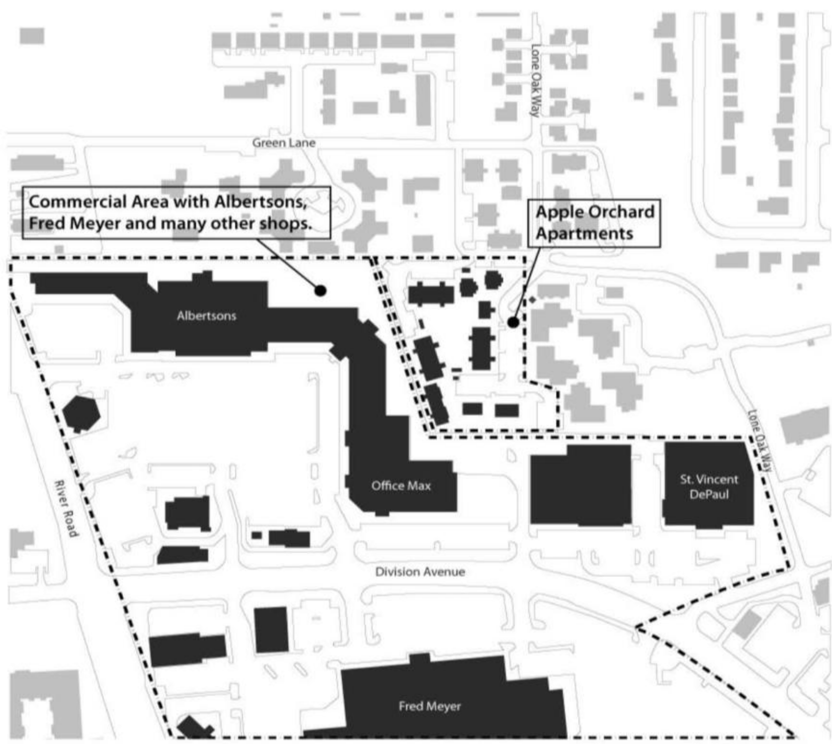
Multifamily Housing Travel Survey

Apple Orchard

We need YOUR help to help improve the design of apartment complexes. **All information provided in the survey will be kept anonymous.** Your response is voluntary and indicates your willingness to participate in this study.

INSTRUCTIONS: The head of the household or a resident of this apartment who is over 18 years of age should complete this survey. Please answer each question to the best of your ability. This survey should take you about 10-15 minutes to complete. Please return your completed survey in the enclosed postage-paid envelope by **March 23, 2009**. Thank you for your time!

The map below shows your apartment complex and your local commercial area outlined in black. Please use this information when asked to answer the following questions about your transportation habits. Throughout this survey, "local commercial area" refers to the commercial area outlined in black. (For a more detailed map of your designated local commercial area, see the back page of this survey.)



How do you travel?

NOTE: Throughout this survey, the word "walk" is used to refer to walking and wheelchair use. The word "bike" is used to refer to any other non-motorized transportation with wheels (bicycle, skateboard, rollerblades, etc.).

1. In the LAST MONTH, how often did you travel to your local commercial area in an average week using the following methods?

LAST MONTH travel patterns	AVERAGE TRIPS PER WEEK							
	0	1	2	3	4	5	6	7+
Drive	☐	☐	☐	☐	☐	☐	☐	☐
Bike	☐	☐	☐	☐	☐	☐	☐	☐
Walk	☐	☐	☐	☐	☐	☐	☐	☐
Bus	☐	☐	☐	☐	☐	☐	☐	☐

2. In a SUMMER MONTH (June, July, or August), how often did you travel to your local commercial area in an average week using the following methods? (Skip this question if you did not live in the complex in summer.)

SUMMER MONTH travel patterns	AVERAGE TRIPS PER WEEK							
	0	1	2	3	4	5	6	7+
Drive	☐	☐	☐	☐	☐	☐	☐	☐
Bike	☐	☐	☐	☐	☐	☐	☐	☐
Walk	☐	☐	☐	☐	☐	☐	☐	☐
Bus	☐	☐	☐	☐	☐	☐	☐	☐

How do you make transportation choices?

If you NEVER drive to your local commercial area, please skip to Question 5.

3. The following is a list of reasons that might influence your decision to DRIVE to your local commercial area rather than walk or bike. Please indicate your level of agreement with these statements:

Strongly disagree -------------------------------- Strongly agree

DRIVING FACTORS	1	2	3	4	5
A. The distance from my residence to my local commercial area is too far for me to walk or bike.	☐	☐	☐	☐	☐
B. I don't have enough time to walk or bike.	☐	☐	☐	☐	☐
C. There are no sidewalks, crosswalks, or bike lanes to walk or bike on.	☐	☐	☐	☐	☐
D. There is too much for me to carry, so I can't walk or bike.	☐	☐	☐	☐	☐
E. I do not like to walk or bike in bad weather.	☐	☐	☐	☐	☐
F. Crime in the area keeps me from walking and biking.	☐	☐	☐	☐	☐

Question 3 continued on page 3

Question 3 (continued) Strongly disagree --------------------------------- Strongly agree

DRIVING FACTORS	1	2	3	4	5
G. I don't feel safe walking or biking because of vehicle traffic.	☐	☐	☐	☐	☐
H. Having to go through parking lots within my apartment complex prevents me from biking or walking.	☐	☐	☐	☐	☐
I. There is no direct walking or biking path to my local commercial area.	☐	☐	☐	☐	☐
J. I have to cross too many busy streets between my home and my local commercial area.	☐	☐	☐	☐	☐
K. I don't like the look or feel of the walking/biking route to my local commercial area.	☐	☐	☐	☐	☐
L. I often combine trips to my local commercial area with trips to other destinations that require a car.	☐	☐	☐	☐	☐
M. Other: ____________________________	☐	☐	☐	☐	☐

4. Please write the letters (A-M) of the THREE MOST IMPORTANT REASONS from Q-3 that might influence your decision to DRIVE rather than walk or bike to <u>your local commercial area</u>:

Most important: _____ Second most important: _____ Third most important: _____

If you NEVER walk or bike to your local commercial area, please skip to Question 7.

5. The following is a list of reasons that might influence your decision to WALK or BIKE to <u>your local commercial area</u> rather than drive. Please indicate your level of agreement with these statements:

Strongly disagree ----------------------------- Strongly agree

WALKING AND BIKING FACTORS	1	2	3	4	5
A. Walking or biking is better for my heath.	☐	☐	☐	☐	☐
B. I do not have access to a car.	☐	☐	☐	☐	☐
C. I want to save money.	☐	☐	☐	☐	☐
D. It is faster to walk or bike to my local commercial area than it is to drive.	☐	☐	☐	☐	☐
E. Parking in my complex is difficult.	☐	☐	☐	☐	☐
F. Parking at my local commercial area is difficult.	☐	☐	☐	☐	☐
G. Walking or biking is better for the environment.	☐	☐	☐	☐	☐
H. I enjoy seeing and meeting other people when I walk and bike.	☐	☐	☐	☐	☐
I. I often combine trips that involve walking or biking, and my local commercial area is on my way.	☐	☐	☐	☐	☐
J. Other: ______________________	☐	☐	☐	☐	☐

6. Please write the letters (A-J) of the THREE MOST IMPORTANT REASONS from Q-5 that might influence your decision to WALK OR BIKE rather than drive to <u>your local commercial area</u>:

Most important: _____ Second most important: _____ Third most important: _____

How easy is it to walk and bike?

7. On a scale of 1 – 5, rate the ease of walking and biking WITHIN your apartment complex (circle the number).

1	2	3	4	5
Not easy				Very easy

8. On a scale of 1 – 5, rate the ease of walking and biking BETWEEN YOUR APARTMENT COMPLEX AND LOCAL COMMERCIAL AREA (circle the number).

1	2	3	4	5
Not easy				Very easy

9. Would you walk or bike more frequently to <u>your local commercial area</u> if it were made easier or more convenient to do so?

☐ Yes

☐ No, it is already easy and convenient

☐ No, it would not influence my decision

→ **(If no, skip to question 14.)**

10. The following is a list of changes <u>WITHIN YOUR APARTMENT COMPLEX</u> that might influence your decision to walk or bike more. Please indicate the importance of the following improvements:

Not Important ----------------------------------- Very Important

WITHIN YOUR APARTMENT COMPLEX	1	2	3	4	5
A. Reduce number or speed of cars.	☐	☐	☐	☐	☐
B. Reduce obstacles (such as parking lots, fences, walls) between my unit and a public street.	☐	☐	☐	☐	☐
C. Provide places to walk or bike (such as sidewalks, bike lanes, crosswalks).	☐	☐	☐	☐	☐
D. Create a more direct path for walking or biking from my residence to a public street.	☐	☐	☐	☐	☐
E. Improve the look and feel (such as trees, benches, landscaping) of the route from my residence to a public street.	☐	☐	☐	☐	☐
F. Separate pedestrian path from vehicular traffic with trees, grass, and/or parked cars.	☐	☐	☐	☐	☐
G. Other: ______________________________	☐	☐	☐	☐	☐

11. Please write the letters from <u>Q- 10 (A-G)</u> of the THREE MOST IMPORTANT IMPROVEMENTS that would influence your decision to walk or bike more:

Most important: _____ Second most important: _____ Third most important: _____

12. **The following is a list of changes <u>BETWEEN YOUR APARTMENT COMPLEX AND LOCAL COMMERCIAL AREA</u> that might influence your decision to walk or bike more. Please indicate the importance of the following improvements:**

Not Important ---------------------------------- Very Important

FROM APARTMENT COMPLEX TO COMMERCIAL AREA	1	2	3	4	5
A. Reduce traffic or speed of cars.	☐	☐	☐	☐	☐
B. Reduce obstacles (such as parking lots, fences, walls) between my development and local commercial area.	☐	☐	☐	☐	☐
C. Provide places to walk or bike (such as sidewalks, bike lanes, crosswalks) from development to local commercial area.	☐	☐	☐	☐	☐
D. Create a more direct path for walking or biking from my development to my local commercial area.	☐	☐	☐	☐	☐
E. Improve the look and feel of the route between my development and my local commercial area.	☐	☐	☐	☐	☐
F. Separate pedestrian path from vehicular traffic with trees, grass, and/or parked cars.	☐	☐	☐	☐	☐
G. Other: ______________________________	☐	☐	☐	☐	☐

13. **Please write the letters from <u>Q-12 (A-G)</u> of the THREE MOST IMPORTANT IMPROVEMENTS that would influence your decision to walk or bike more:**

Most important: _____ Second most important: _____ Third most important: _____

How did you make your housing choice?

14. **Please tell us how important the following characteristics were when choosing your current home:**

Not Important ----------------------------- Very Important

HOUSING CHARACTERISTICS	1	2	3	4	5
A. Proximity to place of work.	☐	☐	☐	☐	☐
B. Ease of walking or biking to stores and restaurants.	☐	☐	☐	☐	☐
C. Ease of walking or biking to neighborhood school.	☐	☐	☐	☐	☐
D. Ease of walking or biking to public transportation.	☐	☐	☐	☐	☐
E. Ease of walking or biking to open space or park.	☐	☐	☐	☐	☐
F. Rent price.	☐	☐	☐	☐	☐
G. Safety from crime.	☐	☐	☐	☐	☐
H. Characteristics of residence itself (size, number of rooms, look).	☐	☐	☐	☐	☐
I. Amenities within apartment complex (pool, gym).	☐	☐	☐	☐	☐

15. **Please write the letters from Q-14 (A-I) of the THREE MOST IMPORTANT CHARACTERISTICS when choosing your home:**

Most important: _____ Second most important: _____ Third most important: _____

Tell us a little bit about yourself and your household.

All information provided in the survey will remain anonymous.

16. How long have you lived in your current home?

_______ years _______ months

17. How many automobiles does your household own? _______

18. Do you have a bicycle for your own use?

- ☐ Yes
- ☐ No

19. Does your apartment complex have secure bike parking?

- ☐ Yes
- ☐ No

20. Please estimate your total household income for 2008 before taxes.

- ☐ Less than $30,000
- ☐ $30,000 - $50,000
- ☐ $50,000 - $70,000
- ☐ $70,000 - $90,000
- ☐ More than $90,000

21. What is your gender?

- ☐ Female
- ☐ Male

22. What is your age? _______

23. What is your current household type?

- ☐ Single with No children
- ☐ Single with children
- ☐ Married/partner with No children
- ☐ Married/partner with children
- ☐ Multiple adults (either related or unrelated) with No children
- ☐ Multiple adults (either related or unrelated) with children

24. What is your race/ethnicity?

- ☐ American Indian or Alaska Native
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Asian
- ☐ Black or African American
- ☐ Latino/Hispanic
- ☐ White / Caucasian (Non-Hispanic)

25. What is your highest education level?

- ☐ High school
- ☐ College
- ☐ Post graduate (Master, professional, Dr.)

26. Please tell us the employment status for all adults in your household.

	Full-time	Part-time	Unemployed	Student	Retired
You	☐	☐	☐	☐	☐
Adult 2	☐	☐	☐	☐	☐
Adult 3	☐	☐	☐	☐	☐
Adult 4	☐	☐	☐	☐	☐

Questions About Your Travel Route

Thank you for taking the time to fill out this survey! Here's the fun part: please grab a bold pen or marker and follow the directions on the map on the next page to show us the places that you visit in your local commercial area and how you get there.

APPENDIX C

TABLE, ALL DEVELOPMENT DATA

Development	Median SLD	Median MEND	PRD ratio	Added distance	Along arterials	Crossing arterials	Large parking lots	% of respondents reporting ever walking/bicycling	Mean % of trips walking/ bicycling	Mean # trips to LCA
Crossings	986.25	1688.79	1.71	702.54	47.1%	36.8%	50.0%	76.2%	42.5%	5.7
Firwood	820.52	1865.51	2.27	1044.99	68.9%	68.9%	57.8%	50.0%	32.4%	4.1
Heron Meadows	848.18	1202.01	1.42	353.83	12.6%	12.6%	15.2%	85.0%	56.3%	5.6
Oak Lane	1489.75	2223.48	1.49	733.73	81.5%	65.1%	35.4%	47.1%	17.6%	5.4
Oak Meadow	1396.07	2354.65	1.68	958.58	77.4%	66.7%	34.5%	40.0%	33.7%	3.9
Parkside	1424.34	2204.24	1.54	779.90	43.1%	32.3%	47.8%	63.4%	33.7%	4.3
Sheldon Village	582.32	833.21	1.43	250.89	4.9%	4.9%	0.0%	90.0%	72.0%	7.7

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