TESTING A METHODOLOGY FOR CALCULATING THE IMPLICATIONS OF LAND DEVELOMPENT PATTERNS ON TRIP LENGTHS, AND GHG EMISSIONS IN ALACHUA COUNTY, FLORIDA

By

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To my family

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LIST OF ABBREVIATIONS

CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DCA	Department of Community Affairs
DOE	Department of Energy
DULA	Dense Urban Land Areas
ECSC	Alachua County Energy Conservation Strategies Commission
EECBG	Energy Efficiency and Conservation Block Grant
EISA	Energy Independence and Security Act
EPA	Environmental Protection Agency
F.S.	Florida Statute
FDOR	Florida Department of Revenue
GHG	Greenhouse Gas
GMA	Growth Management Act
HBO	Home Based Other Production
HBW	Home Based Work Production
ICLEI	Local Governments for Sustainability
LEED	Leadership in Energy and Environmental Design
NHB	Non-Home Based Production
RTS	Gainesville’s Regional Transit System
SGI	Smart Growth INDEX
VMT	Vehicle Miles Traveled
VT	Vehicle Trips

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Over the past decade there has become an unprecedented awareness of the impact of global climate change, greenhouse gas (GHG) emissions and the need to increase energy efficiency in our daily lives. As a result Alachua County and the City of Gainesville are receiving pressure from the state and various government agencies to reduce GHG emissions. With transportation accounting for approximately one third of GHG emissions in the United States, it is imperative that these local governments look for ways to reduce emissions from the transportation section, specifically through the reduction of vehicle miles traveled (VMT). Research has shown that land development patterns have the ability to influence VMT. However this research has predominately been conducted in areas on the west coast of the United States and cannot be applied to Alachua County due to differences in land development patterns.

In order to provide a more accurate representation on the affect land use has on trip length (one aspect of VMT), this research uses models adopted from a Southeast Florida study as an analytical tool to diagnose how land use patterns specific to Alachua County may affect trip length. These models are validated as an appropriate

measurement of this relationship by studying three neighborhoods, representing different land development types, within the County. Because future land use patterns are greatly influenced by policies included in local comprehensive plans, the results of these models are used as a tool to determine what the City and County's comprehensive plans need to change in order to promote land use patterns that decrease trip length.

This research has found that the models utilized in this research are a useful tool for local planners to determine areas that contain land use characteristics that have the potential to decrease trip lengths. The results of the models found that areas located closer to the City of Gainesville's City Center contained the most suitable land use characteristics that have the potential to decrease trip lengths. These models also helped indicate the areas where local comprehensive plans should include policies that encourage compact development to meet the increasing demands to reduce GHG emissions from the transportation sector.

CHAPTER 1
INTRODUCTION

Over the past decade there has become an unprecedented awareness of global climate change, greenhouse gas (GHG) emissions and energy efficiency. So much so, that words like climate change, sustainability and “green” have become part of our every day vocabulary. As a result there has been a movement towards more sustainable building practices and lifestyles; however, our current land development patterns do not reflect this new area of concern.

Since World War II the United States has predominately grown outwards in a relatively low-dense, discontinuous, suburban development pattern. This spread out pattern of development, also known as sprawl, has only been made possible by the automobile (Ewing, 1997). Through rising incomes, increasing percentages of automobile ownership and public policies, such as public investment in extensive road networks, sprawled development continues to be the dominate development type in America.

Existing literature argues that sprawled development uses more energy than traditional neighborhoods (Newman and Kenworthy 1989; Holtzclaw, 1990 as cited in Handy, 1996; Frank and Pivo, 1994; and Kenworthy 1999; Ewing and Cervero, 2001; Bento et al., 2005; Brownstone and Golob, 2008; Transportation Research Board, 2009). In conjunction, it is now widely accepted that climate change is occurring at an unprecedented rate due to human activity. The Intergovernmental Panel on Climate Change (IPCC) scientists “believe that it is very likely (greater than 90% chance) that most of the warming we have experienced since the 1950s is due to the increase in greenhouse gas emissions from human activities” (IPCC, 2007). Greenhouse gases –

consisting mainly of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) – contain heat trapping properties that are attributed to the cause of climate change (EPA, 2009). Climate change potentially brings with it a long list of impacts to ecological systems, agriculture, public health, infrastructure, and commerce (U.S. Department of Transportation, n.d.). On December 7, 2009, the Administrator of the EPA found that these gases in the atmosphere were an endagerment to human health that threaten the public health and welfare of current and future generations (EPA, 2009).

The human activities that are attributed to the rise of GHG emissions are mainly from the residential, commercial, institutional and transportation sectors. According to the U.S. Department of Transportation (n.d.) “energy burned to run cars and trucks, heat homes and businesses, and power factories is responsible for about 80% of the U.S. society's carbon dioxide emissions, about 25% of U.S. methane emissions, and about 20% of global nitrous oxide emissions.” The rate at which these gases are being released into the atmosphere is steadily increasing. Total emissions from the residential, commercial and transportation sectors each increased by more than 25% during the past 25 years (US Department of Energy, 2008). In the future, residential, commercial buildings, and road transportation are expected to continue to dominate energy demand and carbon growth in the United States. As a result, there has been increasing efforts to find ways to curtail the rate of GHG emissions and improve energy efficiencies through public policy and voluntary energy rating systems, such as LEED and Energy Star. However, many of these policies and programs fail to recognize land development pattern's influence on the transportation sector as a way to mitigate energy consumption and GHG emissions.

The transportation sector is one of the largest contributors to GHG emissions. Transportation on U.S. roads and highways totaled 3 trillion VMT, in 2007, and consumed about 176,100 million of gallons of gasoline (FWHA, 2009). Between 1970 and 2005, the average annual VMT per U.S. household increased by almost 50%, to 24,300, as vehicle ownership per household increased even as household size fell (BTS, 2007; Brown, Southworth and Sarzynski, 2009).

There has been increasing awareness of the linkage between fuel consumption and the creation of Carbon Dioxide (CO_2). According to the U.S. Environmental Protection Agency, "80% of U.S. carbon dioxide emissions come from the use of coal and petroleum fuels" (US Department of Energy, 2007a). EPA's 2007 U.S. GHG inventory found that the transportation sector was the second largest emitter of carbon dioxide equivalent (CO_2e), producing 2,036.4 million metric tons of CO_2e. While it is not the largest source of CO_2e emissions, the transportation sector releases the greatest amount of CO_2 emissions (1,902.5 million metric tons of CO_2) than any other sector (US Department of Energy, 2007b). About 80% of GHG emissions from transportation are highway (auto, truck, and bust) transport, with air-, water- and rail-based transport responsible for most of the remainder (Brown, Southworth and Sarzynski, 2009). Thus transportation is a major factor that needs to be included in discussions related to slowing the rate of climate change and reducing GHG emissions.

The responses to climate change are ultimately local and regional. As a Result, the City of Gainesville and Alachua County are receiving increasing pressures from the state and federal government to reduce GHG emissions. The implementation of recently passed legislature will make it mandatory for local governments to monitor GHG emissions and create action plans to reduce their emissions. As of July 1, 2008, the Florida Legislature made changes to Chapter 163, Part II, of the Florida Statutes, included in House Bill 697 and codified in the Laws of Florida Chapter 2008-191, concerning the inclusion of energy reduction strategies in the local comprehensive plans. This bill is avant-garde in that it recognizes the occurrence of climate change due to human activities and the role local governments can play in slowing down the rate of this occurrence.

Section 163.3177 (6) (a), F.S. states that the future land use section shall be based on “the discouragement of urban sprawl; energy-efficient land use patterns accounting for existing and future electric power generation and transmission systems; greenhouse gas reduction strategies” (Laws of Florida Ch 2008-191, p. 4, 2008). Section 163.3177 (6) (b) F.S. states that local comprehensive plans will be required to incorporate transportation strategies to address reduction in GHG emission from the transportation section in the Traffic Circulation Element. Section 163.3177 (6) (d) F.S. requires the future land use map to identify and depict areas of energy conservation. Section 163.3177 (6) (h) requires the housing element to contain principles that pertain to the energy efficiency in the design and construction of new homes.

The reduction of energy and GHG emissions is also endorsed at the federal level. On December 19, 2007 the Energy Independence and Security Act (EISA; Pub. L. no 110-140) created the Energy Efficiency and Conservation Block Grant (EECBG) Program (ICLEI, 2009). The program was established to provide federal grants to assist local government in implementing strategies that reduce fossil fuel emissions, total energy used by eligible entities and to improve energy efficiencies.

As part of the American Recovery and Reinvestment Act, EECBG funds are being awarded to US states, territories, local governments and Indian tribes to lower energy use and reduce carbon pollution. To date, the Department of Energy has awarded more than 1,800 Energy Efficiency and Conservation Block Grants totaling over two billion dollars (DOE, 2010).

The newly established requirements put in place by the HB 697 and the incentive funding from the EECBG funds provide urban planners an opportunity to implement strategies to reduce energy and GHG emissions in their local municipalities, especially through reductions in VMT. Research has shown that land development patterns have the ability to influence VMT. However this research has predominantly been conducted in areas located on the west coast of the United States and cannot be applied to Alachua County due to differences in land use patterns. As a result this study uses models derived from Southeast Florida to attempt to capture the characteristics of land use patterns unique to Florida. These models are used to map the locations where the land use patterns are more favorable towards the reduction of trip length (one aspect of VMT), in Alachua County. They are validated as an appropriate measurement of this relationship by studying three neighborhoods, representing different land development types, within the County. Because future land use patterns are greatly influenced by policies included in local comprehensive plans, the results of these models are used as a tool to determine what the City and County's comprehensive plans need to change in order to promote land use patterns that decrease trip length.

The focus of this research is to show a connection between land use patterns and trip lengths in Alachua County. In this research, trip lengths are used as a proxy for measuring GHG emissions. If individuals drive more vehicle miles (or in this study's case have longer trips) they will consequently emit more GHG emissions into the atmosphere. The researcher's hypothesis is that Alachua County's land use patterns do have an inverse relationship with trip lengths. In other words, areas possessing land use characteristics such as compact and diverse development will experience shorter trip lengths than areas that are less compact and less diverse. If this is the case, this research will support the idea that local governments can help reduce GHG emissions released into the environment by encouraging policies that promote compact, diverse development in areas that are more conducive to reduce trip lengths as indicated by the models.

The overall intent of this study is to:

- Provide further insight of the possible impacts that land use patterns in Alachua County poses on trip lengths
- Raise awareness of the relationship between land use patterns and the GHG emissions from the transportation sector.
- Evaluate Local Comprehensive Plans to determine if they incorporate effective policies that encourage compact development as a means to reduce GHG emissions from the transportation sector.

Following this introduction, the document is organized to include chapters summarizing the existing research, research methodology, results, and conclusions. Chapter 3 sets forth the methodology, Chapter 4 and 5 presents' findings, and Chapter 6 offers discussions on the results, limitations and challenges, and the overall significance of the study.

CHAPTER 2
LITERATURE REVIEW

This chapter provides a review of the literature pertaining to the relationship between the built environment, VMT and energy consumption. Overall the research has found that the built environment has multiple dimensions that affect VMT. These dimensions include but are not limited to density, the mix of land uses, employment density, residential density, spatial arrangement of land uses and design. The review of literature begins by providing a brief overview of the current dominate land development pattern, urban sprawl, in contrast to compact development. Then the remaining portion of the literature review summarizes the existing literature that examines the relationship between the built environment and VMT. The two dominate study design types in the literature are aggregate and disaggregate studies. The aggregate studies use census track and traffic analysis zones to explore the relationships while disaggregate studies use individual travel behaviors as the unit of analysis. Existing research is analyzed on both methodology used and the findings of statistically significance results. The studies are also analyzed on whether the context of the study is applicable to Alachua County. Finally the literature review concludes with an analyzes of a recent study that forecast estimates on the potential impact that changing our development patterns could have on household VMT and energy consumption.

Urban Sprawl

Urban sprawl is a multidimensional issue, which has been at the forefront of many planning debates. The term was first used in its modern sense in 1937 by Earle Draper – “one of the first city planners in the southeastern United States” (cited in Nechyba and Walsh, 2004, p. 1; Black, 1996). By the end of WWII, the major debate on the positive and negative externalities of sprawl had fully emerged. Sprawled development has flourished and spread just as fast as the controversy that surrounds it. Since the 1950 census, data has become readily available documenting the rise of sprawled development (Nechyba and Walsh, 2004). Over the past sixty years, American's have drastically changed their place of residence. "Approximately 65% of the urbanized population lived in central cities in 1950, with the remaining 35% residing in suburbs. By 1990, these percentages had flipped, with central city populations down to 35 of populations within these urbanized areas" (Nechyba and Walsh, 2004). This increasing growth of development in the suburbs continues to raise many questions with regards to whether sprawled development is a desirable and sustainable urban form.

Throughout the years sprawl has been defined by what it is not, rather than what it is (Ewing 1994). In many cases sprawl has been defined in contrast to compact development (Ewing, 1994). Sprawl development lacks the high-density, centralized development, open space and a spatial mixture of functions that the ideal compact city possesses. Today, a commonly accepted definition of sprawl is expressed by Ewing (1997, p. 32) as "(1) leapfrog or scattered development; (2) commercial strip development; and (3) large expanses of low-density or single-use developments- as well as by such indicators as low accessibility and lack of functional open space."

Many proponents of sprawl argue that this form of development is not as bad as planners and policy makers make it out to be (Gordon and Richardson, 1997). They argue that sprawl is the dominate form of development because it provides people with the means of achieving the "American Dream." In other words, urban sprawl provides more square feet of housing for less cost, more privacy, improved schools and a perceived sense of safety (Linberger, 2008). Therefore authors such as Gordon and Richardson (1993, 1997) argue that urban sprawl is the product of the market, consumer preference and technological advancements and thus an attempt to reverse the current trends to more compact development is not feasible or desirable. On the other hand, opponents of sprawl link this type of urban form with automobile dependence, social segregation, ecosystem degradation, increases in greenhouse gas emissions, health implications such as obesity, increase oil dependency and increased cost of public amenities incurred by the public and local governments (Ewing, 1997; Speir and Stephenson, 2002; Carruthers and Ulfarsson, 2003; Leinberger, 2008).

As its consequences suggest, both good and bad, urban sprawl is a multidimensional issue possessing many forms and degrees. Some of these dimensions include but are not limited to density, the mix of land uses, employment density, residential density, spatial arrangement of land uses and design (Ewing and Cervero, 2001).

Built Environment – VMT Connection

There is an extensive literature that examines the relationship between the built environment and VMT. Study designs are generally of two types: aggregate studies and disaggregate studies. Aggregate studies consider relationships at a level of aggregation such as census track or traffic analysis zone, while disaggregate studies use individual travelers as the unit quality. There is overwhelming consensus that density is an essential dimension of land development patterns. It is also the most commonly used measure of the built environment because it is readily measured and easily replicated. Therefore, density is the dominate dimension of the built environment used in all of the studies examined in this paper. However, research suggests that density by itself does not give the full picture of the built environment’s affect on VMT, but dimensions such as mix use and accessibility should be included (Ewing and Cervero, 2001; and Brownstone, 2008). VMT itself is a composite measure - a product of trip length, trip frequency and mode choice (Ewing and Cervero, 2001; Transportation Research Board, 2009). A review of the literature has shown that different combinations of the characteristics of the built environment and VMT have been used in various studies and models to attempt to depict an accurate relationship between the built environment and VMT.

The following sections provide a summary of what is known about the relationship between the built environment and VMT from the current literature. For the purpose of this study, the following research is analyzed on the context in which the study takes place and the findings of statistically significance results. For organizational purposes the exiting literature is categorized by the type of study.

Aggregate Studies

When comparing average travel characteristics in neighborhoods of different design or cities of different densities, researchers mainly use aggregate studies. Generally, this type of research helps to quantify the potential impact of the built environment on overall travel by using simple correlations and comparisons as well as regression procedures (Handy, 1996). The majority of these studies that look at the built environment and VMT have found a highly significant inverse relationship. For example, households that are located in more compact developments will have fewer household VMT. However as, this paper will point out, aggregate studies tend to mask the differences within metropolitan areas, and fail to account for self-selection and socioeconomic characteristics, such as income, household size and employment. By not accounting for self-selection and socioeconomic characteristics, researchers are not able to determine the causal relationships, if there are any, between the built environment and VMT.

A widely cited and debated study (Newman and Kenworthy, 1989; Newman and Kenworthy, 1999) compared 32 international cities to evaluate the physical planning policies for conserving transportation energy in urban areas. They found that per capita gasoline consumption – a proxy for automobile use – is higher in U.S. cities than abroad. Residents of American cities consumed nearly twice as much gasoline per capita as Australians, nearly four times as much as more compact European cities and ten times that of three compact westernized Asian cities, Hong Kong, Singapore and Tokyo (Newman and Kenworthy, 1989). The authors attributed this to the lower metropolitan densities found in the United States. In 1999, they conducted a follow up study of 37 international cities and again found a direct link between low-density cities, particularly in the U.S. and Australia to higher gasoline consumption per capita. While the authors find a highly significant inverse relationship between density and VMT, their results should be used with caution due to methodological flaws such as its inability to be generalized across different areas of the United States and accounting for residential self selection (Gordon and Richardson, 1989; Handy, 1996; and Brownstone, 2008).

First there is a fundamental issue in comparing international cities due to differences in culture, governance, income levels and fuel prices. The authors simplify the measure of density and fail to account for some of its complexities. Since the authors are looking at metropolitan areas as a whole, their results mask the differences in the densities within these metropolitan areas. In addition, by not encompassing the neighborhood differences in each of the metropolitan area, they are not taking into account socioeconomic characteristics that are shown to influence individual travel behaviors, including the use of public transit.

A study with similar findings (Holtzclaw, 1990 as cited in Handy, 1996) analyzed five neighborhoods in the San Francisco Bay Area, using data from biannual odometer readings to determine each neighborhood's total travel. The neighborhoods ranged from "traditional" neighborhoods to low-density suburban neighborhoods with three households per residential acre, and were characterized in terms of net household density, gross population density and local job serving density. Density was used as a determinate of transit service and accessibility to shopping, jobs, entertainment and recreation. The annual VMT was calculated across each neighborhood, and then used to calculate a non-linear relationship between density and VMT. The study's results suggest that residents of higher density neighborhoods drove less by up to 30% per household.

One of the major flaws in this study was that new cars in the San Francisco Bay Area do not have to participate in the odometer readings until they are two years old, thus excluding a sizable portion of the research population. In addition, as with the previous study, socioeconomic factors were not factored into the analysis. The results are also limited by the fact that the study did not factor in the importance of accessibility to different activities and transit.

In 1994, Holtzclaw et al. updated their previous work by expanding the number and location of neighborhoods and by including other determinates of the built environment using a transit accessibility index, a neighborhood shopping index and a pedestrian accessibility index. Thus the authors began to overcome their previous study's limitation of simplifying characteristics of the built environment that are associated with difference in travel behaviors. Nevertheless, since this study only looked at each neighborhood as one entity, the authors were still not able to account for socioeconomic characteristics and self-selection within each neighborhood. In addition this study only looked at how the built environment and VMT are related in the San Francisco area, which has a relatively high density. This prevents this study from being generalized to areas that have a more dispersed pattern of development.

As a result of these flaws in aggregate studies, researchers started to incorporate components of disaggregate studies into their aggregate studies to account for self-selection and socioeconomic characteristics. For instance, an empirical analysis by Frank and Pivo, (1994) tested "the impacts of land-use mix, population density, and employment density on the use of the single-occupant vehicle, transit and walking for both work trips and shopping trips" (p. 44). They obtained Seattle Area data on household travel behavior and demographics from the Puget Sound Transportation Panel, and data on travel behavior, land-use density and land-use mix from the census tract. Because the authors incorporated trip distances and travel time for both work trips and shopping trips at the individual level, they were able to account for multiple characteristics of travel.

The study first correlated the built environment variables and percentage of trips from the three travel modes. Each correlation was calculated for both work trips and shop trips. Then, multivariate regressions equations were estimated at the census travel level with the dependent variables being the trips by mode and the independent variables being the built environment and socioeconomic variables. The results of Frank and Pivo's study suggest transit share of work trips is greater at higher employment densities; transit share of shopping trips is greater at higher population and employment densities; walk share of work trips is greater at higher population densities, at higher employment densities and in areas where there is a greater mixture of uses. Because this study accounted for socioeconomic variables, it provides a better understanding of the causal link between the built environment and VMT.

Disaggregate Studies

To account for the flaws in aggregate studies, the majority of recent studies have turned to disaggregate studies. In contrast to aggregate studies, these studies look at household and individual level travel data instead of neighborhood or zonal level (Handy, 1996). Therefore they are able to account for socioeconomic and travel characteristics as well as begin to control for residential self-selection. Disaggregate studies help contribute to the how and why urban form is linked to travel (Handy, 1996). It is important to note that some aggregate studies that take into account disaggregate variables are included in this section to help emphasize other important causal relationships.

"The Five Ds"

Furthermore, disaggregate studies tend to account for other dimensions of the built environment in addition to density. These dimensions are diversity, design, destination accessibility and distance to transit and are commonly referred to in literature by the shorthand "the five Ds." The original three Ds were coined by Cervero and Kockelman (1997) in their study of 50 residential neighborhoods in the San Francisco Bay Area. Using 1990 travel diary data and land use records obtained from the US Census, regional inventories and field surveys, they modeled the impact of density, diversity and design on VMT as well as their collective impact as a whole on VMT. They also accounted for socio- demographic data obtained from the 1990 Bay Area Travel Survey. This study was the first of its kind of research and found that "density, land-use diversity and pedestrian oriented designs generally reduce trip rates and encourage non automobile travel in statistically significant ways, though their influences appear[ed] to be marginal" (p. 1999).

When looking at each of the three main variables they found that compact development exerted the strongest influence on personal business trips and land use diversity strongly influenced mode choice especially for work trips. Their results were consistent with Ewing's (1994) arguments that many benefits of density may actually be co-existent with accessibility. Limitations in their study included its inability to be generalized, beyond the San Francisco Bay Area, and the lack of data availability for the Bay Area population at large (the majority of the sample was wealthier than the average Bay Area resident). Overall they found modest but moderate results between the collective impact of density, diversity and design on household VMT.

Since Cervero and Kockelman's study, two more "Ds" have been added – destination accessibility, also referred to as regional destinations, and distance to transit. Destination accessibility refers to "the ease or convenience of trip destination from point of origin, often measured at the zonal level in terms of distance from the central business district or other major centers" (Transportation Research Board, 2009 p. 32). Recent literature has shown destination accessibility as an important variable when looking at household VMT (Ewing and Cervero, 2001).

A comprehensive literature review by Ewing and Cervero (2001), looked at more than 50 recent empirical studies to analyze the relationship between the built environment and travel behavior using the four Ds – Density, diversity, design, and destination accessibility (at the time of the study distance to transit was not included in "the Ds"). They used the results of these studies to "compute the elasticities of VMT and VT (vehicle trips) with respect to land-use and design variables" (p. 12). These elasticities were then entered in the U.S. Environmental Protection Agencies' Smart Growth INDEX (SGI) model. The SGI uses a "density measure (residents plus employees divided by land area) represents the construct "density;" a job/population balance measure is used to represent "diversity;" a combination of sidewalk completeness, route directness, and street network density is used to represent "design;" and an accessibility index derived with a gravity model is used to represent "regional accessibility" (p. 13). The model showed that when regional accessibility, density, diversity and design are accounted for together, they have a significant inverse relationship with VMT and VT.

The determinant, distance to transit has also gained increasing attention in recent research. As the name implies, distance to transit is the "ease of access to transit from home or work (e.g., bus or rail stop within ¼ - ½ mile of trip origin)" (Transportation Research Board, 2009, p. 32). A recent study by Chen, Gong and Paaswell (2007) incorporated transit accessibility into their model and found that it had a significant influence in determining the use of transit. Overall their study assessed the role density plays in mode choice decisions in home-based work tours while controlling for confounding factors. Using data collected from the New York Metropolitan region from

1997- 1998, the authors conducted a two-equation simultaneous system taking into account car ownership, the propensity to use the automobile, and multiple exogenous variables. They represented the built environment through measuring population and employment densities, job accessibilities, and distance to transit stops. After controlling for socioeconomic variables, the study's results suggested that density is still a major indicator in determining an individual's mode choice and trip travel. They found that "the right combination of a set of variables that includes cost-variables, job accessibility, density, and transit accessibility will likely encourage people to use transit for home-based work tours" (p. 296). Similar to previous studies, Chen, Gong and Passwell's research cannot be generalized beyond their study area due New York's unique high density development patterns.

Self selection

An important strength of disaggregate studies is that it accounts for self-selection and socioeconomic attributes. Self-selection accounts for individuals who choose their residential location based on their lifestyle preferences including preferred mode choice. An example of this would be a resident who chooses to live in a higher density, mixed-use neighborhood because they dislike driving and would rather bike or walk to places. In this case, self-selection would provide a causal link for why decrease was seen in VMT in the higher density neighborhood.

It is argued in the Transportation Board Research (2009) report that if self-selection is not accounted for the predicted impacts from aggressive land use policies could be over-estimated. This wrong prediction could consequently lead to a high opportunity cost. Nevertheless, even after socioeconomic variables and self-selection are accounted for, the majority of recent studies still find a strong correlation between density and travel. However there have been a few of studies that have found this not to hold true.

A study by Cao, Mokhtarian and Handy (2007) found accessibility to be the most important factor in reducing driving. The authors employed a structural equations model to investigate the relationship among changes in the built environment, auto ownership and travel behavior. Their study population was 547 movers (people who had moved residential locations within the last year) “currently living in four traditional neighborhoods and four suburban neighborhoods in Northern California” (p. 539). By using a quasi-longitudinal design and by controlling for residential preferences and travel attitudes they were able to take into account individual’s self-selection. The authors concluded that self-selection has a significant impact on the choice of residence, auto ownership and driving and walking behavior. In addition they found that “changes in the built environment have a statistically significant association with changes in travel behavior,” (p. 554) with accessibility having the greatest impact on travel behavior, even after controlling for socio-demographics and other exogenous variables.

Bagley and Mokhtarian’s (2001) study is one of the few studies that supports the idea that attitudinal and socioeconomic variables influence travel behaviors more than residential neighborhood type. Their study looked at five neighborhoods in the San Francisco Bay Area in 1993. The neighborhoods were characterized as either “traditional”, “suburban,” or a mix of the two. The data was collected through mail-out surveys and travel diaries from the neighborhood residents. Participants responded to 39 statements that dealt their attitudes to different variables attributable to travel behavior. These responses were then analyzed using a structural equations modeling approach. The results of the model suggest that “land use characteristics have little independent impact on travel behavior” (p. 295). However, this study consisted of a small sample size that only looked at one region. It is also biased towards long term residents, in that on average respondents had lived in the Bay Area for 25 years. Therefore it would be hard to generalize these findings to other areas. Another discrepancy in this study is that it looked at individual travel behavior rather than household travel. Therefore it does not account for the dynamics of household interaction on travel behaviors, which could drastically change the results.

In contrast to Bagley and Mokhatarian’s study, Holtzclaw, Clear, Dittmar, Goldstein and Hass’s (2002) study showed a significant relationship between the built environment and VMT even after accounting for self selection and socioeconomic characteristics. The authors took into account the variables: urban design, transportation infrastructure, auto ownership and distance driven. The traffic zones within three metropolitan areas – Chicago, Los Angeles and San Francisco – were used as the geographic unit of analysis, controlling for household size and income effects. The authors concluded that “urban design and transportation infrastructure have a highly significant influence on auto ownership and distance driven, […] even after the corrections for household size and income effects” (p. 25).

Overall a comprehensive literature review by Cao, Mokhtarian, and Handy (2008) assessed 38 studies that controlled for self-selection and found that the majority of the studies found that the built environment has a significant influence on travel behavior. They analyzed the literature to see the extent to which the observable patterns of travel behavior can be attributed to the residential built environment or be attributed to residents self-selecting a built environment that is consistent with their travel modes and land use preferences. The vast majority of the studies they examined found a statistically significant relationship between the built environment and VMT after self-selection was accounted for. However, a greater majority of the studies found that accounting for self-selection tended to decrease the strength of the relationship.

Comprehensive Look

A recent study that examines the “five Ds” and accounts for self selection and socioeconomic attributes was conducted by Bento et al. (2005). The authors used a disaggregate study to examine a variety of built environment variables and socioeconomic measures to determine the effects on the annual VMT of over 20,000 U.S. households in 114 U.S. Metropolitan Statistical Areas. The authors used the effects of city shape, density of the road network, and the job-housing balance, as determinates of the built environment. The automobile ownership and travel patterns of the households were drawn from the 1990 National Personal Travel Survey. Bento et al. used the data in two sets of disaggregate models. The first set of models looked at commute mode choice distinguishing between driving, walking/bicycling, commuting by bus and commuting by rail. The second set of models looked at the relationship between the number of vehicles owned and the miles driven per vehicle for households.

The results of the two models showed that “individual measures of urban form and public transit supply have a small but statistically significant effect on travel demand” (p.477). The findings suggest that the density of the road network, job-housing balance, city shape, population centrality, and rail supply all have a significant effect on annual household VMT. Nevertheless, the models propose that a “10% change in either the urban form or the transit supply variables is associated with at most a 0.7% change in average miles driven with the exception of population centrality which is associated with a somewhat larger, 1.5% change" (p. 475). As a result, the study implies that the built environment has a limiting impact on VMT and mode choice.

However what makes this study noteworthy is that Bento et al. took their estimated modes and applied it to the metropolitan area of Atlanta, which is one of the most sprawled out urban areas, and to the Boston Metropolitan Areas, considered to be one of the most dense and diverse urban areas. When travel data and travel behavior characteristics from Boston's built environment were applied them to Atlanta's built environment they found that household VMT could be lowered by as much as 25%.

Similarly, Brownstone and Golob (2008) found a significant inverse relationship between residential density and vehicle usage. They analyzed the impact of residential density on vehicle usage and energy consumption in California using data from the 2001 National Household Travel Survey. Their structural equations model included three endogenous variables – annual VMT, annual fuel usage and housing units per square mile – along with multiple socioeconomic variables including self-selection. The results implied that "when comparing two households that are similar in all respects except residential density, a lower density of 1000 (roughly 40% of the mean value) housing units per square mile implies a positive difference of almost 1200 miles per year (4.8%) and about 65 more gallons of fuel per household (5.5%). […] Increased mileage lead to a difference of 45 gallons, but there is an additional direct effect of density through lower fleet fuel economy of 20 gallons per year, a result of vehicle type choice" (p. 97). They also found that the most important socioeconomic factors included the number of household drivers and the number of workers, with education and income also being significant.

While the authors found a significant relationship, they do not recommend that policies be put in place to encourage more compact development. They concluded that "it would be difficult to increase the density of an established urban area by 40%" (p. 97). They based their argument off of historic development patterns that showed that the average U.S. city saw a decrease in population density by 36% between the years 1950 and 1990. Thus Brownstone and Golob are assuming, the current trend of predominately suburban development will continue. However with the rising oil and energy prices and a growing environmentally conscious population it is hard to believe that the current development trend will proliferate.

A study by Kahn (2000) likewise suggests that instead of creating policies that encourages more compact development, we should focus on improvements to fuel efficiency technology. Kahn's research looked at how suburban development impacted the environment using the variables vehicle miles, residential energy consumption, housing lot size, household income and size and county farm acreage in a cross-sectional regression. Using the 1995 Nationwide Personal Transportation Survey (NPTS) to study the driving patterns and land consumption of 22,000 city and suburban household, Khan found that "suburban households drove 31% more than their urban counterparts" (p. 571). However he concluded that the only way to decrease the emissions generated from this increase in travel is through the improvement in automobile fuel efficiencies. However, Kahn's conclusion fails to take into account the rebound effect of more fuel efficient vehicles.

Past studies have showed that a rebound effect for motor vehicles, by which improved fuel efficiency causes additional travel, does exist to some extent. A study by Small and Van Dender (2006) looked at pooled cross sectional time series data from the U.S State level for the time period of 1966 – 2001. Their model accounted for income, urbanization and the fuel cost of driving and distinguishes between autocorrelation and lagged effects. The model estimated that “the rebound effects for the U.S. as a whole are 4.5% in the short term and 22.2% in the long term” (p. 2). Their research differed from past research on the rebound effect that they found evidence that the rebound effect diminishes with income with the possibility of increasing with fuel cost of driving. A flaw in this research is that it did not account for changes in transit accessibility and other factors that could affect an individual’s mode choice. Nonetheless, it provides evidence that we cannot solely rely on improvements in automobile fuel efficiencies to lower the GHG emissions from the transportation sector.

Norman, MacLean, M.ASCE and Kennedy’s (2006) research takes a more holistic approach to deciphering the built environments relationship with energy consumption and GHG emissions. Their study used density as a proxy to energy usage for both the transportation and residential sectors. The authors compared energy usage of a complex with high residential density and a neighborhood with low residential density using a Life Cycle analysis approach. Their research was able to quantify the energy used to produce the building materials and to construct the infrastructure, the energy used for building operations and the energy used for transportation over the whole life of the building. The research involved two case studies in the area of Toronto, Canada: a high density residential development and a low density residential development. The low-density residential case study was a subdivision located on Toronto's suburban fringes and the high-density case study was "a compact, multistory condominium project located near the inner core of the City of Toronto. The authors found that "transportation contributes far more significantly to overall energy use and GHG emission in low-density development context than a high density development" (p. 18). This study starts to provide a complete picture on how density affects the energy used in both the utility and the transportation sides. However this research only looks at two case studies in the Toronto area, thus it cannot be generalized to the general public, especially to Florida due to the differences in climate and overall development patterns.

Forecasting VMT Reduction due to More Compact Development

The Transportation Research Board (2009) used previous reviews of literature to develop "estimates of the potential savings in VMT, energy use and CO2 emissions from more compact, mixed-use development" (p. 93). The board conducted analysis of three scenarios, two low-end estimates of density, and a high-end estimate density, to predict the reductions of VMT in 2030 and 2050 due to more compact and mixed-use development. The first scenario assumed that 25% of all new growth would be more compact and that there would be a 12% reduction in household VMT. The second scenario assumed that 75% of all new growth will be more compact and that there would be a 25% reduction in VMT. The third scenario assumed that 25% of all new growth would be more compact. However due to technology advancements in the improvement in gasoline internal combustion in automobiles, there will only be a 5% reduction in emissions due to VMT. All of the scenarios assumed that reductions seen in CO2 emissions were proportional to reductions in VMT.

The forecasted results showed an overall decrease in VMT in cases where new development is more compact and contains a mixture of uses. The first scenario that assumed a 25% increase in density and a decrease in VMT by 12% saw a reduction in "VMT, energy use and CO2 emissions of nearly 1 to 1.2% by 2030" (p. 96) and a reduction of nearly 1.3 to 1.7% by 2050. The second scenario, that assumed a 75% increase in density and a decrease in VMT by 25%, saw a reduction in VMT, energy use and CO2 emissions of nearly 8% by 2030 and nearly 8 to 11% by 2050. The third scenario, that assumed a 25% increase in density but only a 5% reduction in VMT found that even by 2050 the reductions in VMT, energy use and CO2 emissions would be less than 1%. Therefore the "reductions in VMT, energy use and CO2 emissions resulting from compact, mixed-use development are estimated to be in the range of less than 1% to 11% by 2050" (pg 96).

Summary

An extensive amount of literature has been developed on household VMT and development patterns. Overall existing research has found that more compact development patterns are likely to reduce VMT, however to different extents in different contexts. The most recent and reliable studies have estimated that developing more compactly can reduce VMT as much as 25%. Unfortunately due to the fact that the majority of existing research has focused on specific neighborhoods that are generally located on the west coast of the United States and are characterized by higher densities, their results cannot be generalized across the rest of the nation and especially cannot be generalized to Alachua County, Florida. Therefore, while research shows that it is extremely probably that more compact development will reduce VMT, there is still a need for more research to be done in order to determine the extent to which land development patterns impact trip lengths in Alachua County, Florida.

The next chapter presents the research methodology used in this study to examine the relationship between land use patterns and trip length in Alachua County, Florida.

CHAPTER 3
METHODOLOGY

The focus of this research is to show a connection between land development patterns and trip length. In this research, trip length is used as a proxy for measuring GHG emissions. The idea being, if individuals drive further distances they will consequently emit more GHG emissions into the atmosphere. The researcher's hypothesis is that Alachua County's land development patterns have an inverse relationship with trip lengths. In other words, areas possessing land use characteristics such as compact and diverse development will experience shorter trip lengths than areas that are less compact and less diverse. If this is the case, this research will support the idea that local governments can help reduce GHG emissions released into their environment by encouraging policies that promote compact, diverse development in areas that are more conducive to reduce trip lengths as indicated by the models.

Overall this research hopes to achieve the two objectives outlined below.

1) To show a connection between the land development patterns and trip lengths and thus GHG emissions in Alachua County, Florida
    a) Provide insight on the possible impacts that land development patterns pose of trip lengths
    b) Raise awareness of the relationship between land development patterns and GHG emission from the transportation sector
2) Evaluate the local governments' comprehensive plans to see if they incorporate effective policies that encourage compact development as a means to reduce GHG emissions from the transportation sector.

The study will achieve these two objectives by first applying models, adopted from research conducted by Dr. Ruth Steiner, to map the locations where the land development patterns are more favorable towards the reduction of trip length. The research conducted by Steiner et al. (2010) included three main endogenous variables

–parcel characteristics, neighborhood characteristics**,** and origins proximity to major activity centers – to represent the land development patterns (also referred to as land characteristics). These variables along with other land-use characteristics are incorporated into models to predict trip-lengths. Analyzing the results from this study will provide a detailed account of land development patterns in Alachua County that are favorable towards shorter trip lengths.

To achieve the second objective, the study will perform a policy analysis on two local comprehensive plans – Alachua County's Comprehensive Plan and the City of Gainesville's Comprehensive Plan – to determine the extent to which the local governments promote compact development in appropriate areas as a means to reduce trip lengths and thus GHG emissions.

Study Area

Alachua County, Florida was selected as the study area for this research for several reasons. First and foremost, Alachua County has been at the forefront of the energy conservation movement. In 1991, the County started its initiative to curtail energy use by implementing the County Energy Management Program. Since then Alachua County has been striving to reduce energy consumption and its GHG emissions. In 2001, Alachua County conducted its first GHG inventory for the calendar year 1998. This inventory created a baseline that enabled the County to track and measure the success of County programs to reduce emissions. In response to the results of the 1998 inventory, the County drafted a GHG reduction Plan in 2002, which listed several ways for the County to reduce emission levels by as much as 20%. In conjunction with this plan, the Board of County Commissioners amended the Conservation Element of their Comprehensive Plan, adding Policy 4.1.3.7 which states that by the year 2010 the County would reduce 1990 GHG emission levels by 20%. In order to accomplish this reduction the County has established an Energy Conservation Strategy Commission (ECSC), as well as started to retrofit buildings, buy hybrids vehicles and started using blended biodiesel fuel in county vehicles. Alachua County is currently updating their 1998 inventory to assess their progress in accomplishing their goal to reduce emissions by 20%.

Beyond the County's history of being progressive in reducing GHG emissions, Alachua County has seen a continued steady growth rate, and unlike the rest of the state has continued to experience a steady growth in population into 2010. A recent study commissioned by the ECSC, estimated the County to grow by 3.135% per year totaling 3,631,793 people by 2094 (Hoot, 2008). It is important to note that this is a high estimate of population growth, but it is still relevant in that it shows what could potentially occur in the coming years. The County's continued growth in population provides the County the opportunity to adopt land-use policies that will direct development to occur in certain areas of the County and in such a manner that reduces the average VMT.

Finally Alachua County was chosen because of its unique demographics. Alachua County is located in North Central Florida with a population of about 247,561 people (US Census, n.d.a). The County contains eight local municipalities, the largest being the City of Gainesville with a population of approximately 114,916 people (US Census, n.d.b). The majority of Alachua County's economic development revolves around the University of Florida and Shands Hospital. Both the County and the City of Gainesville are predominately comprised of single use, low density development characterized by a western expansion of single-family residential units (City of Gainesville, 2001). This separates it from past studies that examined the connection between land development patterns and trip lengths due its population composition and predominately low density development patterns.

Land Use Patterns-Trip Length Analysis

The relationship between land development patterns and trip lengths in Alachua County, FL was determined by analyzing the results of research conducted by Steiner et al. (2010). This research used linear-regression models to map the locations where the land use patterns are more favorable towards the reduction of trip length in the County. The following sub-section describes the data collected, and briefly how the data was aggregated in the VMT study. The next sub-section provides a brief overview of the empirical models used in the study. Finally the last subsection describes the analysis of the data used in this study.

Data

Steiner et al.’s (2010) study used the 1999 Southeast Florida Regional Travel Characteristics Study as the primary source of data for trip-lengths. The study used one-day travel information, which recorded each respondents trip timing (start- and end – times), mode (including occupancy for auto mode), purpose, and trip-end locations (addresses) (Steiner et al., 2010). The roadway network and characteristics – linear road miles, number of intersections and number of cul-de-sacs within each neighborhood- were collected using “Dynamap Streets.” The data for the independent variables was collected from the Florida Department of Revenue (FDOR). The data included the following attributes for each parcel: 1) parcel identifiers, 2) parcel area, 3) land-use type, 4) number of residential units for residential parcels, and 5) building square footage for non residential parcels. In addition the following six land-use categories were used: 1) residential (single-family, multi-family, mobile homes), 2) commercial (large retail, regular retail, convenience store, drive through), 3) office (professional and non-professional service building), 4) Industrial (light, heavy, warehousing), 5) Institutional, 6) other.

In order to capture the land-use at the neighborhood level, Steiner et al. (2010) aggregated the parcel level data to create “neighborhoods” of the size four-square miles across the entire County. In addition the authors identified four activity centers and four residential centers in the County to capture the land-use at the regional level. The activity centers were defined “as neighborhoods with the highest commercial square footage (includes, retail, office, and entertainment)” (Steiner et al., p. 9, 2010). The residential centers were defined “as neighborhoods having over 50% of its land use dedicated to residential” (Steiner et al., p. 9, 2010). The location of both the activity centers and the residential centers are shown in Figure 3-1 and Figure 3-2 respectively. The model used “determines the network distance for each neighborhood to each of the regional activity centers and the regional residential centers” (Steiner et al., p. 9, 2010). For more information on the data refer to Steiner et al. (2010).

Models

The research by Steiner et al. (2010) developed two sets of models, containing three models each. The first set of models “examined at the impact of land-use at the production end of trips. The second set looked at the impact land-use at the attraction-end of trips” (Steiner et al., p. 13, 2010). Each set was comprised of three models: one for each of the three trip purposes -- home-based work (HBW), home-based other (HBO), and non-home-based (NHB). For the purposes of this research, the study only examines the protection end of trips. For more information on the models refer to Steiner et al. (2010).

Analysis

To determine which land development patterns are more favorable towards the reduction in trip length in Alachua County Florida, the researcher applied the models developed in Steiner et al.'s (2010) research to the County's land use characteristics. The researcher identified three neighborhoods, the first in an urban location, the second in a suburban location and the third in a rural neighborhood to validate that the adopted models as appropriate measurements of the relationship between land development patterns and trip length. These neighborhoods were chosen based off of the researcher's prior knowledge of the area.

The Duckpond neighborhood was chosen to represent the urban neighborhood. This neighborhood is well established and is located the vicinity of downtown Gainesville. Its built environment is characterized as compact mixed use, with high accessibility. The Town of Tioga was chosen as the suburban neighborhood. This neighborhood is located west of I-75 in an area that has been experiencing significant growth. The houses in the neighborhood meet some energy star standards as well as the neighborhood itself is seen as a new urbanist development. Forest Grove was chosen as the rural neighborhood. This neighborhood is located in the northwest part of the county and consists of mostly agricultural land. The results of the predicted trip lengths produced by these locations are compared and contrasted to determine the land-use with the shortest length.

Policy Analysis

A policy analysis was used to analyze the policies and goals located in two local comprehensive plans to determine whether they incorporated effective policies that encourage compact development as a means to reduce GHG emissions produced by the transportation sector. Alachua County's Comprehensive Plan as well as the City of Gainesville's Comprehensive Plan were chosen to be evaluated. Alachua County's Comprehensive Plan was chosen since it incorporated the entire area being studied. The City of Gainesville's Comprehensive Plan was included in the analysis due to Gainesville containing approximately 50% of the County's population and also including the majority of the major activity and neighborhood centers in the County. These two Comprehensive Plans were evaluated based on common themes and variables that were developed in the literature and reinforced by the results of the models from the first part of this research that these common themes and variables reduce trip lengths. These themes and variables included policies and goals relating to:

- Density: encouraging infill, redevelopment or higher densities
- Accessibility: how accessible different destinations are, including accessibility to transit and regional destinations (activity centers)
- Diversity: encouragement of mixed land uses
- Design: route directness and street network density, and connectivity

The Comprehensive Plan's are laid out in the three tiers mandated by the State (cite Rule 9J-5). The first tier identifies the overall goal and broadly defines the purpose of the element. The next tier consists of the objectives that establish how the features of the goal will be achieved. Then the final tier consists of the policies which outlines the specific actions to achieve that objective.

To effectively evaluate the Comprehensive Plans, the research first identified each goal that incorporated Density, Accessibility, Diversity, and Design in a way that had the potential to promote a reduction in trip length as indicated by the existing research. The researcher then analyzed each of these goals' corresponding policies to determine if they were oriented towards density, accessibility, diversity, and design. When it was determined which one it pertained to it was labeled as such. For instance, Future Land Use Element policy 1.1.2 of the City of Gainesville's Comprehensive Plan states that "To the extent possible, neighborhoods should be sized so that housing job, daily needs and other activities are within easy walking distances to each other," was labeled as accessibility. It is important to note that some policies fell under more than one characteristic. If that was the case, the policy was listed under each characteristic that it pertained to.

In addition to these four themes, the researcher evaluated the Comprehensive Plans on whether they included any policies relating to overall energy reduction strategies. The researcher then determined whether the policy influenced development in a way to reduce trip length, or whether they prevented any type of reduction in trip length and even deterred from reduction.

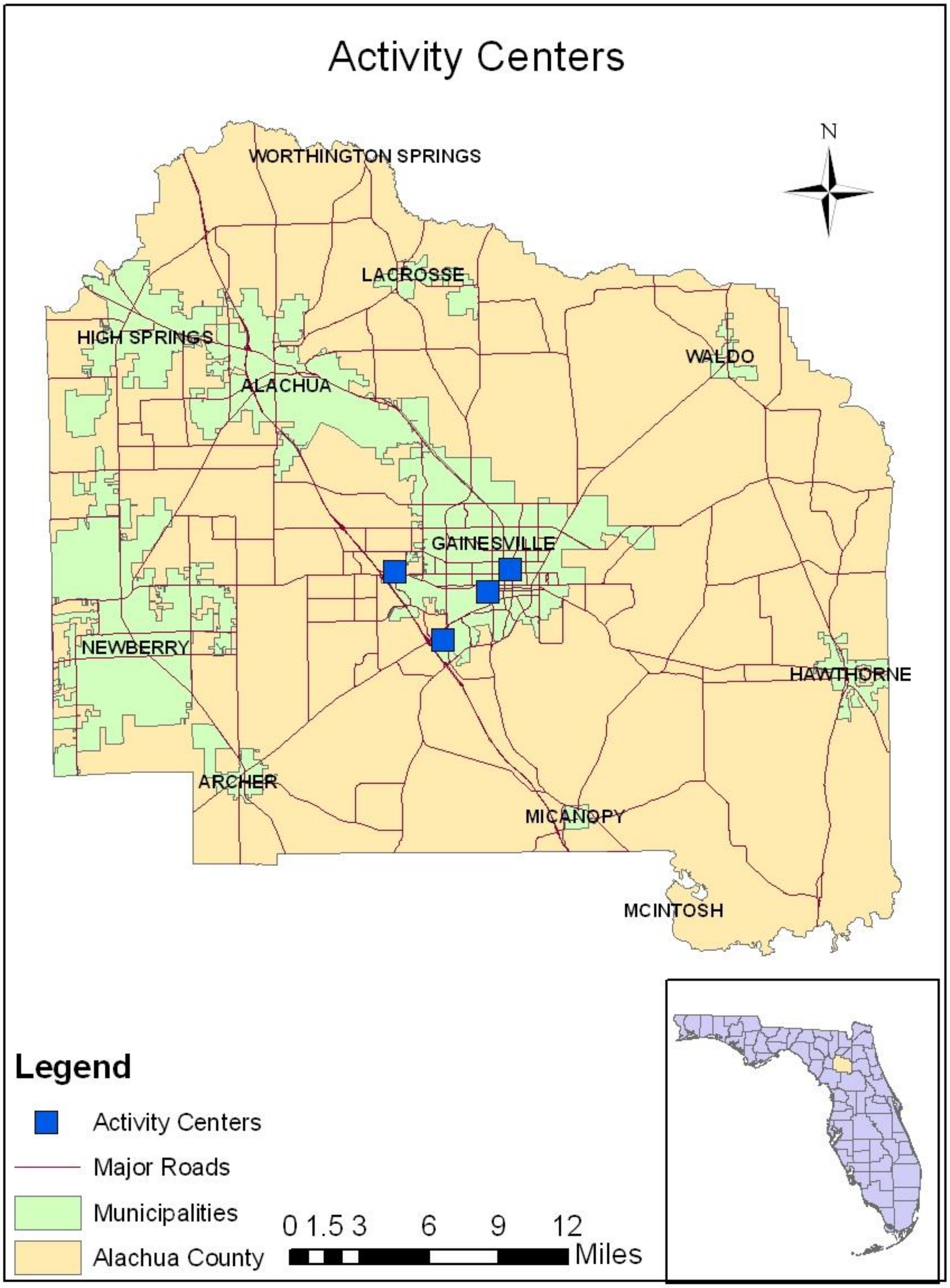

Figure 3-1. Activity centers

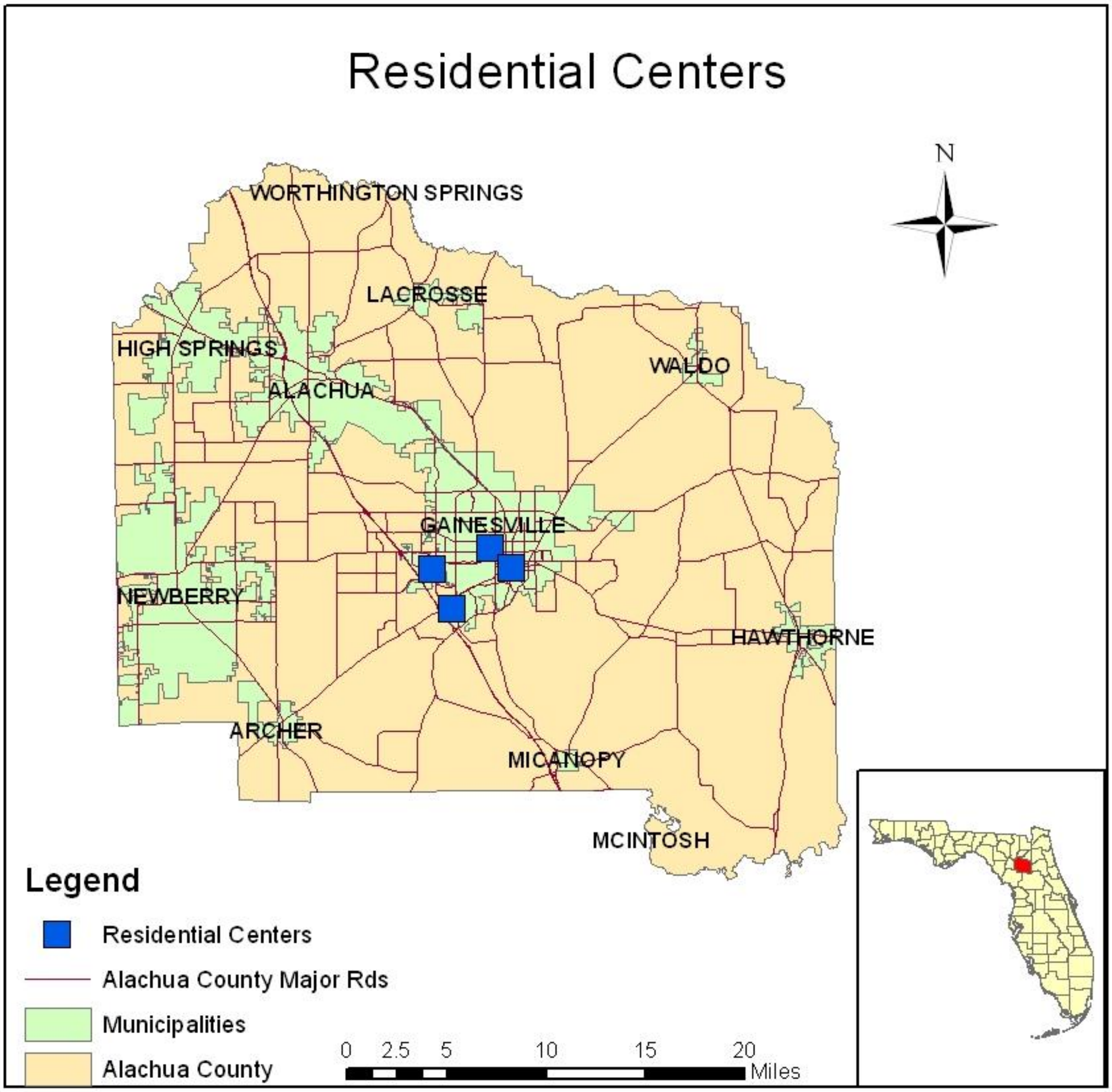

Figure 3-2. Residential centers

CHAPTER 4
MODEL RESULTS

The focus of this research is to show a connection between the land development patterns and trip lengths in Alachua County, Florida. To accomplish this, the study used models from research conducted by Steiner et al. (2010) to locate where land use patterns are more favorable towards the reduction of trip length within the County. The models contain four explanatory variables that are classified by: 1) parcel characteristics, 2) neighborhood land-use characteristics, 3) neighborhood roadway characteristics, and 4) location of neighborhoods within the region. The first part of this chapter list the assumptions made under each of these variables. Then this chapter presents the predicted trip lengths produced in Alachua County by the models. The chapter concludes with a comparison of the characteristics of three neighborhood types classified as urban, suburban and rural as a way to validate the applicability of the results of the models to Alachua County.

Assumptions Made By Explanatory Variables

Steiner et al. (2010)'s models were designed based on an extensive literature review and a case study of three counties in South East Florida: Miami-Dade, Broward and Palm Beach. For the purpose of this research, the assumption is being made that these models will also predict the trip lengths in Alachua County as a function of its specific land-use characteristics. In order to predict trip lengths the models used the four explanatory variables listed above. In this section, the rationale behind and the influence each variable plays in predicting trip lengths is outlined. This information is based off of that collected in Steiner et al.'s (2010) research. Table 4-1 adopted from Steiner et al.'s research provides a list of the coefficients for each variable used in the model.

The first category of explanatory variables is the parcel characteristic. Each parcel is characterized by a land-use type which can be residential, commercial, office, institutional, industrial or other (Steiner et al., 2010). The model for Non-Home Based (NHB) trips indicates that such trips produced in commercial parcels are shorter in length compared to those produced in any other type of parcel. This could be explained by the fact that many shopping trips are chained together, with shopping destinations being close to one another. The model on NHB trips also indicates that larger size establishments produce longer NHB trips.

The second category of explanatory variables is neighborhood land-use characteristics. There are five variables of interest under this category. The first variable is the fraction of developed area by each land use type. Steiner et al. (2010) calculated this variable as “the ratio of the sum of the areas in the six land-use categories (residential, commercial, office, institution, industrial, and other) to the total area of the neighborhood” (p. 16). The model of Home Based Work (HBW) trips indicates that the trip length increases with the increase fraction of the developed area under residential type. This can be explained by the notion that in large areas of residential land-use there are not many opportunities for employment in that vicinity, therefore one would have to travel further to an employment center. Home Based Other (HBO) trips produced in neighborhoods with a larger fraction of commercial areas are shorter and HBW trips produced in neighborhoods with greater fraction of “other” area are estimated to be longer. Thus one could imply “that a greater fraction of non-residential, non-other land use (i.e. greater fraction of commercial, office, institutional or industrial) would lead to shorter HBW trips” (Steiner et al., 2010).

The next variable of interest is the variable “fraction of remaining developed area” which is only applicable for NHB trips. This variable is calculated as the proportion of developed areas in all land-use types except the land use type of the production-end parcel (Steiner et al., 2010). The intent of this variable is to be a “measure of activity opportunities or a NHB trips produced in a parcel” (Steiner et al., p. 16, 2010).

Neighborhood density is also a significant variable. This variable is defined as the number of residential units in the neighborhood divided by the area of the neighborhood that is residential (Steiner et al., 2010). This variable is negatively correlated with lengths of home-based trips. It implies that residential units in high density neighborhoods produce shorter trips (Steiner et al., 2010).

The next variable is the size of buildings, measured by square feet. For HBW trips a greater building area under the “office” land use lead to shorter trip lengths. For HBO trips the model shows that the greater building area under the “institutional” and “other” land uses lead to shorter trips.

Finally the number of parcels that are classified as convenient commercial is the last variable under the classification of neighborhood land-use characteristics. This variable represents that the greater the number of convenient commercial land uses the shorter the HBO and NHB trips are. It is important to note that this variable is not significant in the case of HBW trips.

The next significant explanatory variable is neighborhood roadway characteristics. Roadway characteristics included intersection density, number of cul-de-sacs per mile and length of roadway. In the case of HBW – more intersections per mile of roadway decreases the trip length and more cul-de-sacs per mile of roadway increase the trip length. In the case of non-work trips the length of roadway and intersection density are significant predictors of trip length.

Finally the last explanatory variable is the location of neighborhoods within the region. This variable indicates that with increasing distance of the production-end of the trip to the regional activity centers, the lengths of home-based trips increase. Home based trips produced closer to regional activity centers are of shorter distances. The length of HBW trips is determined by the distance of the home from regional residential centers.

Model Results

The results of running the models with land-use data from Alachua County produced the expected results, showing an inverse relationship between land development patterns and trip lengths. Overall the trips predicted were the shortest in length in the City of Gainesville.

In the case of the Home Based Other Production model, the predicted trips increased in length the farther one moved from Gainesville, as shown in figure 4-1. There were also pockets of relatively short trip lengths around the surrounding municipalities. The trend of development to occur west of Gainesville is evident in the outcome of this model. For instance, the trip lengths are shorter in length in the area that stretches between Gainesville and Newberry and in the area that stretches between Gainesville and Archer. These results seem reasonable because development, including shopping centers have been predominately occurring west of Interstate 75. In addition the Oaks Mall is located in that vicinity and is a major producer of trips.

As shown in Figure 4-2, the Home Based Work Production's model showed similar results. The trips were predicted to be of a shorter distance the closer to Gainesville the home was and around each of the other municipalities located in the County. These results seem reasonable due to the fact that the University of Florida and Shands Hospital are the largest employers in the County and are located in the City of Gainesville.

The pockets of shorter length trips at each of the municipalities represent the businesses that are located in each of these cities. However the trips lengths predicted at these locations are probably on the low end. It is unlikely that these municipalities can contain enough jobs to support their population. Therefore it is likely that many of these cities' residents commute into Gainesville for employment purposes.

Neighborhood Comparisons

Three neighborhoods were compared in Alachua County; one representing a rural area, another one representing a suburban area and the last one representing an urban area to validate the models as appropriate measurements of the relationship in the County. The neighborhood site locations are presented on Figure 4-3. As expected, the trips predicted from the urban neighborhood were the shortest in length, while trips produced from the rural neighborhood were the longest in length. Figure 4-4 and Figure 4-5 illustrate the predicted trip lengths for Home Based Other produced trips and Home Based Work Produced Trips, respectively, for each of the neighborhoods. Table 4-2 presents the results of the neighborhood comparisons.

Rural Neighborhood

The rural neighborhood contained the least amount of land uses. Residential was the dominate land-use (418 acres) followed by industrial (234.7 acres) and then finally Agriculture (73.35 acres). The greatest proportion of the land was undeveloped land (1,825 acres). This neighborhood had the least amount of roadways and was the furthest from both the nearest regional activity center (13.5 miles) and the nearest regional residential center (15 miles). As predicted the rural neighborhood produced on average the longest trips in length. The average predicted HBW trip was 9 miles while the average HBO predicted trip was 8.2 miles.

Suburban Neighborhood

The Suburban Neighborhood had a greater mix of uses compared to the rural neighborhood. The greatest land-use was residential (724.4 acres), while all the other land uses each consumed 55 acres or less. Similar to the rural neighborhood, undeveloped land consumed the greatest proportion of the neighborhood. The average number of intersections per mile of roadway was 3.4. This supports the notion that suburban areas lack connectivity. The suburban neighborhood was located closer to the regional activity center (6.3 miles) and Regional residential center (7.9 miles) than the rural neighborhood. The predicted trip lengths for HBW trips were 5.2 miles in length and the predicted trips lengths for HBO trips were 2.8 miles. It seems reasonable to believe that the HBO trips are predicted to be shorter than the HBW trips, because the HBO trips include not only shopping trips but social trips to see friends. As expected these trips are shorter in length than the rural neighborhood.

Urban Neighborhood

The Urban neighborhood had the greatest mix of land use, containing all of the land-use categories except Agriculture. The two dominate land-uses were residential (1,009 acres) and institutional land-uses (245.4 acres). Not surprisingly it contained the least amount of undeveloped land (724 acres). Interestingly the urban neighborhood also contained the largest number or residential units (7,383 units). It is also important to highlight that this neighborhood had the greatest amount of roadways. As the literature and the models suggest the urban neighborhood produced predicted trips of the shortest length. In fact, the average predicted trip length for both HBW and HBO productions were less than one mile.

Conclusion

The models produced the expected results. Both the HBO and the HBW production models predicted an increase in trip lengths the farther one moved away from the City of Gainesville. From the use of these models the researcher was able to compare and contrast three neighborhoods characterized by different built environments. The first neighborhood was rural, and expectantly produced that longest predicted trip lengths. The suburban neighborhood, characterized as dispersed development, with low connectivity, was predicted to produce shorter trips lengths than the rural neighborhood but longer trip lengths than the urban neighborhood. Finally the urban development characterized by mix use, compact development that has high connectivity, was predicted to produce the shortest trip lengths. These results support the researcher’s hypothesis that areas characterized by compact development and are located closer to the city center are more favorable toward the reduction of trip lengths.

Table 4-1. Models for trip lengths with land-use descriptors at the production-end

	Home-Based Work		Home-Based Other		Non-Home-Based	
	Param.	t stat.	Param.	t stat.	Param.	t stat.
Parcel Characteristics						
Commercial land use	NA	NA	NA	NA	-.099	-2.517
Building square footage (1000s of square feet)	NA	NA	NA	NA	.001	5.264
Neighborhood Land-Use Characteristics						
Fraction of area that is developed	-.209	-1.456	-.235	-1.852	-.462	-2.902
Fraction of developed area that is residential	.527	3.983	-.372	-4.076		
Fraction of developed area that is commercial			-1.211	-4.238		
Fraction of developed area that is other	.781	4.638				
Fraction of "remaining" developed area	NA	NA	NA	NA	-.295	-4.513
Net residential density (units per acre)	-.005	-1.781	-.008	-3.331		
LN(Building square footage - Office)	-.029	-3.313				
LN(Building square footage - Institutional)			-.054	-5.796		
LN(Building square footage - Other)			-.042	-4.511		
LN(Building square footage - Remaining)	NA	NA	NA	NA	-.052	-2.899
Number of "convinient commercial" parcels			-.005	-2.787	-.008	-4.187
Neighborhood Roadway Characteristics						
Length of roadway (miles)			.002	2.695	.004	4.428
Intersections per mile of roadway	-.045	-4.309	-.035	-4.293	-.020	-1.675
Cul-de-Sacs per mile of roadway	.039	2.045				
Location of Neighborhood within Region						
Distance to nearest regional activity center	.025	7.811	.007	2.686	-.006	-1.778
Distance to nearest regional residential center	-.018	-6.595				
Constant	2.003	12.447	2.310	18.561	2.152	12.419
Number of cases	5327		8257		4796	
R^2	0.069		0.045		0.027	

Source: Steiner et al. (2010)

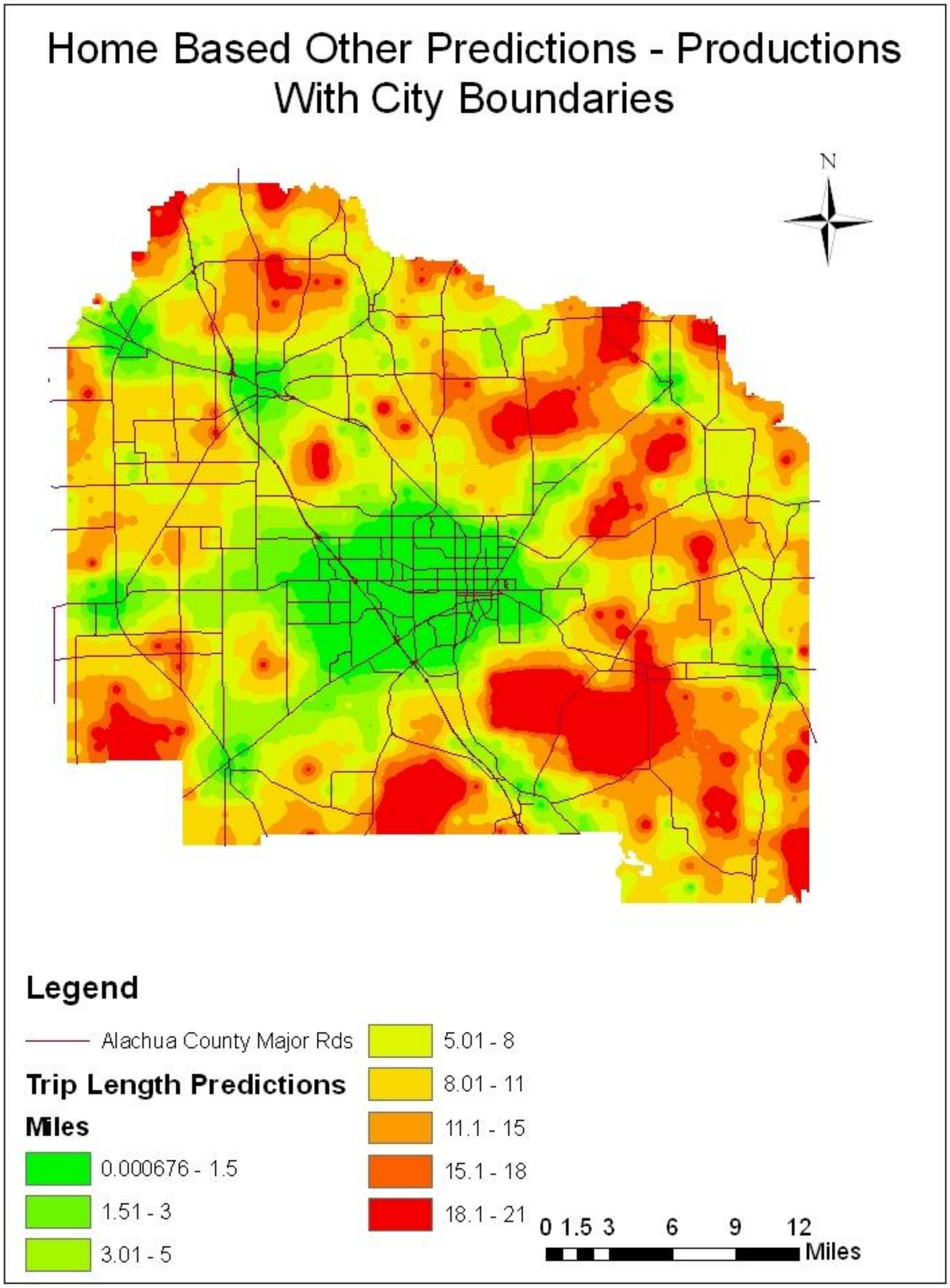

Figure 4-1. Home based other trip length predictions

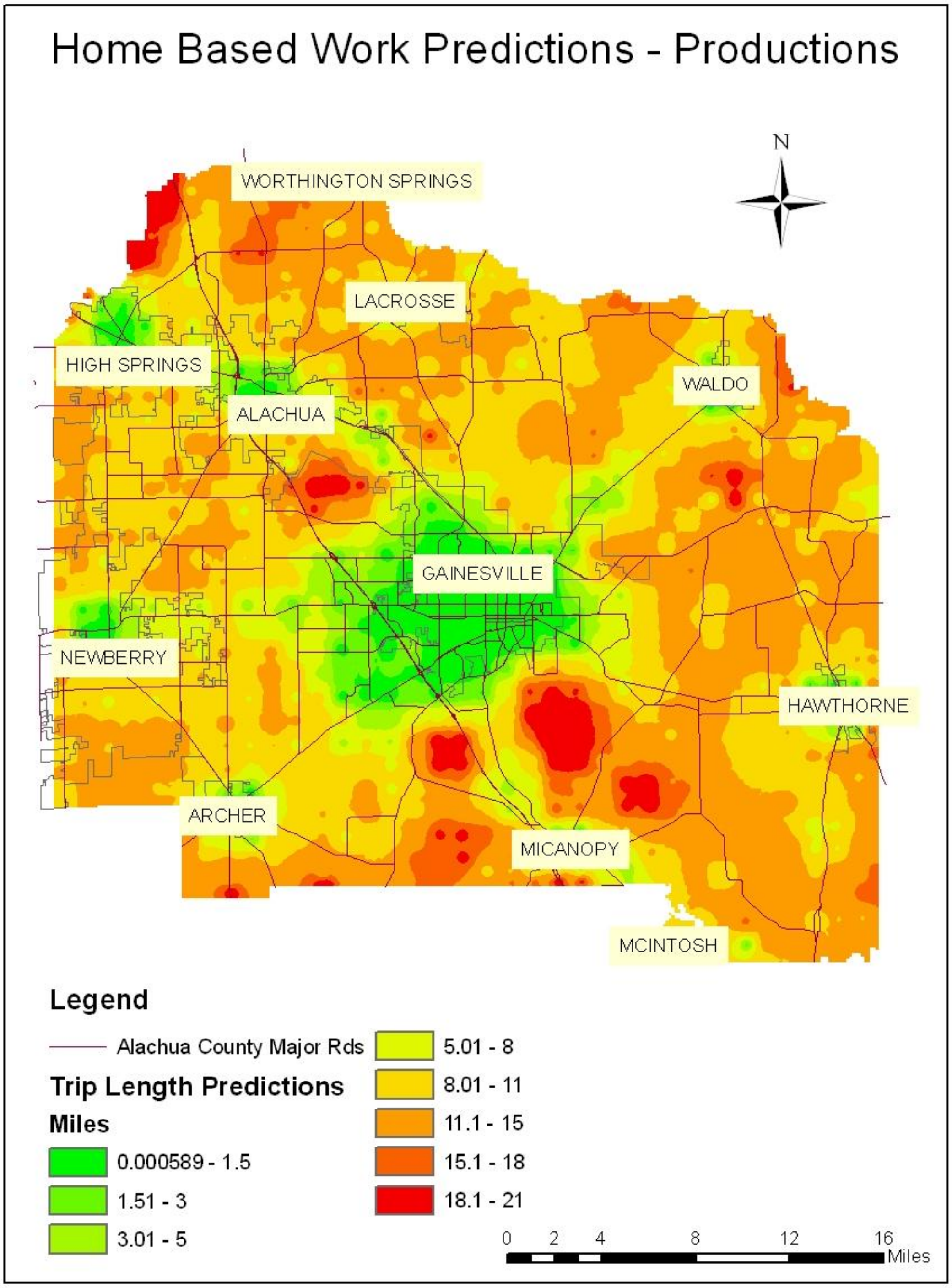

Figure 4-2. Home based work predicted trip lengths

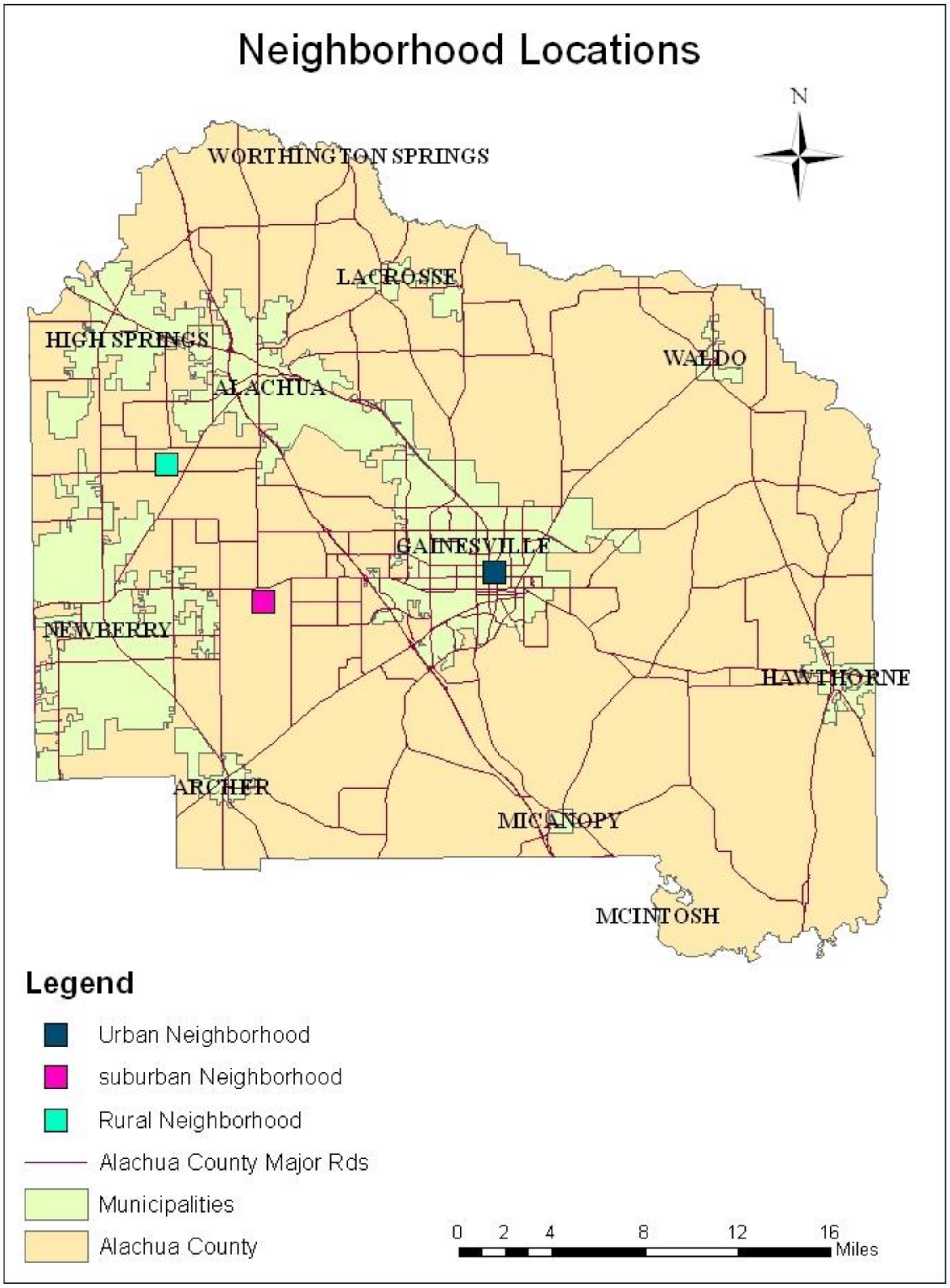

Figure 4-3. Neighborhood locations

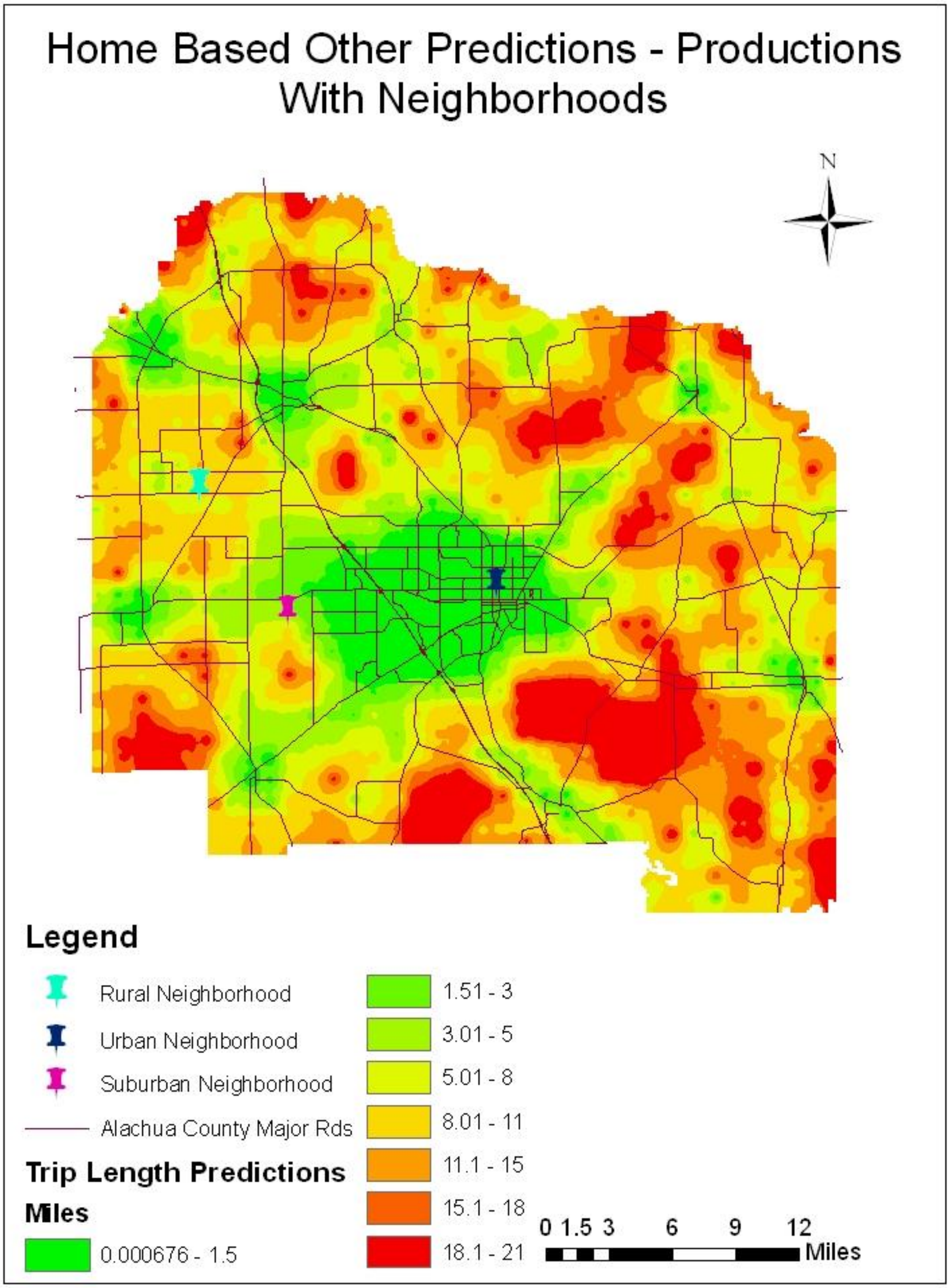

Figure 4-4. Home based other predicted trip lengths with neighborhood locations

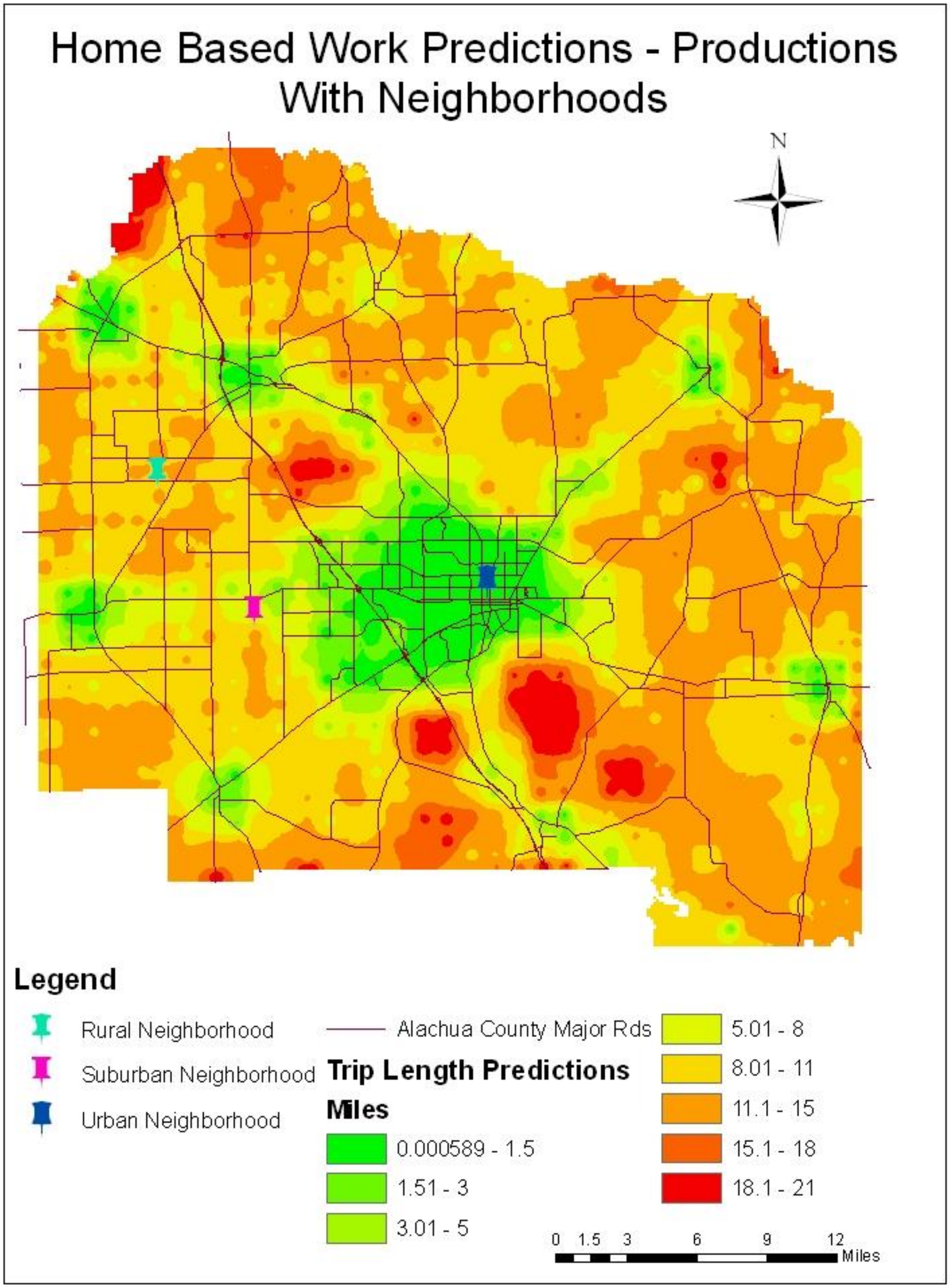

Figure 4-5. Home based work predicted trip lengths with neighborhood locations

Table 4-2. Neighborhood comparison

	Rural	Suburban	Urban
Neighborhood Land Characteristics			
Residential area (acres)	418.0	724.4	1,009
Commercial area (acres)	0	26.5	245.4
Office Area (acres)	0	35.7	187
Institutional area (acres)	0	55.1	313
Industrial areas (acres)	234.7	10.2	31
Other area (acres)	0	40.8	42.2
Agriculture area (acres)	73.35	128.6	0
Undeveloped area (acres)	1,825	1,538	724
Number of residential units	95	1,031	7,383
Building area - commercial (1000 sq feet)	0	117,857	1,480,590
Building area - Office (1000 sq feet)	0	141,926	1,362,564
Building area - Institutional (1000 sq feet)	0	6,992	655,767
Building area - Industrial (1000 sq feet)	0	17,924	274,416
Building area - other (1000 sq feet)	8,875	15,316	412,792
Number of "convenient commercial" parcels	0	1	26
Neighborhood Roadway Characteristics			
Length of roadway (miles)	2.2	20.3	85.8
Intersections per mile of roadway	23.6	3.5	11.3
Location of Neighborhood within Region			
Distance to nearest regional activity center (miles)	13.5	6.28	0
Distance to farthest regional activity center (miles)	17.9	11.2	5.2
Distance to nearest regional residential center (miles)	15	7.9	1
Predicted Trip Lengths			
Home Based Work Production (miles)	9	5.2	0
Home Based Other Production (miles)	8.2	2.8	0

CHAPTER 5
POLICY ANALYSIS RESULTS

The literature and models used to predict trip lengths in Alachua County, suggest compact development, characterized by density, design, destination accessibility, and diversity, reduces the length of trips. This research assumes that a reduction in trip length results in a reduction in GHG emissions from the transportation sector. This knowledge is worth very little if it is not put into practice. As the Growth Management Act of 1985 recognizes, land development practices are best implemented at the local level (DCA, n.d.). This alone is reason enough to examine the prevalence of the promotion of compact development in two local comprehensive plans: the City of Gainesville's Comprehensive Plan and Alachua County's Comprehensive Plan.

This section provides the results of the policy analysis on the two comprehensive plans. First, a background on the Growth Management Act of 1985 is given, to provide the context in which the local comprehensive plans were created. Following the background, a determination is made on whether the City of Gainesville and Alachua County's comprehensive plans are successful in incorporating policies that encourage compact development in a way that will lead to reductions in GHG emissions.

Comprehensive Planning in Florida

Comprehensive planning is seen as a process "that could assist American communities in providing a pleasant, livable and well-ordered urban environments" (Mandelker, p. 900, 1976). Florida first declared a state interest in state and local comprehensive planning with the passing of The Comprehensive Planning Act of 1972 [Florida Statute 186.001]. However, this act gained little momentum and the Division of

State Planning of the Florida Department of Administration's first comprehensive plan was rejected by the state's legislature (Carriker, 2009).

The importance of Comprehensive planning reemerged with The Local Government Comprehensive Planning Act of 1975. This act recognized the role that local governments play in land use controls and required local governments to adopt comprehensive plans (Carriker, 2009). It also provided a three pronged approach for the state government to control growth at the local level: mandating that local governments adhered to State guidelines, protect critical environmental areas and mandated that development of regional impacts be conducted for developments that are expected to have significant regional impact (Nicholas, 2001). However this act created a backlog of paper work that neither the state nor the local governments could keep up with, causing project delays and increased development cost (Nicholas, 2001). There was also little guidance and enforcement of this act from the state level. The result was the creation of local comprehensive plans that were inconsistent and ineffective in managing growth (Rhodes, 2010). Therefore this act was later substantially amended by the Local Government Comprehensive Planning and Land Development Act of 1985 [Florida Statute 163.3161].

Adopted by the 1985 Legislature, Florida's Growth Management Act (Chapter 163, Part II, Florida Statutes, The Local Government Comprehensive Planning and Land Development Regulation Act) requires all of Florida's 67 counties and 410 municipalities to adopt Local Government Comprehensive Plans that guide future growth and development. The passing of this act provided the foundation for community participation and managed growth in Florida communities. Unlike the previous

Comprehensive Acts this act includes the creation of Dense Urban Land Area (DULA) designations, as a means to curb urban sprawl (DCA, n.d.). Overall this act requires local comprehensive plans to: (as cited in Carriker, 2009)

- Guide and control future development
- Address existing problems (such as urban sprawl) as well as problems that may arise in the future as a result of the development and use of land
- Preserve, promote, protect and improve public health, safety, comfort and good order
- Protect human, environmental, social and economic resources

The explicit minimum criteria and requirements as well as the legal precedence for local comprehensive plans can be found in Rule 9J-5 of the Florida Administrative Code, adopted by the Department of Community Affairs. Rule 9J-5 outlines the specific elements, goals and policies that must be mentioned and contains a detailed format that all comprehensive plans must follow. Included in these rules is the requirement of local comprehensive plans to “describe how the local government’s programs, activities, and land development regulations will be initiated, modified or continued to implement the comprehensive plan in a consistent manner” (Rule 9J-5.005 (6)).

As stated in Rule 9J-5, local comprehensive plans are intended to include 12 elements. These 12 elements are: capital improvements, future land use, transportation, sanitary sewer, solid waste, drainage, potable water and natural groundwater recharge, conservation of natural resources, recreation and open space, housing, coastal management, and inter-governmental coordination. In addition local governments have the option to include the elements: historic preservation, arts and culture, economic development, public education and community design. The statute does not mandate that these elements have to be independent but represented throughout the entire comprehensive plan in an interwoven, consistent manner (Rule 9J-5.005).

With the addition of the DUDA to the Growth Management Act, one of the main components of Comprehensive Plans is to discourage the proliferation of urban sprawl. The Future Land Use section of Rule 9J-5 provides a general methodology for examining whether or not a plan or plan amendment discourages urban sprawl, as well as what controls local governments can use to mitigate the presence of sprawl (Rule 9J-5.006 section 5). Due to urban sprawl being multidimensional, Rule 9J-5 includes over 22 determinates that will be evaluated in local comprehensive plans to determine the extent it discourages sprawl. One of these determinants is including the establishment of minimum development density and intensity, affecting the pattern and character of development (Rule 9J-5 section j.3).

Local governments are held accountable to produce comprehensive plans consistent with the state and regional plans. Once a local government completes or amends their comprehensive plan it must be submitted to Florida’s Department of Community Affairs (DCA) for approval and certification. DCA evaluates each plan based on their consistency and if they abide by the rules out lined in Rule 9J-5. If the DCA rules that a plan is not in compliance, the state can withhold grants and funding from them, as well as pursue legal action through the state court system (Dawson, 1996).

In summary, Florida’s Growth Management Act provides governments with rigid standards that must be met before development plans can be certified and approved. These standards outlined in Rule 9J-5 help provide local governments with guidelines and standards that they must uphold and be accountable for.

City of Gainesville's Comprehensive Plan

The City of Gainesville's current comprehensive plan was adopted in the year 2001. At the time of adoption, the City was experiencing a declining share of the overall population of Alachua County; so much so that the urban population growth in unincorporated Alachua County had been increasing at nearly double the rate of growth than within city limits (City of Gainesville, p. 5, 2001a). Before 2001, development in the City of Gainesville tended to be "low-density, single-use land-use patterns, characterized mostly by a western expansion of single-family residential development, interspersed with conventional, car-oriented shopping centers at major street intersections" (City of Gainesville, p. 6, 2001a). To be in compliance with the Growth Management Act of 1985, the main focus of Gainesville's 2001 Comprehensive Plan's Future Land Use Element became "oriented toward continuing Gainesville's pattern of a strong central core, redevelopment and revitalization of older areas, and a continued focus on strong neighborhood centers rich in transportation choice" (City of Gainesville, p. 1, 2001a).

This new focus for the Future Land Use Element of the comprehensive plan was rationalized and qualified, as mandated by state statue, in the City of Gainesville's Future Land Use Element's Data and Analysis Section (City of Gainesville, 2001a). The Data and Analysis section identified the main issues that were to be addressed in the 2000-2010 Comprehensive Plan. These areas of focus included: 1) the declining share of the overall Alachua County population, 2) infill and redevelopment, 3) density, 4) urban design, 5) revisions of their previous definition of "activity centers," 6) the incorporation of more mixed use categories, and 7) provide more transportation choices. In their Data and Analysis, the City of Gainesville recognized that low density, single-use land use character results in high levels of car dependence and decreases the viability of transportation choices (City of Gainesville, p. 6, 2001a). Therefore they designated the key objectives of the Future Land Use Element of the Comprehensive Plan as the promotion of “livable residential densities, neighborhood centers, transportation choice, stabilization of existing city neighborhoods and mix use” (City of Gainesville, p. 6, 2001a).

It is important to note that at the time the Comprehensive Plan was adopted the City was already 90% built out. Therefore one of the City’s main quests was, not to prevent sprawl from happening within its borders but rather to keep development within the City and residents from migrating out of the City’s boundaries. This is reinforced by the fact that Gainesville’s urban service area boundaries coincide with the city’s boundaries as stated in policy 1.5.7 of the Future Land Use Element (City of Gainesville, p. A-5 , 2001b). As a result much of the City’s Comprehensive plan is about creating a more “livable city,” not necessarily about making it a more compact city.

Nevertheless, many characteristics that the existing literature suggests as encouraging compact development are interwoven in the City’s goals, objectives and policies in the Future Land Use Element, Concurrency Management Element and the Urban Design Element. These characteristics, discussed more in depth in previous chapters are density, urban design, destination accessibility, and mixed uses. The use of these characteristics is transcribed from the data and analysis section to the comprehensive plan.

Analysis. Overall the City of Gainesville’s Comprehensive Plan incorporates many of the strategies, listed in Rule 9J-5 to help combat the proliferation of sprawl as a means to encourage other modes of transportation than the automobile, as well as increase densities. The comprehensive plan encourages compact development by encouraging mixed uses, infill and redevelopment, developing traditional neighborhoods, increasing transit options, incorporating village centers and encouraging greater densities around University of Florida's Campus as well as Santa Fe Community College (City of Gainesville, 2001). Table 5-1 provides a summary of how often the four characteristics of compact development – density, urban design, destination accessibility and mixed uses - were mentioned in the comprehensive plan.

Overall, three out of the five goals under the Future Land Use Section and one goal in the Concurrency Management section incorporate at least one of the characteristics of compact development. Because the overarching goal of this content analysis is to evaluate whether the Comprehensive Plan incorporates effective policies that encourage compact development, the remaining analysis will focus on the content of the specific policies listed under each of the three goals identified.

In the Future Land Use Section all of the variables were mentioned approximately the same amount of times in the policies that encouraged compact development. Urban Design and Density standards were incorporated in the most policies (7 policies each), followed by diversity (6 policies each), and lastly Accessibility was incorporated in the least amount (5 policies). A summary of these policies is contained in Table 5-1.

As shown in Table 5-1, these characteristics are used throughout the comprehensive Plan's Future Land Use Element, Transportation Concurrency Element and the Urban Design Element, however they are rarely explicitly stated as a means to create more compact development. As mentioned previously, Gainesville's Plan gravitates towards creating a livable built environment. While the plan has many elements of creating 'livable' downtowns it rarely explicitly encourages compact development to achieve this goal.

In the Future Land Use Element of the 2000-2010 Comprehensive Plan, the explicit use of the word compact is only used twice. The encouragement of compact development is first mentioned in Objective 2.1 of the Future Land Use Element. This Objective states that "Redevelopment should be encouraged to promote compact, vibrant urbanism, improve the condition of blighted areas, discourage urban sprawl, and foster compact development patterns that promote transportation choice" (City of Gainesville, p. A-5, 2005). In this objective compact development is used in conjunction with transportation choice. Therefore it indicates the City understands the relationship between development patterns and transportation choice. The policies under this objective in totality include each of the elements of compact development.

The only other time "compact development" is utilized again is in Goal 4 of the Future Land Use Element. This goal states that "The land use element shall foster the unique character of the city by directing growth and redevelopment in a manner that uses neighborhood centers to provide goods and services to city residents; protects neighborhoods; distributes growth and economic activity throughout the city in keeping with the direction of this element; preserves quality open space and preserves the tree canopy of the city. The land use element shall promote statewide goals for *compact development* and efficient use of infrastructure" (City of Gainesville, A-10, 2000; italics added). In this goal the use of compact development is tagged on at the end. This goal can be interpreted in one of two ways. First as contradictory, the goal states that it will disperse the growth and economic activity throughout the city and then tags on at the end that it will promote compact development. Distributing and compact can be seen as contradicting goals. On the other hand, the goal can also be interpreted in that the growth and economic activity will be in compact clusters across the city and that quality open space will be preserved. Unfortunately the verbiage of this goal and the coinciding objectives and policies make it unclear. It is almost as if the city included the last sentence to meet the requirements mandated by DCA.

The results of the analysis found a deficit in the amount of goals, objectives and policies that supported the reduction in energy consumption and GHG emissions. The City's comprehensive plan mentions energy conservation only twice. In both instances it was used in policies that support the decrease of emissions and energy use from the utility sector. The City's Comprehensive Plan however does not mention anything about decreasing emissions from the transportation sector.

Table 5-1. Policies that encourage compact development in Gainesville's future land use element of their comprehensive plan

Diversity/Mixed Uses	Density	Urban Design	Destination Accessibility
Policy 1.1.1 : Planning shall be in integrated communities	Policy 1.3.4 : Densities should cascade from higher densities at the core to lower densities at the edges	Policy 1.2.2 : Incorporate design standards that create livable densities	Policy 1.1.2: Housing, job and daily needs be within easy walking distance
Policy 1.1.3 : Neighborhoods should contain a diversity of housing	Policy 1.5.7 : Establish redevelopment areas	Policy 1.2.7 : Form interconnected network of neighborhood streets and sidewalks	Policy 1.1.6: Encourage community-serving facilities to be centrally located
Policy 1.1.4 : The city and its neighborhoods should have a center focus that combines uses	Policy 2.1.1 : Encourage student housing to develop within 1/2 mile of UF	Policy 1.2.8 : Restriction of gated residential developments in order to promote connectivity	Policy 1.2.5: Creation of short-cuts for pedestrians and bicyclists with additional connections
Policy 1.2.3 : Encourage mixed-use development	Policy 2.1.4 : Designate an urban infill and development area	Policy 1.3.1 : Neighborhood centers should include gridded interconnected street network	Policy 1.2.7: Form interconnected network of neighborhood streets and sidewalks
Policy 1.3.3 : Centers should contain mixed uses	Policy 4.1.5 : Discourage strip commercial uses and encourage residential uses along 13th St	Policy 1.4.3 : Mixed use developments should emphasize transit design and compatible scale	Policy 4.2.2 : Shall adopt land development regulations that encourage better access between residential neighborhoods and neighborhood centers
Policy 1.4.1 : Office complexes as least 10 acres shall include retail and service and residences	Policy 1.1.2 : Housing, job and daily needs be within easy walking distance	Policy 1.4.4: In mixed-use zoning districts the city will prohibit land uses that discourages pedestrian activity	
	Policy 1.5.9 : Encourage the establishment of residential retail, office and civic uses within 1/4 mile of the center of neighborhood centers	Policy 2.1.1: Encourage neighborhood enhancement and stabilization for areas designated as redevelopment areas	

Alachua County's Comprehensive Plan

Alachua County's 2001-2020 Comprehensive Plan, was most recently approved in May of 2005 by Florida's DCA. Like the City of Gainesville's Comprehensive Plan, the County's plan includes goals, objectives and policies that deter urban sprawl as mandated by the Growth Management Act. However, Alachua County's Comprehensive Plan incorporates the use of compact development more explicitly as a means to prevent the continuation of urban sprawl, than the City's Plan.

As mentioned under the discussion on Gainesville's Comprehensive Plan, the population in the unincorporated part of the County was growing at twice the rate of that of the City of Gainesville, when the comprehensive plan was adopted in 2001. Alachua County also incorporates a larger percent of vacant land. For instance, 48% of the total urban residential land uses consist of vacant land (Alachua County, 2005). Therefore Alachua County has a greater opportunity to protect undeveloped land and direct where future growth should occur. The County does so by incorporating policies that encourage compact development, as well as energy conservation in their comprehensive plan.

Similar to Gainesville's Comprehensive Plan, Alachua County incorporates many policies outlined in Rule 9J-5. However the encouragement of compact development including its benefits to the community at large is more explicit. Unlike the City of Gainesville's Comprehensive Plan, the County's plan contains a section devoted to the conservation element that incorporates policies that encourage the improvement of air quality and the reduction of GHG emissions.

The Future Land Use Element in the comprehensive plan serves as a guide to the development and the use of land within Alachua County's jurisdiction. In the Scope and

Purpose Section of the County's Future Land Use Element, it is listed that the comprehensive plan acknowledges the "determination of an efficient pattern and location of future land uses through the relationship between land use and the transportation system" (Alachua County, p.1, 2002). As a result "the Future Land Use Element contains objectives and policies to promote more compact growth" (Alachua County, p.1, 2002).

Analysis. Two out of the four overall principles in the Future Land Use Element, use language that endorses compact development. In addition, two of the three general strategies specifically mention increasing densities and creating compact development as a way to promote cohesive communities. These strategies include providing incentives for higher average densities for residential development and mixed uses in the urban cluster, transfer of development rights, urban service area, creating neighborhoods that are compact and connected to adjacent development, avoiding areas of single-use and similar densities, and providing infill where appropriate (Alachua County, p.1, 2002).

The County Comprehensive Elements' Future Land Use, Transportation Mobility and Conservation and Open Space all included policies that encouraged compact development. These policies accomplished this through the encouragement of clustering, implementing higher urban densities, encouragement of activity/village centers, traditional neighborhoods, increase transit options, increasing interconnected corridors, the encouragement of higher densities around the University of Florida and Santa Fe Community College Corridors (Alachua County, 2002). Table 5-2 provides a summary of the policies that correspond with the different characteristics of compact development.

Overall, density was mentioned the most frequent in policies that encouraged development patterns that had the potential to decrease VMT (12 policies). Diversity/mixed uses and Destination Accessibility/Connectivity followed (8 policies each). Finally Design was incorporated in the least amount of policies (5 policies). It is interesting to note that Destination Accessibility/Connectivity was the element that was mentioned the most in the Transportation Mobility Element, but the least in the Future Land Use Element.

The actual word compact is used five times in Alachua County's Comprehensive Plan. It is most commonly used (4 out of 5 times) in an objective or policy referring to village centers or activity centers. Village centers are defined as "neighborhood scale, compact, mixed use areas, integrated into residential areas within the Urban Cluster through specific site and design standards" (Alachua County, p.138, 2005). Similarly Urban Activity Centers are defined as an "areas designated on the Future Land Use Map where higher intensity and density land uses are concentrated" (Alachua County, p.138, 2005).

The word compact is also utilized in General Strategy 3(a) of the Future Land Use Element. This strategy is to "create neighborhoods that are compact, connected to adjacent development, have limited mixed uses at centers, and have interconnected, mixed modal streets with pedestrian, bicycle, and transit friendly areas" (Alachua County, p.2, 2005). Again the word compact in this incidence is used in a descriptive manner.

In contrast to the City of Gainesville's Comprehensive Plan, Alachua County's plan incorporates multiple policies that relate to energy conservation, GHG emissions and decrease in air pollutants. In the Conservation Open Space Element policies on air emissions and energy can be found under Goal 4 and Goal 5. Goal 4 promotes the improvement of air quality, pollution prevention and reductions in GHG emissions (Alachua County, 2005). Policy 4.1.6 of the Conservation Open Space Element specifically correlates land-use and transportation as a means to decrease air pollutants. The policy acknowledges the need for "the promotion of a land development pattern conducive to support of public transportation, including containment of urban development in existing urban areas or carefully planned expansions of urban areas" (Alachua County, p.17, 2005).

In addition the management of energy is utilized in Goal 5. The Objective of Goal 5 is to "provide for energy efficiency in human activities, land uses, and development patterns in order to reduce overall energy requirements for the County and its residents" (Alachua County, p.45, 2005). This objective is to be implemented using policies that "encourage the development and use of economically feasible and environmentally safe, innovative energy sources and management techniques for housing, [and] transportation" (Alachua County, p.45, 2005). More specific to this research, the County's Comprehensive Plan includes the County's goal of reducing GHG emissions by 20%.

Table 5-2. Policies that encourage compact development in Alachua County's comprehensive plan

Diversity/ mixed uses	Density	Urban Design	Destination Accessibility
Policy 1.2.1 of the Future Land Use Element: Mixed uses allowed in traditional neighborhood developments	Policy 1.1.1 of the Future Land Use Element: Encouragement of clustering	Policy 1.4.1.4 of the Future Land Use Element: Designed to integrate into the surrounding community	Policy 1.2.1.1 of the Future Land Use Element: Interconnected system of internal circulation
Policy 1.4.1.1 of the Future Land Use Element: Mixes of housing types in planned developments and village centers	Policy 1.1.4 of the Future Land Use Element: Encouragement of higher urban densities	Policy 1.4.2e of the Future Land Use Element: Grid system interconnecting streets	Policy 1.4.2e of the Future Land Use Element: Grid system interconnecting streets
Policy 1.6.1 of the Future Land Use Element: Mixed uses in village centers	Policy 1.3.3 of the Future Land Use Element: Higher densities urban activity centers lower outlying areas	Policy 1.6.6 of the Future Land Use Element: Site and building design and sale integrate with surrounding community	Policy 2.1.11 of the Future Land Use Element: Provide connections to adjacent commercial development and to adjacent residential development
Policy 1.6.5 of the Future Land Use Element: Mixed uses to reduce overall trip lengths	Policy 1.4.2c of the Future Land Use Element: Encouragement of clustering	Policy 2.1.8 of the Future Land Use Element: Building design and scale integrated within community	Policy 1.2.3 of the Transportation and Mobility Element: Connectivity index standards
Policy 2.1.5 of the Future Land Use Element: Activity centers shall be compact multi purpose	Policy 1.6.3 of the Future Land Use Element: Village center urban cluster	Policy 2.5.3 of the Future Land Use Element: Oaks Multi modal access	Policy 1.2.4 of the Transportation and Mobility Element: Provide pedestrian accessibility
Policy 2.1.6 of the Future Land Use Element: Mixed uses to reduce overall trip lengths in activity centers	policy 1.6.4 of the Future Land Use Element: Village centers shall be compact, multiple purpose, mixed use centers		Policy 1.2.12 of the Transportation and Mobility Element: Development eligible for TCE if located 1/4 mile from transit line, mixed uses, range of densities
Policy 2.5.3 of the Future Land Use Element: Oaks Mall Activity Center, high density and mixed use surrounding it	Policy 2.1.5 of the Future Land Use Element: Activity centers shall be compact multi purpose		Policy 1.3.2 of the Transportation and Mobility Element: Adopt connectivity index standards

Table 5-2. Continued.

Diversity/Mixed Uses	Density	Urban Design	Destination Accessibility
Policy 1.2.12 of the Transportation and Mobility Element: Development eligible for TCE if located 1/4 mile from transit line, mixed uses, range of densities	Policy 2.5.3 of the Future Land Use Element: Oaks Mall Activity Center, high density and mixed use surrounding it		Policy 1.3.3 of the Transportation and Mobility Element: New development shall be connected to roadways, bikeways and pedestrian systems
	Policy 3.1.2 of the Future Land Use Element: New commercial facilities encourage to locate on vacant parcels of land within designated activity centers		
	Policy 3.4.1 of the Future Land Use Element: Only infill of commercial strips are allowed		
	Policy 1.2.12 of the Transportation and Mobility Element: Development eligible for TCE if located 1/4 mile from transit line, mixed uses, range of densities		
	Policy 3.4.4 of the Transportation and Mobility Element: Create future densities and intensities suitable for mass transit		

Conclusion

The City of Gainesville and Alachua County both incorporate the characteristics that support compact development in their goals, objectives and policies in their comprehensive plans, however, both governmental entities lack substantial content on policies to support the reduction of energy consumption and GHG emissions. The future land use patterns outlined in the comprehensive plans promote compact development, but the plans fail to overall relate compact development to the reduction in trip length. This is a considerable shortcoming of the comprehensive plans. As the purpose of comprehensive plans are to serve as a guide for future development and land use decisions, it is imperative that the plans include policies that promote land use designations that reduce trip length, as a means to reduce GHG emissions.

CHAPTER 6
DISCUSSION

This chapter will provide a discussion on the implications of the results of the models and policy analysis. The results of the models will be utilized in determining how the City of Gainesville and Alachua County's comprehensive plans can be enhanced to incorporate polices that have the potential to reduce trip lengths. The discussion will focus on the type of development that is needed to reduce trip lengths and evaluate the effectiveness of current policies in local comprehensive plans in promoting this type of development. The discussion then uses two simulations derived from the model results to provide recommendations of where the most suitable locations for new development to occur are. The chapter concludes with the limitations of this study as well as recommendations for future research.

Discussion

The results of this study provide the locations where the land use patterns in Alachua County are more favorable towards the reduction in trip lengths. Compact neighborhoods characterized by density, destination accessibility, urban design, and diversity, were shown to be more favorable toward a decrease in trip lengths when compared neighborhoods characterized by urban sprawl. A decrease in trip lengths can also be translated as a reduction in fuel consumption. Accordingly, a reduction in fuel consumption can be translated into a reduction in GHG emissions released into the atmosphere. With one third of GHG emissions produced by the transportation sector, it is imperative for planners to look for innovative ways to reduce these emissions.

The responses to climate change are ultimately local and regional. Finding new ways to meet energy needs, lower GHG emissions, and face the impacts of climate change will be critical to the future success of Alachua County. Climate change potentially brings with it a long list of impacts to ecological systems, agriculture, public health, infrastructure and commerce. As this research suggests development patterns can play an important role in reducing GHG emissions. Employing strategies to promote compact development in areas that are favorable to shorter trip distances could reduce GHG emissions and improve environmental quality.

Comprehensive plans are seen as a guide for the future development and use of land within local government jurisdictions. Since the purpose of these plans is to guide future development and land use, it is vital that they include elements that promote the reduction of GHG emissions. The analysis of two local comprehensive plans reveal that goals related to energy conservation and the reduction of GHG emissions are not directly associated with land use policies and designations. This is a major shortcoming in our comprehensive plan system. The models utilized in this research can be used as a tool to help improve the comprehensive plans by suggesting the type of development and location of where new development should occur within the County.

Comprehensive Plan's Mechanisms to Promote Compact Development

Both the City of Gainesville's and Alachua County's Comprehensive Plans were influenced by the type of growth they were experiencing at the time their comprehensive plan was being drafted. The City of Gainesville was experiencing a declining share in the overall population of the county. Therefore the goals, objectives and policies were tailored towards implementing strategies to encourage the movement of people back into the city. For instance Objective 1.5 of the City's Future Land Use Element incorporates policies with the intent to make Downtown Gainesville a more livable environment, by means such as enhancing the schools within city limits (City of

Gainesville, p. A-4, 2000). The importance of creating a desirable built environment in downtown Gainesville is again evident in that the City created an element called Urban Design. This element contains goals, objectives and policies all oriented toward creating a friendlier and more welcoming downtown area (City of Gainesville, 2000).

On the other hand, unincorporated Alachua County was experiencing a greater share of the population and was experiencing a population growth rate twice as large as the City's growth rate. Unlike the City of Gainesville, Alachua County incorporated planning tools that instead of encouraging growth to occur in a certain area, directed where growth should occur. For instance the County incorporated an urban growth boundary in their Comprehensive Plan. This urban growth boundary contains growth in a specific section of the unincorporated part of the County. The County also utilizes an urban service area to designate where growth should occur.

While both comprehensive plans incorporate polices that promote compact development and to influence the location of new growth, they have not been implemented in a way that supports compact development as a means to reduce trip length. For instance Both the City and the County used the encouragement of mixed use development as a way to curtail sprawl and promote compact development. In Alachua County's Data and Analysis Section of the Future Land Use Element, the County sites the Town of Tioga as an example of mixed use development (Alachua County, 2001). In the neighborhood comparison the Town of Tioga represented the suburban neighborhood. As the results of that section showed the HBW predicted trip lengths were on average 5.2 miles in length, compared to the urban neighborhood where the predicted trip lengths were less than one mile. This indicates that while mixed use is an element that makes up compact development, it has to be implemented in an area that contains the other three identified characteristics of compact development: density, urban design and destination accessibility, to contribute to the reduction in trip lengths. This example helps illustrate the need for all four characteristics identified by the literature as compact development, to coincide with one another in order to see reductions in trip lengths.

The models also suggest that mixed use is more likely to reduce the trip lengths for HBO trips while access to major employment centers is more likely to reduce HBW trip lengths. The Town of Tioga would is also a good example of this. The Town of Tioga is located in an area of mixed use and therefore the results indicates that it the development is predicted to have relatively short HBO trip lengths (2.8 miles). However Town of Tioga's low accessibility to employment centers causes it to have a HBW predicted trip length of 5.2 miles. However if a "neighborhood" incorporates all of the characteristics of compact development it will see the largest decrease in both HBW and HBO trip lengths. This was illustrated with the Duckpond neighborhood. To determine areas that possess all of the characteristics of compact development in the County, the following section combines the results of the HBO and HBW models in two simulations that illustrate the ideal locations for new development to occur.

Recommendations on Where Future Development Should Occur

The ultimate way to reduce GHG emissions from the transportation sector is to get people out of their cars. The only way to do so is by providing development patterns that allow for alternative forms of transportation such as by foot, bicycle and transit. The areas where the models represented shortest trip lengths, also encourages higher level of transportation choice than areas that represented longer trip lengths. Therefore the most appropriate places to encourage further development is in areas that are depicted as having the shortest trip lengths for both HBO trips and HBW trips. Two simulations were run using the results of the HBW and HBO models to determine the most suitable locations for development to occur in order to reduce trip lengths.

The first simulation looks at where both the HBO and HBW trip lengths are predicted to be one mile or less. The results of this simulation, shown in Figure 6-3, represent the ideal location for development to occur in order to create a walkable community. It is predicted that if development occurs in these areas, individuals will not be reliant on an automobile because they will be in close enough proximity to both shopping destinations and employment centers that they will be able to walk to these destination. The encouragement of development in these locations will further minimize walking distances and create a more pedestrian friendly area. Therefore the results of this simulation denote where both the City and the County should prioritize future development to occur.

The second simulation looks at where both HBO and HBW trip lengths are predicted to be three miles or less. The results of this simulation, shown in Figure 6-4, represents where shopping destinations and employment centers are easily reachable by the use of a bicycle. The encouragement of development in this area should be the second area of prioritization for future development.

The encouragement of development to occur in both of these areas will also increase the accessibility to transit. A study conducted by Gainesville Regional Transit System (RTS) found that their service area is “approximately 38 square miles if ridership is drawn from a one-quarter miles walking distance from bus routes, but expands to approximately 84 square miles if ridership is drawn from a one-mile bicycling distance" (City of Gainesville, p. 34, 2001). A map of the cities bus routes, as well as their bicycle service area is represented in Figure 6-5. This map shows that the majority of the areas within the City limits are accessible to transit with the use of a bicycle. However transit use on some of these routes is greatly inhibited by their low trip frequency. Routes that have a frequency of equal to or greater than once ever hour are highlighted on the map. Therefore while these routes are easily accessible by bicycle their low trip frequency decreases the convenience of these routes and thus will see a lower ridership than bike routes that have a greater trip frequency. Thus the City should encourage development in areas in close proximity to bus routes that have a greater trip frequency or increase the trip frequency of the highlighted routes in order to decrease trip lengths produced by the automobile more effectively.

Limitations and Opportunities for Future Research

It is important to recognize some of the shortcomings of the models and policy analysis used in this research. First the models do not control for socio-economic characteristics of the traveler. As mentioned in the literature review, this is an area of concern. However these models are intended to predict the trip-lengths associated with land-development. In this case, it is almost impossible to know what the characteristics of the traveler are going to be. As shown in Table 4-1 the "r squared" values produced by the regression model are relatively small. Therefore while land development patterns have a significant inverse relationship with trip length, the "r squared" value suggests that there are other additional predictors of trip length. This could be a result of not incorporating socioeconomic characteristics.

In addition this some of the trip lengths produced could be biased low. As mentioned previously in Chapter 4, the HBW production model predicted trips lengths of less than a mile and a half in the small municipalities located in Alachua County. Due to limited employment opportunities in these cities, it is very unlikely that all of the residents work within their borders. Therefore this model does not take into account the residents in these municipalities who commute to the City of Gainesville for employment.

Additionally, VMT is a composite measurement of trip length and trip frequency. The model used only accounts for trip length and fails to account for trip frequencies as related to the land development patterns. Past research has shown that greater accessibility has a tendency to encourage trip making and thus increase the overall VMT (Polzin, 2006). This is an inverse effect of accessibility and should be considered in future research looking at the relationship between land development patterns and VMT.

Congestion created by more compact developments was also not considered in this research. Increased congestion as a result of more compact development could cause an increase in GHG emissions from idling cars. It is recommended that further research be conducted to account for the potential influence of congestion on the relationship between the built environment and GHG emissions.

The policy analysis conducted in this research only considered the goals, objectives and policies in the City of Gainesville's and Alachua County's Comprehensive Plans. While the Comprehensive Plan's main purpose is to serve as a guide for future development and land use decisions, it is not the only planning tool that influences development patterns and planning practices. By not examining other City and County operations, the research is unable to provide a full account of the initiatives currently being undergone by the City and County to promote energy conservation and GHG emissions. Thus while the City and County lack content in their comprehensive plans related to energy conservation and GHG emissions, it does not mean that both governments are not actively addressing these issues through specific city and county department operating procedures.

Both the City of Gainesville and Alachua County are members of the ICLEI- Local Governments for Sustainability (ICLEI). This membership is associated with local governments committed to advancing climate protection and sustainable development (ICLEI, n.d.). In addition Alachua County has established the Energy Conservation Strategies Commission (ECSC) whose purpose to look for way to reduce energy consumption in the County. The County is continuing to monitor their GHG emissions through the Pollution Protection section of the Environmental Protection Department, while the City is monitoring their GHG emissions through their Gainesville Regional Utility Department.

The purpose of the thesis was to determine areas within the County that were contained land use patterns that were the most conducive to reductions in trip length. By doing so this research was able to effectively evaluate areas where the City of Gainesville's and Alachua County's comprehensive plans could be improved upon in order to encourage development patterns that will help mitigate GHG emissions from the transportation sector. Further research is needed to look deeper into the relationship between land development patterns and trip lengths and to explore to a greater extent how local governments can incorporate policies supporting compact development into their comprehensive plans and their land development codes. As policies are implemented at both the federal and state level to promote energy conservation and GHG reductions, it would be valuable to conduct a follow up study to examine the extent to which Alachua County and the City of Gainesville amend their comprehensive plans to incorporate the state and federal goals.

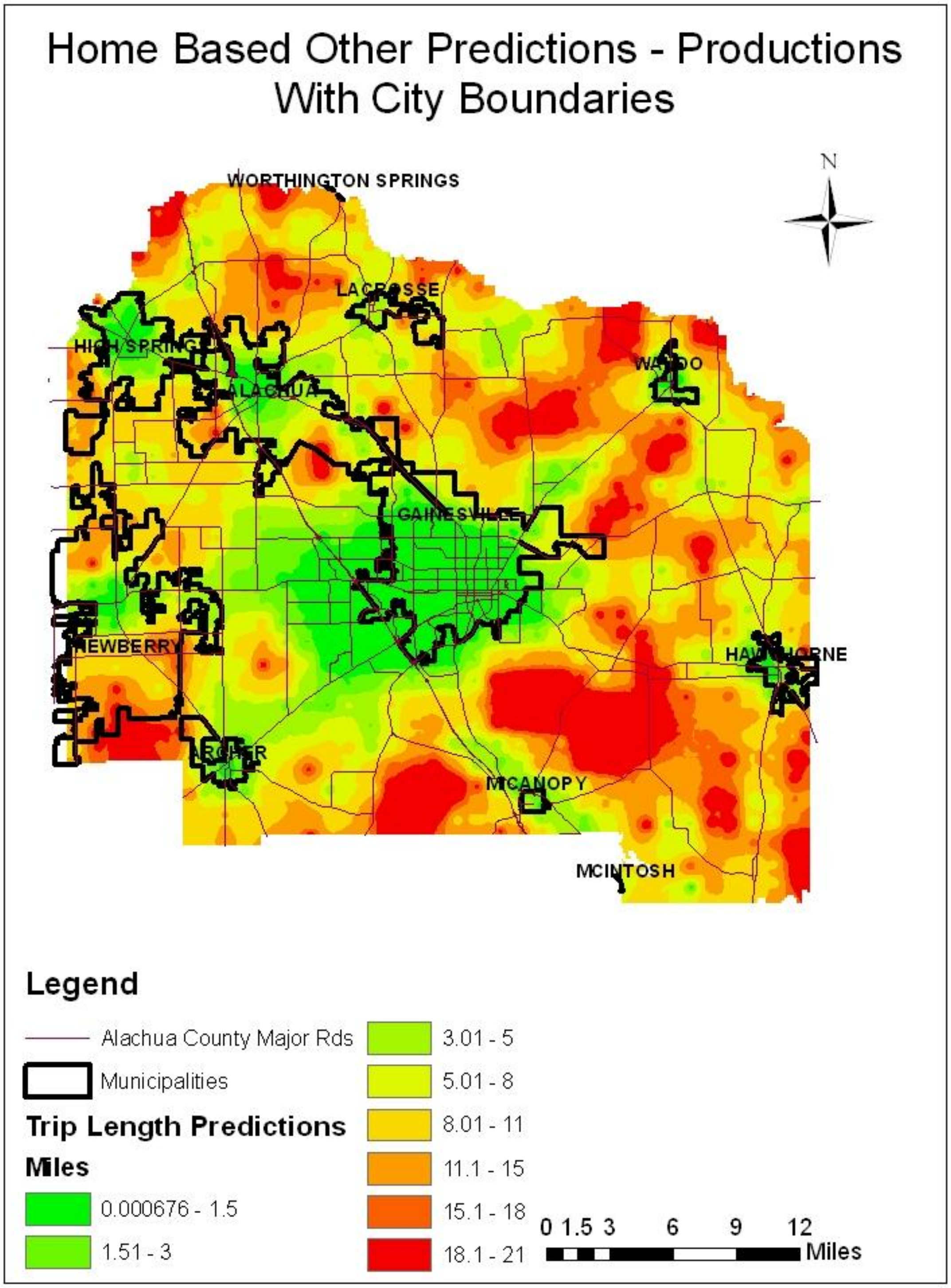

Figure 6-1. Home based other predicted trip lengths including city boundaries

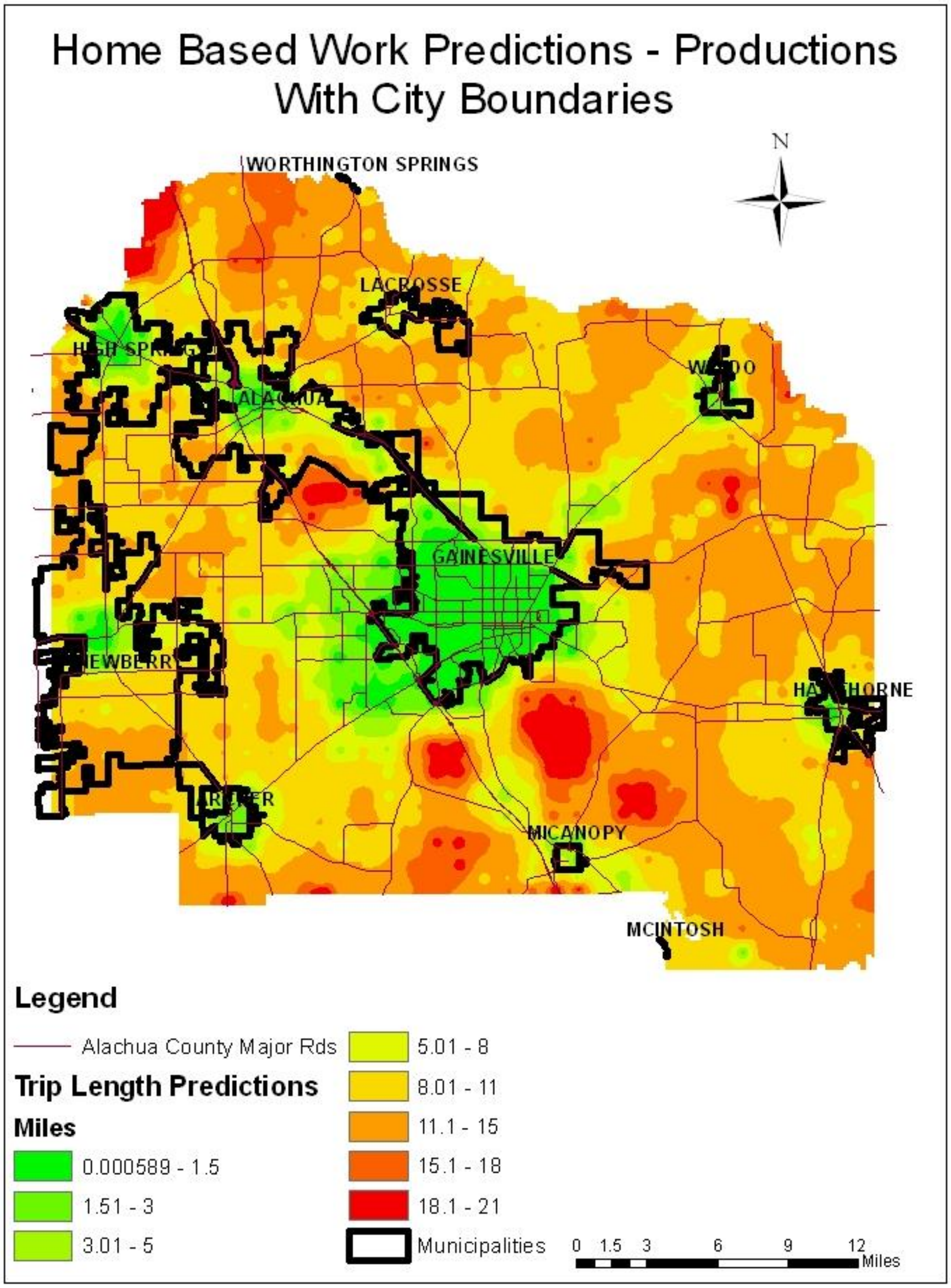

Figure 6-2. Home based work predicted trip lengths including city boundaries

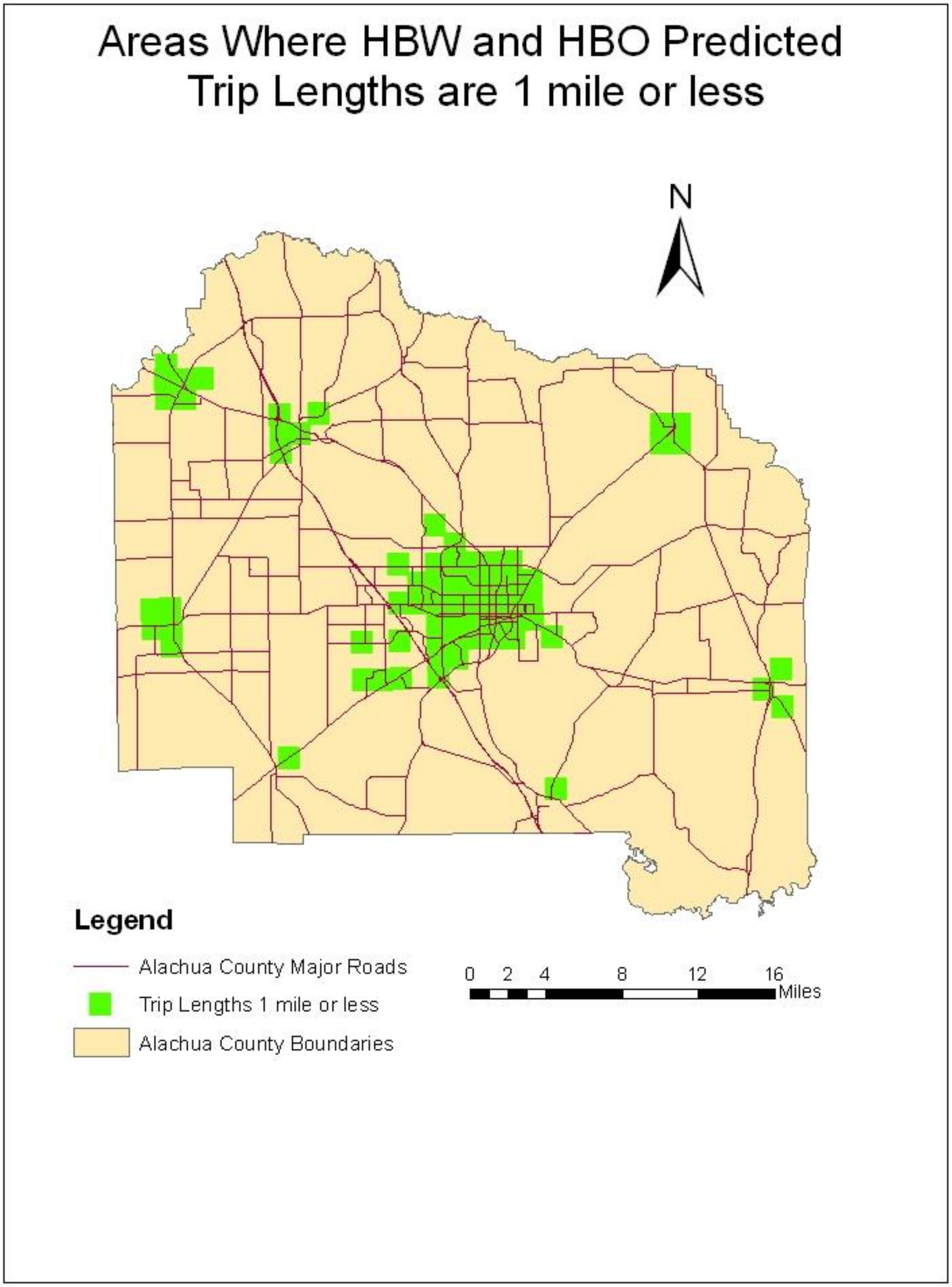

Figure 6-3. Areas where HBW and HBO predicted trip lengths are 1 mile or less

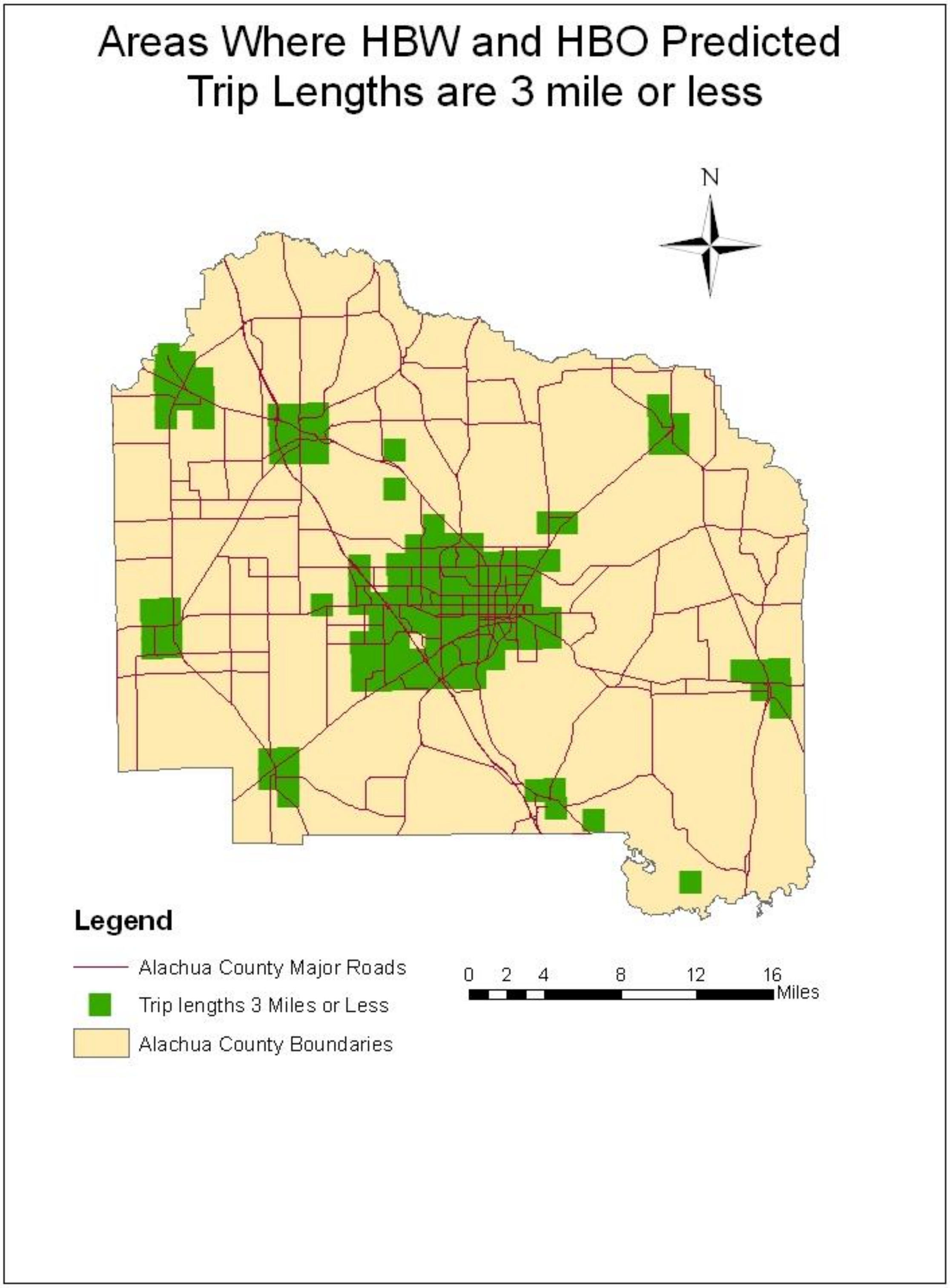

Figure 6-4. Areas where HBW and HBO predicted trip lengths are 3 miles or less

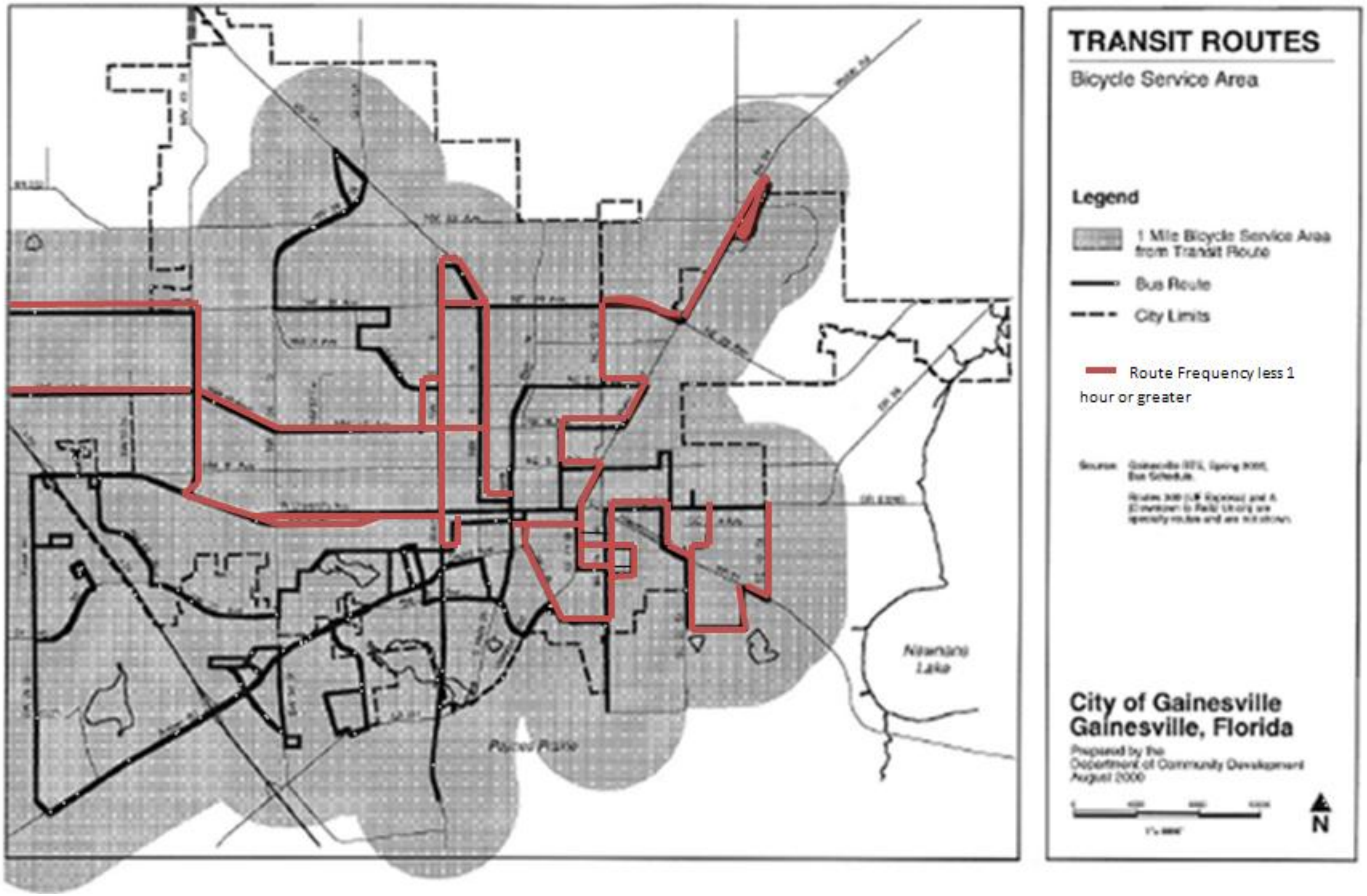

Figure 6-5. Transit routes with bicycle service area

CHAPTER 7
CONCLUSION

With the transportation sector accounting for approximately one third of GHG emissions in the United States, it is imperative that local government find new ways to curb the rate that these emissions are released into the atmosphere. Through the enactment of Florida's House Bill 697 and increasing incentives from the federal government, both the City of Gainesville and Alachua County are receiving pressure to come up with innovative ways to decrease GHG emissions, especially from the transportation sector. The literature has shown that land development patterns have the potential to decrease trip lengths. A decrease in trip lengths can also be translated as a reduction in fuel consumption. Accordingly, a reduction in fuel consumption can be translated into a reduction in GHG emissions released into the atmosphere.

The HBO and HBW trip generation prediction models utilized in this research, map the locations where land use patterns are more favorable to the reduction in trip lengths in Alachua County. These models can be used as a tool to help local governments determine what policies the City and County need to include in their comprehensive plans to promote land development patterns that decrease trip length.

The results of this study provide the locations where the land use patterns in Alachua County are more favorable towards the reduction in trip lengths. Compact neighborhoods characterized by density, destination accessibility, urban design, and diversity, were shown to be more favorable toward a decrease in trip lengths when compared to neighborhoods characterized by urban sprawl. The models showed that on average trip lengths were expected to increase the farther the neighborhood was from Gainesville's City Center. The models also suggest that mixed use is more likely to reduce the trip lengths for HBO trips while access to major employment centers is more likely to reduce HBW trip lengths. Therefore, in order to effectively reduce trip lengths, local governments need to encourage development to occur in areas where both HBO and HBW trips are predicted to be the shortest in length. As a result the researcher recommends that areas on the map that represent where the predicted trip lengths are one mile or less for both HBW and HBO trips are the most suitable locations for new development to occur. These areas should be identified in the local comprehensive plans as the first priority of where to guide future development. Areas where HBW and HBO trips that are predicted to be three miles or less should be the second area of prioritization for future development.

Comprehensive plans are seen as a guide for the future development and use of land within local government jurisdictions. Since the purpose of these plans is to guide future development and land use, it is vital that they include elements that promote the reduction of GHG emissions. The analysis of two local comprehensive plans reveal that goals related to energy conservation and the reduction of GHG emissions are not directly associated with land use policies and designations. This is a major shortcoming in our comprehensive plan system. The models utilized in this research can be used as a tool to help improve the comprehensive plans by suggesting the type of development and location of where new development should occur within the County.

The responses to climate change are ultimately local and regional. Finding new ways to meet energy needs, lower GHG emissions, and face the impacts of climate change will be critical to the future success of Alachua County. Climate change potentially brings with it a long list of impacts to ecological systems, agriculture, public health, infrastructure and commerce. As this research suggests development patterns can play an important role in reducing GHG emissions. Employing strategies to promote compact development in areas that are favorable to shorter trip distances could reduce GHG emissions and improve environmental quality.

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BIOGRAPHICAL SKETCH

Kelly Rhinesmith was born in 1987 in Bamberg, Germany. She grew up in Oviedo, Florida and graduated from Oviedo High School in 2005. Upon graduating from high school, Kelly attended the University of Florida and enrolled in the 4+1 program with the Department of Urban and Regional Planning, graduating with her Bachelor of Arts degree in sociology in December 2009 and Master of Arts in urban and regional planning degree with a certificate in historic preservation in May 2010. While attending the University of Florida, Kelly interned with Alachua County's Environmental Protection Department. This experience fueled her interests environmental planning specifically on the topics energy and climate change. In addition to environmental planning, her interests include transportation planning, historic preservation and community redevelopment. Outside of school, Kelly enjoys spending time with her family and friends, cooking, and traveling. Upon graduating Kelly looks forward to pursuing her planning career in Little Rock, Arkansas.