Center for Accessibility and Safety for an Aging Population

Florida State University

In Partnership with Florida A&M University and University of North Florida

RESEARCH FINAL REPORT

Transit Oriented Development for Aging Adults: An Evaluation of Recent Trends, Best Practices, and Future Prospects

Michael Duncan
Mark W. Horner

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Accessibility for an Aging Population:
Measuring and Ensuring Access to Goods, Services, and Vital Needs

Final Report

Mark W. Horner, Ph.D.
Professor
Department of Geography
Florida State University

Michael Duncan, Ph.D.
Assistant Professor
Department of Urban and Regional Planning
Florida State University

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Disclaimer

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Abstract

From securing healthy food to obtaining medical care, as well as simply remaining socially connected to family and friends in their communities, transportation systems have a critical role to play in ensuring our aging population can safely and efficiently reach desired destinations. In this project our key objective is to develop approaches that can be used to assess aging populations' accessibility to essential goods and services. We conduct two literature reviews: one for research that focuses on the research trends in accessibility modeling and then another that focuses on travel behavior and accessibility needs of aging populations. In the latter case, we also analyze household travel data from Florida travelers in an effort fill in gaps we find in the existing literature. We then combine these two lines of research into a modeling framework that will allow for accessibility measures that are aimed at understanding aging populations. Application of the accessibility metrics allows us to evaluate how well different modes of transportation equitably serve the needs of the aging population. We explore these issues using Leon County, FL as a case study

Chapter 1 Introduction and Scope of Research

1.1 Project Background

The demographics of the U.S. are changing rapidly. With the aging cohort of Baby-Boomers now reaching retirement age, there will be an unprecedentedly large group of people with distinctive needs in terms of going about their day to day life activities. From securing healthy food to obtaining medical care, as well as simply remaining socially connected to family and friends in their communities, transportation systems have a critical role to play in ensuring our aging population stays accessible and can safely and efficiently reach desired destinations in their later stages of life. However, despite substantial research on both the travel behavior and needs of aging populations as well as research on measuring transportation accessibility itself, these streams of work have largely proceeded along separate tracks. In this project our key objective is to identify context-specific multimodal modeling and measurement approaches that can be used to assess aging populations' accessibility to essential goods and services. The resulting accessibility approaches will allow us to evaluate how well different modes of transportation equitably serve the needs of the aging population. This in turn will facilitate planning and policy initiatives aimed at improving their accessibility.

As we learn more about aging populations' needs, a number of key transport-related research questions arise:

- How do aging populations effectively reach goods and services? How well are these populations served by current transportation systems?
- How does people's accessibility differ across mode of transportation available? How does their accessibility differ by age and other potential variables?

- How do we know current accessibility approaches accurately measure the needs of aging populations?

To address these interrelated questions, this research (a) reviews and synthesizes the literature from the scholarly and practitioner fields on aging and accessibility, (b) develops accessibility indices and (c) demonstrates the measurement of accessibility across multiple modes (e.g. auto, transit, walk) taking Leon County, FL as a case study and looking at the distribution of accessibility benefits across multiple age groups.

Accessibility related research has thrived during the last few decades with new data and computational tools facilitating innovations stemming from classical approaches (Shen 1998; Handy and Niemeier 1997; Miller 1999; Bhat et al. 2006, Neutens et al. 2011; Levine et al. 2012). While precise definitions vary across disciplines, generally accessibility is thought to mean the ease with which activities can be reached in space. Accessibility is contingent on transportation whereby other factors held constant, more diverse, faster, and efficient systems improve accessibility. Accessibility is often further parsed based on how it is measured. Place-based metrics capture the accessibility assumed to be available at a given location (Horner 2004; Li et al. 2011). For example, these metrics can be used to gauge how many employment opportunities may be visited by a given mode of transportation (driving, public transit, or walking) from a specific location within a city (Horner and Mefford 2005). They have found wide use in social policy contexts (Shen and Sanchez 2005), as they are readily quantified and mapped to locations such as network nodes and/or census geographies. People-based measures of accessibility allow one to account for individual constraints on movement, activity participation, and other contextual factors that shape transportation outcomes (Kwan and Weber

2003). Collectively, accessibility metrics can be used to assess the efficiency, effectiveness, or equity of service with respect to any travel mode.

1.2 Aging Populations and Travel Behavior

According to the U.S. Census, about 49.9 million people, or 16.2%, were 62 years or older in 2010. In Florida, that percentage rises to 20.9%, which is approximately 3.9 million people. Earlier research conducted this decade examining the interconnections between an aging population and their transportation needs paints a fairly bleak picture in terms of the challenges faced. With these populations set to double by 2025, decades of suburbanization and urban sprawl have stacked the deck against finding easy solutions to helping aging populations remain connected to their vital needs (Rosenbloom 2003, Bailey 2004). Needs include reaching locations that provide health care, food, shopping opportunities, personal business functions, social interaction, and other essential activities. Earlier data analysis suggests aging populations face increasing isolation as driving cessation occurs, and that these impacts are not equally distributed when factors such as race, socioeconomic status, and geography are considered (Bailey 2004). The aging population's transportation needs evolve in different ways following retirement age, whereby older people have needs that are distinctive from their 'younger' counterparts (Alsnih and Hensher 2003). Schwanen and Paez (2010) echo this sentiment, noting recent research shows older adults are more immobile, travel shorter distances and make fewer trips than younger groups when they do leave the home. Clearly among the possible solutions, more robust and available forms of alternative travel options could help mitigate these issues. Along these lines Mercado et al. (2010) conclude that transit systems should be evaluated for their ability to provide equitable service given their important role in potentially serving the aging market. Further, the built environment should be evaluated in terms of its ability to provide safe walking environments for older pedestrians (Rosenbloom 2009).

1.3 Synthesis Opportunities in Accessibility and Aging

Although studies have considered issues of accessibility and aging in various contexts (e.g. Alsnih and Hensher 2003, Hess 2009, Mercado et al. 2010, Paez et al. 2010), there seems to be no comprehensive work that explicitly seeks to fuse accessibility modeling and measurement with understanding aging population's travel needs. Searching the TRB's research in progress database for the terms 'accessibility and aging', one active project housed at the National Center for Intermodal Transportation for Economic Competiveness focuses on understanding the unmet travel needs of nonmetropolitan adults via a nationwide survey. A recently completed project by the New England UTC looked at friction points among older adults within multimodal and transit systems to identify impediments to movement. A much earlier NCHRP project (2003) focused on mobility, access and safety issues for an aging population and funded a symposium to contemplate these issues. Therefore, there are opportunities for new research exploring aging issues in the context of transportation accessibility.

1.4 Research Approach, Methodology, and Tasks

The proposed research consists of several intertwined components. First we will conduct a synthesis of current and past literature on aging and accessibility with a focus on understanding current modeling approaches, using conventions in the literature such as location based vs. individual based accessibility, etc. and combining these with the travel needs of aging people. We will also analyze secondary data from the National Household Transportation Survey with an emphasis on Florida to help build stronger transportation profiles of aging populations. We will utilize our data resources in conjunction with lessons learned from our literature reviews to design accessibility modeling approaches and scenarios for use in a Geographic Information Systems (GIS) environment. Lastly, we will apply these measures in a case study of multimodal accessibility in Leon County, with an emphasis on disaggregating older populations by dimensions such as relative age. Specific tasks include:

- **Task 1: Comprehensive Literature Review of Accessibility**. We will identify the state of the practice in accessibility modeling and effort will be made to analyze multiple approaches to accessibility models, with a particular emphasis on aging and disadvantaged populations. (Results appear in Chapter 2)
- **Task 2: Comprehensive Literature Review Activity/Travel Patterns of Aging Populations**. We will review the state of knowledge in terms of where, when, and how older adults travel. Much work has also been done in recent years using the National Household Travel Survey (NHTS) to track the travel patterns of older adults and we will review this literature in depth. (Results appear in Chapter 3).
- **Task 3: Data Analysis to Augment Literature Reviews.** We will conduct our own analysis of the NHTS that focuses specifically on Florida respondents. This analysis will be used to enhance and elucidate knowledge and issues uncovered in the literature reviews and inform the accessibility modeling. (Results appear in Chapter 4)
- **Task 4: Compilation of Modeling Approaches, Issues, and Scenario Identification.** We will combine the knowledge obtained in the first three tasks into a coherent accessibility modeling approach. Accessibility metrics will be formulated (i.e., equations will be provided) and scenarios will be designed based on the state of the practice

determined in Task 1, the travel patterns of the aging determined in Task 2, and analysis of Task 3. (Results appear in Chapter 5)

- **Task 5: Case Study Application to Leon County.** Leon County, FL is analyzed in GIS using various spatial data resources. These include roads networks and activity locations. We systematically calculate aging-specific accessibility metrics for locations across Leon County. We produce a set of accessibility assessments by mode and activity showing how well the accessibility needs of the aging populations are being met within the region. (Results appear in Chapter 5 and 6)

Chapter 2 Literature Review of Accessibility

As the current population ages, this group is expected to double in size by the year 2025, and one in three persons in the Western world will be 65 years of age or older (Rosenbloom, 2003). These changes in the composition of the population will ultimately challenge those who manage transportation systems in their attempts to satisfy the older population's transportation needs. There has been recent research involving the aging population and transport mobility (DeGood, et al, 2011; Mercado, et al, 2010). Definitions of transport mobility have included the following points: access to goods and services, psychological benefits of travel, benefits of physical movement, maintaining social networks, and potential travel (Alsnih & Hensher, 2003). In this section we focus on understanding some of the research that explores mobility and accessibility issues for older populations, with an emphasis on reviewing some of the issues and findings in this area, as well as developing a basic framework for measuring accessibility in future analyses.

2.1 Mobility

Many have argued that access to reliable transportation for aging people is essential (Bailey, 2004; Metz, 2003; Rosenbloom, 2003). Isolation of older citizens could be an unfortunate effect of their inability to access easy and affordable transportation (Bailey, 2004). If the aging population's transportation needs are not met, they may be living by themselves with limited patterns of interaction. Some argue social interaction helps keep older people healthy and engaged with the rest of society (Metz, 2000). Not only would their mental and emotional health be compromised, but also their physical health because they are not as active. With that said, mobility, or the ability of an individual to gain access through movement to the facilities an individual desires to reach, is an important concept often discussed in the context of aging populations and transportation.

There are many constraints that aging populations will face in order to gain mobility to their desired locations. Some of these constraints are articulated by Metz (2000) as possible physical and mental deficiencies that could lead to disabilities, which leave aging individuals unable to operate or access a means of transportation such as drive a car or board public transport modes. There may also be impairments in the design and infrastructure of transportation systems, as they exist now. Some of these include spatial mismatch where activity locations may be located far away from where the aging actually live or traffic conditions, such as congestion that may make some older persons uncomfortable to drive due to perception of safety (Metz, 2000; Spinney, et al, 2009). Additionally, financial constraints may inhibit aging populations from utilizing all forms of transportation. Aging persons relying on a fixed income may no longer be able to afford the costs of maintaining a personal vehicle. It has been estimated that, for older people living at or below the poverty line, the average cost of owning a vehicle would take up 78 percent of income (DeGood et al., 2011). The relationship between mobility and quality of life has been focused on extensively, with researchers calling for a clear and quantifiable concept of mobility for aging populations (Metz, 2000). Essentially, mobility is central to the aging being able to access the people, places, and activities necessary for life maintenance, life satisfaction, and personal well-being (Spinney et al., 2009).

Metz (2000) also argues that mobility is more than getting from origins to destinations but it is also about getting the benefits from social and physical movements that can be obtained from traveling to and from activities. As such there are many researchers who focus on the causes of driving cessation and how older people cope after the loss of driving privileges

(Banister & Bowling, 2004; Hakamies-Blomqvist & Wahlstrom, 1998; D. . Metz, 2000; Spinney et al., 2009). Driving cessation is generally defined as the decision to stop driving an automobile. This decision is usually influenced by a variety of factors related to physiologic health, such as the ability to see, hear, reaction time, etc. (O'Neill, 2010). Other older drivers may not cease driving all together but instead self regulate to only driving in situations where they feel comfortable. Examples of this include, avoiding night time driving or busy intersections (Adler & Rottunda, 2006).

As a result, the impacts of transport mobility on the quality of life have been explored with a focus on psychological, exercise, and community benefits of transport mobility (Spinney et al., 2009). Researchers have also explored the reasons why older drivers give up driving, with the most common reasons being deteriorating health and traffic related stress (Hakamies-Blomqvist & Wahlstrom, 1998). Another study utilizes focus groups with older people who have recently stopped driving in order to assess transportation alternatives to operating personal automobiles (Adler & Rottunda, 2006). Older individuals who relied on personal automobiles will rarely utilize public transit after their driving cessation occurs, and will oftentimes rely on family members or close friends for their transportation needs (Adler & Rottunda, 2006; Banister & Bowling, 2004). The effects of driving cessation on the aging have been associated with the loss of freedom in being able to come and go as one pleases, resulting in the need to plan trips ahead of time. There is also the added fear of becoming an inconvenience to those who must provide transportation to the aging individual, as well as the loss of independence (O'Neill, 2010). In response to the needs of the heterogeneous aging populations, studies have explored potential transport policy initiatives that would address the lifestyle, preferences, resources, health, and physical abilities of the aging population as a whole (Mercado et al., 2010).

Specifically, older populations groups with lower automobile access, those who live in suburban communities, lower income older persons, and minority aging females have been found to experience immobility (Kim, 2011). As driving cessation is a reality for many aging individuals, naturally the role of other transportation modes must be considered as a part of the suite of options that can help preserve or enhance their mobility. Walking and public transit by bus can be two possibilities in fulfilling this need.

Not only do studies focus on the effects of driving cessation, but there is also considerable literature that explores the travel behavior and choices of older populations (Collia, et al., 2003; Kim, 2011; Kostyniuk & Shope, 2003; Newbold, et al., 2005; Su & Bell, 2009). While some of that literature is reviewed elsewhere in this report, we highlight a few studies that most directly motivate our present discussion. Overwhelmingly, studies have found that this generation's older people are used to driving their own personal automobiles, and are driving at a later age than past older people generations (Collia et al., 2003; Kostyniuk & Shope, 2003; Newbold et al., 2005). Studies have also found that aging populations tend to reside in suburbs and are dependent on the personal automobile for transportation (DeGood et al., 2011; Kostyniuk & Shope, 2003). Additionally, travel behavior varies according to the income, gender, and race of aging populations (Kim, 2011). One study explored transportation mode choices in Michigan and found that older adult households owned at least one automobile, while former drivers obtained rides from close family or friends. This study also found that many of the former drivers had no knowledge of how to use public transit (Kostyniuk & Shope, 2003). According to the 2001 National Household Travel Survey, older adults take fewer trips, travel shorter distance, and have shorter travel times than their younger driving counterparts (Collia et al., 2003).

In short, travel behavior and choices of the aging show that this generation's aging people are used to driving their own personal automobiles and that they are driving longer than past older generations. While mobility is the ability or level of ease with which people may move from place to place, this concept is closely related to accessibility, which is generally defined as the ability to reach opportunities, but not mobility itself. Since the majority of older people rely on personal automobiles, this is how they would achieve mobility, but mobility does not necessarily equate to accessibility. Mobility has the potential to provide access, while accessibility does not equate to mobility.

2.2 Accessibility of Aging Populations

Accessibility or the ease with which individuals or populations can travel to and from goods and services has not been adequately explored when it comes to aging populations. Accessibility is facilitated by well organized transportation systems that move people efficiently, and accessibility is enhanced as more activities are reachable to people given the travel means that they have available to them (Hansen, 1959; Mcallister, 1976). A lot of the research on the accessibility of aging populations tends to conflate mobility with accessibility, which are two different theoretical frameworks. Essentially, mobility is concerned more with obtaining movement, across the transportation system, while accessibility gets at the ability to reach opportunities and not the movement itself. Additionally, most of the studies concerned with accessibility relating to aging populations utilize surveys in order to investigate perceived lack of access to various goods and services (Alsnih & Hensher, 2003; Nemet & Bailey, 2000; Wilson, et al., 2004). Specifically, one study examined distance and health care utilization through surveys where participants were asked to describe trips to their travel to work, whether or not they have access to private transportation, and living arrangements which were then associated with the number of doctor's visits (Nemet & Bailey, 2000). Another survey questioned aging participants about their access to food and dietary variety in order to explore accessibility to food stores (Wilson et al., 2004).

Many studies concerned with the accessibility of aging populations also investigate access to transit (DeGood et al., 2011; Hess, 2009). Hess (2009) uses surveys in order to examine access to transit and its influence on ridership for the older population. Specifically, the authors compare associations between older adults who do and do not ride fixed-route public transit and their neighborhood walking access to buses and trains. Essentially, the study determined that while aging populations had consistent transit coverage, automobile-oriented patterns of development have created places that are difficult to serve with public transit because origins and destinations are dispersed and housing and employment are mismatched (Hess, 2009). Another study examines poor transit access for older people at the metropolitan level (DeGood et al., 2011). The authors argue the need for better public transit targeted at aging populations. Since many aging people live in suburban neighborhoods and rely on personal transportation, there is a concern that when driving cessation occurs due to disability and other factors associated with aging, aging populations will essentially be facing a mobility crisis (DeGood et al., 2011).

Studies have not measured accessibility in terms of quantifying the ease with which aging populations can reach goods and services. Doing this would provide insight into any issues that they may face in terms of achieving maximum benefits from the transportation system. Essentially, there has been relatively little work that models the geographic accessibility of aging populations to goods and services, with the exception of a few studies. Love & Lindquist (2005) used GIS to measure accessibility of the aged population to hospital facilities. This study used census block groups as the geographical unit of measure and focused on the number of aging people (aged 65 and older, who could reach a hospital in less than twenty miles. Another study does not specifically look at accessibility, but instead examines the distribution of the older population in relation to essential services, and attempts to explore whether their residential locations are related to the essential services located in the vicinity of their neighborhood (Somenahalli & Shipton, 2013). As the population continues to age it will be essential to understand how the aging access origins and destinations, such as shopping, medical facilities, etc., through different travel modes. Accessibility metrics for analyzing the activity patterns of aging populations can be utilized to assess how efficiently the transportation system serves these populations and if any deficiencies exist.

2.3 Measuring Accessibility

Accessibility has been a pragmatic term for many researchers who wish to quantify the ease with which populations use the transportation system to reach their desired locations (Handy & Niemeier, 1997). Primarily, transportation systems that are efficient and allow people to reach a range of activities per unit of time are viewed positively (Handy & Niemeier, 1997). The more activities that can be reached, the greater the degree of accessibility that exists. Over the years researchers have developed a multitude of methods that have expanded upon the basic accessibility measures developed decades ago. Contingent on the research application or discipline there have been a number of approaches that have been used to measure accessibility. At an elemental level, measures of accessibility have revolved around the costs involved in traveling to and from destinations and the attractiveness of a particular activity (Hansen, 1959). In this section we selectively review various measurement issues and models to build a foundation for later analytical work.

Essentially, accessibility measures are frequently used to evaluate the efficiency of the transportation system that will allow populations and individuals to access jobs, health care facilities, shopping opportunities, etc. (Handy & Niemeier, 1997; Horner & Mefford, 2005; Kwan, 1998; Talen & Anselin, 1998). Most researchers generally agree on the definition of accessibility as the ease with which populations reach goods and services based on the transportation network and activity patterns in a particular region, but there are still a variety of ways with which accessibility can be measured and quantified (Páez, et al., 2012). While specific measures and applications of accessibility are numerous and diverse, in general accessibility measures can be adjusted to fit the study's needs. In any event, the modeling approach always includes activity and transportation elements, but the scale and unit of measurements can differ across studies.

There has been emphasis placed on the distinction between place-based and people-based accessibility measures (Kwan, 1998). People based studies focus on individual movements across transportation networks, while place based studies take a more generalized view assuming the paths between origins and destinations are the actual movements of individuals.

2.3.1 Modes

Accessibility measures often measure access taking into account the different modes of transportation that are available to a given user. Different modes can play a major difference in providing accessibility to populations. Mode choice is often dependent on the needs, preferences, and what is available to a given user. For example, individuals with disabilities will likely have different transportation modes available to them than those individuals with no disabilities. Another consideration is that modes such as walking or cycling are better served for shorter distance trips, while automobile and transit modes are better served for long distance trips

(Litman, 2003). Many accessibility models can account for the different modes of transportation available to their particular study area of interest. For example, Larsen and Gilligand (2008), model accessibility to food stores by bus, transit, and walking modes. Researchers interested in capturing equitable access must also consider that households without vehicles have considerable constraints on their modal choices, which directly affects their accessibility to a given set of opportunities.

2.3.2 Place-Based Accessibility Measures

Place-based measures typically measure accessibility using locations or places as proxies for an individual's starting and ending movements (Miller, 2007; O'Kelly & Horner, 2003). These measures usually employ aggregate datasets, with census tracts or Traffic Analysis Zones (TAZ) as the unit of measurement, essentially generalizing a particular population's travel behavior locations (O'Kelly & Horner, 2003). Place-based methods are often used by researchers because data is relatively easy to collect and results are generally interpretable (Hansen, 1959; Horner & Mefford, 2005). A disadvantage of this set of methods is that it assumes that all people at a given location can make the same choices about how to reach opportunities (e.g. taking same travel route such as shortest path) and have the same ability to visit those opportunities (e.g. personal time availability). This could be problematic because, in reality, individuals make different choices about how they travel depending on the mode of available transportation, time of day, and other personal constraints.

The earliest place-based approaches stem from the gravity model as it was adapted from physics (Taaffe, et al., 1996). These approaches reward greater concentrations of activities at locations and penalize locations that are more difficult to reach spatially (Erlander & Stewart, 1990; Hansen, 1959; Horner & Mefford, 2005). Although frequently applied in network settings, gravity-based measures can be considered a continuous measure because they discount opportunities with increasing time or distance from the origin out to infinity (Bhat et al., 2000). The following represents a standard gravity measure based on the Hansen framework as derived from his original equation (Hansen, 1959; Horner & Mefford, 2005):

$$A_i = \sum_j \frac{O_j}{f(C_{ij})} \qquad (1)$$

where
A_i is the accessibility at origin i,
O_j are the opportunities at point j,
$f(C_{ij})$ is an impedance function as applied to the travel cost C from i to j.

The two most important components of this model are the attraction (O_j) and cost (time or distance) factors, where the travel time or distance between geographic units in a given study area along with the size and position of attractions are used to compute the accessibility values (Morrill & Symons, 1977). An example of a gravity-based index appears in Figure 2.1, where accessibility scores are computed for Florida counties using 2010 population as the attraction and Euclidean distance as the travel costs. Generally, researchers have experimented with three different components of the gravity model depending on the situation. These include, a given zone's attractiveness, the cost between zones, and the form of the impedance function (Erlander & Stewart, 1990). For example, the model typically assumes that the farther away opportunities are from the origin, the lower their accessibility values would be. However, it has been noted that for some specific opportunities, such as jobs or shopping, individuals are willing to travel further to reach these destinations. As such, researchers typically assign different values for the parameterization of f() depending on the attractions being measured (Bhat et al., 2000).

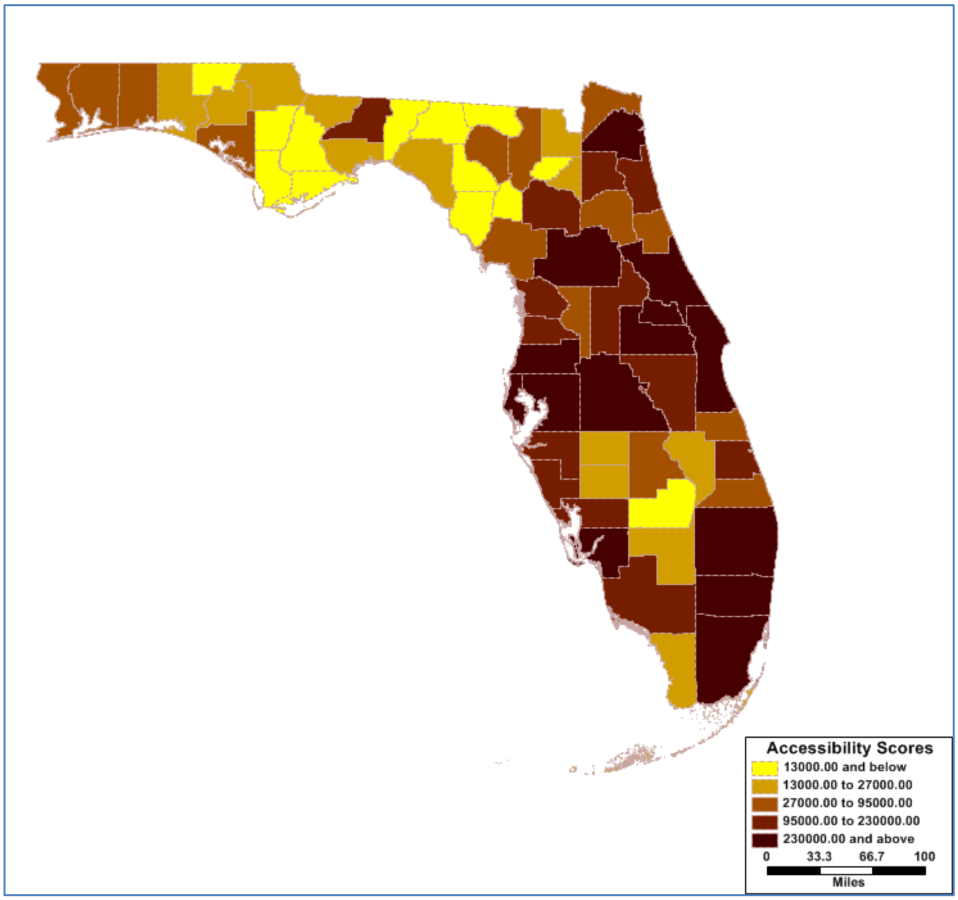

Figure 2.1: Example of a Gravity-based Accessibility Index

Gravity based measures have been utilized to explore a range of different activities. These include access to food stores (Apparicio, et al., 2007), access to primary care (Guagliardo, 2004), access to public playgrounds (Talen & Anselin, 1998), and access to jobs (Wang, 2012). The two-step floating catchment area method is a popular enhancement of the gravity-based model that has been used to measure access to healthcare facilities (Yang, et al., 2006). In the first step of the method, the number of available opportunities is assessed according to a pre-specified travel time and ratio of opportunities to the population of concern is calculated. The second step sums the ratios around each destination location (Yang et al., 2006) .

Cumulative opportunities measures are among the least complicated accessibility metrics and essentially measure the number of opportunities that can be reached within a given distance or travel time threshold from a particular origin (Guy, 1983; Song, 1996). Primarily, this class of measures serves to assess the number of activity choices available to the study population within a specific travel impedance from the specified origin (Apparicio et al., 2007; Horner & Mefford, 2005; O'Kelly & Horner, 2003; Páez et al., 2012). This metric requires data on the time or distance it takes to travel from origins to potential destinations and spatially disaggregate counts of the number of opportunities within the study region. The formula is depicted below as:

$$A_i^S = \sum_{j \in N_i} O_j \qquad (2)$$

where

$N_i = \{j \mid C_{ij} \leq S\}$

S is a predefined travel time or distance.

Typically, several different cost increments are used to compare the number of opportunities that can be reached across different thresholds (Bhat et al., 2000). Figure 2.2, depicted below, is an example of the cumulative opportunities measure where the 2010 census population that can be reached within a 100 mile buffer from the county centroids. Many applications of this method have been used to measure accessibility to opportunities such as jobs (Handy & Niemeier, 1997) and food opportunities (Páez et al., 2012). In addition to measuring the total opportunities within a specified travel time or distance, cumulative opportunities measures can also be adjusted to control for population in each zone. This essentially allows for a measure that more accurately captures accessibility by accounting for the population and opportunities matched for each origin and destination zone (Horner & Mefford, 2005). Horner and Mefford (2005) use this specific measure to control for the effects of the origin zone population when measuring accessibility to jobs by transit.

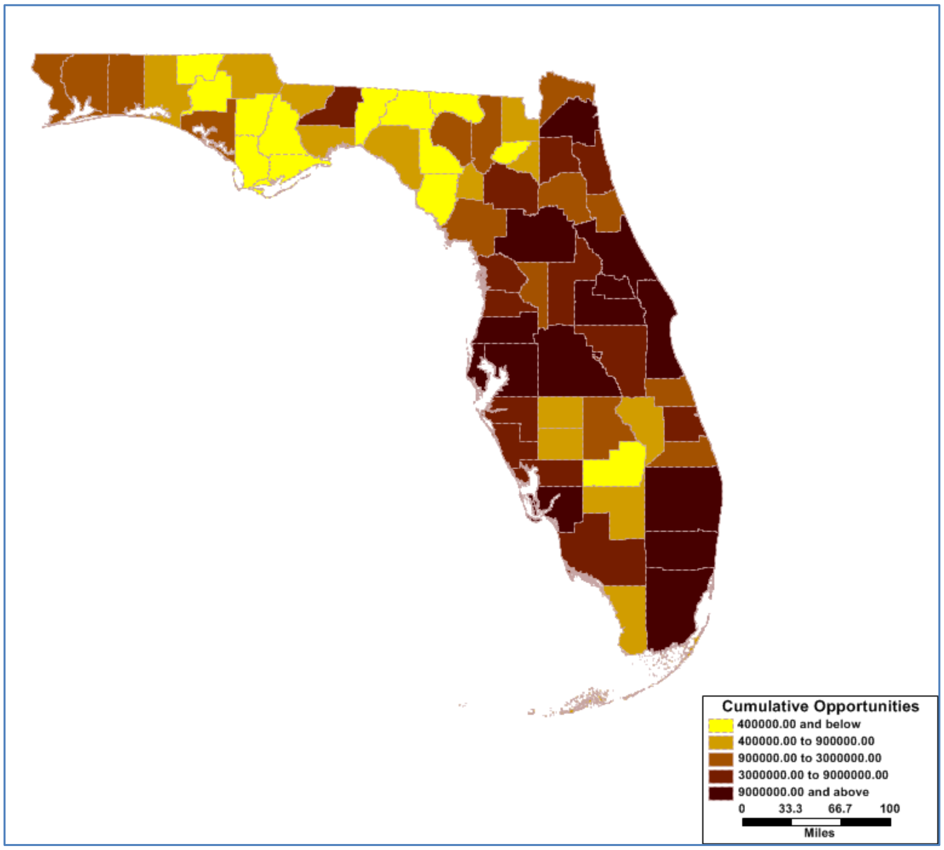

Figure 2.2: Example of a Cumulative Opportunities-based Accessibility Index

An additional measure used frequently when modeling accessibility is based on random utility theory, where the probability of an individual making a choice is dependent on the utility of that choice relative to all other choices the individual could make (Handy & Clifton, 2001; Manski, 1977). In other words, these measures are designed to capture the benefit to users accessing opportunities, so instead of capturing an individual's accessibility as the nearest activity, it is calculated based on their preferred activities (Miller, 2000). It has been noted that this form of accessibility does not decrease in value with the addition of alternatives, and it does not decrease if the mean of any one alternative's utility increases (Bhat et al., 2000). While utility measures can be used to assess the change in a travelling individual's benefit measured by the costs for consumers and producers, there is still the assumption that land use and travelling costs are fixed (Bhat et al., 2000). Researchers have used this type of measure in order to assess changes or choice in modes across socioeconomic groups (Niemeier, 1997). Utilities measured often include the economic benefits for individual users or for the community as well as the social or environmental benefits across different modes of transportation (Scheurer & Curtis, 2007). Some of the utility components include the cost of service or the time it takes to reach destinations. Bhat et al. (2000), stress that the utility approach to measuring accessibility does not account for the fact that not all options are available to all users of the transportation system. Another difficulty identified with this measure includes the fact that there is a lack of empirical evidence for the link between infrastructure provision and economic performance (Geurs & Van Eck, 2001; Scheurer & Curtis, 2007). Even still, the benefits of utility-based measures include being able to model travel choices at an individual level instead of assuming that all individuals have the same preferences and behave identically (Bhat et al., 2000). A major disadvantage of utility based models is that they require more extensive data collection on individuals' preferences,travel patterns and behaviors, which makes the development of such models expensive and time consuming (Lamondia, et al., 2010). For these reasons we do not pursue this approach as one of our accessibility measures.

2.3.3 People-Based Accessibility Measures

A people-based accessibility measure is sometimes utilized to account for some of the shortcomings of the place-based measure. As more individualized data has become available, implementing these measures has become more feasible. This class of measures is derivative of Hagerstrand's space-time geography framework, where an individual's specific movements are examined across time and space from origins to destinations (Hagerstrand, 1975). In other words, instead of using places as proxies for individuals' origins and destinations, a people-based perspective focuses on an individual's actual movement in space and time, and their habits in the real world (Miller, 2007). In this way, time availability is a very important aspect of measuring this type of accessibility, as time of day and different activity schedules that may or may not affect an individual's travel patterns (Miller, 2007). A people-based perspective does not necessarily discount a place-based perspective, but instead offers more detailed insight to an individual's movements and activity patterns. The space-time accessibility measure in Figure 2.3 seeks to predict where a vehicle was located at times for which no position data is available. Darker colored shadings indicate where the vehicle most likely could have been given a known travel budget. One challenge associated with people-based measures is that many are difficult to generalize across individuals, hence rendering any systematic evaluation of the transportation systems under use quite difficult.

Within this literature, time-space accessibility measures attempt to not only capture the spatial constraints placed on individuals but also the time constraints. These constraints are generally grouped into three dimensions. Capability constraints are described as the limits to human performance, such as the fact that individuals need to sleep everyday (Miller, 2005).

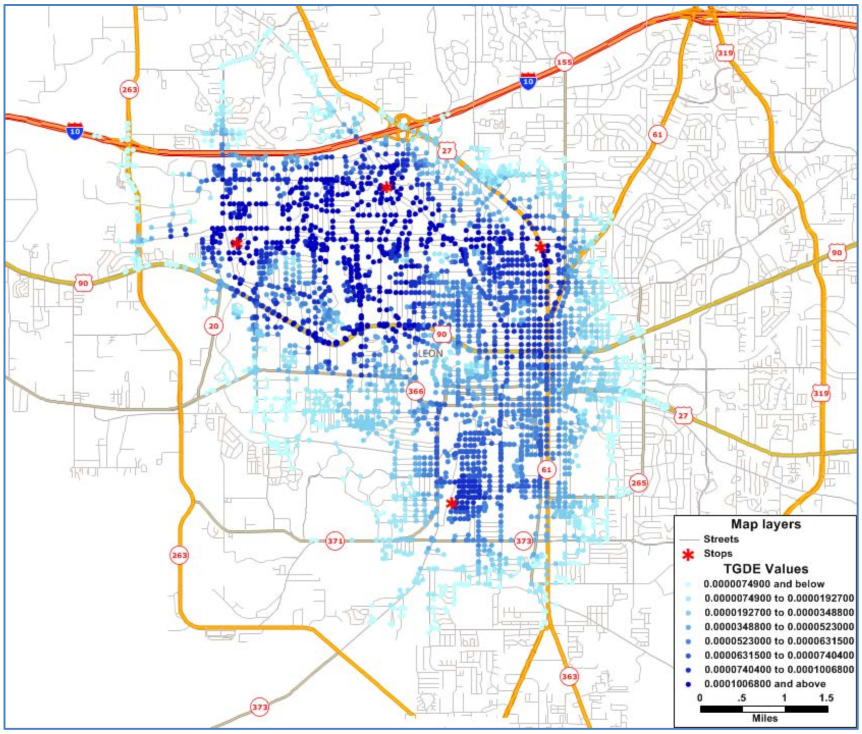

Figure 2.3: Example of a People-based Individual-Level Accessibility Index

Another constraint to consider is when an individual needs to be at a particular location at a particular time, such as picking up a child from daycare (Bhat et al., 2000; Kwan, et al., 2003). The final constraint on an individual's travel behavior is the authority constraint where higher authorities do not allow movement or activities, such as businesses closing for the workday (Neutens, et al., 2011). Since time-space modeling focuses on individuals there are many specific advantages to using these methods as compared to place-based measures. For example, as previously mentioned, place-based measures tend to aggregate accessibility at the household or geographic unit level, while time-space measures look at one specific individual (Bhat et al., 2000). This allows a more accurate measurement of the accessibility of individuals at the finest level.

Additionally, time-space measures are able to focus on specific trip chains of individuals instead of single trips, which is a limitation of place-based measures (Hagerstrand, 1975). If a given individual makes multiple trips on a single journey, all of these will be accounted for, as opposed to just measuring trips from original origins to the destination of interest. Another benefit of time-space measures is that they capture the unique paths a given individual will take. For example, it is often assumed that individuals take the shortest path from any given origin and destination pair, but since time-space measures attempt to model individual accessibility, they are able to examine specific choice paths an individual will take regardless of shortest path (Downs & Horner, 2012). Applications of time-space measures include an analysis of day-to day variations in individual space-time accessibility, where travel diaries are examined in order to assess the accessibility to urban opportunities over a given period (Neutens, et al., 2012). Kwan (1998) also uses time-space measures to assess gender and individual access to urban opportunities, where travel diary data is utilized in a GIS network-based individual accessibility measure to examine differences in access across gender. Given the purposes of our analysis and the information available to us, placed-based measures are the most appropriate method of our examination. This is because we want to be able to produce location-based assessments that can be used to compare how well people in different areas are able to reach different services.

2.3.4 Other Accessibility Considerations

With recent developments in geographic information systems (GIS), accessibility measures have become easier to implement. Utilizing GIS to measure accessibility has many benefits due to its capacity to combine data on activity locations with other non-spatial characteristics, such as demographic data. GIS allows users to merge large amounts of data and information in order to assess patterns and spatial relationships. Beyond the more complicated measures summarized above, there are more simple accessibility measures that can be implemented in a GIS environment. Many studies use standard GIS tools such as buffering, where a general area is demarcated around a particular destination based on time or distance and then the population characteristics within this boundary are examined (Higgs, 2005). Network analysis in GIS allows actual road networks to be mapped and the shortest path distance and or time to be computed from origins and destinations. This method of modeling distance or time to and from destinations is preferred because it takes into account the actual roads, routes, and paths that could be traversed by individuals in the real world. There have also been even more complex developments within GIS where stand-alone toolkits blending these techniques have been created in order to explore accessibility (Delafontaine, et al., 2012).

2.4 Equity and Demographic Populations

Another component of accessibility frameworks is the differential access to opportunities for individuals of different income, gender, race, etc. Many researchers concerned with measuring accessibility have acknowledged that there are disparate levels of access across different population groups (M.P. Kwan et al., 2003). As such there have been a multitude of studies exploring equity issues in relation to accessibility (Horner & Mefford, 2005; Talen & Anselin, 1998).

Many accessibility analyses are concerned with modeling the accessibility of specific populations to a specific good or service in order to assess the equity and efficiency of the transportation system. Specifically, Larsen and Gilliland (2008) determined if individuals could reach a supermarket within a pre-specified amount of time by foot, automobile, and transit and compared access across demographic characteristics such as race and income (Larsen & Gilliland, 2008). Another study models the spatial accessibility of immigrants to culturally diverse family physicians using the gravity model and the two-step floating catchment area model in order to measure accessibility (Wang & Roisman, 2011). Locations of employment services to people with disabilities have also been analyzed at the national level, using census tracts as the geographic unit of analysis (Metzel & Giordano, 2007). Kwan (1999) compared the accessibility of women to men in a study that focused on space-time accessibility measures. Results found that women have lower levels of individual access to urban opportunities compared to their male counterparts (Kwan, 1999). Our current work attempts to identify inequities that may exist across different age groups, specifically comparing younger and older populations' accessibility to different opportunities.

2.5 Measuring the Accessibility of Aging Populations

In respect to aging populations, many of the accessibility metrics used to assess the effectiveness of any transport mode can be applied to discovering access patterns across this population. For example, just as demographic census data is parsed by income, gender, or race in studies concerned with equity, the same could be done to attributes characterizing age. Currently, there is a lack of studies that hone in on specific accessibility analyses regarding the aging population. Existing research focuses on mobility concerns and frequently cites issues that the aging may face after driving cessation occurs (Metz, 2003). Since it is projected that the aging will make up a large majority of the United State's population, it is essential that their accessibility needs and deficiencies are assessed and identified. It has been articulated that the aging need to reach goods and services and social activities in order to lead happy and productive lives (Metz, 2000). If accessibility metrics exist that can estimate the needs of this population, social policy initiatives can be formulated to address any issues expressed by analyses. Place based metrics are a good place to start because they offer relatively low barriers to entry with in terms of data requirements. Further, there are things we can do with simple GIS measures that will be explored as well. Overall, our analyses will identify any accessibility limitations that may exist that affect aging populations.

Chapter 3 Review of Aging Populations' Travel Behavior Issues

It is no secret that the population of the United States is becoming older. People from the large baby boom generation, those born during the first couple of decades following World War II, are moving into the later stages of their lives and also living longer thanks to healthcare improvements (Bloom et al. 2011). Since this generation is so large in comparison to other generations, this means that a large share of the population is made up and will be made up of older adults (i.e. those 65 years and older). By 2030, the percentage of the American population 65 and older is expected to be about 20%, or about 70 million people (Dickerson et. al. 2007; Wacker & Roberto 2013). In other words, at least one out of every five people will be above the age of 65.

While this has many implications for American society, the aging of the population will have one of the most profound effects on transportation planning as there become more and more older drivers on the road (Burkhardt and Mcgavock 1999). In fact, the aging population has been identified as one of the biggest challenges facing transportation providers for the future (Pisarski 2003; Newbold et al. 2005). This will undoubtedly require changes to policies and development of special programs designed to fit the unique needs of such a large portion of the population. Such needs include alternative transportation options and safety initiatives for these older adults as their traveling abilities decline due to health issues (OECD 2001; Dickerson et. al. 2007).
In order to develop future transportation plans that take into account the large percentage of older adults, an important question to answer is how well the current transportation system caters to the older population. To determine if these older adults' needs are being met in regards to transportation, it is first important to understand how this group typically travels and what transportation choices they currently make. This can give insight on the transportation desires of

the group and also reveal areas where they may be underserved. Knowing the travel behavior of the older population might also provide suggestions for what travel behaviors might become more abundant in the future. In order to better plan for the future changes in transportation demand for the older generations, it is extremely important to understand how these people are traveling now.

3.1 Amount of Travel

Over the past several years, the share of total travel made by the aging, in both miles and trips, has increased significantly (Lynott & Figueiredo 2011). However, one of the biggest differences in the travel behavior of the older population is that compared to the rest of the US population that can drive, they travel less and reduce driving (Rosenbloom 2000; Giuliano, Hu, Lee 2003; Bauer 2008). For instance, those 65 and older travel far fewer miles per year than their younger counterparts (Mattson 2012). Older adults, particularly females, typically make less daily trips- about one less a day than younger females (Heaslip 2007; Sikder 2010). Also, when compared to younger travelers, the aging are much less likely to travel on a given day and much more likely to stay in the same place all day (Heaslip 2007; Mattson 2012). The aging typically choose, or are forced to choose, to travel less.

Furthermore, over the past decade or so, on a daily per capita basis, travel among the aging has been decreasing in both miles and trips (Lynott & Figueiredo 2011; McGuckin & Lynott 2012b). This decrease in travel, however, is not just specific to the older population; the entire population experienced this decrease. This is assumed to largely be a result of high gas prices and a down economy and is only a prevalent trend of the past decade (Skufca 2008; Lynott & Figueiredo 2011; McGuckin and Lynott 2012b). Some have pointed out that the older population today (i.e. the Baby Boomers) is much more active, wealthy, and takes more trips than those in the past (Marattoli et al. 2000; Rosenbloom 2001; Waldorf 2003; Banister & Bowling 2004; Heaslip 2007; McGuckin & Lynott 2012b; Samus 2013;). With the economy improving, the increasing proportion of aging drivers is expected to increase their amount of travel significantly in terms of trips and distance in the coming decades (Rosenbloom 2001; Burkhardt & Mcgavock 2007).

3.2 Mode Choice

When the aging population does travel, they mostly do so by personal automobile- much like the rest of the population (Rosenbloom 2000, 2003; OECD 2001; Lynott & Figueiredo 2011). Over the past couple of decades, there has been an increasing propensity for older adults to obtain a driver's license, own a car, and use their personal vehicles to make trips (Rosenbloom 2001; Alsnih & Hensher 2003; Buehler & Nobis 2010). The dependence, culture, and familiarity of driving an automobile, along with the lack of other transportation options, has trapped the older population in their vehicles and may serve as a barrier for aging people in the future (Giuliano, Hu, & Lee 2003; Eby 2009; Samus 2013). Even without owning a car, aging Americans still find a way to make their trips in an automobile, whether this be through ride-sharing or other special services (Kostyniuk 2003; Newbold et al. 2005). In recent years, older non-drivers still took the majority of their trips by personal vehicle (Rosenbloom 2000, 2009).

More recently, the aging population has started to take less trips by personal vehicle and has increased the percentage of trips taken by transit (Lynott & Figueiredo 2011; McGuckin & Lynott 2012b). Although there has been a significant increase in the number of trips taken by transit among the aging population, the share of trips taken by transit still remains very small.

This share also remains smaller than the share of trips taken by transit for younger populations (Rosenbloom 2009; Lynott & Figueiredo 2011). Furthermore, even those who consider themselves non-drivers are not likely to take transit. The current transit system simply does not attract older travelers, whether it be because of safety concerns or inability of the system to match desired travel patterns (River, Straight, Evans 2002; Rosenbloom 2009).

Aside from driving, walking remains the most popular form of transportation compared to other modes like transit or taxi. Adults 65 and over take a relatively high percentage of trips- about 9%- by walking (Rosenbloom 2009; Farber & Shinkle 2011). Unfortunately, older Americans seem to be underserved when it comes to pedestrian infrastructure, which may deter some from walking (Farber & Shinkle 2011). Other main issues include destinations that are too far and too dangerous to reach (River, Straight, Evans 2002). At some point, walking becomes an unrealistic form of travel for the oldest segment of the population - those 85 and older (River, Straight, & Evans 2002; Arentze et al. 2008). These issues have resulted in a steady overall decline in walking by older populations (OECD 2001; Whelan 2006). Nevertheless the share of trips done by walking, as well as the share of trips done by bicycle, has increased in recent years (Lynott & Figueiredo 2011; Mattson 2012).

This recent decrease in driving and increase in travel by modes other than automobile may be a result of other variables such as gas prices, the economy, and movement to offer other transportation options (Lynott & Figueiredo 2011). However, with the many advantages of the personal automobile and the sprawling development in the US, it is predicted that the aging will continue using automobiles as the main source of transportation (OECD 2001; Rosenbloom 2001). For example, one of the main advantages of personal automobiles for the aging, which may seem counter-intuitive, is safety. Though it is believed that aging are more dangerous when driving, they themselves feel safest in a car (OECD 2001). For this and many other reasons, the automobile seems to be the older population's transportation mode of choice for the near future.

3.3 Length of Trips

Building off of mode choice, it is also important to understand how far the aging travel, or how their trip distances vary. In general, the aging tend to travel shorter distances (Rosenbloom 2000; Giuliano, Hu, Lee 2003). In a study focusing on the variability of the aging population's distances of travel in Canada, which can be compared to the U.S. in terms of having a large share of the aging who rely on driving, it was found that travel distances decrease as age increases (Mercado & Paez 2009). It was determined that, in this case, the average aging person (65 and older) can be expected to make trips that are about 5 kilometers less than younger adults. Interestingly, this was found to be true only for when the older adult was driving.

When an aging person was a car or bus passenger, travel distances changed very little. However, in regards to walking, the aging tend to walk shorter distances, despite having the longest walking travel times among the population (Yang & Diez-Roux 2012). Almost half of the trips taken by those 65 and older are under two miles (Farber & Shinkle 2011). More currently, as compared to past, the aging population is taking longer trips (Heaslip 2007; Samus 2013).

3.4 Trip Purpose

Perhaps one of the most important factors of the aging population's travel behavior to consider is what type of trips they make. In other words, where are older adults traveling? The biggest difference among older adults' travel behavior is that they do not make as many work-based trips as the rest of the population. While the general population makes a large number of work-related trips, the aging are more likely to be making other types of trips (OECD 2001; Rosenbloom 2001; Newbold et al. 2005). Shopping, family, recreation, and social trips make up a much larger share of the older population's trips than do work-related ones (Collia, Sharp, & Giesbrecht 2003; Mattson 2012). The percentage of the older population's trips that are for medical purposes is also significantly higher than much of the population despite being a relatively small percentage overall (Mattson 2012). It should be noted that the age of retirement is being pushed back in recent years and that more adults are working later into their lives, which in turn results in more work-based travel by the aging (McGuckin, Lynott, & Figueiredo 2013).

With the increased amount of free time the aging have, leisure travel would be expected to increase (McGuckin & Lynott 2012a). In recent years, this increase in leisure travel (i.e. travel for relaxation or vacation) has been realized. Leisure travel has increased significantly among older adults- alluding to the increase in wealth and vitality of newer generations of adults. These longer trips are often done by driving and tend to be longer distance (McGuckin & Lynott 2012a).

3.5 Time of Travel

Aging drivers travel also tend to travel at different times of the day. Peak hours for older adults are typically later in the morning around 10 to 12 a.m. (Collia, Sharp, & Giesbrecht 2003; Heaslip 2007). Most travel for the older drivers is done in between typical peak hours (i.e. 7-8 a.m. and 5-6 p.m.). The aging population tends to limit their travel to times of day when there is less traffic and when driving conditions are optimal (OECD 2001).

3.6 Behavior Differences among Older Persons

Though this travel behavior is generally indicative of how the aging travel, it should be noted that the travel patterns vary even among the aging population (Hilderbrand 2003). In general, there is a negative relationship between age and travel demand. For instance, looking at different cohorts of aging starting at about 65 years old, the number of trips taken and mileage driven decreases as the elderly age further (Rosenbloom 2004; Whelan et. al. 2006). The travel distances also differ as younger aging people tend to make longer trips than their older counterparts (Whelan et. al. 2006). Furthermore, as an older person ages, the percentage of trips taken by alternative modes of transportation- not by personal automobile- tends to decrease as well (Hjorthol, Levin, Siren; OECD 2001). On the other hand, the purpose of the aging's trips tends to stay relatively the same. The magnitude of these behavior changes as this population ages further is not particularly large, but it should still be recognized as there is a significant difference, especially among those 85 and older (Rosenbloom 2000; Giuliano, Hu, & Lee 2003;).

Recognizing how behavior changes among the older cohorts highlights the fact that the aging population is not a homogenous group. Though they are often studied as a singular group, there are behavioral differences among the aging just as there are among the rest of the population. One identifiable difference is the disparities in travel behavior between aging males and females. Nearly every travel behavior difference between the aging and the rest of the population is magnified for females, but this disparity seems to be decreasing (OECD 2001; Lynott & Figueiredo 2011; Mattson 2012). Aging females tend to travel less, take shorter trips, and have the highest percentages of shopping and leisure trips (Whelan et. al. 2006; Bauer 2008). Those who were found to travel the least were low-income, older females who did not own a vehicle (Sikder 2010). The differences among the aging population are just as significant in determining their travel behavior as it is for the rest of the population and should not be overlooked by grouping them into the same category.

3.7 Summary

The number of travelers who are aging is increasing, which consequently means more aging drivers on the road. As a result, there will be changes in travel behavior that need to be addressed by planners and government officials. While the aging have been traveling less per person, the overall increase in share of driving by the aging and the probability of increased travel by this group make it important to prepare for a future where travel needs are different. Understanding the behavior differences older travelers have is the first step to ensuring future plans and methods are developed to more accurately address future scenarios.

Chapter 4 Analysis of Florida NHTS Data

4.1 Chapter Overview

The aging of the population will have one of the most profound effects on transportation planning (Burkhardt and Mcgavock 1999). Future transportation plans must take into account the large and growing percentage of older adults. A first step in effectively serving aging populations is gaining an understanding of the transportation choices they currently make. With this in mind, the main objective of this chapter is to conduct an exploratory analysis of aging travel behavior, with a focus on the state of Florida. The long standing status of Florida as a retirement destination makes it a particularly relevant area to study the travel behavior of older populations.

While there is a large and growing body of literature (as discussed previously) that examines aging travel behavior, this chapter will build upon this work by exploring differences in aging travel behavior across different metropolitan contexts (i.e., large Metropolitan Statistical Areas (MSAs), Small MSAs and non-MSAs). Using the National Household Travel Survey (NHTS) Florida “add-on”, we conduct a set of statistical cross-tabulations that directly compare travel behavior and housing choices by age and MSA category. Our results suggest some clear differences among aging populations living in different regional contexts that largely parallel the differences among younger populations. For example, older people living small MSAs and especially non-MSAs tend to travel longer distances, rely more heavily on automobiles. This type of information can hopefully serve to make transportation planning more effective within a given regional context.

4.2 Background

The literature on the travel behavior of the aging has produced a series of important findings. Foremost, the evidence indicates that while aging people travel more now than in the past (Lynott and Figueiredo 2011; Rosenbloom 2001; Waldorf 2003; Banister and Bowling 2004; Heaslip 2007; Samus 2013), they still travel significantly less than younger populations (Giuliano, Hu, and Lee 2003; Bauer et al. 2003).

In terms of mode choice, the aging rely heavily on auto travel, much as the rest of the population (Rosenbloom 2004; Lynott and Figueiredo 2011). Older adults are much more likely to own a car and maintain a driver's license than in the past (Rosenbloom 2001; Alsnih and Hensher 2003). This dependence on automobile travel is likely to lead to greater mobility barriers in the future(Giuliano, Hu, and Lee 2003; Eby, Molnar, and Kartje 2008; Samus 2013). There has been some shift towards using transit among older groups in recent years, but the overall transit shares remain small (Lynott and Figueiredo 2011). Further, the transit share is smaller among the aging than for younger populations (Rosenbloom 2009). Even non-drivers are unlikely to use transit.

Walking represents the next most popular form of transportation among the aging (Rosenbloom 2009; Farber et al. 2011). However, as with the population in general, a lack of pedestrian infrastructure in some locations likely limits the ability of the aging to consistently rely on walking. Further, walking becomes unrealistic beyond a certain age, as there is little walking among those over 85 years old (Arentze et al. 2008). With some improvement to the pedestrian environment, walking has growth potential among older populations because they tend to travel shorter distances (Giuliano, Hu, and Lee 2003; Rosenbloom 2001).

In terms of the types of trips made by the aging, they obviously make much fewer work trips than younger groups. Shopping, family, recreation, and social trips make up a much larger share of the aging population's trips (Collia, Sharp, and Giesbrecht 2003; Mattson, Urban, and

Center 2012). Leisure travel becomes particularly important as people age, as they have an increased amount of free time available.

The lack of work schedule also means that older groups follow a different temporal travel pattern. The peak period for their travel is after the morning rush hour, between 10 AM and 12 AM (Collia, Sharp, and Giesbrecht 2003; Heaslip 2007). Older people also tend to limit their travel to the times with the best driving conditions (i.e., daylight hours and good weather).

Travel patterns also vary among the aging population (Hildebrand 2003). The trend towards less travel continues even after age 65 (Rosenbloom 2004; Whelan et al. 2006). The percentage of trips made by non-auto modes also appears to decline after age 65 (Hjorthol, Levin, and Sirén 2010).

While the findings above suggest general trends in the behavior of aging populations, there has been little exploration of how these behavioral characteristics and choices might differ across geographies. Understanding what differences might exist would help to inform planning efforts aimed at providing services to these aging populations.

4.3 NHTS Data

In order to see how the travel patterns of aging populations differ by regional context, we analyze travel patterns among respondents of the 2009 National Household Travel Survey (NHTS) Florida add-on. When conducting this survey, the Federal Highway Administration allows states and/or Metropolitan Planning Organizations (MPOs) to pay for a large sample size within their jurisdictions. In 2009, the state of Florida commissioned a relatively large add-on. Overall, the survey includes 14,000 Florida households with 30,952 persons. The travel of each of these household was tracked over a one day period, which produced information about 114,910 trips. Thus, this survey produces statistically valid information about various aspects of

Floridians' travel behavior (e.g., travel distances, mode of transportation, travel purposes, and time of travel) and further allows comparisons of this behavior by age.

The dataset provides ages of all respondents and, given that our focus is on older populations, we divided the survey respondent into two groups: those 65 years or older and those between ages 21 and 64. The latter group is included as a point of comparison. Because differences in travel behavior across MSAs can be found over the entire population, it is useful to understand whether regional differences in aging travel behavior is just part of a broader trend or if the *relative* differences among older and younger populations changes depending on the geographical context.

To get at these regional differences we divided the individuals from both age groups into three different groups, depending on their home location: 1) those living in MSAs with a population of one million or more (i.e., large MSAs), 2) those living in MSAs with less than a million people (i.e., small MSAs) and 3) those living in counties that are not part of an MSA (i.e., non-MSAs).

In all, this analysis will compare travel behavior statistics across six groups:

- age 65+ in large MSAs
- age 21-64 in large MSAs
- age 65+ in small MSAs
- age 21-65 in small MSAs
- age 65+ in non-MSAs
- age 21-65 in non-MSA

Although it is clearly possible to break our groups into more detailed age and/or MSA classifications than those above, we determined that the creation of additional categories would make it much more difficult to detect relative trends in aging travel behavior.

4.4 Location and Housing Trends

Before exploring travel behavior trends, we provide some basic locational and housing trends by age, as this often has a direct relationship with the way people choose to travel (Ewing and Cervero 2010; Pucher and Renne 2003). Figure 4.1 shows that older Floridians are less likely to live in large MSAs. 49% of older people live in large MSA in comparison to 55% of younger adults. This has implications for transportation planning because it demonstrates that older populations have a moderately stronger propensity to live outside of the urban centers where it might otherwise be easier to provide them with a variety of transportation options as they age (DeGood 2011).

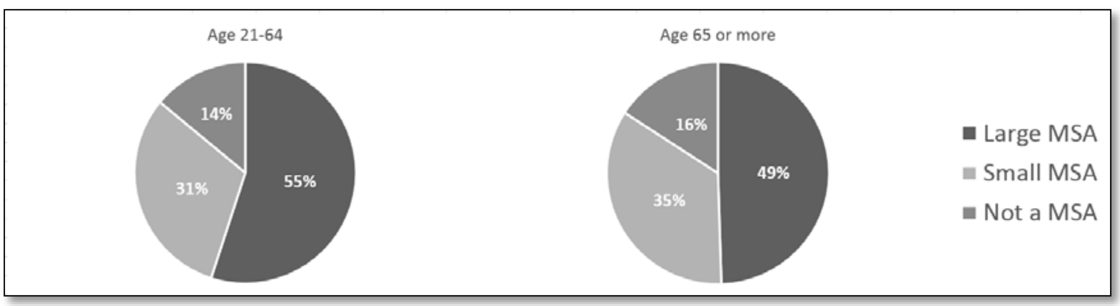

Figure 4.1 Population Distribution by MSA Type

Table 4.1 shows that older people are more likely to live in townhouses or apartments, particularly in large MSAs. The market for apartments and especially townhomes in Florida is largely driven by older populations. For instance, 22% of older adults in large MSAs live in townhomes compared to 11% of younger adults. Further, the majority of townhome and apartment occupants are older adults despite being well under half of the population. This indicates that transportation planners have significant opportunities to provide tailored strategies for aging travelers in townhome and apartment developments, particularly within the major metropolitan centers of Florida.

Table 4.1 Type of Housing Unit by MSA Type

MSA Size	Housing	Age 21-64		Age 65 +		Difference
		Frequency	%	Frequency	%	
Large MSA	Single house	27895	78.8	12225	63.9	14.9
	Duplex	2381	6.7	1372	7.2	-0.5
	Row or townhouse	3972	11.2	4175	21.8	-10.6
	Apartment	1107	3.1	1340	7	-3.9
Small MSA	Single house	16363	83.4	10078	72.7	10.7
	Duplex	1043	5.3	734	5.3	0
	Row or townhouse	1156	5.9	1428	10.3	-4.4
	Apartment	1040	5.3	1611	11.6	-6.3
Non-MSA	Single house	6201	76.5	4412	75.5	1
	Duplex	248	3.1	158	2.7	0.4
	Row or townhouse	220	2.7	215	3.7	-1
	Apartment	1432	17.7	1054	18	-0.3

The difference in housing preferences decreases with the size of the MSA to the point that younger and older adults have very similar preferences when living outside of MSAs. This trend may be related to the fact that baby boomers living in less urbanized areas prefer “aging in place” (DeGood 2011).

4.5 Transportation Trends

In examining differences in travel behavior, we first look at travel times. We found a slight difference between the older and younger groups. On average, older people make trips that are 1.5 minutes shorter than their younger counterparts. This difference is consistent across the different MSA classifications. Figure 4.2 shows average travel time per trip by MSA type and by age, where one can see that there is very little variation between large and small MSAs. Those living in non-MSAs have travel times that are roughly 10% longer, as one might expect for more rural areas. However, the relative difference between older and younger populations is the same across the MSA types. In other words, living outside an MSA may add to one's travel time burden, but this burden falls on older and younger populations alike.

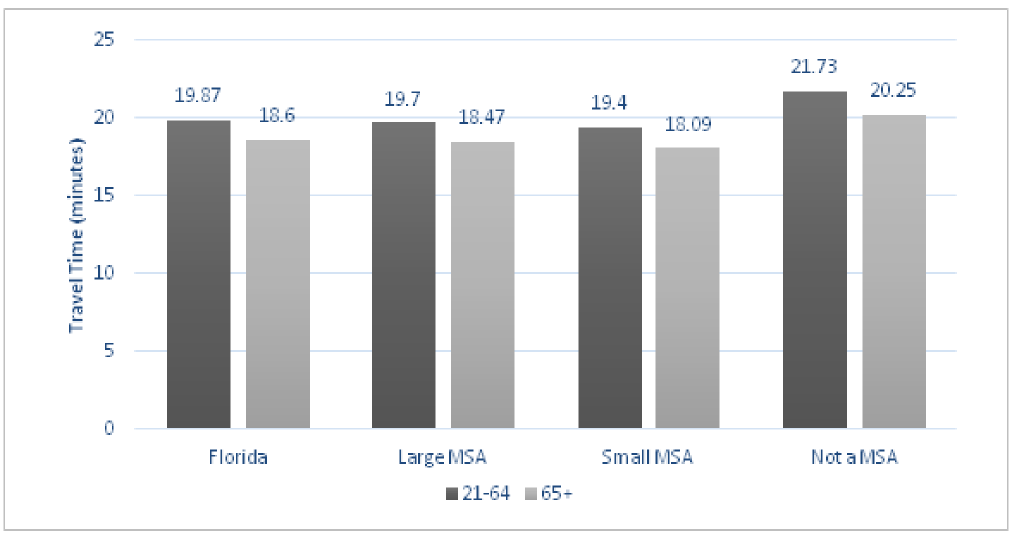

Figure 4.2 Average Travel Time per Trip by MSA Type

Table 4.2 shows a breakdown of the percent of trips within a given travel time range. Older populations in all MSA types are more likely than younger adults to make trips in the 10-20 minute range (bold lines). They also are less likely to make very long trips (40+ minutes), which may relate to lack of long distance commuting among the aging. Overall the pattern displayed in this table indicates that older populations are unwilling to dedicate much more than 20 minutes to travelling and efforts to make various goods and services available to older population should keep this threshold in mind.

Table 4.2 Average Travel Time per Trip by MSA Type (Minutes)

MSA Size	Time	Age 21-64		Age 65+		Difference
		Frequency	Percent	Frequency	Percent	
Large MSA	1-4	2615	7.4	1280	6.7	0.70
	5-9	7134	20.2	3734	19.6	0.60
	10-14	**6744**	**19.1**	**4115**	**21.6**	**-2.50**
	15-19	**6035**	**17.1**	**3725**	**19.5**	**-2.40**
	20-24	**3489**	**9.9**	**1923**	**10.1**	**-0.20**
	25-29	1829	5.2	822	4.3	0.90
	30-34	3080	8.7	1627	8.5	0.20
	35-39	900	2.5	346	1.8	0.70
	40+	3524	10	1522	8	2.00
	Total	35350	100	19094	100	-
Small MSA	1-4	1538	7.8	921	6.6	1.20
	5-9	4020	20.5	2812	20.3	0.20
	10-14	**3863**	**19.7**	**2985**	**21.5**	**-1.80**
	15-19	**3545**	**18.1**	**2737**	**19.8**	**-1.70**
	20-24	**1991**	**10.2**	**1536**	**11.1**	**-0.90**
	25-29	1016	5.2	636	4.6	0.60
	30-34	1526	7.8	1074	7.8	0.00
	35-39	366	1.9	217	1.6	0.30
	40+	1739	8.9	934	6.7	2.20
	Total	19604	100	13852	100	-
Non-MSA	1-4	748	9.2	469	8	1.20
	5-9	1710	21.1	1198	20.5	0.60
	10-14	**1449**	**17.9**	**1164**	**19.9**	**-2.00**
	15-19	**1314**	**16.2**	**1202**	**20.6**	**-4.40**
	20-24	**705**	**8.7**	**521**	**8.9**	**-0.20**
	25-29	356	4.4	212	3.6	0.80
	30-34	644	7.9	420	7.2	0.70
	35-39	188	2.3	96	1.6	0.70
	40+	1002	12.3	558	9.6	2.70
	Total	8116	100	5840	100	-

Table 4.3 looks at trip length from the perspective of distance instead of time. It shows that older adults are more likely to make short distance trips, particularly trips under 2 miles (highlighted). Around 60% of trips made by the aging are under five miles as compared to under 50% for younger populations. Again, this pattern holds up across all three MSA categories.

Table 4.3 Traveled Distance by MSA Size (Miles)

MSA Size	Distance	Age 21-64		Age 65+		Difference
		Frequency	Percent	Frequency	Percent	
Large MSA	0-1.99	8614	24.7	5648	30.4	-5.7
	2.00-4.99	9958	28.6	5925	31.9	-3.3
	5.00-9.99	7391	21.2	3828	20.6	0.6
	10.00-14.99	3439	9.9	1440	7.7	2.2
	15.00-19.99	1911	5.5	634	3.4	2.1
	20.00-24.99	1213	3.5	360	1.9	1.6
	25+	2296	6.6	750	4	2.6
	Total	34822	100	18585	100	
Small MSA	0-1.99	4333	22.3	3699	27.1	-4.8
	2.00-4.99	5486	28.2	4350	31.8	-3.6
	5.00-9.99	4619	23.8	3230	23.6	0.2
	10.00-14.99	1975	10.2	1098	8	2.2
	15.00-19.99	1050	5.4	454	3.3	2.1
	20.00-24.99	546	2.8	227	1.7	1.1
	25+	1414	7.3	612	4.5	2.8
	Total	19423	100	13670	100	
Non-MSA	0-1.99	1879	23.4	1756	30.3	-6.9
	2.00-4.99	1991	24.7	1541	26.6	-1.9
	5.00-9.99	1542	19.2	1162	20	-0.8
	10.00-14.99	807	10	477	8.2	1.8
	15.00-19.99	489	6.1	235	4.1	2.0
	20.00-24.99	326	4.1	143	2.5	1.6
	25+	1012	12.6	487	8.4	4.2
	Total	8046	100	5801	100	

Table 4.4 demonstrates the different mode splits among the age groups. Auto travel dominates across all categories. However, the older group is more likely to be riding in, rather than driving, an automobile. This pattern is most pronounced in large MSAs, and least apparent in non-MSAs, possibly because it is harder for people to help drive them around in a rural context. Among the non-auto modes, the older group does not differ more the 0.3 percentage points from the younger group within the same MSA category. There is somewhat more transit use and walking among both age groups in large MSAs than in small MSAs, and there is a bit more of this type of travel percent wise in non-MSAs than small MSAs. Only a small percentage of people choose biking across all categories.

Table 4.4 Mode Share by MSA Type

Area	Purpose	Age 21-64 (%)	Age 65+ (%)	Difference
Large MSA	Auto-Driver	73.8	65.7	8.10
	Auto-Not Driver	14.0	22.3	-8.30
	Transit	1.2	1.5	-0.30
	Walk	9.5	9.4	0.10
	Bike	1.0	0.7	0.30
	Other	0.5	0.4	0.10
Small MSA	Auto-Driver	73.5	66.8	6.70
	Auto-Not Driver	16.0	22.9	-6.90
	Transit	0.7	0.3	0.40
	Walk	8.3	8.5	-0.20
	Bike	1.1	1.2	-0.10
	Other	0.4	0.3	0.10
Non-MSA	Auto-Driver	71.9	67.1	4.80
	Auto-Not Driver	18.2	23.4	-5.20
	Transit	0.5	0.4	0.10
	Walk	7.3	7.6	-0.30
	Bike	1.4	1.1	0.30
	Other	0.7	0.4	0.30

Table 4.5 shows trip purpose rates, which is the average daily trips per person for a given purpose. The trip purpose categories are based on the general purpose groupings used in the NHTS database: Home-based work (HBW), home-based shop (HBShop), home-based social and recreational (HBSoc), home-based other, (HBO), and non-home-based (NHB). As one would expect, we found that the older group made very few work trips (<0 .1 per day compared to 0.5 for the younger group). Aging people also make fewer NHB trips, which indicates that they tend to not chain trips as frequently. For shopping and recreational activities older people made more trips than their counterparts, although this pattern is less prominent in large MSAs and most prominent in small MSAs.

Table 4.5 General Trip Purpose Rate by MSA Type

MSA Size	Purpose	Age 21-64	Age 65+	Difference
		Rate	Rate	
Large MSA	HBO	0.8	0.65	0.15
	HBSHOP	1	1.08	-0.08
	HBSOCREC	0.6	0.6	0.00
	HBW	0.5	0.1	0.40
	NHB	1.3	0.94	0.36
		4.1	3.37	0.73
Small MSA	HBO	0.7	0.64	0.06
	HBSHOP	0.9	1.14	-0.24
	HBSOCREC	0.5	0.63	-0.13
	HBW	0.5	0.09	0.41
	NHB	1.3	1.02	0.28
		4	3.53	0.47
Non-MSA	HBO	0.6	0.61	0.01
	HBSHOP	0.9	1.05	-0.15
	HBSOCREC	0.5	0.52	-0.02
	HBW	0.5	0.1	0.40
	NHB	1.2	1.03	0.17
		3.7	3.31	0.39

Table 4.6 shows trip rates by more specific destination categories. The older group makes more trips to medical and shopping destinations than the younger group across all MSA types. Aging people make more than twice as many trips to medical destinations, which one would expect given that health care needs increase with age. However, it should be noted that medical trips represent a small portion of overall trips. Aging people, on average, make more trips for shopping, recreation, and meals than they do for medical purposes. Shopping represents the most frequent non-home destination for both age groups and for all three MSA types.

Table 4.6 Specific Trip Destination Rate by MSA Type

MSA Size	Reason	Age 21-64 Rate	Age 65+ Rate	Difference
Large MSA	Home	1.43	1.22	0.21
	Work	0.57	0.1	0.47
	School/Daycare/Religious activity	0.07	0.08	-0.01
	Medical Dental Services	0.08	0.15	-0.07
	Shopping/Errands	0.79	0.85	-0.06
	Social/Recreational	0.45	0.44	0.01
	Family/personal business	0.16	0.14	0.02
	Transport someone	0.28	0.13	0.15
	Meals	0.28	0.27	0.01
	Other Reason	0.02	0.01	0.01
Small MSA	Home	1.35	1.26	0.09
	Work	0.55	0.09	0.46
	School/Daycare/Religious activity	0.08	0.08	0
	Medical Dental Services	0.08	0.15	-0.07
	Shopping/Errands	0.84	0.91	-0.07
	Social/Recreational	0.45	0.45	0
	Family/personal business	0.15	0.16	-0.01
	Transport someone	0.23	0.11	0.12
	Meals	0.28	0.31	-0.03
	Other Reason	0.02	0.01	0.01
Non-MSA	Home	1.24	1.14	0.1
	Work	0.54	0.09	0.45
	School/Daycare/Religious activity	0.08	0.1	-0.02
	Medical Dental Services	0.08	0.14	-0.06
	Shopping/Errands	0.79	0.89	-0.1
	Social/Recreational	0.43	0.41	0.02
	Family/personal business	0.14	0.15	-0.01
	Transport someone	0.15	0.1	0.05
	Meals	0.26	0.29	-0.03
	Other Reason	0.01	0.01	0

Figure 4.3 Travel Trips Rate by Hour of the Day and MSA Size

Figure 4.3 shows trip rates at different hours of the day. The first graph for large MSAs shows that the older population make more trips between 9 AM and 3 PM than their younger counterparts, with trip generation peaking at 10 AM. The second and third graphs shows that this temporal pattern largely holds in small MSAs and non-MSAs, respectively. Older populations appear to make a rational decision to focus their travel in-between the morning and afternoon rush hour. They also generate much fewer trips during non-daylight hours. This pattern may actually serve to even out traffic flow and improve the efficiency of the transportation network as the percentage of the population in the older category grows.

4.6 Summary

The above statistical summary of the Florida NHTS data largely supports existing research about aging travel behavior. Compared to their younger counterparts, older travelers tend to:

- take shorter trips both in terms of travel time and distance
- rely more heavily on being driven rather than driving themselves, although they rely just as heavily on private automobiles
- make fewer work trips but more medical and shopping trips
- generate more trips in the mid-morning hours

These patterns appear to hold across MSA categories. While the travel patterns of the aging may differ across MSAs (and non-MSAs) of different sizes, these differences apply almost equally to younger populations. In other words, the relative differences between older and younger populations stay constant, independent of regional context. For, example large MSAs have shorter trips and higher shares of trips made by non-auto modes, and this holds true for both age groups. The transportation needs of the aging in non-MSAs (i.e., rural areas) may, in some ways, be more similar to the needs of younger people in non-MSAs than they are to similarly aged populations in urban areas. This means that serving the transportation needs aging populations may require varying strategies, depending on the regional context.

In the future, this work could be extended by using alternate classifications for age groups, perhaps breaking younger traveler cohorts into additional categories. This would allow additional probing of how travel behavior manifests itself differently across various age categories. Further, comparisons of aging travel behavior could be made by specific geographical areas or regions of the state could be made, similar to past research (Marion and Horner 2007).

Chapter 5 Case Study of Accessibility in Leon County, Florida

5.1 Introduction

Scanning the literature, *accessibility*, or the ease with which individuals or populations can travel to reach goods and services has not been adequately explored in relation to aging populations. Accessibility is facilitated by well-organized transportation systems that move people efficiently, and it is improved as more activities are reachable to people given the means of available travel modes (Hansen 1959; McAllister 1976).

Missing from the transportation literature is a systematic quantitative analysis of the aging population's accessibility to potential activities. Given their residential patterns and the prevailing transportation system, do they have as much potential accessibility to activities as their younger counterparts? And what about the potential accessibility for those near retirement? These questions are especially important for aging populations who live independently and have not relocated to retirement homes or assisted living facilities, where transportation is often regularly arranged and supplied by the facility itself.

We explore the aging population's accessibility to activities for a smaller metropolitan area in the state of Florida. Using highly disaggregate spatial data containing the locations of populations and possible activities, we implement a series of accessibility models in a Geographic Information Systems (GIS) environment to assess potential disparities between older and younger populations. Mode of transportation is taken into account, and the scenarios and activities analyzed are informed by review of the broader literature as well as our own analysis of the 2009 National Household Travel Survey. We find that the potential accessibility of the aging population varies by activity type and differs with other age group cohorts.

5.2 Background

Accessibility describes the ease with which people's desired activities are reached via the transportation system (Handy and Niemeier 1997). On the transportation side, systems that are efficient and allow people to reach a larger amount of locations per unit of time are viewed positively (Handy and Niemeier 1997). On the land use or destinations side, the more activities that can be reached in a given area, the greater the degree of accessibility that exists. Over the years, researchers have developed numerous methods of measuring accessibility, many of which have expanded upon the basic accessibility measures developed decades ago (Chen et al. 2011).

At an elemental level, measures of accessibility involve an assessment of the costs involved in traveling to desired destinations and the attractiveness of the activities at these destinations (Hansen 1959). In practice, accessibility measures are frequently used to evaluate how effectively transportation systems allow populations to access jobs, health care facilities, shopping opportunities, and other life activities. (Handy and Niemeier 1997; Talen and Anselin 1998; Kwan 1999; Horner and Mefford 2005). Most researchers generally agree on the definition of accessibility per the above discussion, but there are still a variety of ways with which accessibility can be measured and quantified in terms of scale, units of measurement, regional extent, and other parameters (Páez, Scott, and Morency 2012).

Examining the literature, there is limited comparative quantitative work examining the ease with which aging populations can reach goods and services. Such efforts would provide insight into issues older people may face in terms of achieving maximum benefits from the transportation system and reaching essential life activities. One study by Love and Lindquist (Love and Lindquist 1995) used GIS to measure the accessibility of the aged population to hospital facilities. This study used census block groups as the unit of analysis and focused on the number of older people (aged 65 and older), who could reach a hospital in less than twenty miles. Although it does not employ a traditional accessibility model, another study examines the distribution of the aging and their accessibility to essential services by measuring the correlation between their residential locations and a range of activities located in their neighborhoods (Somenahalli and Shipton 2013). Essentially, as the population continues to age, we must gain a better understanding of how the aging may best reach desired destinations such as shopping, social activities, etc., via different travel modes. Accessibility metrics can provide a tool for assessing how well the transportation system serves these populations and if any disparities exist across age cohorts.

5.3 Case Study Overview

Several previous studies have looked into how accessibility varies across different population groups, controlling for the dynamics of the transportation system and local land use configuration, however limited work has been done focused specifically on the older population. In this section we provide an overview of our study design, including describing our accessibility modeling methodology, study area, and data sources.

5. 3.1. Accessibility Modeling Approaches

A full accounting of the range of accessibility measures is beyond the scope of this section, as this has been discussed previously and in reviews which can be found elsewhere (Handy and Niemeier 1997; Geurs and Van Eck 2001; Páez, Scott, and Morency 2012; Wang 2012). Although gravity-based metrics of accessibility are popular in the literature (Taaffe, Gauthier, and O'Kelly 1996; Handy and Niemeier 1997; Bhat et al. 2000; Páez, Scott, and

Morency 2012), in the interest of interpretability and comparison, we use cumulative opportunities measures to assess aging populations' accessibility. These accessibility metrics are among the least complicated and most easily understood as they measure the number of opportunities that one can reach within a given distance or travel time threshold from a particular origin (Guy 1983; Song 1996; O'Kelly and Horner 2003; Apparicio et al. 2008). Such measures require data about the time or distance it takes to travel from origins to potential destinations and spatially disaggregate counts of the number of opportunities throughout the study region. Recall that the basic formula is:

$$A_i^S = \sum_{j \in N_i} O_j \qquad (5.1)$$

where

A_i is the accessibility at origin *i* within a distance or time threshold *S*
O_j are the opportunities at destination *j*, and
$N_i = \{ j \mid C_{ij} \leq S \}$, which is the set of destinations *j* within the time or distance threshold *S*, defined for origin *i*

Typically, multiple values of *S* are used to compare the number of opportunities that can be reached across different time or distance thresholds (Bhat et al. 2000). Many applications of this method have been used to measure accessibility to job locations (Handy and Niemeier 1997) and other opportunities (Chen et al. 2011; Páez, Scott, and Morency 2012). Larger values of *A* are considered favorable as this indicates that the population at a given location has access to more opportunities.

A second approach employed to gauge accessibility measures the minimum time or distance it takes to reach a specific activity from a given origin (Love and Lindquist 1995). It is termed a proximity or 'nearest opportunity' measure. For example, a particular location may be

5.5 minutes away from the nearest library, while a different location would be 6.5 minutes away from its nearest library. While simple, this approach is arguably more appropriate than a cumulative opportunities measure in some cases when having just ‘one’ activity nearby is enough. A library illustrates this point well, as people typically would travel to their nearest public library for most purposes. On the other hand, for activities like restaurants, having more nearby options implies choice and availability. Thus, we consider both of types of accessibility (cumulative opportunities and nearest opportunity) in this analysis.

5.3.2 Study Area and Local Travel Characteristics

We use Leon County, Florida as the study area for our accessibility analysis. Leon County is the home of Tallahassee, Florida’s capital city. According to the U.S. Census, Leon County’s population was approximately 275,487 in 2010. There were 25,980 people in Leon County age 65 and up, or approximately 9.4% of the total population. For comparison, 17.33% of Florida’s 18,801,310 residents fall into this older age group. With three major colleges and universities located in Leon County, coupled with a local economy intimately tied to state government, the population skews slightly younger than the state as a whole. Leon County is shown in **Figure 5.1**, along with the percent of the population over the age 65 by census blocks and the distribution of activities.

We used the 2009 National Household Travel Survey (NHTS) Florida ‘add-on’ to generate some descriptive local and Florida-scale statistics to help guide our analysis. The NHTS ‘add-on’ program allows states (and Metropolitan Planning Organization (MPOs)) to pay for a larger sample within their jurisdiction. The sample size of the NHTS Florida dataset (including the add-on) has relevant travel information for about 14,000 households. This sample also includes information for 30,952 persons, 114,910 trips and 29,459 vehicles, which makes it a statistically valid dataset for modeling and planning activities.

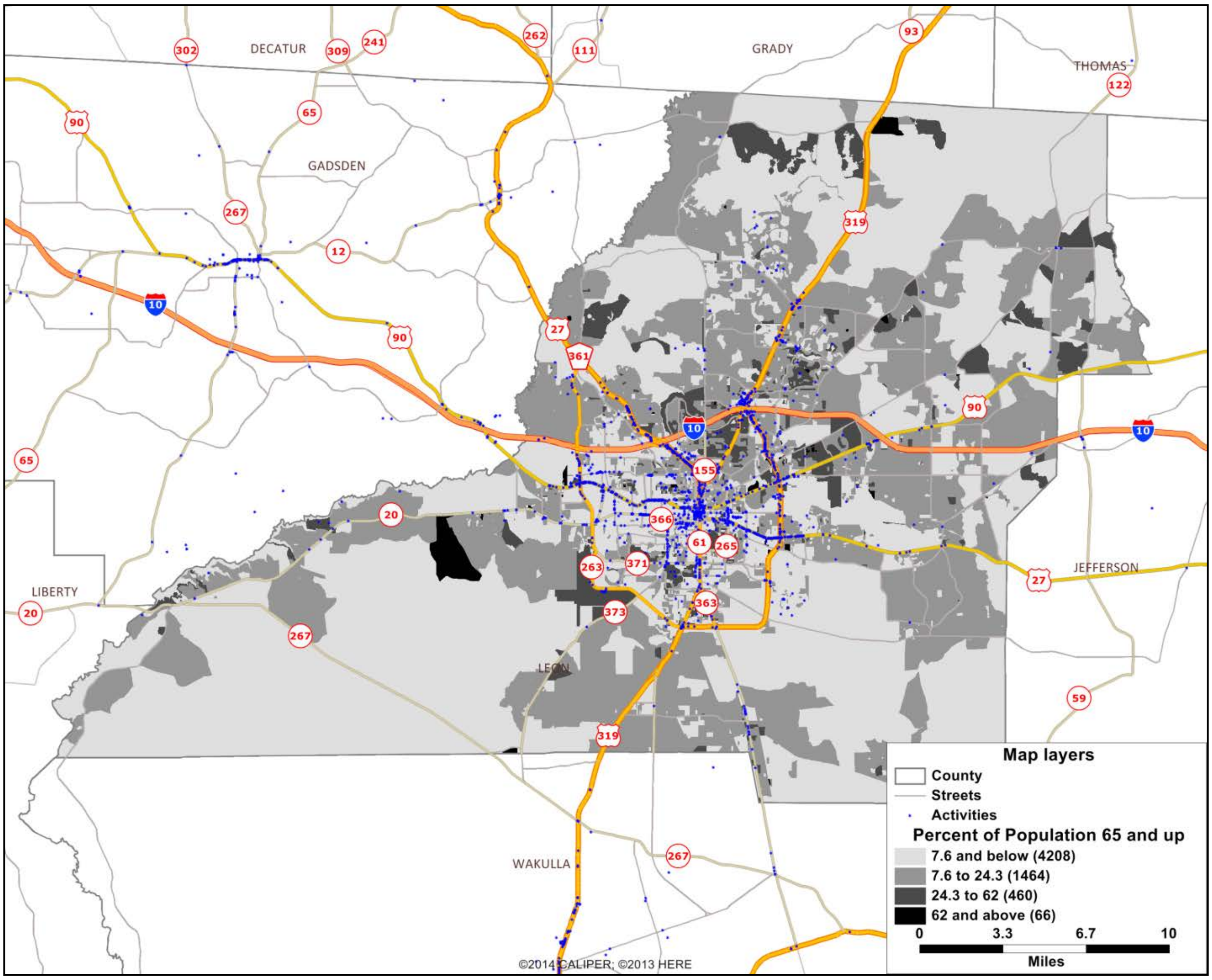

Figure 5.1 Leon County Study Area

Table 5.1 shows mode shares by travel trip purposes and by age for Florida as a whole and also Leon County. The sample was divided into four age groups: children (age 1-17), those essentially working age and generally younger (age 18-49), aging workers and those nearing retirement (age 50-64), and those who are entering retirement and older (age 65+). The NHTS has traditionally coded five general purposes for trips: Home-based Work (HBW), Home-based

Shop (HBSHOP), Home-Based Social and Recreational (HBSOCREC), Home-Based Other trips (HBO), and Non Home-Based (NHB). Finally we include the most representative modes in Florida, which are auto, transit, bicycle and walk.

Table 5.1 Mode Share and Trip Purpose by Age in Florida and Leon County

Mode Share by age and purpose in Florida and Leon County											
Age	Purpose	Florida					Leon County				
		Auto	Transit	Bicycle	Walk	Total	Auto	Transit	Bicycle	Walk	Total
1-17	HBO	2,935	11	61	318	3,325	82	2	2	3	89
		88%	0%	2%	10%	100%	92%	2%	2%	3%	100%
	HBSHOP	1,492	4	18	41	1,555	45	0	0	0	45
		96%	0%	1%	3%	100%	100%	0%	0%	0%	100%
	HBSOCREC	1,630	5	205	545	2,385	50	0	6	13	69
		68%	0%	9%	23%	100%	72%	0%	9%	19%	100%
	HBW	83	1	2	6	92	1	0	0	0	1
		90%	1%	2%	7%	100%	100%	0%	0%	0%	100%
	NHB	2,240	21	27	187	2,475	85	0	5	4	94
		91%	1%	1%	8%	100%	90%	0%	5%	4%	100%
	Total	8,380	42	313	1,097	9,832	263	2	13	20	298
		85%	0%	3%	11%	100%	88%	1%	4%	7%	100%
18-49	HBO	5,321	38	51	709	6,119	119	3	2	25	149
		87%	1%	1%	12%	100%	80%	2%	1%	17%	100%
	HBSHOP	5,918	17	43	180	6,158	147	0	0	5	152
		96%	0%	1%	3%	100%	97%	0%	0%	3%	100%
	HBSOCREC	2,847	23	147	1,080	4,097	74	0	0	30	104
		69%	1%	4%	26%	100%	71%	0%	0%	29%	100%
	HBW	4,124	49	25	46	4,244	84	0	2	2	88
		97%	1%	1%	1%	100%	95%	0%	2%	2%	100%
	NHB	8,651	51	23	542	9,267	283	0	0	11	294
		93%	1%	0%	6%	100%	96%	0%	0%	4%	100%
	Total	26,861	178	289	2,557	29,885	707	3	4	73	787
		90%	1%	1%	9%	100%	90%	0%	1%	9%	100%
50-64	HBO	4,814	37	25	812	5,688	94	0	0	15	109
		85%	1%	0%	14%	100%	86%	0%	0%	14%	100%
	HBSHOP	8,350	30	75	223	8,678	181	0	0	0	181
		96%	0%	1%	3%	100%	100%	0%	0%	0%	100%
	HBSOCREC	3,013	11	240	1,530	4,794	68	0	0	39	107
		63%	0%	5%	32%	100%	64%	0%	0%	36%	100%
	HBW	4,153	34	16	44	4,247	114	2	4	1	121
		98%	1%	0%	1%	100%	94%	2%	3%	1%	100%
	NHB	10,233	92	37	563	10,925	300	2	0	16	318
		94%	1%	0%	5%	100%	94%	1%	0%	5%	100%
	Total	30,563	204	393	3,172	34,332	757	4	4	71	836
		89%	1%	1%	9%	100%	91%	0%	0%	8%	100%
65+	HBO	6,442	58	16	685	7,201	88	1	0	4	93
		89%	1%	0%	10%	100%	95%	1%	0%	4%	100%
	HBSHOP	11,892	85	74	343	12,394	186	0	0	0	186
		96%	1%	1%	3%	100%	100%	0%	0%	0%	100%
	HBSOCREC	4,587	25	234	1,939	6,785	69	0	1	12	82
		68%	0%	3%	29%	100%	84%	0%	1%	15%	100%
	HBW	1,061	10	1	8	1,080	17	0	0	0	17
		98%	1%	0%	1%	100%	100%	0%	0%	0%	100%
	NHB	10,509	54	29	424	11,016	148	-	-	1	149
		95%	0%	0%	4%	100%	99%	0%	0%	1%	100%
	Total	34,491	232	354	3,399	38,476	508	1	1	17	527
		90%	1%	1%	9%	100%	96%	0%	0%	3%	100%

The table shows that regardless of age group, auto is the predominant mode of transportation in Florida and Leon County, with shares ranging from 85-96%. The second most popular mode of transportation is the walk mode, with shares between 3-11%. Compared with other trip purposes, home-based social and recreation (HBOSOCREC) tends to involve larger shares of walking trips and less use of auto. Focusing on Florida, the aging (age 65+) have a lower percentage of home based work trips at 3.08% (1,061 / 34,491) when compared with their younger counterparts. Using similar calculations, conversely, the aging have higher shares of trips for all other home-based trip types as, with the exception of HBO trips made by those in the 18-49 age category. This highlights the types of trips that are important to older populations.

To gain more insights into possible variations among the older subgroups, Table 5.2 presents the same travel statistics, but for those persons age 65-74, age 75-84, and age 85+. Interestingly the table reveals that the aggregate trips made declines with age in both Florida and Leon County as a whole. Looking at Florida, mode shares are also fairly similar across the three older age groups, with automobile trips accounting for roughly 90% of each cohort's total travel. Trips made by walking account for the second highest total, and this is consistent across each age group. If we focus on the trip purposes in Florida, the number and proportion of work-related trips (HBW) declines substantially from the 65-74 to the age 85+ group, as this represents people leaving the workforce. For respondents aged 65-74 in the state of Florida as a whole, home-based shopping (HBSHOP) represents the most frequent trip taken with about a 31% share. The HBSHOP is also the most popular trip purpose for the other two age categories, though by age 85+, this represents slightly more than 37% of all trips taken. Leon County exhibits similar characteristics on the HBSHOP statistic. With regard to Leon County, one of the more noteworthy findings is that the trips for social and recreational purposes (HBSOCREC) occupy a substantial share of trips, particularly in the 85+ group with an approximate 24% share. This compares with about a 17% share of HBSOCREC trips for the state as a whole.

Table 5.2: Mode Share and Trip Purpose for Older Adults(ages 65+) in Florida and Leon County

Mode Share and Trip Purpose by Age in Florida and Leon County											
Age	Purpose	Florida					Leon County				
		Auto	Transit	Bicycle	Walk	Total	Auto	Transit	Bicycle	Walk	Total
65-74	HBO	3,424	24	5	437	3,890	41	0	0	4	45
		88%	1%	0.1%	11%	100%	91%	0%	0%	9%	100%
	HBSHOP	6,457	34	47	167	6,705	100	0	0	0	100
		96%	1%	1%	2%	100%	100%	0%	0%	0%	100%
	HBSOCREC	2,623	7	142	1,037	3,809	33	0	1	6	40
		69%	0.2%	4%	27%	100%	83%	0%	3%	15%	100%
	HBW	895	9	1	8	913	17	0	0	0	17
		98%	1%	0.1%	1%	100%	100%	0%	0%	0%	100%
	NHB	6,117	26	15	276	6,434	87	0	0	0	87
		95%	0.4%	0.2%	4%	100%	100%	0%	0%	0%	100%
	Total	19,516	100	210	1,925	21,751	278	0	1	10	289
		90%	0%	1%	9%	100%	96%	0%	0%	3%	100%
75-84	HBO	2,459	22	8	214	2,703	35	0	0	0	35
		91%	1%	0.3%	8%	100%	100%	0%	0%	0%	100%
	HBSHOP	4,366	32	24	141	4,563	65	0	0	0	65
		96%	1%	1%	3%	100%	100%	0%	0%	0%	100%
	HBSOCREC	1,622	12	80	740	2,454	25	0	0	4	29
		66%	0%	3%	30%	100%	86%	0%	0%	14%	100%
	HBW	158	1	0	0	159	0	0	0	0	0
		99%	1%	0%	0%	100%	0%	0%	0%	0%	0%
	NHB	3,663	21	13	129	3,826	53	0	0	1	54
		96%	1%	0.3%	3%	100%	98%	0%	0%	2%	100%
	Total	12,268	88	125	1,224	13,705	178	0	0	5	183
		90%	1%	1%	9%	100%	97%	0%	0%	3%	100%
85+	HBO	559	12	3	34	608	12	1	0	0	13
		92%	2%	0%	6%	100%	92%	8%	0%	0%	100%
	HBSHOP	1,069	19	3	35	1,126	21	0	0	0	21
		95%	2%	0%	3%	100%	100%	0%	0%	0%	100%
	HBSOCREC	342	6	12	162	522	11	0	0	2	13
		66%	1%	2%	31%	100%	85%	0%	0%	15%	100%
	HBW	8	0	0	0	8	0	0	0	0	0
		100%	0%	0%	0%	100%	0%	0%	0%	0%	0%
	NHB	729	7	1	19	756	8	0	0	0	8
		96%	1%	0.1%	3%	100%	100%	0%	0%	0%	100%
	Total	2,707	44	19	250	3,020	52	1	0	2	55
		90%	1%	1%	8%	100%	95%	2%	0%	4%	100%
Total		34,491	232	354	3,399	38,476	508	1	1	17	527

5.3.3 Data Sources and Computing Platforms

The locations for potential trips origins were taken from 2010 U.S. Census Blocks. There are 6,198 Blocks in Leon County and these units represent a very high level of spatial detail. Population counts disaggregated by age group were attached to each Census Block. Recent data on the street network's geography was obtained from Navteq's HERE database (2013). This database contains information on the estimated time to traverse network linkages and we used this to estimate auto travel times between origins and possible activity locations. With the exception of the health facilities, activity locations were also taken from Navteq's HERE landmark database of points representing various businesses such as restaurants, shopping opportunities, hospitals, financial services, etc. Whereas the origin locations (blocks) were limited to Leon County, the activities available to Leon County residents extend beyond the county boundaries. Thus, we include activity locations from surrounding counties when calculating accessibility.

Locations of 'health facilities' were taken from the Florida Geographic Data Library, with the original source being University of Florida's GeoPlan center, where the locations were geocoded for the year 2009. The health facilities data includes address locations of approximately 97 medical resource locations in the region including dialysis centers, walk-in clinics, surgery centers, medical doctors, geriatric healthcare centers, and health and rehabilitation centers. This data is not inclusive of all general practitioners or other medical services within the area. Moreover, it contains facilities only for locations reachable in the state of Florida. As a result, our accessibility analysis excludes nearby medical facilities in Georgia. Because most health insurance plans fall under state jurisdiction, the idea of limiting Leon County residents to reaching facilities within Florida is not unreasonable. That said, accessibility results based on this particular data item should perhaps be viewed with some caution.

Analyses were conducted in TransCAD GIS version 6. Accessibility models described above were implemented using TransCAD's network analysis and matrix functions. We constructed a shortest path matrix between origins (census blocks) and destinations (activity locations). We then used matrix processing routines to identify the number of activities within a given time threshold *S* of each block. We further identified the minimum travel time from each block to all relevant activities

5.4 Analysis and Results

5.4.1 Scenario Overview

Consistent with the table presented above, we divide the study area population into three groups – those essentially working age and generally younger (age 18-49), aging workers and those nearing retirement (age 50-64), and those who are entering retirement and older (age 65+). Children are not analyzed. For each group we measure accessibility to a range of activity and opportunity types. The nature of the activities chosen to examine were informed by both our own analysis of NHTS data, as well the literature on this topic (Scott and Horner 2008; Somenahalli and Shipton 2013). We separately measure accessibility by auto and walking. Although there is a fixed bus transit system (Star Metro) in Leon County and the city of Tallahassee, its relatively limited route structure and low share of regional ridership are such that accessibility comparisons with the auto and walk modes are not direct, and as such, the transit analysis is presented in a separate section. As previously stated, the HERE database provided estimates of network travel time and we directly used these estimates in the auto analysis. For the walk analysis, we assumed that trips could be taken at a speed of 2.5 miles per hour and did not vary this by age cohort. We chose a lower walking speed per (Langlois et al. 1997) to account for the fact that the aging may walk slower than speeds used in past studies (Larsen and Gilliland 2009). We estimate the two previously described types of accessibility measures for each mode. For all metrics, we present weighted average accessibilities by age group, which can be used to identify any disparities between people's proximity to opportunities.

5.4.2 Walk and Auto Mode Results

Table 5.3 reports the results of the auto accessibility analysis for ten classes of activities. We created travel thresholds in increments of 5 minutes with a maximum of 30 minutes. We used a 30 minute maximum threshold based on our reading of the literature and because separate analysis of the 2009 NHTS (not shown) revealed that 80% of all trips were 29 minutes or less.

Table 5.3 Accessibility Analysis for Auto Mode, Leon County, FL

Threshold (Minutes)	Ages	Activities										
		Grocery Stores	Libraries	Parks	Pharmacies	Post Offices	Restaurants	Hospitals	Finanancial Services	Shopping (Apparel)	Shopping (Other)	Health Facilities
5	18-49	2.84	1.35	4.88	2.93	0.60	34.35	0.18	5.99	4.85	2.42	1.86
	50-64	1.80	1.21	3.28	2.23	0.38	21.10	0.22	4.66	3.86	1.45	1.74
	65 and up	2.04	1.22	3.65	2.50	0.47	23.85	0.28	5.34	4.04	1.57	2.25
10	18-49	11.34	2.50	22.27	12.22	2.63	140.11	0.95	26.94	22.53	10.27	9.12
	50-64	7.81	1.93	14.95	9.79	1.83	97.64	1.04	22.23	15.85	7.32	8.76
	65 and up	8.55	1.98	16.79	10.76	2.07	109.85	1.26	25.06	17.64	7.95	10.35
15	18-49	22.01	3.86	43.72	24.67	5.01	268.12	2.13	54.67	44.10	20.94	19.52
	50-64	16.94	2.98	32.47	20.62	3.99	208.71	2.07	46.55	33.18	16.12	17.91
	65 and up	18.33	3.18	35.74	22.43	4.34	231.01	2.34	51.78	37.25	17.29	20.06
20	18-49	31.31	4.83	61.01	36.17	7.26	376.61	3.15	80.92	60.26	31.95	29.19
	50-64	26.81	4.14	51.03	31.83	6.53	323.26	2.94	71.80	50.99	25.90	26.54
	65 and up	28.42	4.34	54.17	33.87	6.86	345.25	3.12	76.78	54.89	27.41	28.19
25	18-49	39.52	5.63	72.71	45.66	9.78	453.58	3.76	99.33	70.19	39.91	36.21
	50-64	36.63	5.30	66.23	42.62	9.51	420.21	3.62	92.82	65.23	35.28	34.18
	65 and up	37.53	5.41	68.24	43.80	9.65	432.80	3.67	95.33	66.87	36.31	34.79
30	18-49	46.57	6.31	81.16	53.03	12.83	504.99	4.08	110.40	76.06	44.95	40.77
	50-64	44.35	6.20	76.98	50.73	12.66	485.35	4.18	106.76	73.59	42.76	39.25
	65 and up	44.62	6.19	77.80	50.96	12.63	489.30	4.14	107.46	73.98	43.28	39.26
Minimum Time to nearest activity (Minutes)	18-49	3.81	9.15	3.64	4.15	6.35	2.62	13.09	3.99	5.60	4.87	6.05
	50-64	4.92	11.61	4.60	5.46	7.84	3.69	13.67	5.58	7.56	6.30	8.29
	65 and up	4.59	11.26	4.30	5.01	7.26	3.42	12.61	5.08	7.07	5.82	7.44

Among the activity types, people have the best access to restaurants at a time threshold of 30 minutes. All age groups have access to more than 485 restaurants, on average, with 30 minutes of home, with the 18-49 age group having access to the most at about 505. Among the least accessible activity types are those that are not as populous on the landscape, such as libraries, post offices, and hospitals. Of all activities, hospitals are least accessible regardless of the time threshold examined, though all age groups can reach an average of at least 4 hospitals within 30 minutes. Financial services such as banks and credit union locations appear to be very plentiful in the Leon County region, as evidenced by the fact that there are, on average, more than 71 opportunities within a 20 minute drive of all age groups. There are also more shopping opportunities for apparel versus other types of shopping (e.g., hardware, electronics, etc.) regardless of age group or time threshold. The average minimum time statistics shown at the bottom of Table 2 also help to highlight the relative accessibility of these activity types.   The nearest parks and hospitals tend to be more distant, while more bountiful activities such as restaurants and grocery stores are more accessible to people in the average census block. In terms of access to health facilities, people across all age groups tend to have lower levels of accessibility.

Some of the more compelling insights stem from the differences in accessibility by age groups. To preface that discussion, it is important to note that, to the extent that our travel time and activity data are reliable, the numbers in the table represent real empirical differences that exist in accessibility as opposed to statistically estimated differences. We have a full enumeration of where people live based on the 2010 Census, and we assume we have an enumeration of the region's activities (with the exception of the health facilities). Looking at most activities, it tends to be the case that the youngest age group (18-49) has the greatest accessibility, with the middle group (50-64) having the lowest accessibility and the elder group (65+) in between. For example, at a driving threshold of 10 minutes, the youngest age group has, on average, access to 5 more parks than do their elder counterparts (22.27 vs. 16.79). People in the middle group have access to even fewer parks (14.95). This pattern persists across most activities and thresholds, with the notable exception of hospitals. Those age 65 and up have the greatest levels of accessibility at lower thresholds; while those aged 50-64 have the highest accessibility at the highest threshold. No doubt this variation is attributable to the relatively small number of hospitals in Leon County, and where one lives relative to these facilities can make a significant difference in their accessibility. Similarly, this pattern persists for the health facilities locations whereby older people's accessibility is comparatively less as thresholds increase. As retirement homes and assisted living facilities may tend to cluster around medical and hospital facilities, this may explain the aging's higher level of accessibility to these types of locations, particularly when using the lower thresholds.

When we examine the average minimum travel times for differences across ages, people in the age 50-64 group have the lowest accessibility across *all* activities. This finding is consistent with the cumulative opportunities calculations discussed above. These results show that the middle age group tends to be farthest from the nearest *single* activity of a given type. With regards to the cumulative opportunities calculations, the other two age groups (18-49, 65+) tend to have more choices within a given threshold.

We report the walk-mode metrics in Table 5.4. This table reveals trends similar to those shown in the auto analysis. For most time thresholds, the 18-49 age group tends to have the greatest accessibility to activities while those in the 50-64 range have the least. Overall, the magnitude of numbers is much smaller in this table than in Table 2 because not as many locations can be reached per unit of time when walking. In the case of hospitals, no populated census blocks were within a 5 minute walk threshold. Also, for most of the walk time thresholds, the fact that the cumulative opportunities numbers are below 1 indicates that most locations in Leon County generally have poor walk access. Again, much like in the case of driving, restaurants tend to be the most accessible activity, with the average person in the age 65+ group accessible to about 10 restaurants in a 30 minute walk. Perhaps more troubling from an aging perspective, large numbers of other useful destinations such as libraries, hospitals, pharmacies and grocery stores are all relatively inaccessible by walking. Even at a 30 minute walk threshold, the average person has access to less than 1 of these types of activity locations. Turning to the minimum time statistics reported at the bottom of Table 3, these results show that several activity types are quite difficult to reach. Notably, people in the 50-64 age group have more than a 90 minute walk to their nearest health facility and more than a 2 hour walk to the nearest library. This analysis shows that the 50-64 population has the least accessibility to goods and services.

Table 5.4 Accessibility Analysis for Walk Mode, Leon County, FL

Threshold (Minutes)	Ages	Activities										
		Grocery Stores	Libraries	Parks	Pharmacies	Post Offices	Restaurants	Hospitals	Finanancial Services	Shopping (Apparel)	Shopping (Other)	Health Facilities
5	18-49	0.02	0.0010	0.03	0.02	0.0006	1.00	0	0.02	0.01	0.01	0.007
	50-64	0.01	0.0010	0.03	0.01	0.0001	0.08	0	0.01	0.01	0.004	0.006
	65 and up	0.01	0.0006	0.03	0.006	0.0002	0.08	0	0.02	0.01	0.004	0.020
10	18-49	0.09	0.01	0.17	0.08	0.03	1.43	0.002	0.18	0.13	0.08	0.05
	50-64	0.06	0.003	0.14	0.05	0.01	0.54	0.003	0.10	0.05	0.04	0.03
	65 and up	0.08	0.003	0.17	0.06	0.006	0.58	0.01	0.12	0.06	0.03	0.09
15	18-49	0.27	0.03	0.46	0.27	0.08	4.10	0.02	0.61	0.38	0.27	0.12
	50-64	0.15	0.02	0.34	0.16	0.04	1.66	0.02	0.35	0.18	0.11	0.11
	65 and up	0.19	0.02	0.38	0.18	0.05	1.81	0.03	0.39	0.21	0.11	0.20
20	18-49	0.51	0.08	0.91	0.54	0.16	7.63	0.03	1.15	0.76	0.51	0.27
	50-64	0.31	0.04	0.66	0.33	0.07	3.50	0.04	0.73	0.44	0.23	0.23
	65 and up	0.36	0.04	0.71	0.37	0.08	3.68	0.07	0.77	0.45	0.21	0.37
25	18-49	0.90	0.16	1.54	0.90	0.25	12.25	0.05	1.94	1.38	0.78	0.47
	50-64	0.49	0.07	1.01	0.55	0.11	5.90	0.07	1.19	0.84	0.37	0.42
	65 and up	0.57	0.06	1.11	0.61	0.12	6.32	0.10	1.28	0.85	0.35	0.60
30	18-49	1.41	0.22	2.43	1.39	0.38	18.65	0.08	3.09	2.04	1.18	0.74
	50-64	0.76	0.10	1.47	0.85	0.17	9.17	0.10	1.89	1.34	0.60	0.65
	65 and up	0.86	0.10	1.63	0.93	0.18	10.02	0.12	2.13	1.42	0.59	0.88
Minimum Time to nearest activity (Minutes)	18-49	39.62	94.14	37.76	42.7	63.8	27.5	119.87	40.88	56.43	48.96	66.55
	50-64	55.51	132.38	51.32	61.46	87.29	41.34	143.54	62.25	83.33	69.76	98.24
	65 and up	51.42	123.8	46.78	55.85	79.87	38.03	130.13	56.22	76.36	62.86	86.91

5.4.3 Results: Accessibility Comparisons among Older Adults

Table 5.5 reports on the automobile accessibility results for the age 65+ group, broken down into the three finer age classes. The same travel time thresholds and activities are utilized once again. Comparing the older subgroups, it seems to be the case that the oldest age group (85+) tends to have the best accessibility across multiple time thresholds and activities. For example, in the 10 minute threshold, those people age 85+ have access to about 136 restaurants, while those in the 64-75 age category have access to about 101 restaurants. As a second example, for the 15-minute threshold, those aged 85+ have access to about 9 more parks than do those in the 64-75 age category. For many activities, adults in the 75-84 year range have better accessibility than their younger counterparts but not quite as good as those in the oldest category. Generally speaking, many of these accessibility differences are mitigated once the largest bandwidth (30 minutes) is reached. The minimum time to the nearest activity statistic corroborates the idea that those in the 85+ population group have higher levels of accessibility. Picking up on the point mentioned about retirement homes and assisted care facilities likely being located near health and hospital facilities, here the 85+ group has the highest accessibility to those facilities particularly at the lower thresholds. Given their age, this group would be the most likely to live in retirement and managed care facilities.

Threshold (Minutes)	Ages	Activities										
		Grocery Stores	Libraries	Parks	Pharmacies	Post Offices	Restaurants	Hospitals	Finanancial Services	Shopping (Apparel)	Shopping (Other)	Health Facilities
5	65-74	1.82	1.21	3.35	2.24	0.41	21.33	0.23	4.84	3.62	1.45	1.80
	75-84	2.28	1.22	3.95	2.79	0.53	26.67	0.33	5.91	4.60	1.69	2.66
	85 and up	2.60	1.25	4.56	3.25	0.66	31.07	0.44	6.78	5.24	1.97	3.66
10	65-74	7.93	1.90	15.39	9.97	1.90	100.59	1.09	23.11	16.06	7.39	9.12
	75-84	9.24	2.07	18.34	11.60	2.27	120.14	1.42	27.29	19.32	8.57	11.64
	85 and up	10.22	2.18	20.76	13.04	2.54	135.96	1.78	30.66	22.52	9.47	14.25
15	65-74	17.28	3.01	33.33	21.11	4.12	215.16	2.15	48.13	34.12	16.30	18.54
	75-84	19.55	3.38	38.50	23.90	4.62	248.95	2.54	55.75	40.77	18.42	21.69
	85 and up	21.15	3.64	42.10	26.08	4.94	274.59	2.88	62.12	46.10	19.90	24.46
20	65-74	27.33	4.19	52.01	32.52	6.68	330.70	2.99	73.52	52.21	26.33	26.98
	75-84	29.71	4.51	56.73	35.42	7.06	362.26	3.28	80.47	57.97	28.71	29.57
	85 and up	31.20	4.72	59.60	37.41	7.30	382.60	3.48	85.47	61.55	30.03	31.37
25	65-74	36.84	5.30	66.74	42.95	9.58	423.52	3.61	93.35	65.52	35.58	34.24
	75-84	38.39	5.51	70.08	44.84	9.75	444.07	3.74	97.70	68.53	37.25	35.47
	85 and up	39.18	5.57	71.73	45.88	9.81	455.38	3.82	100.36	70.05	37.99	36.16
30	65-74	44.31	6.19	77.06	50.69	12.66	485.16	4.14	106.61	73.46	42.87	39.14
	75-84	45.04	6.19	78.76	51.33	12.61	494.64	4.14	108.56	74.69	43.83	39.46
	85 and up	45.29	6.15	79.34	51.56	12.55	498.68	4.11	109.52	75.08	44.26	39.45
Minimum Time to nearest activity (Minutes)	65-74	4.87	11.65	4.48	5.38	7.61	3.64	13.46	5.47	7.44	6.13	8.08
	75-84	4.26	10.79	4.07	4.56	6.89	3.15	11.70	4.61	6.63	5.43	6.76
	85 and up	3.86	10.25	3.90	4.05	6.29	2.83	10.11	4.07	6.14	5.06	5.67

Table 5.5: Accessibility Analysis for Auto Mode, Leon County, FL (older population) (number of activities and minimum time to nearest activities)

Turning to the walk mode, accessibility results for the disaggregated older population group are displayed in Table 5.6. Similar to the auto results, people aged 85+ tend to have the highest levels of accessibility. However, in contrast with the auto results, walking accessibility levels are much lower overall. Accessibility to libraries is among the lowest of activities for all three age cohorts, mirroring the results of the other younger age groups reported in Table 4. Also like the younger age groups, the three older age groups here tend to have the highest levels of accessibility to restaurants. Focusing on the thirty minute threshold, all three of the older population groups had access on average to at least one activity in the parks, restaurants, financial services, and shopping (apparel) categories. The minimum time statistics reported at the bottom of the table are informative in terms of pointing out how distant some of these activities are from older populations, and how unrealistic walking might be to reach them (e.g. measured as more than 100 minutes walking on average to reach nearest library).

Table 5.6: Accessibility Analysis for Walk Mode, Leon County, FL, (older pop.) (number of activities and minimum time to nearest activities**)**

Threshold (Minutes)	Ages	Activities										
		Grocery Stores	Libraries	Parks	Pharmacies	Post Offices	Restaurants	Hospitals	Finanancial Services	Shopping (Apparel)	Shopping (Other)	Health Facilities
5	65-74	0.01	0.00	0.03	0.01	0.00	0.07	0.00	0.01	0.01	0.00	0.01
	75-84	0.02	0.00	0.04	0.01	0.00	0.08	0.00	0.02	0.01	0.00	0.04
	85+	0.02	0.00	0.04	0.01	0.00	0.10	0.00	0.04	0.01	0.01	0.09
10	65-74	0.06	0.00	0.15	0.05	0.01	0.51	0.00	0.10	0.06	0.03	0.04
	75-84	0.10	0.00	0.19	0.07	0.01	0.63	0.01	0.13	0.07	0.02	0.12
	85+	0.12	0.00	0.23	0.08	0.01	0.81	0.02	0.19	0.09	0.03	0.24
15	65-74	0.16	0.02	0.34	0.16	0.04	1.58	0.02	0.32	0.18	0.10	0.13
	75-84	0.23	0.02	0.42	0.21	0.06	2.04	0.04	0.46	0.22	0.11	0.26
	85+	0.27	0.02	0.51	0.26	0.09	2.53	0.07	0.61	0.29	0.14	0.51
20	65-74	0.31	0.03	0.64	0.32	0.07	3.29	0.04	0.68	0.41	0.21	0.24
	75-84	0.42	0.04	0.78	0.43	0.09	4.07	0.08	0.88	0.47	0.21	0.47
	85+	0.48	0.04	0.90	0.51	0.13	4.85	0.15	1.08	0.58	0.24	0.85
25	65-74	0.50	0.06	1.00	0.53	0.10	5.60	0.07	1.14	0.75	0.34	0.43
	75-84	0.65	0.06	1.21	0.69	0.13	7.09	0.12	1.42	0.98	0.35	0.74
	85+	0.73	0.07	1.44	0.81	0.17	8.37	0.19	1.69	1.14	0.36	1.20
30	65-74	0.77	0.09	1.48	0.83	0.16	8.86	0.10	1.88	1.24	0.56	0.67
	75-84	0.96	0.10	1.78	1.05	0.20	11.31	0.15	2.40	1.68	0.61	1.04
	85+	1.06	0.11	2.10	1.20	0.26	13.27	0.22	2.84	1.90	0.67	1.58
Minimum Time to nearest activity (Minutes)	65-74	55.52	131.25	49.59	60.90	84.83	41.15	140.78	61.27	81.70	67.44	95.57
	75-84	46.56	114.70	43.41	49.81	74.31	34.33	118.24	50.12	69.98	57.29	77.15
	85+	41.32	105.60	40.51	43.28	66.41	30.40	101.08	43.63	63.49	52.00	64.03

5.4.4 Transit Mode Results

Leon County contains a bus transit service known as StarMetro. Running along several major thoroughfares, it is comprised of 12 routes and approximately 830 stops of various headways. The map shown in Figure 5.2 depicts the geography of the StarMetro routes. A network model of the StarMetro routes was constructed in TransCAD GIS v. 6.0 to allow estimates of the time to reach various activity locations by transit. Transfers between routes are allowed at stops and it is assumed that people can walk up to .5 miles in order to access the system, and then up to another .5 mile to reach activity locations. In our analysis, the time threshold allowed to reach a certain activity includes the time required to walk these distances, bus wait/transfer times, and in-vehicle travel time. The service protocol assumes typical weekday service.

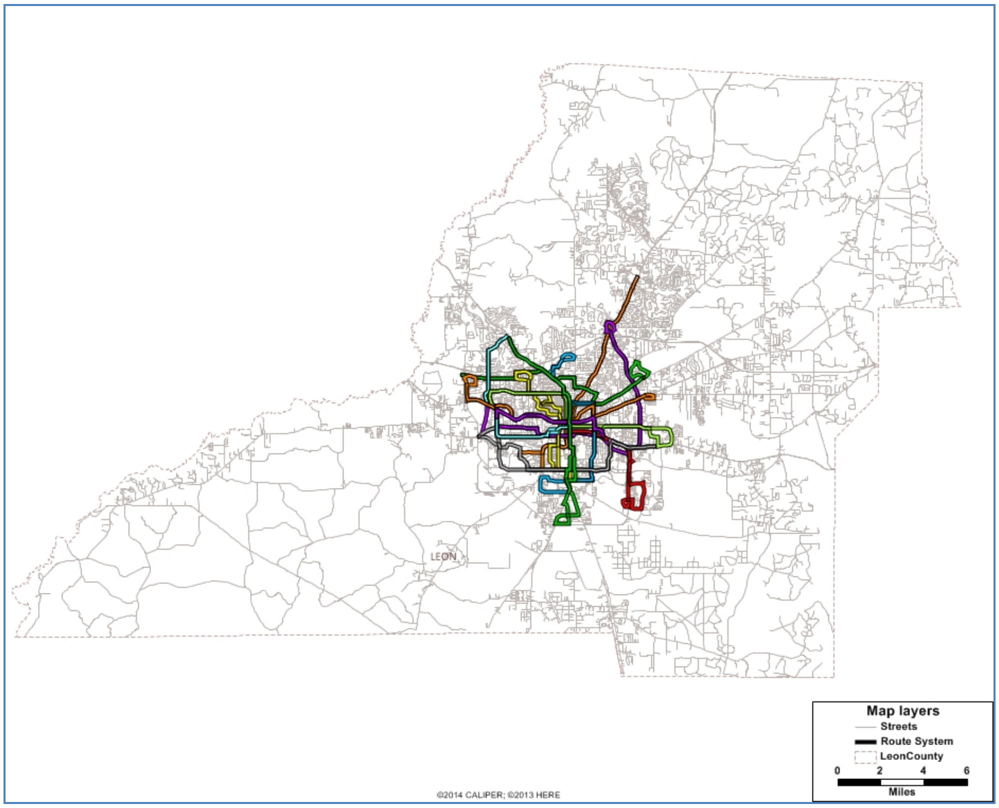

Figure 5.2: Star Metro Routes in Leon County, FL

As shown in the map, coverage of the transit system is limited to several major thoroughfares, and not every location in Leon County has direct access to the system. By our estimates, approximately 160,637 of the 275,487 population are within .5 miles of a bus stop and assumed to be served by transit. This constitutes 46.85% of the aging population (ages 65 and up), where 12,172 of 25,980 aging people have suitable access to the system. For the population aged 50 to 64, only 42.47% or 19,913 out of 46,886 pre-retirement aged adults are within .5 miles of a bus stop.

Results are shown in Tables 5.7 and Table 5.8 and are presented in a manner similar to both the auto and walk-based accessibility analyses of the prior section. Because 100% of the population is not covered by transit service, these accessibility estimates are not necessarily comparable to those for auto and walk in the previous section. However, the same activity data from the same sources is used from the prior analyses. Table 5.7 reports the number of activities reachable for thresholds of 15-60 minutes in increments of 15 minutes, disaggregated by age group. For any of the activity locations, relatively few are reachable in the two lower (15 and 30 minute) thresholds, with far many more accessible in the two higher thresholds. Restaurants and shopping are the two most plentiful activity types, and comparing population accessibility, it tends to be the case that the youngest age group has the best accessibility to activities while those of pre-retirement age have the worst accessibility.

Table 5.7: Cumulative Opportunities-based Transit Accessibility

Threshold (Minutes)	Ages	Activities										
		Grocery Stores	Libraries	Parks	Pharmacies	Post Offices	Restaurants	Hospitals	Finanancial Services	Shopping (Apparel)	Shopping (Other)	Health Facilities
15	18-49	0.036	0.0041	0.19	0.065	0.007	0.55	0.0019	0.096	0.07	0.06	0.76
	50-64	0.023	0.005	0.15	0.031	0.005	0.22	0.0041	0.06	0.053	0.046	0.59
	65 and up	0.05	0.007	0.16	0.034	0.007	0.29	0.01	0.08	0.07	0.08	0.77
30	18-49	2.29	0.405	0.79	2.39	0.63	23.5	0.12	5.84	5.03	6.64	6.77
	50-64	1.62	0.28	0.51	1.73	0.37	15.15	0.12	3.97	3.68	4.45	4.03
	65 and up	1.91	0.35	0.59	2.04	0.47	18.08	0.17	4.68	4.52	5.4	4.62
45	18-49	10.27	1.77	1.67	11.06	2.35	112.16	0.61	27.01	26.79	35.32	12.93
	50-64	6.79	1.24	1.02	7.47	1.48	73.37	0.55	18.24	18.04	24.03	7.03
	65 and up	7.95	1.49	1.18	8.73	1.73	85.33	0.64	21.26	20.86	27.93	7.83
60	18-49	16.95	2.78	2.99	19.38	3.34	186.97	1.32	45.28	46.62	62.42	15.06
	50-64	10.87	1.79	1.74	12.36	2.2	121.32	0.89	29.45	30.36	40.53	7.86
	65 and up	12.48	2.08	2	14.14	2.49	138.78	1.01	33.78	34.89	46.56	8.67

Findings are somewhat different for the minimum time analysis presented in Table 5.8. There is not as much consistency across age groups as in some cases the aging group are the most accessible (e.g. libraries), but not in others (e.g. restaurants). However, what the table does point to is that a fairly substantial amount of time is required to reach most activities given transit is being used. The minimum time for any activity is about 19 minutes for a restaurant and the maximum is about 42 minutes for hospitals. And moreover, not all activities are accessible by transit, thereby further limiting people's possible choices.

Table 5.8 Proximity-based Transit Accessibility

	Ages	Activities										
		Grocery Stores	Libraries	Parks	Pharmacies	Post Offices	Restaurants	Hospitals	Finananci al Services	Shopping (Apparel)	Shopping (Other)	Health Facilities
Minimum Time (Minutes)	18-49	24.35	31.48	25.53	22.7	29.97	18.74	41.73	21.8	22.26	21.96	24.49
	50-64	22.98	29.49	25.27	23.01	30.06	19.44	37.46	21.63	22.22	22.58	24.01
	65 and up	22.54	28.64	24.17	22.7	28.98	19.33	35.94	21.39	22.12	22.38	23.31

5.5 Summary

This chapter has analyzed accessibility for aging vs. other populations using Leon County FL as a case study. Auto accessibility measures were presented, as were those derived from pedestrian and transit modes. While the auto accessibility measure sets a clear standard in terms of reaching activities in the car-dominant study area, it is limited in the sense that not all older adults are able to drive. In this way, the question of who has access to, or can utilize a vehicle is an important consideration, but one that is ultimately left for future research. Along these lines however, as adults age, it can affect their ability to utilize transit or pedestrian modes as well.

Chapter 6 Mapping Framework for Understanding Accessibility

Having collected the spatial data and selected the measurement approaches for assessing aging people's accessibility, we produced a series of tabular summaries in Chapter 5 that gave a broad sense of how different populations experienced opportunities. However, utilizing these collected resources, it is possible to engage in mapping activities that identify particular geographical areas of interest for further analysis, investigate accessibility differences among and across neighborhoods, and focus at smaller geographical scales on disparities. With our collected information in a GIS, it is possible to query and map any number of attributes, at various locations, scales, and extents. Here, we focus on five mapped examples that serve to illustrate the nature of the analysis possible with data/approaches such as ours. These examples could be insightful to planners, agencies, stakeholders, and citizens who are interested in more detailed accounts of accessibility tracking for aging populations. They were chosen based on a careful consideration of the study area geography; to incorporate scenario diversity into a range of realistic applications. The scenario examples focus on auto-based accessibility and make use of the minimum time to nearest facility approach.

Example 6.1: East Side Accessibility to Restaurants

Figure 6.1 shows a map of accessibility to restaurants on the eastern side of Leon County. This is near the Capital Circle/U.S. 90 intersection (a major commercial area) and includes part of the 'Buck Lake' neighborhood area, and the map shows accessibility to restaurants by census block, showing the aging population (those 65+) as a scaled symbol theme on each block as well. Darker areas correspond with those places that have a higher minimum travel time necessary to reach their nearest restaurant (i.e., locations with poorer access to restaurants). From a correlative perspective, it could be viewed negatively to have larger numbers of aging populations with higher minimum times to a particular service. Maps such as 6.1 can be used to identify such disparities and problem areas.

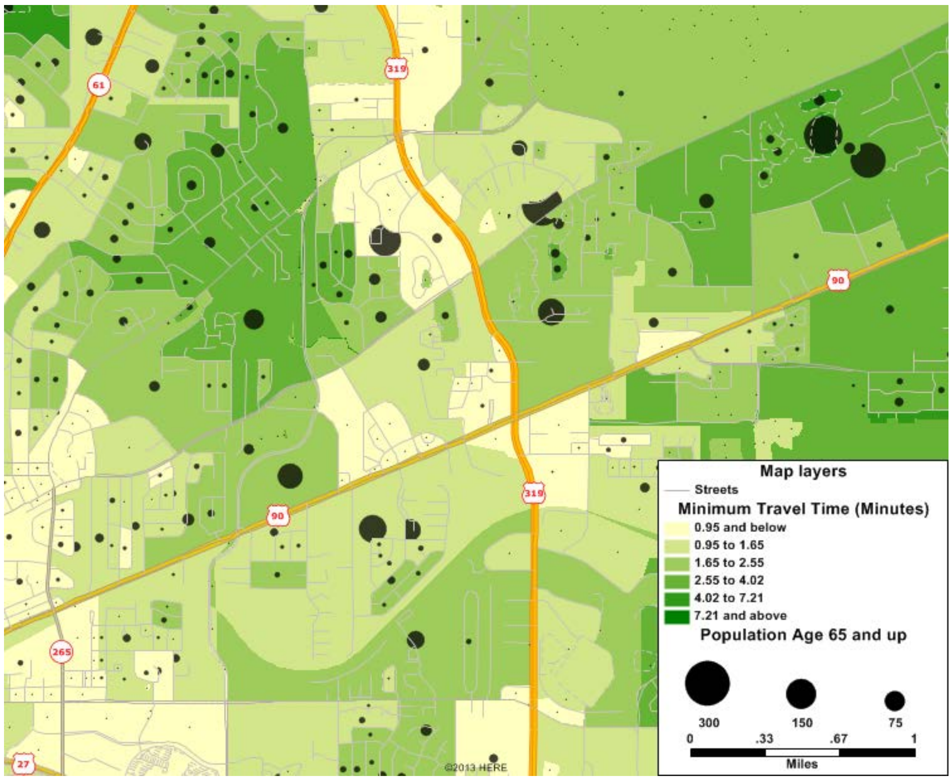

Figure 6.1: Minimum Travel Times to Nearest Restaurant by Block, East Tallahassee

Example 6.2: Florida A&M University Area Accessibility to Health Facilities

Figure 6.2 focuses on the area around Florida A&M University and maps the minimum time to health facilities. Florida A&M University is a major institution of higher learning. It too shows counts of aging people (those 65+) by block. The map also includes a large area of South Monroe Street, a major thoroughfare running north-south through the city of Tallahassee, which contains a substantial amount of commercial development. Patterns of accessibility are evident from the map.

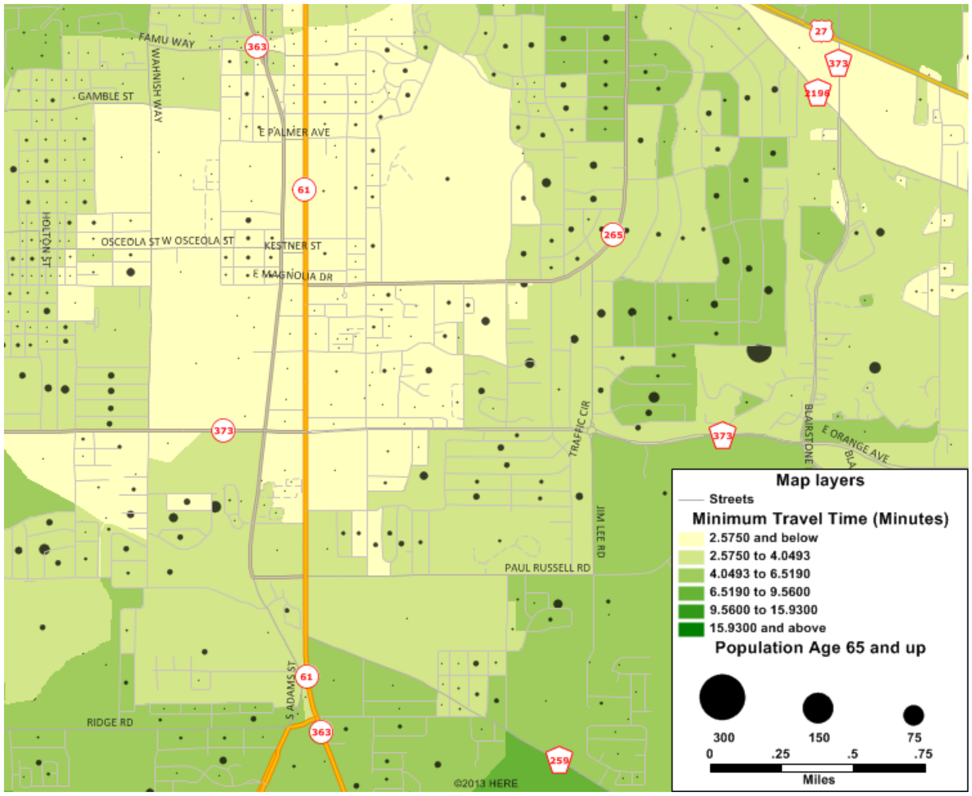

Figure 6.2: Minimum Travel Times to Nearest Health Facility by Block, South Tallahassee

Example 6.3: North Monroe Area Accessibility to Financial Service Locations

Figure 6.3 mirrors the prior figures in its construction, but shifts its focus to the area around the I-10/North Monroe intersection, and looks at financial services locations. Similar to the South Monroe Area depicted in the prior map, North Monroe is also largely commercial in nature with heavy retail throughout the area.

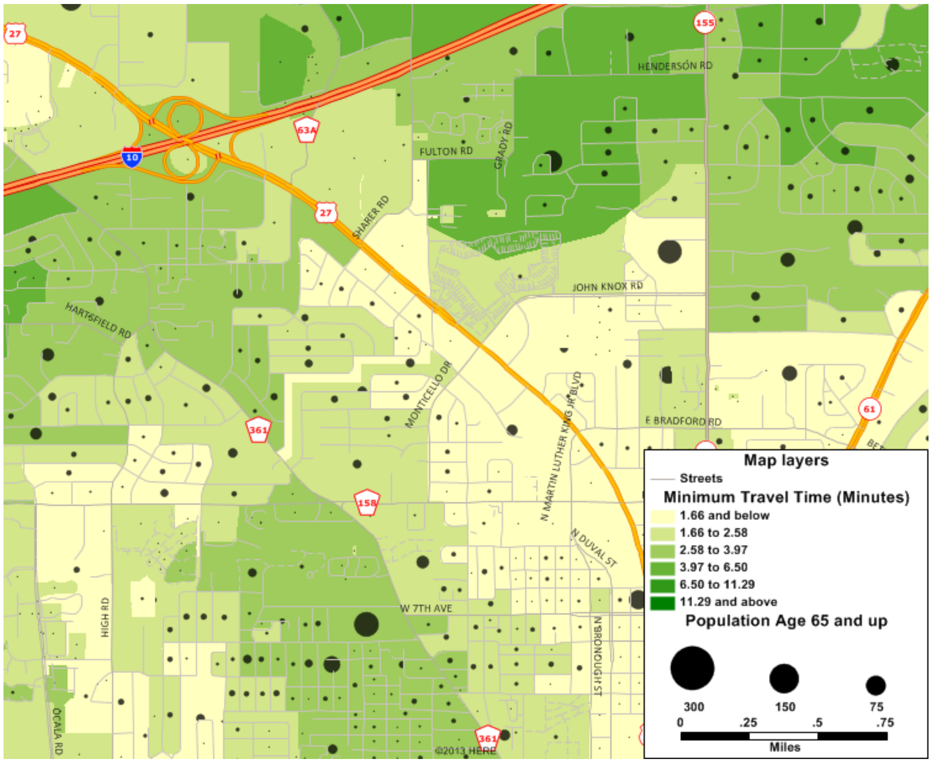

Figure 6.3: Minimum Travel Times to Financial Services by Block, North Tallahassee

Example 6.4: Larger-scale Accessibility to Park Locations

Figure 6.4 represents a shift to a larger map extent covering a wider portion of the county in the view. It also reflects a change in the mapped population to show those persons older than 85; the oldest of the aging cohorts. At this scale it is more difficult to see neighborhood level disparities in accessibility but broader trends are discerned. The attribute of interest is access to park locations and darker colors indicate lower levels of accessibility, as measured by the closest-activity approach.

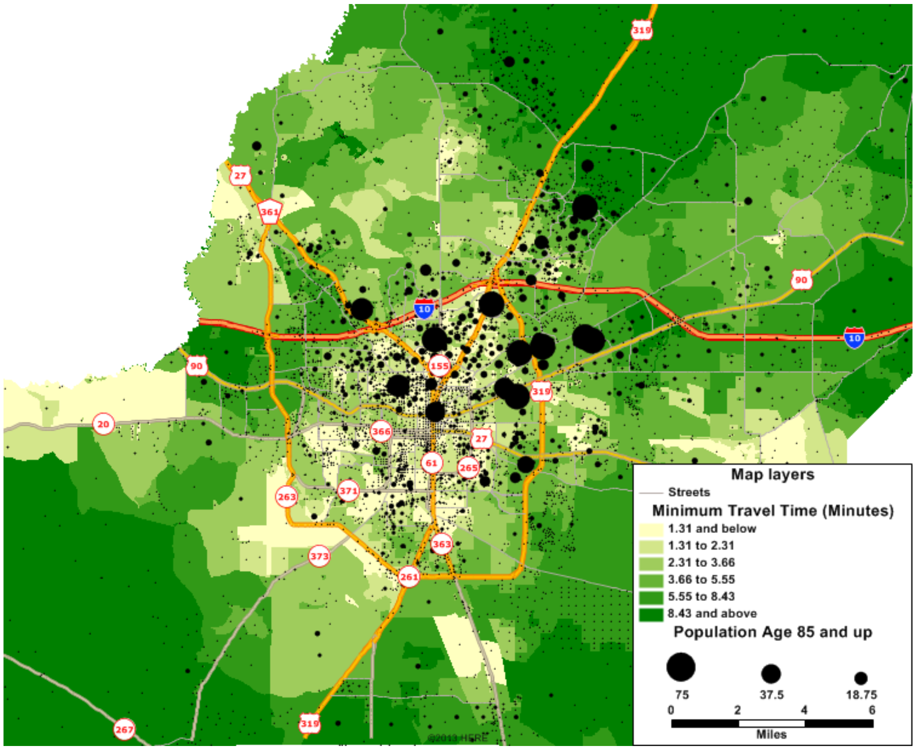

Figure 6.4: Minimum Travel Times to Parks by Block, Greater Leon/Tallahassee

Example 6.5: Larger-scale Accessibility to Library Locations

Similar to Figure 6.4, Figure 6.5 maintains the larger map extent covering a wider portion of the county in the view, but returns to look at the population 65+ and considers library locations.

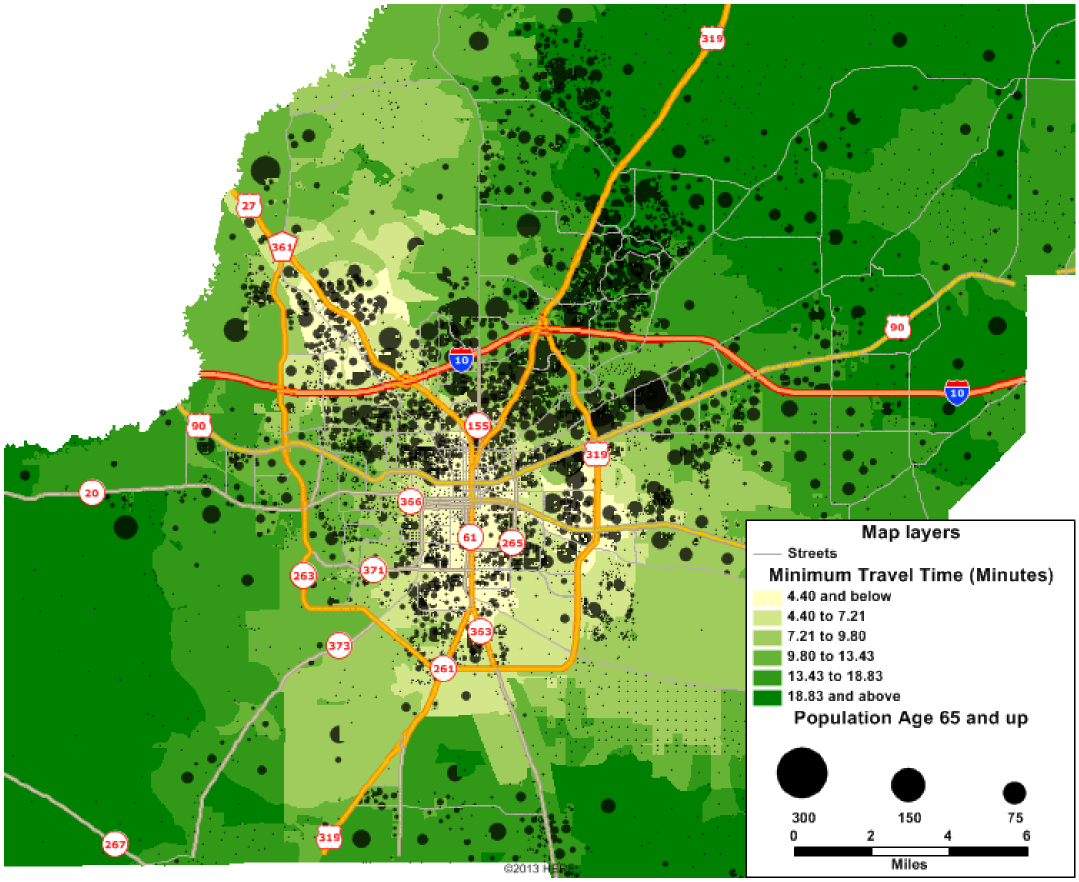

Figure 6.5: Minimum Travel Times to Libraries by Block, Greater Leon/Tallahassee

6.6. Summary

The examples we showed here are but a few of the possibilities available in mapping accessibility for the study area. With the spatial data resources collected and archived in the GIS, various attributes and extents may be mapped to visualize areas and identify issues of interest to a given constituency or audience. Often times this can result in disparities being unearthed, which can help guide planning policies an interventions.

Chapter 7 Summary and Conclusions

This project represents our efforts to look at the spatial accessibility patterns of aging populations. We considered a wide range of possible activities and used highly spatially disaggregate data, hence avoiding issues that stem from using more coarse areal units. Judging from the tabular results presented in Chapter 5, the urban structure of Tallahassee and Leon County favors the youngest age group in terms of proximity to activities. Further, the results suggest the middle age range of the population have the lowest levels of accessibility, which raises longer-term questions about their future ability to secure goods and services, particularly as they approach retirement age. This likely relates in part to the residential locations selected by many in this population group. As these age ranges typically represent post childrearing years, many in this group may have selected more suburban locations in Tallahassee and Leon County that had offered them access to good schools, green space, and other amenities such as larger lot sizes. This assertion is consistent with life course theory which suggests this outcome as a possible location pattern for middle-aged populations (Kim, Horner, and Marans 2005).

The fact that the aging population group does not tend to have the lowest levels of accessibility can be viewed positively. However, this finding should be viewed in light of issues with retirement homes in Leon County. While we have no specific data breaking the aging population down into those living independently vs. those in retirement, assisted living and related facilities, anecdotally many of these homes are in accessible locations. Thus from a spatial perspective, many aging are well-positioned to remain active within society. However, from a mobility perspective, many may not be able to take advantage of this accessibility, particularly auto-based accessibility, because of personal constraints on their ability to travel, such as health, lack of available transportation, etc.

Moreover, the limited walk access demonstrated in our analysis may not bode well for aging people who begin to drive less and must rely more on the walk mode. One can question whether they will have substantial choices in terms of nearby pharmacies, libraries, and other destinations critical to having a high quality of life. Many aging individuals reside in suburban locations and depend mostly on the personal automobile. Clearly this raises concerns that when driving cessation commences due to potential disabilities and other conditions of growing older aging populations will face major transport difficulties (DeGood et al. 2011).

The mapping examples undertaken revealed the diverse range of information that can be gleaned from our collected spatial data resources. Potentially any attribute for any set of areas may be explored in more detail relative to population subgroups of interest to identify accessibility differentials. The collected data and range of activities considered can serve as a possible template on which others build or emulate. With the widespread availability of spatial data resources, coupled with capable, robust GIS tools, accessibility analyses are well within reach for a range of groups.

Future research on this topic is wide open. Besides adopting additional types of accessibility models such as gravity based approaches, and exploring other forms of medical location and opportunity data, future research could also include additional disaggregation to account for the aging population living in retirement homes, assisted living facilities, and other group type quarters which would facilitate an even more detailed understanding of aging accessibility in Leon County.

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