HOW DOES URBAN FORM IMPACT THE POTENTIAL FOR CHILDREN TO WALK AND BICYCLE TO SCHOOL: A CASE STUDY OF ORANGE AND SEMINOLE COUNTIES IN CENTRAL FLORIDA

By

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To my Family and Friends

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Arts in Urban and Regional Planning

HOW DOES URBAN FORM IMPACT THE POTENTIAL FOR CHILDREN TO WALK AND BICYCLE TO SCHOOL: A CASE STUDY OF ORANGE AND SEMINOLE COUNTIES IN CENTRAL FLORIDA

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Chair: Name: Ruth L. Steiner
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Childhood obesity in the United States has become a national epidemic. One of the reasons that researchers have suggested that this may be occurring is due to a decrease in the amount of physical activity that children are participating in. One solution aimed at increasing physical activity among children, is by providing enhanced opportunities for children to walk and bicycle to school.

This study examines how urban form impacts the potential for children to walk and bicycle to school, by examining several characteristics of the built environment around elementary schools within Orange and Seminole Counties in Central Florida. The two primary characteristics used in this investigation are street connectivity and residential density. Within street connectivity, three indicators are used to measure the potential for walkability to school. These indicators include street density, intersection density, and Pedestrian Route Directness (PRD), which is a ratio of the network walking distance to the straight-line distance between two points. Residential density characteristics also use three indicators for measuring potential walkability. These include gross residential density, net residential density, and Effective Walking Area (EWA), which calculates the percentage of residential parcels that are found along

a street network. These indicators are compared against four influential development periods which correspond to growth management and school coordination legislation in the State of Florida. These include historic schools built before 1950, pre-growth management schools built between 1950 and 1985, pre-school coordination schools built between 1986 and 1995, and post-school coordination schools built after 1995.

The general findings from this study suggest that historic schools built before 1950 and those schools sited after 1995 in Orange County reveal the highest potential for walkability. The general findings in Seminole County reveal the greatest potential for walkability occurring around schools built during the pre-growth management period between 1950 and 1985. By examining the Counties across the four development time periods, there does seem to be a correlation between the patterns of development in Orange County, while the development trends in Seminole County seem to be less apparent, following no coordinated patterns.

Developments that are more compact, consisting of more traditional grid-like street patterns and higher residential densities, appear to support greater potential for walking and bicycling. Because the intention of this study was to investigate how urban form impacts walkability, analysis within the four influential time periods was critical, especially in examining how policy factors may be affecting the development of Florida's built environment. Providing a better understanding of how our built environments affect our health is imperative as we plan communities for generations to come.

CHAPTER 1
INTRODUCTION

The connection between physical activity and health is as old as civilization. Hippocrates (460 BC – 377 BC) once stated, "Walking is man's best medicine." As our populations and cultures have grown and evolved, so too have our ways of life; we tend to eat more and walk less (Kahn, 2008). Paralleling this trend for the past twenty-five years is a notable increase in obesity rates among adult individuals (Centers for Disease Control and Prevention, 2007). Just as astonishing is the percentage of children and adolescents who are overweight or obese (Ogden, Carroll, & Flegal, 2008). One particular factor associated to the increase in rising obesity rates can be associated to physical inactivity, which is particularly deleterious for the health of children and adolescents. Many children do not engage in enough physical activity to meet the recommendations required to maintain a healthy weight that supports healthy lifestyles (Dellinger & Staunton, 2002). Alternatively, children are spending more time indoors, participating in less-physically active alternatives, such as watching television and playing videogames (Robinson, 1999). One solution to consider in addressing this issue is the encouragement of physical activity by providing safe and accessible opportunities for children to walk and bicycle to school. Though providing such an option may not entirely address physical activity concerns, the notion at least serves as a stepping-stone to promote further opportunities. It is not feasible to either predict or estimate the probability of children that might engage in physical activity, largely due to a diverse range of variables (e.g., dietary behaviors, safety concerns (real and perceived), personal choices). This makes the understanding of childhood obesity and its relationship to urban form extremely difficult to measure. However, further research is important and necessary in the continued effort to reveal the connections between health and the built environment.

The issue of childhood obesity has become a major health concern for the U.S. and abroad (Wang & Lobstein, 2006). Although rates have stabilized between the periods of 2003 – 2006, we must not allow ourselves to become complacent on the issue (Centers for Disease Control and Prevention, 2006). If obesity rates have reached a plateau, the plateau is still incredibly high. Previous data collected by the National Health and Nutrition Examination Survey (NHANES) for the time periods between 1976-1980 and 2003-2004, show the prevalence of overweight increasing: For children aged 2-5 years, prevalence increased from 5.0% to 13.9%; for those aged 6-11 years, prevalence increased from 6.5% to 18.8%; and for those aged 12-19 years, prevalence increased from 5.0% to 17.4% (Centers for Disease Control and Prevention, 2006). The current trend of overweight and obesity levels among children and adolescents has nearly tripled since 1980. In aaddition, another 15% of children and 14.9% of adolescents are considered "at risk" for becoming overweight, based on BMI (body mass index) measures (Centers for Disease Control and Prevention, 2006). Overweight and obesity concerns are particularly risky for children as they may experience immediate health consequences with a greater risk for weight-related health problems in adulthood (Serdula, 1993), including cardiovascular disease, diabetes (Fagot-Campagna, Pettitt, Engelgau, Burrows, Geiss, Valdez, Beckles, Saaddine, Gregg, Williamson, & Narayan, 2000), psychosocial illnesses (Strauss, Rodzilsky, Burack, & Colin, 2001; Dietz, 1998), and a host of other chronic disorders.

Physical inactivity among other varying factors is associated with the increase in childhood overweight and obesity. Currently the U.S. Department of Health and Human Services recommends that American adults accumulate at least 30 minutes of moderate physical activity most days of the week, while children should participate in at least 60 minutes. Even greater amounts of physical activity may be necessary for the prevention of weight gain, for weight loss, or for sustaining weight loss. One solution to combat physical inactivity among younger populations is to increase the number of children who walk or bicycle to and from school. In 2003, the U.S. EPA (Environmental Protection Agency) reported a decline in the number of students who walked or bicycled to school from 48 percent in 1969 to 15 percent in 2001 (Steiner, Crider, & Betancourt, 2006). This trend was also projected in a "Home-to-School Transportation" study conducted by the Florida Department of Transportation (FDOT) in 1992, stating that only one out of six children in Florida walk or bicycle to school while the rest are transported by bus or private motor vehicle (Starnes, Stein, Crider, Audirac, & Pither, 1992). Fewer children engaging in active transportation methods as a mode of travel to school leads to an influx of motor vehicle traffic around school sites. The result of this occurrence often creates severe congestion increasing the incidence for pedestrian-vehicular accidents creating additional health risks. Unfortunately, this transportation mode shift is causative of many ambiguous planning and development decisions made over the last half-a-century.

In the U.S., public school enrollment reached a record high of 49 million in 2004; That number is projected to reach 53 million by 2016 (ICMA, 2008). With public school enrollment on the rise, it is becoming increasingly important for decision makers to address issues associated with the siting of public school facilities, including but not limited to a variety of factors that influence a child's mode of travel to school. This issue is especially important in the State of Florida, where populations are expected to double to 36 million by the year 2060 (1000 friends of Florida). More people will presumably mean more children equaling a greater need for strategic planning and decision making regarding land use development and school siting. The State of Florida currently requires coordination between local planning agencies and district school boards mandating concurrency and the establishment of a public school facilities element in every local comprehensive plan. This requirement was implemented to ensure consistency between land use development and school siting decisions. The intent of this cooperative effort is to support the safety, health, and welfare of the general public and prevent further unnecessary urban disinvestment and sprawl as Florida's population continues to grow.

This study intends to contribute further investigation into how physical (in)activity corresponds to childhood overweight and obesity issues, by exploring how urban form impacts the potential for children to walk and bicycle to school. Similar research has led to this study and has fostered its process of evaluation, using a like methodology. This study examines two counties across four temporal development periods in the Central Florida region using several indicators to measure the impact that urban form presents on school walkability[1]. Two main characteristics of urban form are explored in this study: *Street Connectivity* and *Residential Density*. Street Connectivity is analyzed using three indicators: (1) Street Density, (2) Intersection Density, and (3) Pedestrian Route Directness (PRD) (Bejleri, Steiner, Provost, Fischman, & Arafat, 2008). Residential Density is also analyzed using three indicators. The first two are strict measures of residential density including (1) Gross Residential Density and (2) Net Residential Density (Bejleri, et al., 2008). The third measure (3) Effective Walking Area (EWA), will be used to make assumptions on potential walkability based on the percentage of residential parcels that are found along the street network. The initial analysis is then examined, comparing each set of findings across four temporal development periods which correspond to pre- and post-Growth Management laws and coordinated school planning legislation in the State of Florida. Through these findings, the author intends to provide insight into how urban form has impacted the potential for children to walk and bicycle to school. Exploring these findings

[1] Walkability (including walkable) will be used throughout the paper referring to active-mobility (walking, bicycling, etc.) within the built environment

within the context of the different development periods provides further insight into how the built environment has impacted walkability.

The central Florida region is the fastest growing region in the State of Florida. According to a recent report presented by Floridians for a Sustainable Population (in conjunction to findings from "Florida 2060: A Population Distribution Scenario"), the central Florida region will experience "explosive" growth with continuous urban development from Ocala to Sebring, and St. Petersburg to Daytona Beach. The study projects that the I-75 and I-4 corridors will be fully developed by 2060 (Floridians for a Sustainable Population, 2006). Resting squarely within this area are Orange and Seminole counties. Due to the projected growth and development of this region, it is important to provide research insight to help alleviate the stresses that will presumably exist into the future. The author's concentration on these two counties was chosen due to the availability of GIS data and the additional resources and information provided from previous studies within the area specifying the need for further research and investigation.

This document contains five chapters. The first chapter is an introductory section justifying the value of this research. The second chapter provides a review of the literature pertaining to issues of childhood obesity and physical inactivity. Connections between health and the built environment are discussed, specifically examining the various impacts that urban form presents on walkability. The third chapter highlights the methodology that is used in this study. The fourth chapter presents in detail the research findings. Finally, chapter five presents discussions and conclusions based on the findings. This section will also include suggestions for valuable future research.

CHAPTER 2
LITERATURE REVIEW

This chapter illustrates the connections between physical activity and childhood obesity through a review of the literature pertaining to urban form and walkability. This section will primarily focus on issues associated with school siting and the factors that affect a child's ability to walk and bicycle to school. The literature will begin with a review of the issues surrounding childhood obesity and the connection to physical inactivity and the built environment. Next, a brief historical look into transformations of U.S. land development patterns will be discussed, specifically examining regulatory functions mandated by Florida legislation that are used in guiding land use and school-site development decisions. Then a section briefly outlining some of the major issues associated with the siting of public school facilities is discussed. Finally, a section describing the characteristics of urban form is discussed, including the relationship between the built environment and walkability, particularly concerning school walkability. This section will provide a foundation and context for the arguments stated in this research study.

Childhood Obesity and Physical Inactivity

Childhood obesity rates have reached such astonishingly high levels in the United States that the condition is now considered an epidemic (Centers for Disease Control and Prevention, 2006). The rise in childhood obesity has been attributed to complex interactions across a number of relevant social, environmental, and policy contexts that have collectively created an adverse environment for maintaining a healthy weight. Factors associated with weight gain and childhood obesity include energy input (food intake), energy output (amount of work), and genetic predisposition. Although dietary behaviors and genetic make-up play vital roles in regulating obesity levels, the research presented in this study takes an approach that focuses primarily on factors affecting physical activity and inactivity (expenditure of energy) within the built environment, particularly the various physical and institutional impediments that exhibit a child's ability to walk or bicycle to school.

Scientific evidence has shown that physical activity plays a critical role in supporting weight loss based on the first law of thermodynamics[1]. Unfortunately, many children do not participate in the recommended amount of physical activity needed to maintain a healthy weight that supports healthy lifestyles (Dellinger & Staunton, 2002). In many cases, children are deprived of the opportunities to engage in physical activity due to a growing separation between residential dwellings and commercial, civic, and institutional services (e.g., school facilities), inadequate provision of community places for children to commune (e.g., parks, ball-fields, and other (natural) recreational destinations), and the lack of necessary infrastructural elements like sidewalks, bicycle lanes, and other pedestrian pathways that support recreational and travel opportunities (Day, 2009).

Many of these issues are directly related to failures in policies, planning, and design. Unfortunately, there can be many negative implications related to these policy decisions, including preventable disorders such as obesity, which is a known risk factor for many chronic disorders (e.g., diabetes, coronary heart disease) (Weight Control Information Network, 2009). These conditions contribute to the billowing stress on our health care system and have added to the enormous increase in health care costs (Weight Control Information Network, 2009). One study, conducted in 1995, reported that the direct monetary costs related to physical inactivity – a contributor to the obesity epidemic – may be as high as $24.3 billion annually (see Table 2-1)

[1] The first law of thermodynamics generally states that a thermodynamic system can store or hold energy and that this internal energy is conserved. Heat is a process by which energy is added to a system from a high-temperature source, or lost to a low-temperature sink. In addition, energy may be lost by the system when it does mechanical work on its surroundings, or conversely, it may gain energy as a result of work done on it by its surroundings. The first law states that this energy is conserved: The change in the internal energy is equal to the amount added by heating minus the amount lost by doing work on the environment.

(Colditz, 1999). The estimated hospital costs alone in treating children for obesity-associated conditions rose from $35 million in 1979-1981 to $127 million in 1997-1999, in 2001 dollars (Wang & Dietz, 1999). To deliver adequate and practical solutions that will aid in remedying these conditions, policy makers must recognize some of the causative factors that are contributing to these instances.

Introducing more opportunities to be physically active is one solution in helping relieve a portion of the outrageous health care costs that are associated with preventive disease control and the overweight and obesity epidemic. There are many ways to encourage and increase levels of physical activity. Several ways to promote children to participate in physical activity is through parental encouragement and cooperative participation, development of positive attitudes about exercise, modeling healthy behaviors, and encouraging healthy eating habits. Encouragement of physical activity can also be strengthened through physical education programs in schools and within the community through an assortment of community organizations. Additional methods for encouraging physical activity can also be achieved through a variety of physical planning strategies, design implementations and a host of regulatory factors which are the focus of the research presented in this paper.

Automobile-Dominated Land Development

A viable and effective way to provide younger populations the opportunity to engage in increased levels of physical activity is to provide safe and accessible means for children to travel to and from school by walking and bicycling. Unfortunately, many communities in the U.S. have deserted the ideal of creating environments that are friendly for the pedestrian and healthy for the populations that inhabit them. To better conceptualize these implications, it is important to understand the evolution of development trends that have historically inhibited community walkability and propelled us into an age of automobile-dominated living.

Cities have been recognized as places for people to come together, to enjoy the benefits of company, commerce, and mutual defense for thousands of years (Frumkin, Frank, & Jackson, 2004). By the 1950s, the "American Dream" was thriving in post-World War II suburban land development, spurred on by middle class American society fleeing the atrocities of the inner city in the so-called "pursuit of happiness" (specifically the ownership of land) (Calthorpe, 1993). This era instituted a new America, in which both the city and the suburb were now locked in a mutually negating evolution toward the loss of community, human-scale environments, and the beauty of natural surroundings. Ultimately, these patterns of development and growth created on one side, congestion, pollution, and isolation, and on the other, urban disinvestment (inner city retraction) and economic hardship. Some of the negative conditions resulting from this movement include environmental stresses, intractable traffic congestion, lack of affordable housing, irreplaceable open space and gathering places, lifestyles which burden working families and isolate undervalued populations, and declines in public health and overall quality of life issues (Calthorpe, 1993).

Functional, inhabitable communities are products of great planning, good policy, and forwards thinking of design and the appropriate use of space. Reviewing historic U.S. development trends reveals communities consisting of narrow tree-lined streets, with sidewalks, where people walked and rode their bikes. Towns were simple; in many instances, shopkeepers lived above their businesses and residents knew one another. Although reverting back to the simplicity of yesteryear is daringly unrealistic, the notion of recreating the small town livability does not have to be entirely disregarded. In fact, the small towns of the mid-1900s, as we remember them, consisted of the most valuable elements that supported healthy livable places, including community-oriented designs, with civic and institutional facilities at the core of the neighborhood, places for people to commune and engage in public activities, and most of all, a sense of belonging, captured by a strong sense of place (Lynch, 1960).

Today, the automobile has reconstructed our daily lives and has reshaped the ways in which we live and function in the modern world (Frumkin, Frank, & Jackson, 2004; Calthorpe, 1993). The focus on small town development, with pedestrian friendly through-fares is rare – in some instances it is completely non-existent. Modern development patterns that strictly facilitate automobile accommodation and lack human-scale environments have left us with communities where the segregated lifestyle of individuality with long commutes between home, work (school) and play prevail. This disinvestment in community building destroys the cohesion that people and their environments (both natural and built) need in sustaining health, wellness, and a satisfactory quality of life.

Making sound decisions about developing healthy places for people to live, work, and play begins with good community planning (Lucy 1994), especially when it comes to the health and well being of children in the community. At the core of such decision making is a host of rules and regulations that are aimed at addressing these issues. In particular, the topics of growth management and land use regulation; two extremely important mechanisms that assist in fostering sensible development for both current and future populations. To better understand the connection between land development patterns and the locations of schools within the community, it is important to understand the regulatory framework by which development decisions are frequently made.

While the challenges described above are fairly common across the United States, not all States deal with such challenges the same way. Some States, like Florida, have chosen to adopt a top-down planning approach to govern and manage their growth. This paper will focus on the planning and development structure that Florida constitutes in order to put into context the case studies for this research.

Florida Growth Management and Coordinated School Planning

In 1972 the Florida legislature passed the Florida State Comprehensive Planning Act. This act was designed to provide long-range guidance for the orderly social, economic, and physical growth of the state, setting forth goals, objectives, and policies (1972 Florida Laws, Chapter 72-295). Also part of the 1972 Florida legislation, was the development of the Environmental Land Management Study (ELMS) Committee, which drafted the Local Government Comprehensive Planning Act of 1975. This act was intended to control land use and guide development. The act specified two major mandates. The first was a requirement for local governments to adopt comprehensive plans. The second requirement mandated that all development plans conform to the adopted comprehensive plan. Unfortunately, the act would eventually fail due to unclear expectations and a failure in implementing it effectively. Then in 1985 the Local Government Comprehensive Planning and Land Development Act (a.k.a. "GMA") (Chapter 163, Part II, Florida Statutes) was created. This act was similar to the 1975 act, in that it required all of Florida's counties and municipalities to adopt local government comprehensive plans to properly guide future growth and development. However, when the act was amended in 1986, the requirement that all local governments ensure "that public facilities and services needed to support development shall be available and concurrent with the impact of development" (Powell, 1993) was added. The term "concurrency" is often used to describe this provision. Understanding concurrency and its intent is an important aspect in bridging the relevance of land use development and the impact it presents in the siting of public school facilities. Concurrency, as explained by Boggs and Apgar is "a land use regulation which controls the timing of property development and population growth. Its purpose is to ensure that certain types of public facilities and services needed to serve new residents are constructed and made available contemporaneously with the impact of new development" (1991, p.1).

Neither the 1985 document nor the amended document in 1986 described what public facilities needed to be included within this concurrency requirement. In 1993 a detailed list of public facilities and services was introduced, including sanitary sewer, solid waste, drainage, potable water, parks and recreation, and transportation facilities (including mass transit), was added to the GMA. These facilities and services were the only ones subject to the concurrency requirement (FSA § 163.3180 (1)(a)). Additional facilities and services could not be made to meet concurrency unless appropriate studies revealed such a need with approval by the Florida legislature. Missing from this list was a requirement recognizing public school facilities. During this same period (1993), Florida legislation, (specifically ELMS III, established by Governor Lawton Chiles) proposed bringing about more coordinated efforts between local governments and district school boards. The primary objective of the proposal recommended that formal inter-local agreements between local government and district school boards be implemented to ensure consistency between plans for public school facilities and new land development (Powell, 1999). It wasn't until 1995, in response to overcrowding issues in Florida's public schools, that Florida Educational Facilities Legislation mandated the requirement of the aforementioned inter-local agreements proposal (§ 1013.33(2) F.S. and either § 163.3177(6)(h)4 F.S. or § 163.31777 F.S.). These inter-local agreements were critical to land development decisions as public schools encouraged residential growth and vice-a-versa residential growth required a need for updated (or new) schools. In 2002, further legislation was passed requiring the State's school boards and local governments to review school siting with a comprehensive approach. It was the responsibility of the school board to review and take into consideration local comprehensive plans before making any school facility decisions.

Schools are expected to meet specific criteria concerning enrollment capacity, size and location of new and existing schools, and the infrastructure needed to promote safe and accessible transportations options to and from public school facilities. In 2005, an amendment to the GMA recognized the need for public school facilities to meet concurrency requirements. However, this requirement does not apply to those districts with reported slow growth and adequate enrollment capacity (Florida Department of Community Affairs, 2008). The concurrency requirement does however require local governments to be consistent with the plans of the local school board by including a Public Schools Facility Element in their comprehensive plans. This portion of the comprehensive plan includes objectives and policies which illustrate the development needs of public school facilities including, infrastructural provisions, collocation of new schools with other public facility needs, locations of new schools near residential areas, and the use of school facilities as emergency shelters [9J-5.025, FAC].

Issues with the Siting of Public School Facilities

There are many issues associated with school siting. This study will briefly discuss a couple of the major components, including enrollment capacity and school site location and site size. Although there are stringent regulations regarding concurrency and policies requiring inter-governmental agreements – used to coordinate and ensure consistency in development – the implementation process can sometimes get complicated and be ill-effective. As part of the school board's responsibilities, there are explicit powers and duties that must be met to ensure that each district provides adequate and functional public school facilities that are governed effectively (§ 1001.41 F.S. & § 1001.42 F.S.) However, in developing communities where children can walk and bicycle to school, coordinated efforts must be met. If we do not change the location of schools to ensure that more students live within walking and bicycling distance, we will either pay increasing amounts to bus or drive our children to school or continually be retrofitting neighborhoods to ensure that children are able to walk and bicycle to school (Steiner, Bejleri, Wheelock, Boles, Cahill, & Perez, 2008).

School Enrollment Capacity

Since the 1950s, average school size (measured by enrollment capacity) has gown while school facilities have become increasingly larger in size and distant from the neighborhoods they serve. Florida public school enrollment in 2007, for elementary school-aged students was approximately 765,200 (American Fact Finder, 2008). This number represents just a 1.03 percent increase based on the approximated 757,300 students enrolled in 2006 (American Fact Finder, 2008). Although the increase seems minimal, that's approximately an additional 7900 students across the entire State. Furthermore, the National Center for Education Statistics reported that from 1930 to 2001, public school enrollment in the U.S. nearly doubled, from 26 to 48 million students (across all grade levels), yet the number of public school buildings decreased 60 percent in the same period, from 247,000 to 93,000 (ICMA, 2008). This statistic indicates a shift from an average of 105 students to nearly 516 students per school building. As the average size of a school has grown, so to have the distances between schools and the neighborhoods they serve. This trend not only relates to growth in average enrollment size, but is also causative of the policies and practices that encourage large site locations and discourage expansion and renovation of existing school sites.

Part of controlling enrollment capacity in schools is directly related to decisions made by the Superintendant and the district school board's establishment of School Attendance Zones (SAZ). School attendance zones are the geographical boundaries that institute which communities (area) a school will serve. SAZs are established based on a series of factors, of which enrollment capacity plays a critical role (see Table 2-2).

SAZs are also developed with the purpose of integrating a diversity of students into school facilities. However, balancing the structure of a student body is quite difficult, due to residential development patterns which often produce neighborhoods that are demographically and socio-economically unbalanced. The result is a set of attendance boundaries that vary considerably in shape and size (Steiner, et al., 2008). The location of a school site relative to the neighborhood it is intended to serve may be quite distant. This poses an inherent transportation issue concerning the mode choice of children getting from home to school. While recognizing this problem and understanding its implications, the scope of this research study does not specifically address the issue of establishing SAZ boundaries.

School Site Location and Site Size

The escalation in school site size also plays a critical role in determining school walkability. Over the past three decades, the acreage required for school sites has grown so large that it has become a challenge for local governments and school boards to even consider walkability as a critical factor in site location. Overly large school sites, have by necessity, become typical throughout many communities and are usually located on the periphery or outer regions of a community and sometimes completely outside of the neighborhoods the school is intended to serve. In many instances, this is resultant of costs and availability of land within existing urban areas. With scarce budgetary resources under a weakened economy (current 2009), government dollars are being spent to cover the most crucial needs, particularly wages for teacher’s positions, and the cost of text books, among other needs. Citing school walkability as a priority is typically an afterthought. It should also be noted that in many communities, school siting decisions are also based upon educational specifications and community expectations such as the need for athletic fields and courts, parking, and storm water management requirements, which subsequently drive the need for excessively large school sites (Maryland Department of Planning, 2008). In some instances, new school sites have shifted to the periphery due to low enrollment capacity within existing urban areas. Due to the increased distances between many schools and the neighborhoods they serve, walking and bicycling is simply not feasible and the school bus is typically acknowledged as the solution to the problem. In the State of Florida, district bussing is not provided within a two mile radius around school sites, unless hazardous walking conditions exist preventing safe and accessible access for children to walk or bicycle to school (e.g., road construction). Under these circumstances, courtesy bussing is provided for those students until such problems hindering access from home to school are remedied. In many cases, parents drive their children to school despite factors related to distance (Campbell & Wang, 2008), increasing the amount of traffic in and around school sites.

There are many tradeoffs between overly large school sites and smaller sites built with more community-oriented approaches. While the upfront cost of land may be less at the periphery of a community, the long-term costs appear to be much higher. Costs of sprawl in terms of land consumption and water and air pollution are some of the more recognizable factors (Maryland Department of Planning, 2008) while other literature is beginning to hypothesize about the negative long-term consequences associated with community degradation and public health (Frumkin, Frank, & Jackson, 2004).

Urban Form Characteristics and Walkability

Addressing the physical characteristics of the built environment is an essential component in coordinating school sites that facilitate more walkable conditions. One of the many tools used to assess physical environments and the people who travel within them is travel demand (Cervero & Kockelman, 1997). Travel demand (or travel demand management) refers to the management of traffic conditions, including traffic flow, traffic congestion, and the provision of travel options needed to meet specific demands (U.S. Department of Transportation, 2009). "Managing traffic demand today is about providing travelers, regardless of whether they drive alone, with travel choices, such as work location, route, time, and mode" (U.S. Department of Transportation, 2009). Subsequently land development issues must be addressed to support these options. This requires strategic planning efforts that recognize the connection between transportation planning and land use development.

In general, planning and development techniques can influence active mobility. In a study examining travel demand, Cervero and Kockelman introduce three dimensions of the built environment (a.k.a. the 3Ds), which include: (1) density of land uses (the agglomeration of spaces within a particular area), (2) diversity of land uses (the aggregate mix of spaces within a particular area), and (3) design (the physical layout and compositional elements of the urban structure). Additionally, there is literature that also suggests two other components; distance & destinations, which relate to the length and time between places) (Cervero & Kockelman, 1997). This development archetype is particularly important in providing the opportunity for children to walk and bicycle to school, assuming school facilities as a specific land use. At a macro-level, density (the number of residential dwelling units per acre), distance (total length of connected road segments), and destination (in this case, a school site) are the discernible factors in examining the general (potential) walkability between home and school. At the micro-level (design implications), additional features must be provided like sidewalks (with adequate widths), street trees that provide shading, safe crossing opportunities (medians and pedestrian refuge areas), buffering or separation of pedestrian and vehicular traffic, and the addressing of safety issues (Frank, Engelke, & Schmid, 2003; Knack, 2008). However, even with the provision of the appropriate infrastructure to support walkability, active travel is not inevitable.

Complexities in Determining Mode of Travel

So, what influences a person's decision to either walk, bicycle or drive to a destination? This is a complex question. In addition to factors related to urban form, research shows that individual behaviors (multivariate factors of personal choice) and other determinants also play a role. This makes measuring actual walkability an extremely difficult task. One factor in determining an individual's mode choice is vehicle accessibility. Undervalued populations[2] may not have equal access or be legally allowed to operate a motor vehicle, thus shifting mode choice to non-personal automobile options. Another factor that influences a person's mode of transport is micro-economic problems relating to benefits weighed against costs (Boarnet & Crane 2001). This theory is further supported by Randall Crane, a professor at the University of California at Los Angeles:

> The cost of a trip consists of those things that add hassles to one's day or burden one's pocketbook: the amount of time it takes to travel, the amount of traffic that might be encountered along the journey, and how much money the trip might require. The choice to drive, take transit, walk, or bicycle is therefore viewed as a function of one's preferences for a particular mode plus the costs of the different modes relative to one another (Frank, Engelke, & Schmid, 2003, p. 108).

This is particularly relevant in the mode choice of young children whose parents typically assume the responsibility of deciding how a child gets to and from school. Moreover, safety and physical or social environments may also play critical roles in contributing to the proportion of children who travel to school by motorized vehicle (Cooper, Page, Foster, & Qahwaji, 2003; Dellinger & Staunton, 2002). Still, the most common reason for not walking has been directly

[2] Undervalued populations refers to those individuals that are underserved or unable to reap all the benefits that society provides due to income constraints, personal disability, infrastructure provision, and/or policy implications.

attributed to distance (Goldsmith, 1992; Aultman-Hall, Roorda, & Baetz, 1997). Given its quantitative nature, "distance is a reasonable measure of the impedance between the origin and destination for walking" (Aultman-Hall, Roorda, & Baetz, 1997, pp.11). Taking into consideration these few examples of mode choice, it's easy to see some of the difficulties involved in measuring actual levels of walkability.

Measuring Potential Walkability

Some research on walkability (both nationally and internationally) has cited one-quarter mile (or 400 meters) as an acceptable distance an individual might be expected to walk to any given destination (Atash, 1994). However, in the State of Florida (where this research study takes place), a two-mile radius (pedestrian shed) has been established around school sites, defining the boundary by which parents are responsible for getting their children to school. As noted a moment ago, the acceptable distance a person might be expected to walk is approximately one-quarter mile. This suggests that the two-mile radius established in the State of Florida is a highly unrealistic distance to expect a child to walk or bicycle to school. To investigate the potential walkability of children who walk or bicycle to school, the author will focus on the factors of urban form residing within more reasonable walking distances, specifically one-half and one-mile radii.

As mentioned previously, measuring walkability is a difficult task. However, there are many characteristics of built environments that can provide measurable outcomes in examining the potential walkability of a place. To better understand how walkability can be measured, it is important to review several of the defining characteristics that support pedestrian walkability. The author will utilize two publications to define these characteristics, which will provide the foundation for this research study. The first study was originally presented to the Joint Congress of ACSP-AESOP[3], entitled "*Measuring Network Connectivity for Bicycling and Walking.*" This paper illustrates a general set of urban form characteristics useful in assessing potential walkability patterns:

1. Block Length,
2. Block Size,
3. Block Density,
4. Street Patterns
5. Street Density,
6. Intersection Density
7. Connected Node Ratio
8. Link Node Ratio
9. Pedestrian Route Directness
10. Effective Walking Area (Dill, 2004)

It should be noted that while each of these characteristics provides a distinctive value for quantitatively evaluating walkability, there is a wide level of variability that can be interpreted from case to case. When specifically examining the walkability of a place, it's important to choose the appropriate characteristics that support what is being investigated. Analysis may require the use of two or more characteristics to support or negate one finding from another. For instance, block density may be a good proxy for street connectivity. However, it may not necessarily indicate good walkability. Although the census block density of two completely different regions is the same, further research may reveal that one portrays less walkability due to the physical design of the block. For this reason, using multiple indicators is important in examining the walkability of places.

The second selection of literature, developed by Dover, Kohl & Partners and Chael, Cooper & Associates in conjunction with the City of Raleigh, North Carolina, presents a list of characteristics more specifically aimed at assessing the walkability of neighborhood schools:

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[3] ACSP is the Association of Collegiate Schools of Planning; AESOP is the Association of European Schools of Planning.

1. Street Connectivity
2. Completeness of Sidewalk Network
3. Availability of Public Transportation
4. Number of Dwelling Units within Walking and Bicycling Distance
5. Mixture of Uses in Immediate Vicinity
6. Street Trees
7. Posted Speed Limits
8. Curb Radii at Intersections
9. Vehicle Lanes and Lane Widths
10. Defined or Guarded Crosswalks
11. Pedestrian Refuge/Median Strips
12. Street Lighting
13. Natural Surveillance (City of Raleigh, N.C., 2008)

This research will focus primarily on examining the characteristics of *Street Connectivity* and *Residential Density*, utilizing the supportive literature from both of the above listed documents. The researcher has established an explicit set of indicators to measure both characteristics of urban form in determining potential walkability. The following literature will justify the use of these two publications as a guideline in conducting this study while validating the significance of the chosen indicators for measurement of potential walkability.

Street Connectivity

Because streets accommodate most forms of travel and facilitate connectivity, their importance serves as a central focus in measuring travel patterns and behaviors (Frumkin, Frank, & Jackson, 2004). Traditionally, in the United States, street patterns were laid in gridiron patterns. These road networks divided land into manageable urban blocks accessible by people who traveled mainly by foot, horse & buggy, and in later years, powered automobiles. Such networks reduced the distance between origin and destination, providing many intersections, and therefore many possible routes of travel (Frumkin, Frank, & Jackson, 2004). By the mid 1900s, urban planners deserted the ideal gridiron pattern for a more highly sought after pattern which typified the development of middle class suburbia. This included a street hierarchy system which separated automobile through-fares from developed areas (specifically residential neighborhoods), creating a whole new style of street patterns. By the early 1990s another street pattern began to surface consisting of "loops and lollipops"[4], subsequently turning straight-line distances into journeys of considerable length. The intent of the hierarchy street system and the circuitous nature of looping roadways was strategically aimed at reducing the number of automobile thoroughfares, making [residential] streets safer for the pedestrian. Unfortunately, the street hierarchy system has had very adverse affects resulting in reduced connectivity, the promotion of urban sprawl, an increase in vehicle miles traveled, and a host of other public nuisances and health related issues (Frumkin, Frank, & Jackson, 2004). In recent times, development strategies like the New Urbanism[5] (neo-traditional design), transit-oriented design (TOD)[6], and the ideology of Smart Growth[7] have attempted to address issues of suburban sprawl and loss of community by returning to traditional development styles. These development models call for more compact uses of land, united by traditional grid-like street patterns and higher residential and population densities. These archetypes are intended to reconnect people and place, providing greater connectivity between origin and destination through multi-modal transportations options which facilitate efficient travel modes for a diversity of individuals, including pedestrians.

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[4] "Loops and lollipops" refer to large circuitous and winding streets and dead-end / cul-de-sac street development patterns.

[5] The New Urbanism is a planning movement in support of the abandonment of auto-centric development and Euclidean zoning. It suggests a return to more traditional, pedestrian-oriented development patterns and a mix of uses and housing types. See CNU (Congress for the New Urbanism) website for further description and information. More information available at: http://www.cnu.org/

[6] TOD is a development initiative that involves "the creation of compact, walkable communities centered around high quality train systems. This makes it possible to live a higher quality life without complete dependence on a car for mobility and survival." More information available at: http://www.transitorienteddevelopment.org/tod.html)

[7] Smart Growth refers to "development decisions that affect many of the things that affect people's everyday lives - their homes, their health, the schools their children attend, the taxes they pay, their daily commute, the natural environment around them, economic growth in their community, and opportunities to achieve their dreams and goals. What, where, and how communities build will affect their residents' lives for generations to come." More information available at: http://www.epa.gov/livability/about_sg.htm)

The “Design Guidelines for Pedestrian-Friendly Neighborhood Schools” booklet published by the City of Raleigh, North Carolina explains *Street Connectivity* as a well-connected network of local streets, supporting transit by providing direct routes and a high degree of connections for pedestrians between origins/destinations (City of Raleigh, N.C., 2008). “Because traffic can be dispersed over a large network of streets, local streets in a well-connected network tend to carry lower volumes of vehicular traffic”(City of Raleigh, N.C., p. 3). This makes active forms of travel along such roadways safer in terms of decreasing the incidence for automobile-pedestrian interference. Additionally, well connected networks of local streets potentially maximize the number of residential dwellings that could be located within walking distance of a school site location (City of Raleigh, N.C., 2008).

Pedestrian Route Directness (PRD) is often cited as a measurable indicator for evaluating the connectedness of places. “PRD is the ratio of route distance to straight-line distance for two selected points” (Dill, 2004, p.5). The lowest value for PRD is 1.00, whereas the network distance is equal to the straight-line distance. Cited in Dill’s work (2004), the “INDEX Plan Builder” developed by Criterion Planners Engineers, recommends PRD values of 1.2-1.5 as an acceptable level of connectivity, whereas values ranging between 1.6-1.8 characterize less direct routes.

A study conducted by Lawrence Frank & Co., in King County, Washington, found that compact development utilizing connected street networks with pedestrian facilities could help improve air quality and the health of people in a community (Frank, Sallis, Saelens, Bachman, & Washbrook, 2005). The study also found that residents in the most interconnected areas of King County traveled 26 percent fewer vehicle miles per day, while residents in the most walkable areas tended to be less overweight or obese (Frank, et al., 2005). Communities exhibiting more compact development patterns show a greater incidence of individuals engaging in physical activity. Investment in well connected street networks, a mix of land uses, and an orientation towards more multi-modal transportation options can be beneficial to the public welfare of a community (Frank, et al., 2005).

Another study, evaluating the effects of urban form and distance on travel mode to school among middle school students in Oregon, found that urban form does play a role in determining a child's decision to participate in active forms of school travel (Schlossberg, Greene, Phillips, Johnson, & Parker, 2006). Schlossberg and colleagues (2006) utilize several of the same common indicators of street connectivity that this study uses in conducting its analysis, including street density, intersection density and pedestrian route directness (See Table 2-3). While sixteen percent of the students surveyed listed walking or bicycling as their primary means of travel from home to school (1 to <1.5 miles), more than double (forty-two percent) listed walking or bicycling as their primary means of travel from school to home (1 to <1.5 miles). The increase in students engaging in active travel from school was found to be connected to parents who drove their children to school, but were not available to pick their children up after school (Schlossberg, et al., 2006). Although there were some limitations in this study (primarily small sample sizes), the findings reveal that students are willing to walk at distances greater than the accepted standard of one-quarter mile. These findings support the need for further research investigating the impact of urban form at greater distances around school sites. Additionally, this study found that while holding distance and other urban form measures constant, intersection density was a strong indicator which influenced overall walkability (Schlossberg, et al., 2006). In support of the findings from this study, Frank and colleagues (2005) suggest that areas with densities equal to or greater than 30 intersections per square kilometer (approximately equal to

78 intersections per square mile) have been associated with greater overall connectivity and increased levels of physical activity.

Residential Density

The term "Density" (referring to urban development density) is a controversial term and not surprisingly, a hot topic issue among most planning practitioners as well as citizens in many communities (Forsyth, 2003). The debate of over density has resulted in many arguments both for and against the issue. In many instances density is seen as the opposition to natural, healthy environments, postulating that its effects constitute crowded, ugly, dirty places (Forsyth, 2003). However, higher urban density is essential in shifting mode choice from automobile travel to active forms of travel for utilitarian purposes, especially for school walkability.

Many studies have been published relating walkability and increased levels of physical activity to various characteristics of urban form including, residential density, mix of land uses, street connectivity, and aesthetics & safety (Saelens, Sallis, Black, & Chen, 2003). However, little research has been conducted specifically examining the impact of residential density on a child's ability to walk and bicycle to school.

Although not specifically regarding schools in its calculation, one study utilizing data collected by the SMARTRAQ household travel survey in the Atlanta, Georgia region found that number of cars (within household), nearby recreational space, and residential density were most strongly related to walking among younger populations (Frank, Kerr, Chapman, & Sallis, 2007). Similarly in another study, analysis also utilizing SMARTRAQ data revealed that land-use mix and intersection density were also positively related with time spent participating in moderate levels of physical activity (Frank, Schmid, Sallis, Chapman, & Saelens, 2005).

Another study conducted in six cities in the Netherlands while adjusting for age (children age 6-11), sex, BMI, and level of education, found that physical activity was significantly ($p <$

.05) associated with residential density, among other relationships with green space, and active-friendliness of the neighborhood (de Vries, Bakker, van Mechelen, & Hopman-Rock, 2007). Although there is little research specifically examining residential density and school walkability, related studies show that there are connections between residential density and general walkability, including increased levels of physical activity.

In this research study, the author will examine the impact of residential density on school walkability. A key issue to consider when using density as a measurable characteristic of walkability is the differences in calculating density types. Depending on the type of research one might be conducting, it is important to differentiate the classification of density calculations being used, as results can sometimes be confusing or misinterpreted (Forsyth, 2003). For instance when calculating either Gross or Net residential density, it's not enough to state the one is calculating "Net" residential density. This is due to a difference in mathematical equating. Net density refers to densities where the base land area calculation focuses only on the parcel or, if covering larger areas, excludes certain uses (e.g.: commercial and retail uses). Gross densities do not have such exclusions (calculations include all land uses) (Forsyth, 2003). Research suggests that schools be located in neighborhoods with a minimum net residential density of 5 dwelling units per acre (City of Raleigh, N.C., 2008). However, other research has shown that more walkable areas have a net residential density equal to or greater than 6 dwelling units per residential acre while less walkable areas experienced less than 4 dwelling units per residential acre (Frank, et al., 2005). This study will examine both *Gross Residential Density* and *Net Residential Density* as potential factors influencing a child's ability to walk or bicycle to school.

Summary

There are many factors contributing to the current childhood obesity epidemic. One of those factors is the amount of physical activity that children engage in. Studies have shown that the percentage of children walking and bicycling to school has declined over the past 30 years (Steiner, Crider, & Betancourt, 2006), while obesity rates have nearly tripled since 1980 (Centers for Disease Control and Prevention, 2006). Increasing the number of children who walk and bicycle to school can potentially reduce the prevalence of childhood obesity rates. One solution in addressing the obesity epidemic is through examination of the built environment. This will help researchers and practitioners alike to better understand how urban form impacts the potential for individuals to walk and bicycle within their communities. The next chapter of this study provides a detailed description of the methodology that will be used in conducting the research case studies.

Table 2-1. Costs of Inactivity (billion $), in the United States, 1995

Condition	Relative Risk	PAR%	Direct Costs
Type 2 Diabetes	1.5	12%	6.4
CHD	2	22%	8.9
Hypertension	1.5	12%	2.3
Gall Bladder Disease	2	22%	1.9
Cancer			
Breast	1.2	5%	0.38
Colon	2	22%	2
Osteoporotic Fractures	2	18%	2.4
Total			24.3 Billion

Source: Colditz, G.A. (1999). Medicine & Science in Sports & Exercise, Vol. 31(11)

Table 2-2. Criteria for Establishing School Attendance Zones

Priority	Determinants
1	School Capacity
2	Convenience of access to schools
3	Safe and efficient student transportation and travel
4	Effective and appropriate instructional programs
5	Socioeconomic diversity in school enrollments
6	Financial and administrative efficiency

Source: Florida Statutes 1001.41(2), F.S.; 1001.42(4); 751.01-.05, F.S.

Table 2-3. Common Street Connectivity Measures

Measure	Description	Ideal Values
Block Length	Blocks are the land area carved out by the street network. It is presumed that shorter the block, the greater amount of connectivity	300 to 600 feet (Dill, 2004)
Block Size	Measured by the length and the width, blocks that are smaller in total size presumably infer better connectivity	Fort Collins, Colorado requires block sizes to be between 7 and 12 acres (Steiner, et al., 2006)
Street Density	The total linear miles (or kilometers) of streets per unit of area (usually in square miles or kilometers)	Not Identified
Intersection Density	The number of intersections per unit of area (usually in square miles or kilometers). It is presumed that higher density equates to higher connectivity	Over 78 intersections per square mile (Frank, et al., 2005)
Connected Node Ratio	The number of street intersections divided by the number of intersections plus cul-de-sacs	Values of 0.7 or higher are favored (Dill, 2004)
Link Node Ratio	The number of links (road sections between intersections) divided by the number of nodes (intersections)	Higher than 1.4 (Dill, 2004)
Pedestrian Route Directness (PRD)	The ratio of network distance to straight-line distance for two selected points. Numbers closer to one may represent better connectivity	Values between 1.2 and 1.5 have been recommended as acceptable standards (Dill, 2004)

CHAPTER 3
METHODOLOGY FOR MAPPING AND ANALYZING POTENTIAL WALKABILITY

This chapter provides a detailed description of the reasoning for this work and the methodology that is used to analyze and evaluate the case studies concerning this research. The focus of this project is to provide further examination of how urban form impacts the potential for children to walk and bicycle to school. The methodology used in this study is largely based upon like methods being used in concurrent research ongoing at the University of Florida funded in part by the Robert Wood Johnson Foundation[1] (Steiner, et al., 2008; Bejleri, et al., 2008). The analysis area for this particular project involves elementary schools in Orange and Seminole Counties, located in and around the Orlando area in the central region of Florida.

Establishing the Analysis Zones

As mentioned in Chapter Two, the State of Florida has established a two mile buffer around school sites, which identifies the area that district-school bussing is not provided, unless extenuating circumstances are present. Recognizing the impracticality for students to walk or bicycle a distance of two miles to school, this study examines potential walkability within two smaller analysis zones: (1) Half-mile and (2) One-mile distances. These are assumed to be reasonable distances a child could be expected to walk or bicycle to school based on findings from previous studies (Schlossberg, et al., 2006). This study uses ArcGIS software to generate half- and one-mile straight-line buffers around each school site in both of the case study regions. These buffer zones are referred to throughout this study as the "Pedestrian Shed." Another zone has also been created by calculating the distance along the network path of streets around each school site. This zone is referred to throughout the study as the "Pedestrian Network Shed" or

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[1] Robert Wood Johnson Foundation is an independent philanthropy devoted to improving health policy and practice. More information available at: http://www.rwjf.org/

simply the “Network Shed.” This zone represents a more realistic path a child might be expected to walk from home to school. However, due to the location of school sites within established SAZs, the analysis zones sometimes extend beyond the boundary of the SAZ. In these unique circumstances, adjustments to the analysis zones are made to reflect the area that is contained within the SAZ boundary. Figure 3-1 provides an illustration of how these pedestrian (network) sheds are created around each school.

As a means of investigating the affects of urban form on walkability, each school is examined within the parameters of the established analysis zones, while controlling for school age based on development patterns that follow a linear timeline of growth management and school coordination legislation in the State of Florida. The four development periods used to make comparisons are as follows: (1) Historical Schools (constructed before 1950); (2) Pre-Growth Management Schools (constructed between 1950 and 1985); (3) Pre-School Coordination Schools (constructed between 1986 and 1995); and (4) Post-School Coordination Schools (constructed after 1995). By comparing findings across these influential periods, the researcher intends to evaluate how physical development and policy actions have shaped urban environments and walkability around the case study school sites over time.

Calculating Potential Walkability: Indicators for Analysis

This study utilizes two primary characteristics of urban form to analyze these conditions: (1) Street Connectivity and (2) Residential Density. These two characteristics were chosen based on the literature supporting their ability to provide a quantitative means of measuring potential walkability. The following sub-sections describe in further detail how each one of the above mentioned characteristics will be examined to analyze and evaluate walkability.

Street Connectivity Indicators

To measure street connectivity three walkability indicators are used: (1) Street Density (the total number of linear miles of street per square mile); (2) Intersection Density (the total number of intersections per square mile); and (3) Pedestrian Route Directness (the ratio of the network distance to the Euclidean (straight-line) distance between two points).

Indicator #1: Street Density

Street Density is used as an indicator to provide a quantitative measure of the number of available pathways (available miles of streets) a child might be able to travel between home and school. This study will utilize the street network as the surrogate pathway for measuring these connections. These pathways are identified by a calculation measuring the distance along the centerline of each street. A greater street density within the proximity of a school site presumably means that there is greater connectivity thus increasing the potential for a child to walk or bicycle to school. Street density is a calculation derived from dividing the total number of street miles by the total area (square miles) within a specified range. In this case, the established analysis zones will be used as parameters in this study.

Indicator #2: Intersection Density

Intersection density is correlated to street patterns in that intersections rely on the presence of street networks. Intersection density is also used to provide information of connectivity by illustrating nodes of intersection (junction between streets and roadways). Like street density, a higher degree of intersection density presumably indicates higher levels of connectivity, thus providing environments that support a greater potential for walkability. Intersection density is calculated by dividing the total number of intersections by the total area (square miles) within a specified range. Again this calculation will be conducted using the half- and one-mile analysis zones as boundaries.

Indicator #3: Pedestrian Route Directness

PRD in the simplest of terms is a value representing the directness of travel between two points. More specifically, it is a ratio between the straight-line distance of two points divided by the network distance between those same two points (an origin and a destination). In this study, PRD is measured using schools as destination points and using individual residential dwelling units as origin points. PRD is then tallied for each analysis zone using the average network and straight-line distances between residential dwelling units to the corresponding school they are zoned. Although a formative indicator of connectivity, PRD is not always representative of walkable environments (Dill, 2004).

Residential Density Indicators

Residential density is also measured, using three indicators: (1) Gross Residential Density (total number of dwelling units per gross acre); (2) Net Residential Density (total number of dwelling units per residential parcel acre); and (3) Effective Walking Area (the ratio of residential parcels within a [specified] network distance to the number of residential parcels within the [same specified] radius distance of a destination). Residential density information used for this study was provided from data prepared in previous research (Steiner, et al., 2008; Bejleri, et al., 2008). Both *Gross* and *Net* residential densities are calculated by assigning dwelling unit counts to residential parcels within each school attendance zone. This information was created using land use codes acquired by the Department of Revenue, dwelling unit counts for multifamily parcels using data from the 2006 American Community Survey, and additional information provided by the Bureau of Economic and Business Research, and county apartment complex records (Steiner, et al., 2008; Bejleri, et al., 2008).

Indicators #4: Gross Residential Density

Gross residential density provides a value representing the total number of dwelling units per gross acre. Gross acreage includes all land use designations (e.g.: residential, commercial, industrial, etc.) in its calculation of residential density. Gross residential density will be used to compare the gross densities of residential dwellings between each analysis zone and the entire County over the four time periods.

Indicator #5: Net Residential Density

Net residential density provides a value representing the total number of dwelling units per residential parcel acre. The residential parcel acre is the acreage containing only residential land uses, excluding such land uses as mentioned in the calculation of gross residential densities (e.g.: commercial). Net residential density will be compared to acceptable standards of net residential density to determine levels of walkability within the established half- and one-mile analysis zones. These density findings will also be compared to the net densities for the entire County during the four time periods.

Indicator #6: Effective Walking Area

In addition to analyzing gross and net residential densities (total number of dwelling units per area), the researcher will also use EWA to investigate residential parcel ratios within proximity to school sites along connected street networks. EWA is a ratio calculated by dividing the total number of residential parcels within a [specified] network distance to the total number of residential parcels within the [same specified] radius distance of a destination (in this study, the destination is the school site). EWA values range between 0 and 1.00. Values closer to 1.00 represent greater percentages of residential parcels within the connected road network within a specified distance. Greater values presumably indicate higher levels of potential walkability. EWA will be examined along the half- and one-mile networks around each school site.

Summary

The methodology described in this chapter will help quantify patterns of urban form that impact the potential walkability of children traveling between home and school. Although there are many factors that can influence walkability, it should be noted that the indicators chosen for this study have proven to be effective in providing reasonable determinations of potential walkability. It is assumed, based on the literature concerning development patterns and the regulatory factors for the State of Florida, that street connectivity and residential densities will be best around the school sites built before 1950. Chapter four of this study presents the findings resultant of these methods providing a means for evaluation and further discussion.

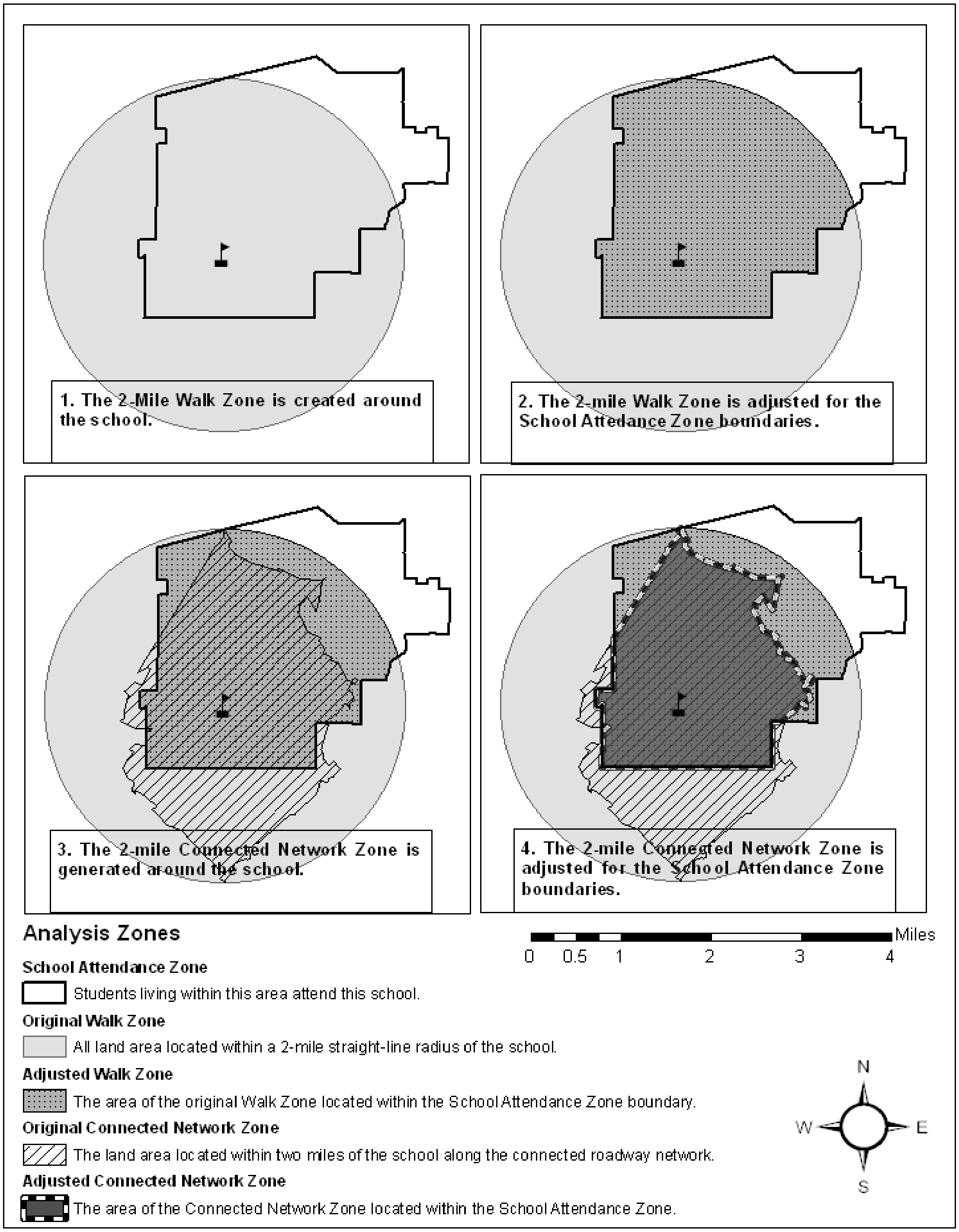


Figure 3-1. Creation of Analysis Zones (Pedestrian Sheds) (Steiner, et al., 1008)

CHAPTER 4
CASE STUDY FINDINGS AND RESULTS

In this Chapter, findings from each case study are presented based upon the methodology that was described in Chapter Three. This Chapter is divided into four sections. The first section provides an overview of the case study areas to put into context the findings from this chapter. The second section presents findings from the Orange County case study while the third presents those from Seminole County. These two sections will include a synopsis of the findings related to each of the six walkability indicators described in the previous chapter. The last section provides a summary and comparison of the findings from both case study areas.

Context of Study Region

The two counties chosen for case study research represent two distinct geographical regions of central Florida (see Figure 4-1). The first case study examines Orange County, which is traditionally more urban in nature, encompassing an area of approximately nine-hundred square miles. Seminole County on the other hand is about a third of the size – in total land area – and consists of approximately three-hundred square miles. Both Counties have seen steadily growing populations since 1950, which in turn has spurred an incredible amount of land development in and around this area of the State. In response to these growth rates, a number of new public school facilities have been constructed. The greatest influx of new school construction for both Counties occurred during the pre-growth management period in the State of Florida between 1950 and 1985. This growth accounted for 43 percent of the total schools built in Orange County and 59 percent of the total schools built in Seminole County. Prior to 1950, eight schools were constructed in Orange County, while only one was built in Seminole. Development before 1950 was certainly at a minimum in both Counties during this time, especially in Seminole County. Based on 2007-08 estimates, the total number of enrolled elementary students in Orange and Seminole Counties is 82,501 and 21,756, respectively. These numbers are expected to increase in the coming years as the total population increases throughout the central Florida region. Acknowledging these growth projections, it will be increasingly important to understand and address the impacts of the built environment as we plan for the future.

Orange County Case Study

The Orange County case study analyzed 120 elementary schools, representing all of the elementary public school facilities within Orange County (see Figure 4-2). Six indicators of walkability were analyzed across four temporal development periods to provide the following findings. The first three indicators present findings related to street connectivity while the second set of three indicators present findings associated with residential density.

Indicator #1: Street Density

An influential indicator used in determining the potential walkability of a place, is the density of streets. In Orange County, the highest total average for street density across all analysis zones was found around schools built prior to 1950, with the highest of those values found within the half and one-mile pedestrian network sheds. The actual highest average value of street densities is found within the half-mile network shed during the pre-school coordination time period between 1986 and 1995. This is due to an outlier school embodying a street density of 51.1. During this same period, densities within the one-mile pedestrian network shed revealed a slight decrease, while both the half and one-mile pedestrian sheds saw considerable declines. For the schools built after 1995, street density continued to decrease across all analysis zones with the exception of the one-mile pedestrian network shed which revealed a minimal increase. Figure 4-3 provides a graphical illustration of these findings.

Indicator #2: Intersection Density

Intersection densities are also measured to determine connectedness for walkability. Intersection density findings revealed the same general patterns as street density. Consistent with street density, the highest total average across all analysis zones is found around schools built prior to 1950, with the highest of those values found within the half and one-mile pedestrian network sheds. After 1950, intersection density declined during the following two time periods, though the average within the half-mile pedestrian network shed increased between 1986 and 1995. Again this is due to the outlier school, whose indicator value was 432.9. Paralleling street density values for schools built after 1995, intersection density decreased across all analysis zones with the exception of the one-mile pedestrian network shed which revealed a slight increase. Although the indicator values revealed a declining trend across all four time periods, the average density values for all analysis zones exceeded the acceptable standard (78 intersections per square mile) during each of the four time periods, except within the one-mile pedestrian shed around schools built after 1995. Figure 4-4 provides a graphical illustration of these findings.

Indicator #3: Pedestrian Route Directness

Similar to street and intersection density indicators, PRD ratios revealed the lowest values for schools built before 1950, supporting the notion that schools built during this period were located within more connected networks. Values during this time period averaged 1.6, which is slightly above the accepted standard (1.2 – 1.5) considered to be representative of good connectivity. As the overall trend for street and intersection density declined during the following two time periods, PRD ratios increased accordingly. However, around schools built after 1995, as street and intersection densities continued to decrease, PRD ratios revealed decreasing values. Again the lowest values (still above the acceptable range) were found along the street networks for both the half and one-mile pedestrian sheds. Interestingly, the PRD ratio for the one-mile pedestrian network shed revealed lower values (presumably better connectivity) than those shown within the half-mile network shed for all time periods, with exception of those schools built after 1995. This pattern is a reflection of more direct street routes occurring within the one-mile network area. Figure 4-5 provides a graphical illustration of these findings.

Indicator #4: Gross Residential Density

In Orange County, the average gross residential density for the entire county is 1.9 dwelling units per gross acre. This number is based on total parcel acres within the entire county. Not surprisingly, schools built before 1950 revealed the highest levels of gross residential density across all analysis zones, with the highest levels occurring within the half and one-mile pedestrian network sheds. Gross residential densities revealed a decline in density during the two time periods following 1950, with signs of regeneration occurring around schools built after 1995. An interesting pattern to note is the trend of gross residential densities within the half and one-mile pedestrian network sheds across the four time periods. Prior to 1950, the greatest gross residential density was found within the half mile network shed. During the following two periods, gross residential densities were greater within the one-mile network shed, with a resurgence of density within the half-mile network shed after 1995. Figure 4-6 provides a graphical illustration of these findings.

Indicator #5: Net Residential Density

Net residential density is also calculated, representing the number of dwelling units per residential parcel acre. The current average net residential density for Orange County is 4.5 dwelling units. The findings for net residential density are similar to the trends found with gross residential density, as the greatest densities are found to occur around schools built before 1950, with declining values during the following two time periods, and rebounding occurring around schools built after 1995. Again, findings reveal that the greatest net residential densities occur within the half and one-mile pedestrian network sheds across all time periods. Furthermore, net residential density values within the connected networks exceed that of the average for the entire County. These findings show that greater net residential densities are occurring within connected networks around schools supporting even greater potential for children to walk and bicycle to school. Figure 4-7 provides a graphical illustration of these findings.

Indicator #6: Effective Walking Area

EWA is measured to determine the potential for walkability based on the percentage of zoned residential parcels that exist along the street network around school sites. Similar findings show consistency with the development patterns of residential density indicators, in that the highest values are seen around the schools built before 1950. For these schools, EWA findings show that just more than fifty percent of residential parcels within a half-mile of school sites are found along the half-mile street network. An additional eighteen percent of residential parcels are found along the street network when calculating outward a distance of one-mile. Consistent with patterns of gross and net residential densities, EWA values began to decline during the pre-growth management and pre-school coordination time periods. Although residential densities show some resurgence following the pre-school coordination time period, EWA values remain fairly static with little movement around schools built after 1995. Figure 4-8 provides a graphical illustration of these findings.

Seminole County Case Study

In the Seminole County case study, 28 of a total 37 elementary schools were analyzed. All thirty-seven schools considered for analysis were public school facilities. However, the nine schools not included in this study are part of cluster attendance zones in which multiple schools exist within a single attendance zone (see Figure 4-9). For the twenty-eight schools analyzed, findings will be presented based on the methodology set out in Chapter Three. Again, the first three indicators present findings related to street connectivity while the second set of three indicators present findings associated with residential density.

Indicator #1: Street Density

Street densities in Seminole County revealed vastly different trends than did findings from Orange County. Before 1950, development in Seminole County was minimal with the construction of only one school in the entire County. Street densities in Seminole County reflected the lowest averages around this school site, with considerable growth occurring during the pre-growth management period. Following 1985, street densities within the half and one-mile pedestrian network sheds continued to increase, while densities within the half and one-mile pedestrian sheds showed a decline. After 1995 – during the post-school coordination period (1986 to 1995) – street densities began to decline across all analysis zones. Figure 4-10 provides a graphical illustration of these findings.

Indicator #2: Intersection Density

Intersection density followed the same general patterns as street density with relatively low values occurring around the single school site built before 1950. Like street density, average intersection density values increased within all analysis zones during the following two time periods, except for a considerable decline among the average values within the one-mile pedestrian shed between 1986 and 1995. During the same period that values fell within the one-mile pedestrian shed, the average indicator values within the half-mile pedestrian network shed increased sharply. The overall trend shows that intersection densities have been increasing since 1950. However, consistent with street density trends, intersection density also showed a decline across all analysis zones around schools built after 1995. Although there are some fluctuations in the overall findings, it's important to note that densities within the half-mile and one-mile pedestrian network sheds exceeded the acceptable standard (78 intersections per square mile) during all time periods, except within the one-mile pedestrian network shed prior to 1950. Figure 4-11 provides a graphical illustration of these findings.

Indicator #3: Pedestrian Route Directness

PRD ratios revealed somewhat consistent values related to both street and intersection densities. However, PRD was lowest for the school site built prior to 1950, even though indicators of street connectivity revealed relatively low values of street and intersection densities. Although the PRD ratio during this period averaged 1.4 (for all analysis zones), good street connectivity is apparent only within the half-mile network shed. When extending the analysis area out to the one-mile network, PRD ratios remain constant, likely due to long stretches of roadway. This type of scenario proves why using a single indicator for measurement can convey misleading findings. Furthermore, as street connectivity presumably increased based upon street and intersections densities, PRD values also increased, revealing less direct travel patterns. After 1985, PRD ratios decreased within the half and one-mile pedestrian network sheds, while values increased within the half and one-mile pedestrian sheds, revealing some consistency with street density patterns. Other than dropping to a value of 1.9 within the one-mile network shed during the pre-school coordination time period, PRD values were found to be well above the accepted standard for good connectivity within all analysis zones across all time periods. Figure 4-12 provides a graphical illustration of these findings.

Indicator #4: Gross Residential Density

In Seminole County, gross residential density currently consists of about 1.6 dwelling units per gross acre. Again, this number does not exclude any land uses in its calculation. The gross residential density for the school site built before 1950 showed the lowest values for all analysis zones. The highest value during this time period is still less than one dwelling unit per gross acre

(0.73 within the half-mile pedestrian network shed). Gross residential densities increased across all analysis zones for schools built between 1950 and 1985. Numbers then began to decline during the following period, with exception of the one-mile pedestrian network shed which saw a slight increase (nothing of statistical value). After 1995, gross residential densities declined for all analysis zones, with the highest values occurring within the half and one-mile pedestrian network sheds. Figure 4-13 provides a graphical illustration of these findings.

Indicator #5: Net Residential Density

Net residential density for Seminole County was conducted only within the analysis zones around each school site and not at the County level, due to unforeseen circumstances regarding data availability. However, the information gathered from the analysis zones have provided valuable insight. Consistent with the findings of gross residential density, net densities were lowest around the school site built before 1950. During the pre-growth management period from 1950 and 1986, net residential densities increased sharply, especially within the half-mile pedestrian network shed. Average densities during this period peaked at 4.7 units. Following this period, slight increases were found within the half-mile pedestrian shed and the one-mile network shed, while there were reductions within the one-mile pedestrian shed and half-mile network shed. Net residential density then decreased within all analysis zones around schools built after 1995, with the greatest densities, again found along the street networks in both the half and one-mile pedestrian network sheds. Figure 4-14 provides a graphical illustration of these findings.

Indicator #6: Effective Walking Area

After calculating the EWA for Seminole County, findings revealed that seventy-two percent of residential parcels found within a half-mile of the school site built before 1950 were sited along the street network. The percentage of residential parcels along the one-mile street network was only fifty-six percent, revealing that a greater number of zoned residential parcels were situated within the half-mile range of the school site. Although findings from both gross and net residential densities showed considerable increases in density for the time period between 1950 and 1986, EWA began to decrease, especially the average number of parcels found within the half-mile network area. Findings reveal that schools built during this period and through to 1995, showed continual declines. For the school locations that were sited after 1995, EWA remained constant within the half-mile network, but continued to decline within the one-mile network area. Figure 4-15 provides a graphical illustration of these findings.

Summary

In both case studies, the majority of findings revealed that there were symbiotic relationships between each of the measurable indicators. In Orange County, it was apparent that street connectivity and residential density were the greatest around the schools built before 1950. During the following two time periods, values declined, with some resurgence of residential density around the schools built after 1995. Unlike Orange County, Seminole County revealed the lowest values for both street connectivity and residential density around the school site built before 1950. Additionally, indicator values increased during the pre-growth management period, with fluctuating values during the pre-school coordination period. Seminole revealed some similarities to the findings in Orange County, in that street connectivity indicators revealed decreasing values for schools sited after 1995. However, the most remarkable finding from both Counties was the average values for intersection densities within the half- and one-mile pedestrian network sheds. In both Counties, values exceeded the acceptable standard (except within the pedestrian network shed in Orange County), which is indicative of good connectivity. The most notable difference between the two Counties was the continual decline of residential density values in Seminole County, while values in Orange County revealed some resurgence after 1995.

Although the two Counties returned different results, the indicator values have proven to be effective. This is apparent from the paralleling relationships between both the street connectivity and residential density indicators within each of the studies. However, in some instances, findings revealed contradictory behavior, making it difficult to provide any explanation. For instance differing patterns between increasing values within the network shed and decreasing values within the pedestrian shed (concerning a single indicator such as street density). The item to note, however, is that better connectivity is occurring along the street network. It is also important to understand that this study has examined data at the aggregate level and that the findings have been evaluated holistically across the four time periods and not at a micro level investigating the exact reasoning's for all shifts.

The next chapter provides a discussion of the findings detailed here. With a better understanding of how urban form has evolved over the past half-a-century, the researcher will begin to relate how the findings from this study correspond to trends in physical activity and rising childhood obesity rates. The following chapter also presents conclusions and provides recommendations for future research regarding this and related topics.

	2007 Population	Land Area (Square Miles)	Persons per Square Mile	Number of Elementary Schools in Study	Number of Enrolled Elementary Students (2007- 2008)
Orange County	1,066,113	907.5	1,174.80	120	82,501
Seminole County	409,509	308.2	1,328.70	28	21,756

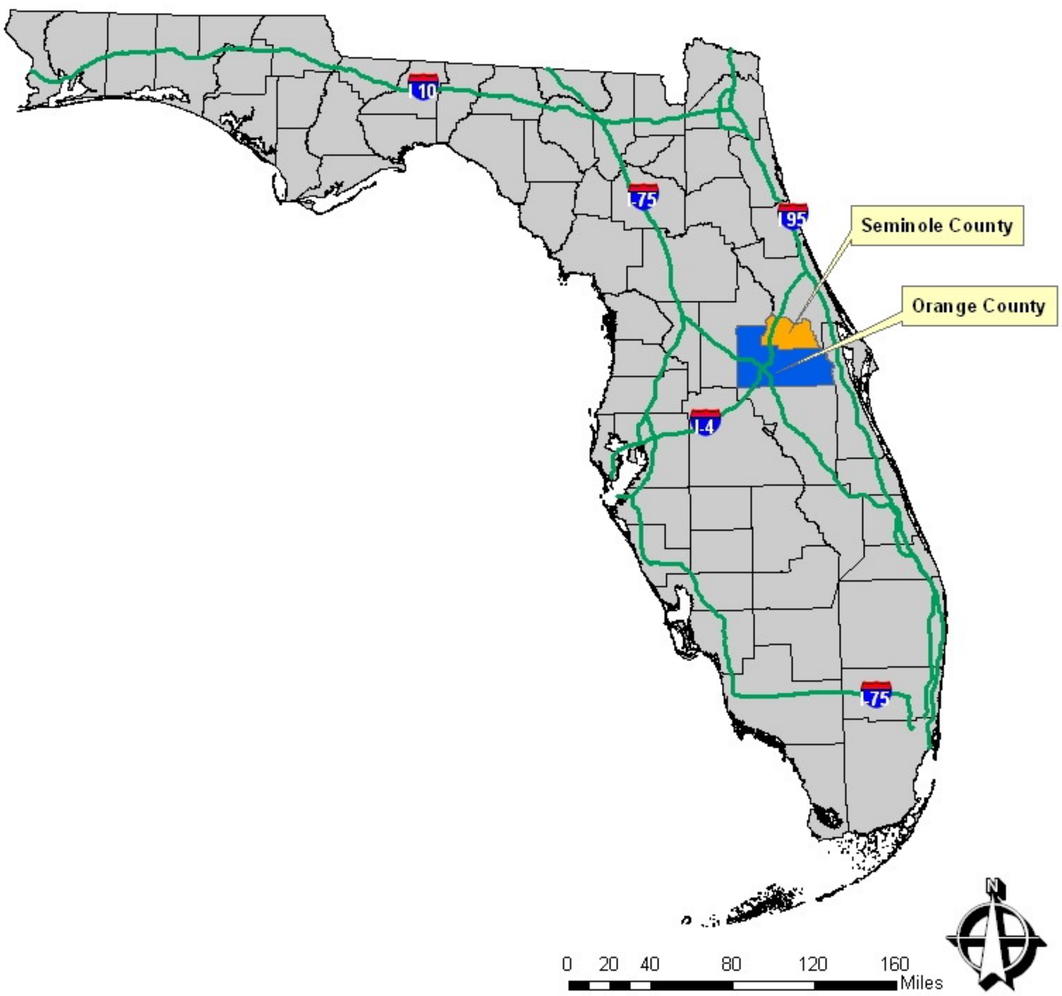


Figure 4-1. Overview of Study Area

Street Density	Before 1950	1950 - 1985	1986 - 1995	After 1995
Half-mile Pedestrian Shed (adjusted)	18.83	14.91	13.06	12.58
Half-mile Pedestrian Network Shed (adjusted)	20.93	19.98	22.68	22.14
One-mile Pedestrian Shed (adjusted)	15.80	13.64	11.98	11.66
One-mile Pedestrian Network Shed (adjusted)	19.41	18.50	18.35	18.98
Total Average	18.74	16.76	16.52	16.34

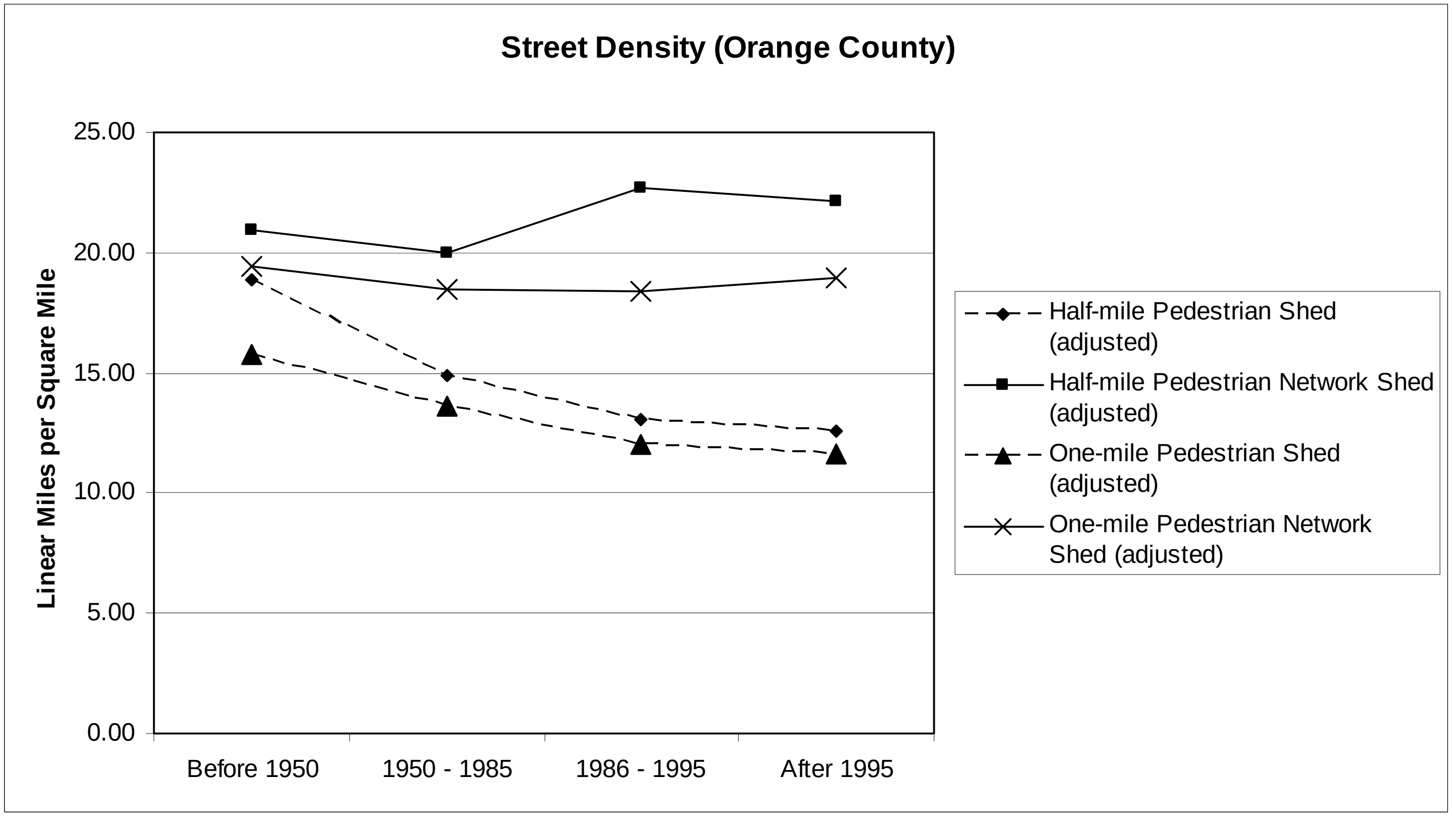


Figure 4-3. Graphical Illustration of Street Density in Orange County

Intersection Density	Before 1950	1950 - 1985	1986 - 1995	After 1995
Half-mile Pedestrian Shed (adjusted)	149.13	106.03	82.93	81.91
Half-mile Pedestrian Network Shed (adjusted)	177.43	156.21	173.83	145.26
One-mile Pedestrian Shed (adjusted)	121.59	98.08	80.20	76.34
One-mile Pedestrian Network Shed (adjusted)	152.45	137.00	124.57	134.69
Total Average	150.15	124.33	115.38	109.55

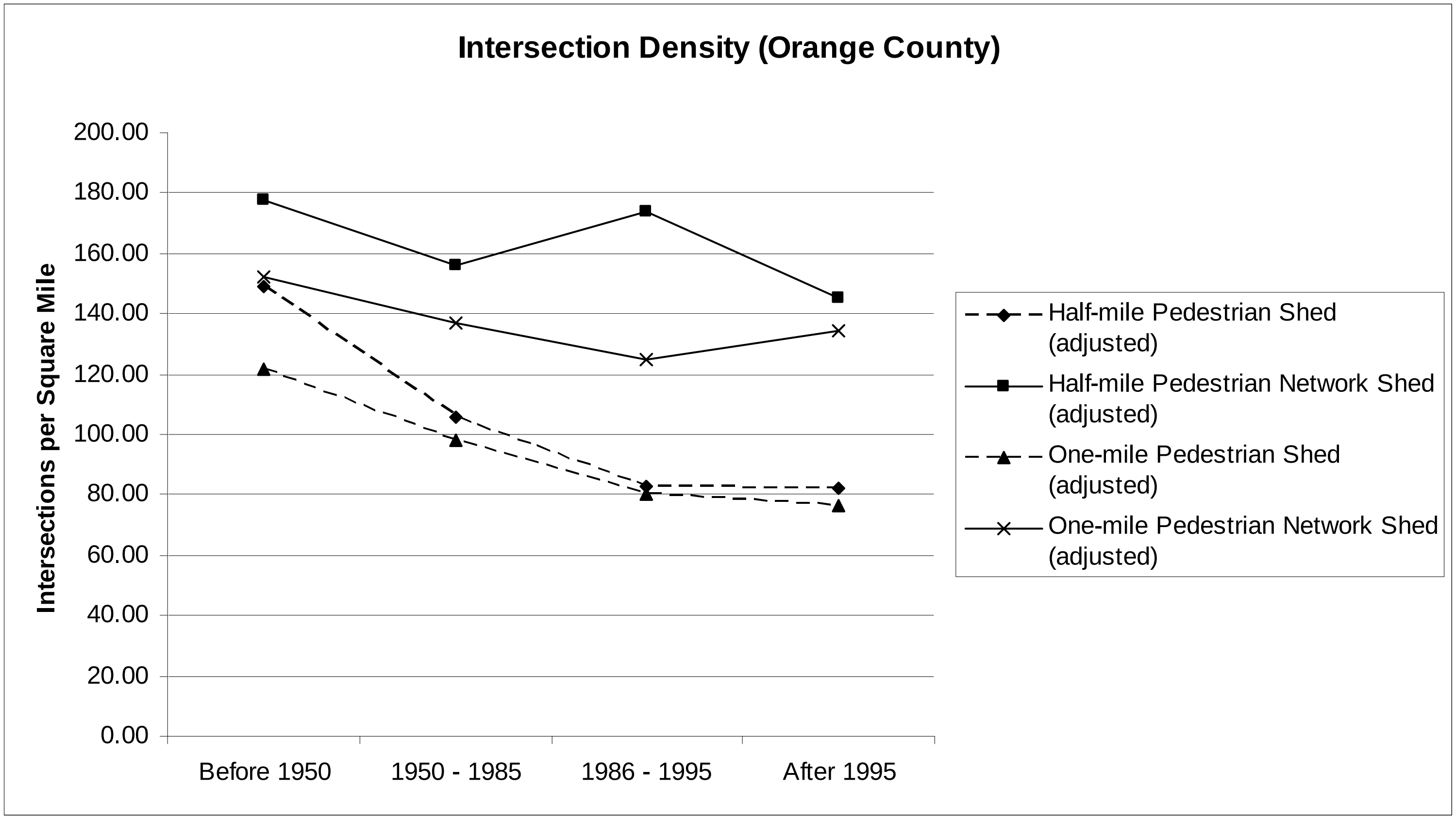


Figure 4-4. Graphical Illustration of Intersection Density in Orange County

Pedestrian Route Directness	Before 1950	1950 - 1985	1986 - 1995	After 1995
Half-mile Pedestrian Shed (adjusted)	1.68	2.23	2.91	2.47
Half-mile Pedestrian Network Shed (adjusted)	1.57	1.80	2.15	1.92
One-mile Pedestrian Shed (adjusted)	1.56	1.91	2.46	2.17
One-mile Pedestrian Network Shed (adjusted)	1.51	1.78	1.94	1.93
Total Average	1.58	1.93	2.36	2.12

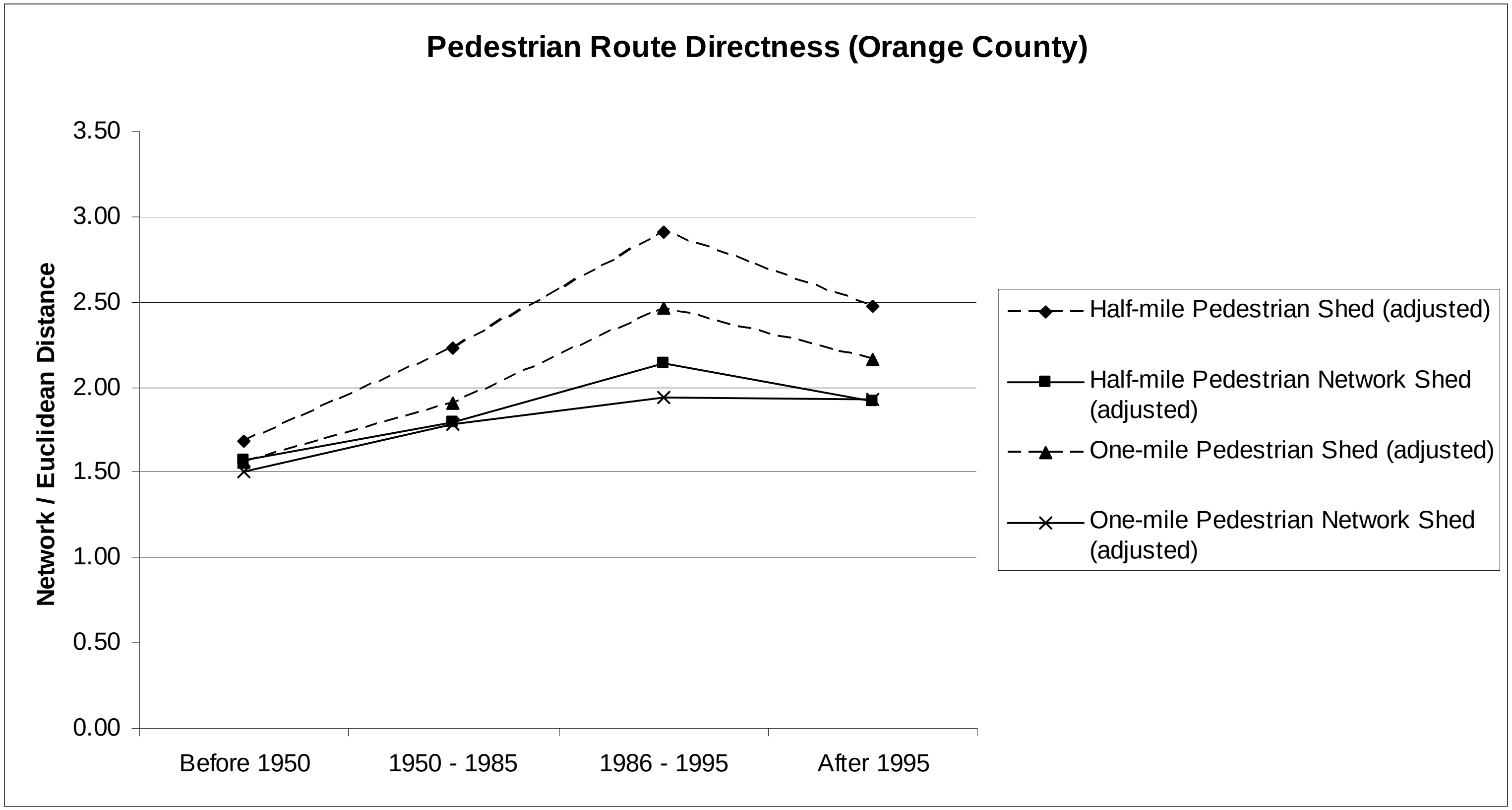


Figure 4-5. Graphical Illustration of Pedestrian Route Directness in Orange County

Gross Residential Density	Before 1950	1950 - 1985	1986 - 1995	After 1995
Half-mile Pedestrian Shed (adjusted)	3.87	2.56	1.70	1.89
Half-mile Pedestrian Network Shed (adjusted)	4.26	2.73	1.87	2.55
One-mile Pedestrian Shed (adjusted)	3.40	2.26	1.49	1.69
One-mile Pedestrian Network Shed (adjusted)	3.90	2.81	2.14	2.43
Total Average	3.86	2.59	1.80	2.14

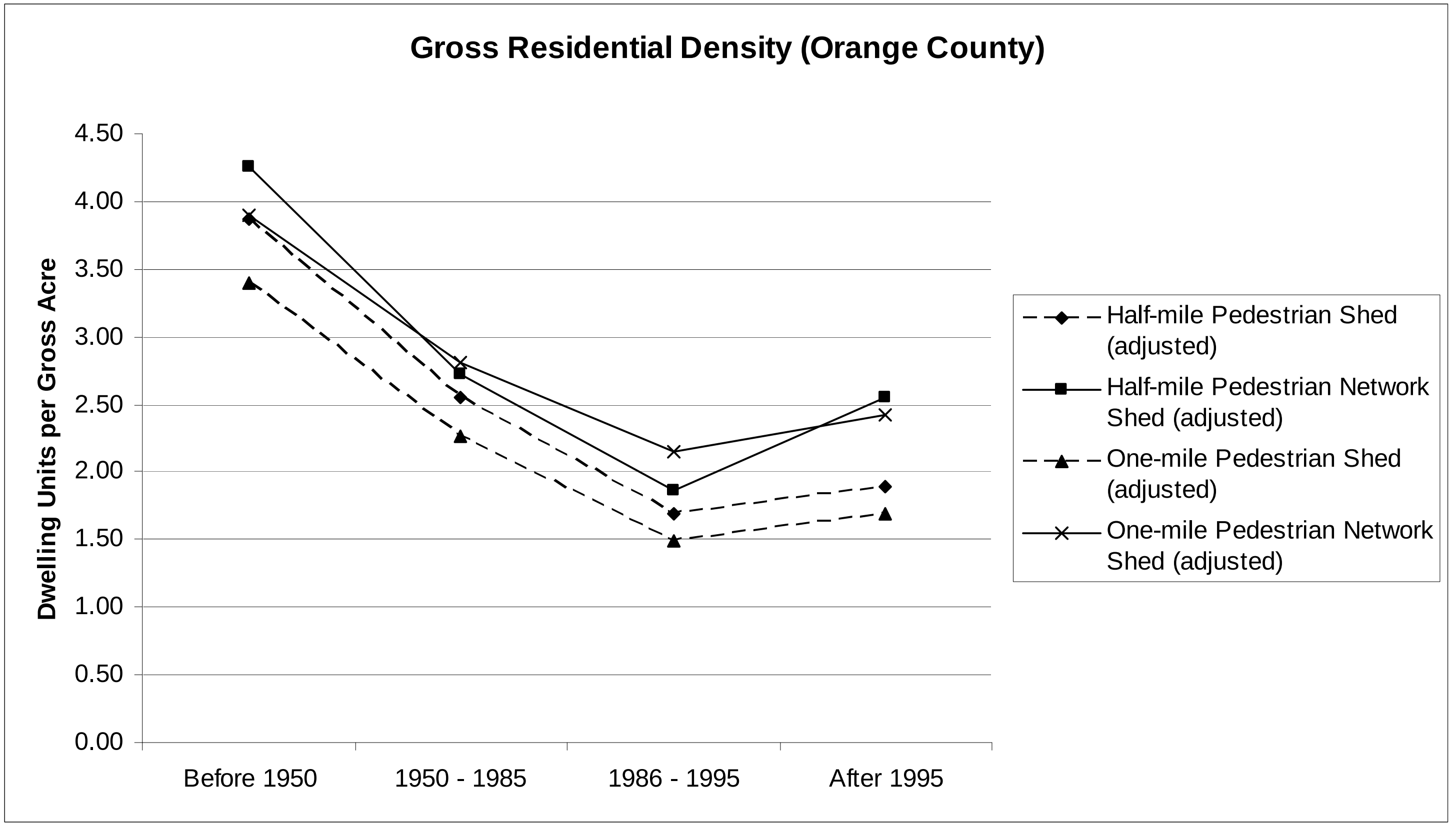


Figure 4-6. Graphical Illustration of Gross Residential Density in Orange County

Net Residential Density	Before 1950	1950 - 1985	1986 - 1995	After 1995
Half-mile Pedestrian Shed (adjusted)	8.40	5.35	3.51	3.81
Half-mile Pedestrian Network Shed (adjusted)	8.99	6.24	3.91	5.32
One-mile Pedestrian Shed (adjusted)	8.65	5.21	3.26	3.76
One-mile Pedestrian Network Shed (adjusted)	8.75	5.96	3.96	4.61
Total Average	8.70	5.69	3.66	4.38

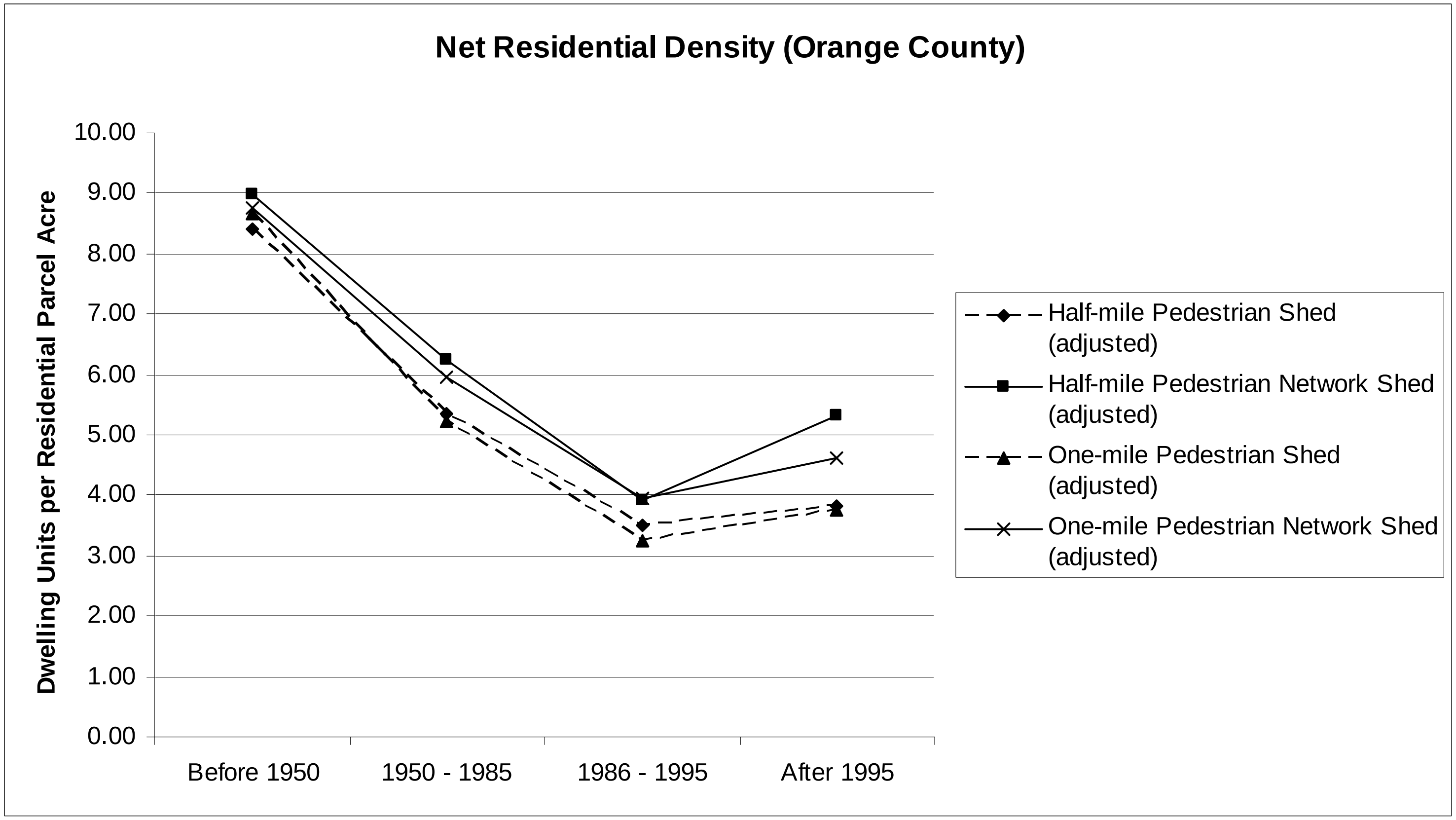


Figure 4-7. Graphical Illustration of Net Residential Density in Orange County

Effective Walking Area	Before 1950	1950 - 1985	1986 - 1995	After 1995
Half-mile Pedestrian Network Shed (adjusted)	0.53	0.34	0.22	0.24
One-mile Pedestrian Network Shed (adjusted)	0.71	0.57	0.40	0.40

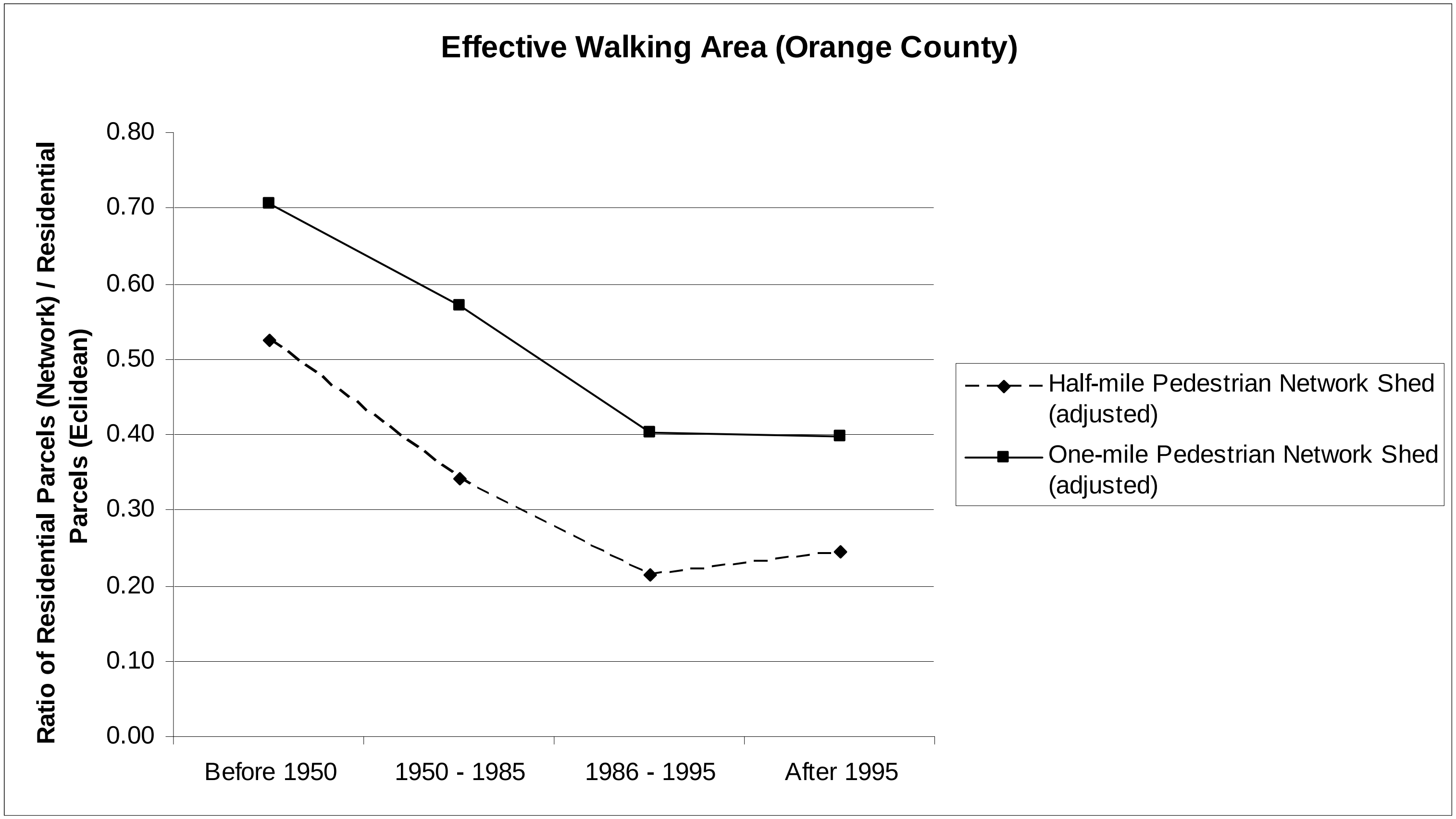


Figure 4-8. Graphical Illustration of Effective Walking Area in Orange County

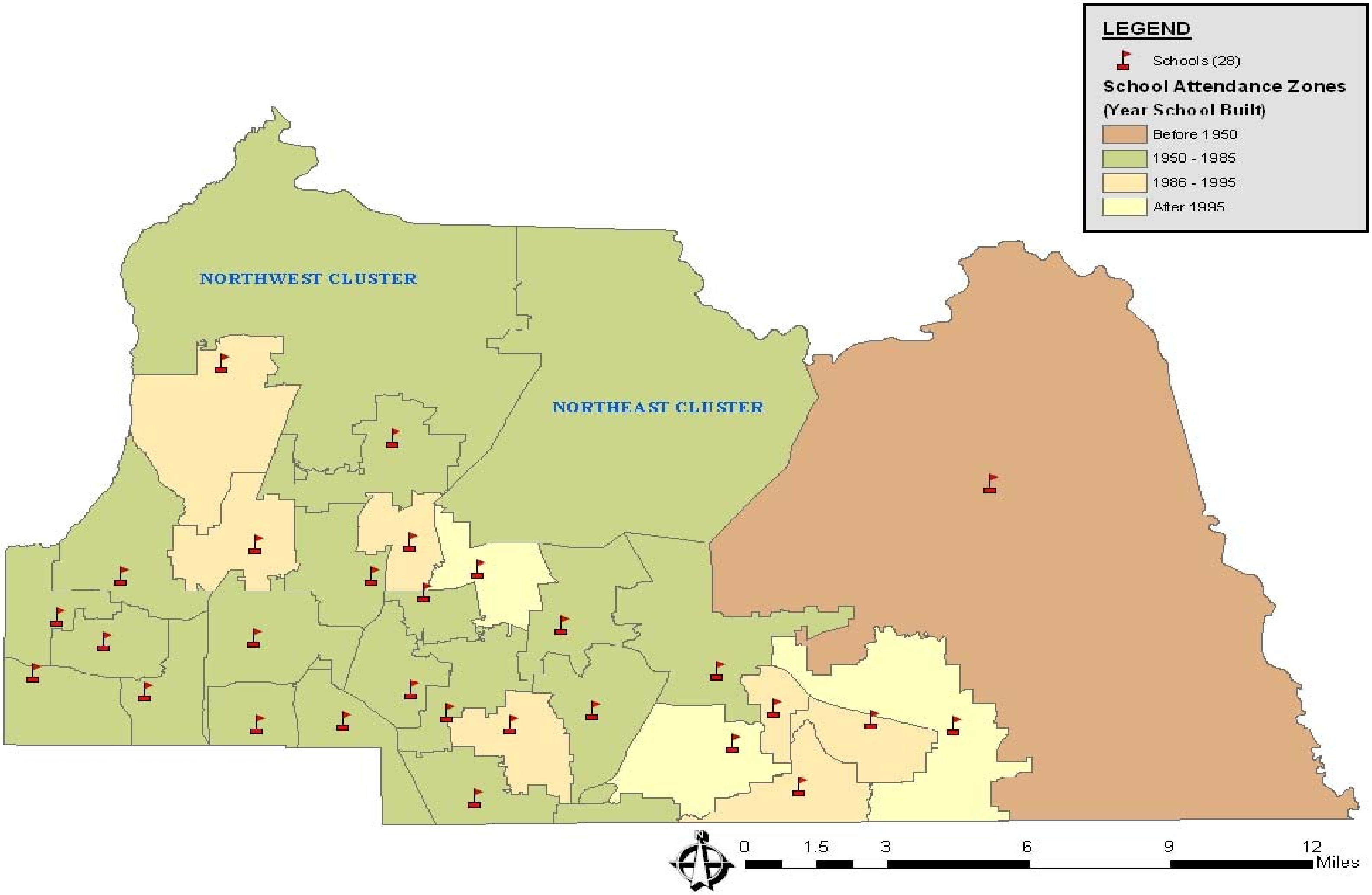


Figure 4-9. Map of Seminole County School Attendance Zones and Schools

Street Density	Before 1950	1950 - 1985	1986 - 1995	After 1995
Half-mile Pedestrian Shed (adjusted)	9.31	15.53	13.18	10.74
Half-mile Pedestrian Network Shed (adjusted)	17.96	19.45	25.10	22.30
One-mile Pedestrian Shed (adjusted)	5.56	14.01	11.18	10.43
One-mile Pedestrian Network Shed (adjusted)	13.50	18.09	20.64	19.70
Total Average	11.58	16.77	17.53	15.79

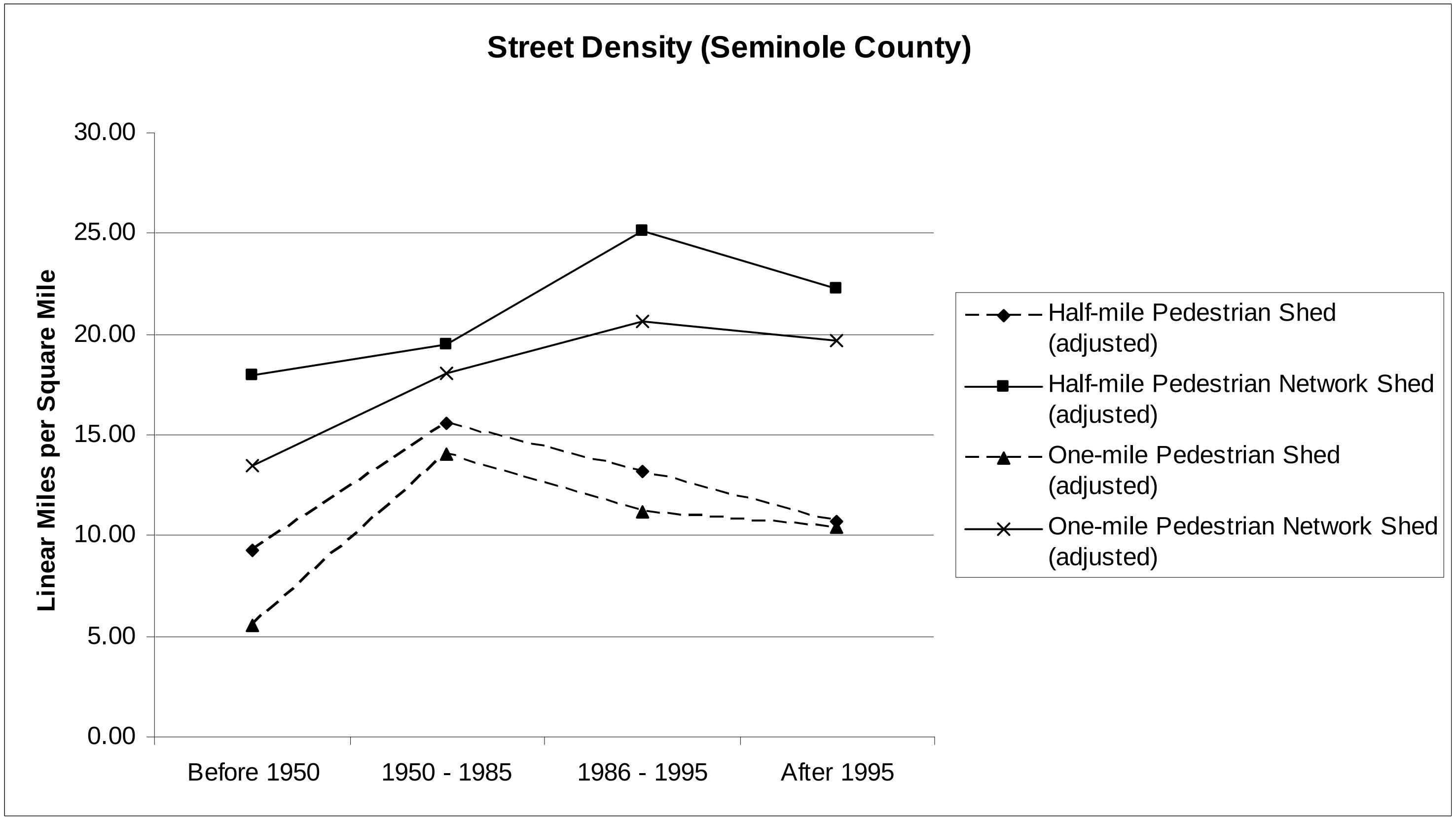


Figure 4-10. Graphical Illustration of Street Density in Seminole County

Intersection Density	Before 1950	1950 - 1985	1986 - 1995	After 1995
Half-mile Pedestrian Shed (adjusted)	31.84	61.88	69.38	46.76
Half-mile Pedestrian Network Shed (adjusted)	114.62	133.92	203.03	91.07
One-mile Pedestrian Shed (adjusted)	21.33	94.39	64.09	47.60
One-mile Pedestrian Network Shed (adjusted)	62.65	127.42	138.52	94.13
Total Average	57.61	104.40	118.75	69.89

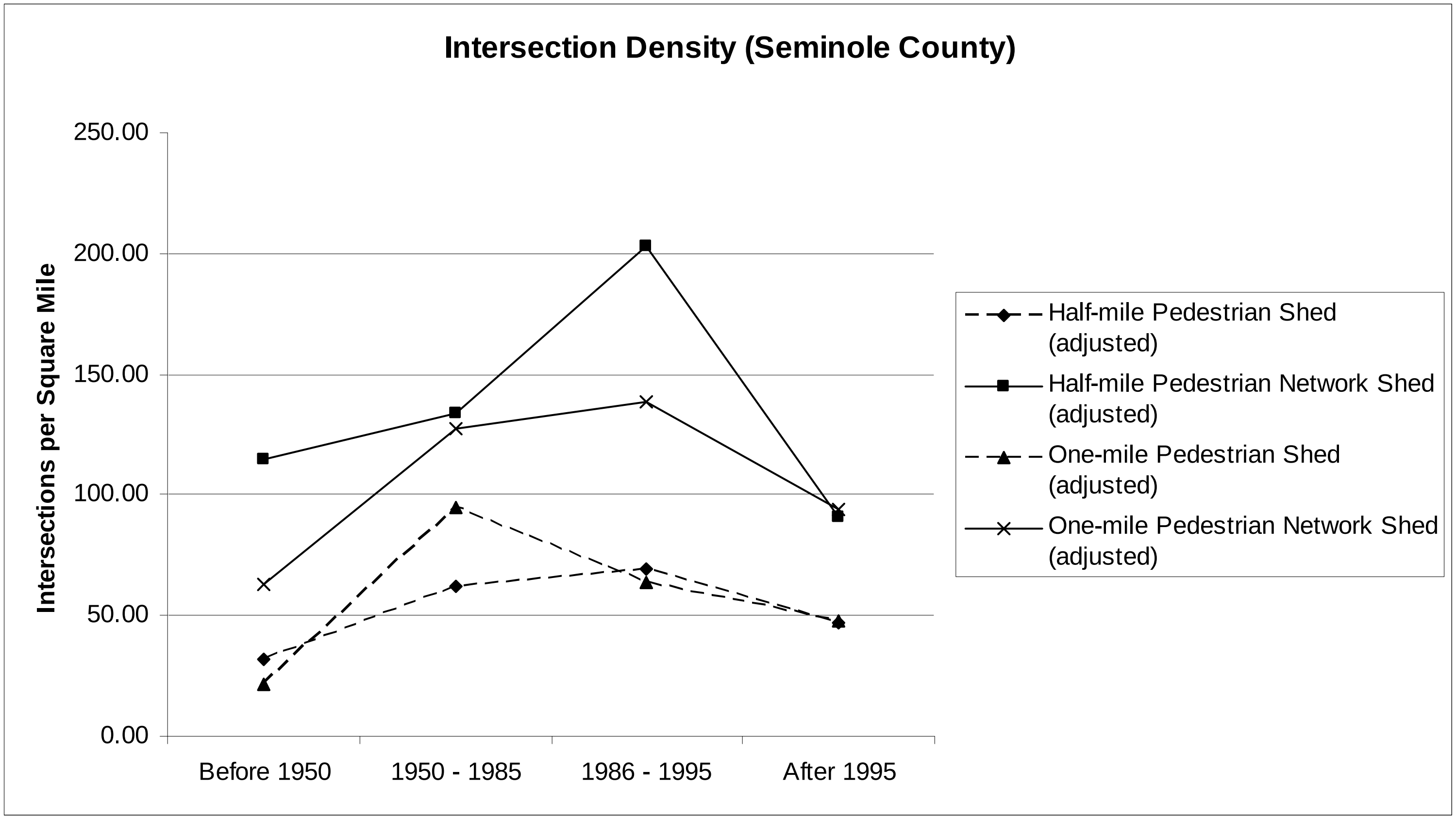


Figure 4-11. Graphical Illustration of Intersection Density in Seminole County

Pedestrian Route Directness	Before 1950	1950 - 1985	1986 - 1995	After 1995
Half-mile Pedestrian Shed (adjusted)	1.45	2.46	3.26	3.19
Half-mile Pedestrian Network Shed (adjusted)	1.41	2.31	2.01	2.49
One-mile Pedestrian Shed (adjusted)	1.45	2.02	2.52	2.49
One-mile Pedestrian Network Shed (adjusted)	1.44	2.07	1.92	2.26
Total Average	1.44	2.22	2.43	2.61

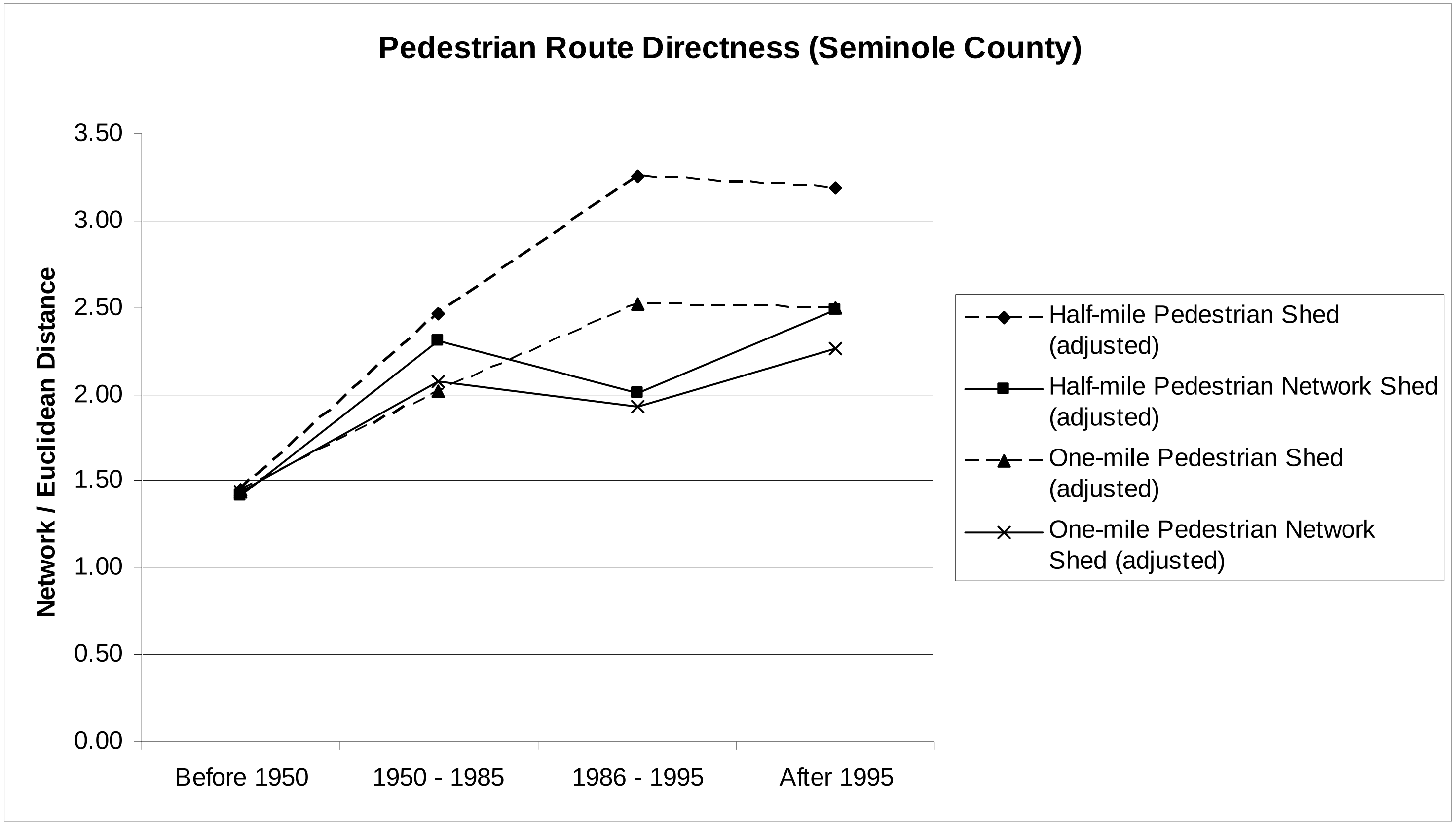


Figure 4-12. Graphical Illustration of Pedestrian Route Directness in Seminole County

Gross Residential Density	Before 1950	1950 - 1985	1986 - 1995	After 1995
Half-mile Pedestrian Shed (adjusted)	0.36	2.25	1.88	0.97
Half-mile Pedestrian Network Shed (adjusted)	0.73	2.19	2.00	1.24
One-mile Pedestrian Shed (adjusted)	0.18	2.13	1.50	1.09
One-mile Pedestrian Network Shed (adjusted)	0.35	2.25	2.38	1.56
Total Average	0.40	2.21	1.94	1.21

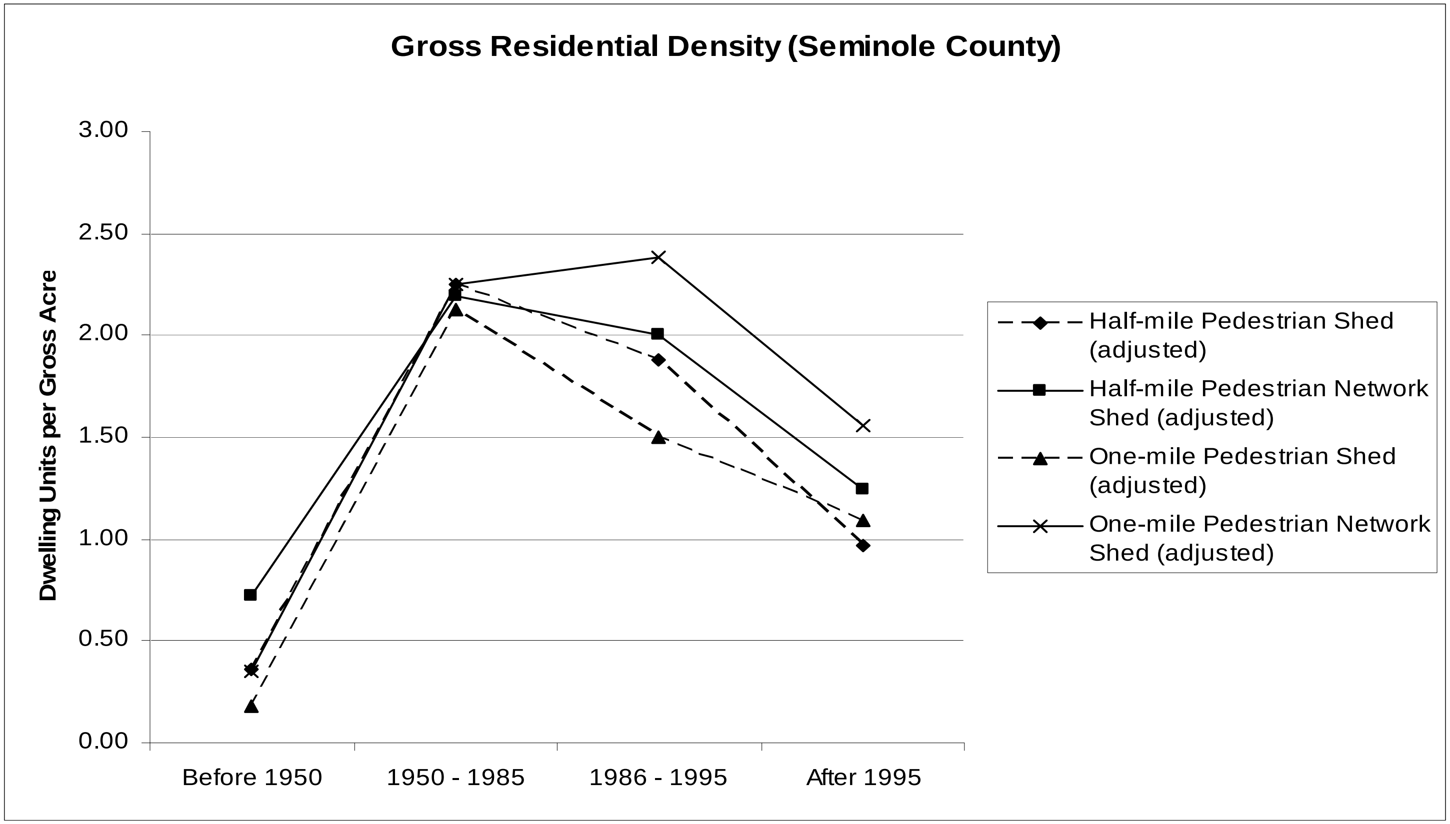


Figure 4-13. Graphical Illustration of Gross Residential Density in Seminole County

Net Residential Density	Before 1950	1950 - 1985	1986 - 1995	After 1995
Half-mile Pedestrian Shed (adjusted)	0.78	4.29	4.38	2.79
Half-mile Pedestrian Network Shed (adjusted)	1.82	4.72	4.51	3.16
One-mile Pedestrian Shed (adjusted)	0.41	4.05	3.68	2.60
One-mile Pedestrian Network Shed (adjusted)	0.89	4.36	4.44	3.61
Total Average	0.98	4.36	4.25	3.04

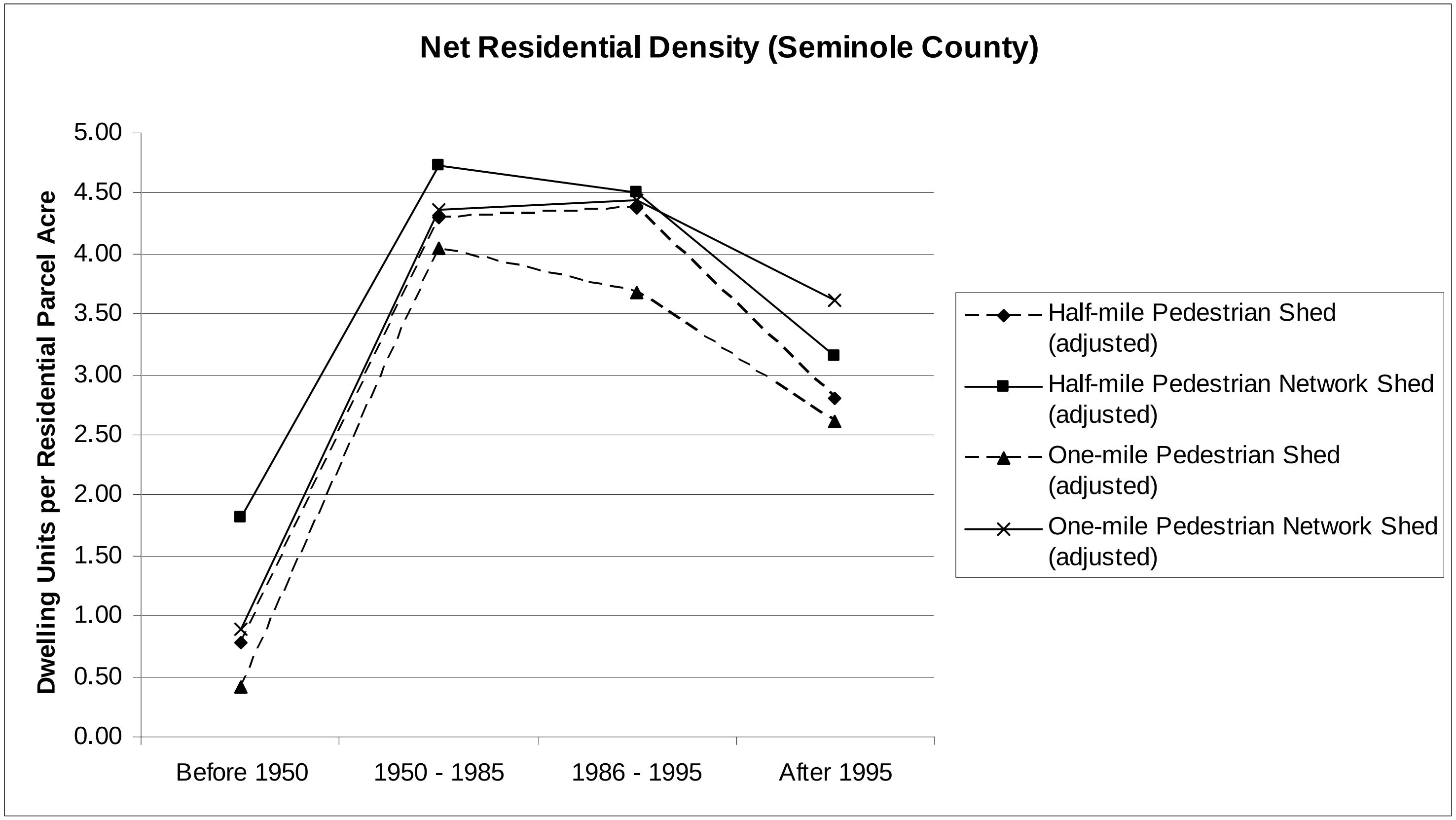


Figure 4-14. Graphical Illustration of Net Residential Density in Seminole County

Effective Walking Area	Before 1950	1950 - 1985	1986 - 1995	After 1995
Half-mile Pedestrian Network Shed (adjusted)	0.72	0.27	0.19	0.19
One-mile Pedestrian Network Shed (adjusted)	0.56	0.43	0.36	0.26

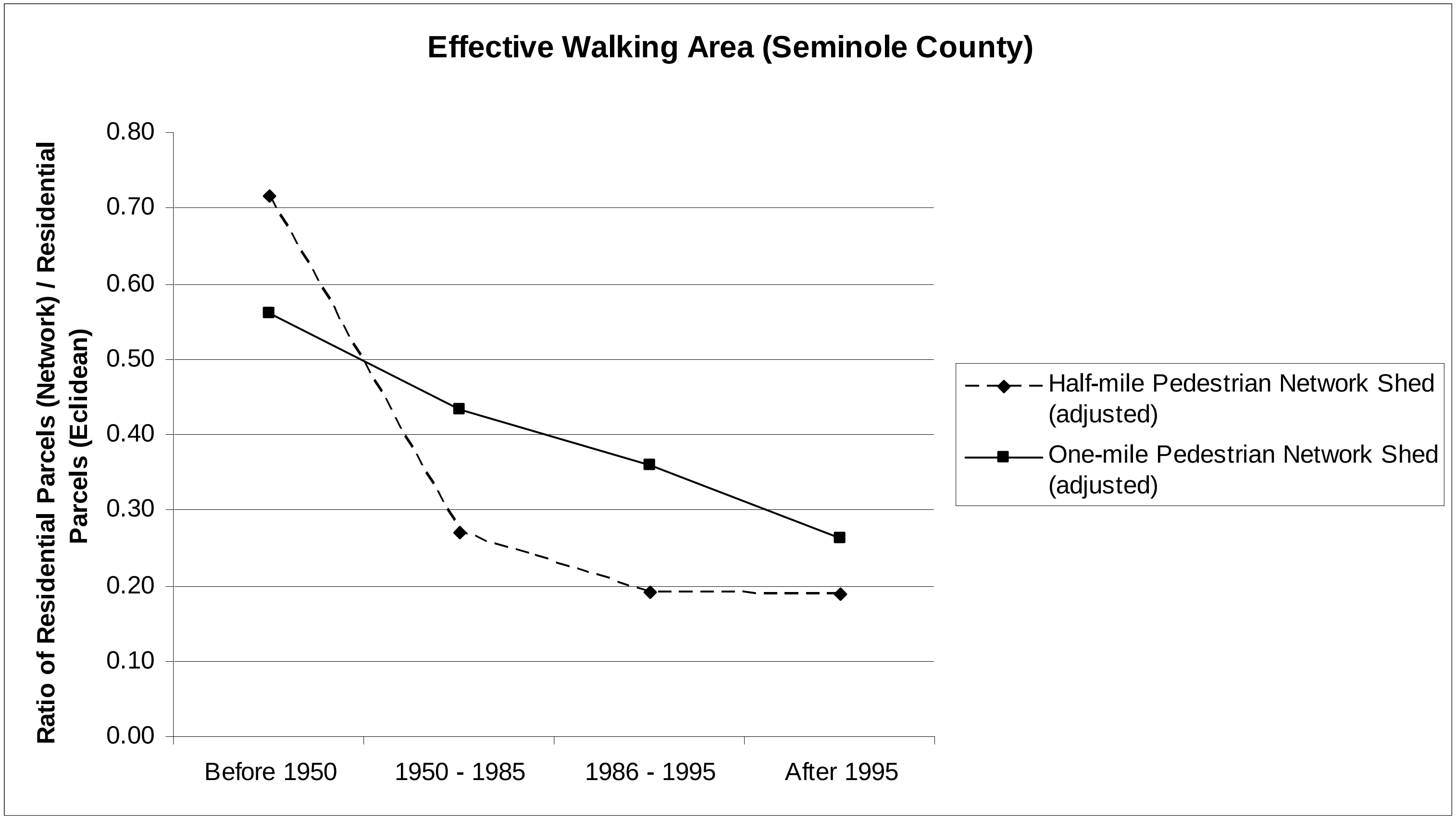


Figure 4-15. Graphical Illustration of Effective Walking Area in Seminole County

CHAPTER 5
DISCUSSIONS AND CONCLUSIONS

The final chapter of this paper will provide a discussion of how the research conducted in this study supports the question of how urban form impacts the potential for children to walk and bicycle to school. These discussions will also address a subsequent research question – somewhat of an undertone of this study – that asks "how does the built environment impact physical activity and childhood obesity?" The intent of this study was to:

- Provide further insight of the impacts that the built environment poses on public health
- Make a valuable contribution towards the understanding of urban form and how it impacts physical activity;
- Raise awareness about the relationship between the built environment and the ability for people to participate in active travel;
- Provide a useful resource for others to use in developing similar studies for future research

Although this study focuses primarily on the ability of children to walk and bicycle to school, the same methodology could be used to determine the potential walkability of any population within the built environment.

Discussions and Conclusions

This study chose to use street connectivity and residential density – two characteristics of urban form – to investigate potential walkability around school sites. Based on the findings from this study and the supportive literature, it is assumed that there is a higher probability for walkability within the areas exhibiting more traditional styles of development. These consist of more grid-like street networks and a structured grouping of residential densities. In the Orange County case study it was clear that street connectivity was best around the historic schools built before 1950, considering all analysis zones. More traditional development patterns were found around these school sites particularly influenced by intersection density indicators. Additionally, above average intersection density values were found along the street network for all time periods further indicating good connectivity around Orange County schools. These patterns also hold true for residential density trends, which show the highest density of residential parcels around school sites built before 1950. Respective values decreased during the following two time periods, with a slight resurgence around the schools built after 1995. Not surprising, the effective walking area for school sites in Orange County showed that the greatest potential for walkability around schools built before 1950, based on the high percentage of residential parcels found along the street network. Figure 5-1 provides an illustration of schools (one for each time period), characterizing the more traditional development styles before 1950, the more suburban nature of development during the following two time periods, and the resurgence of residential density after 1995. Considering these findings, it's clear that the potential for walkability is highest around the historical schools which exhibit more traditional development styles. Although patterns revealed decreased walkability based on declining street connectivity and residential densities between the pre-growth management and pre-school coordination time periods, it is encouraging to see residential density patterns increasing around the schools built after 1995. Furthermore, intersection densities, although decreasing on the whole, are still well above the acceptable standard for all but one of the analysis zones.

Seminole County exhibited different trends than those seen in Orange County. Both street connectivity and residential density indicators revealed the weakest values during the period before 1950, though during this same time period EWA was exceptionally high. This is likely due to the minimal amount of residentially developed parcels around the school site (low number of dwelling units compared to the total number of existing residential parcels). The EWA ratio is based on the total number of zoned residential parcels and not the number of dwelling units within those parcels. Ultimately, EWA can only provide a generalization of potential walkability based on the number of residential parcels that exist in a specific area. However, the positive thing to note (especially in the example noted above) is that, although residential development is low, the majority of residential parcels are located along the street network, thus exhibiting a greater potential for walkability. This is especially true if the area were to be developed more intensively in the future. Figure 5-2 provides a visual illustration of EWA to help explain. Following 1950, there was a boom in development with an increase of residential densities and street connectivity around a host of new schools across the entire County. However, following 1985 patterns became erratic, with increasing and decreasing values across all analysis zones. However, intersection density values within the pedestrian network sheds exceeded the acceptable standard, providing some semblance of good connectivity around schools in Seminole County. Figure 5-3 provides an illustration of a sample of schools across the different development periods, showing the general trends occurring in Seminole County. The low connectivity and residential density findings seen before 1950 may also be due to a small sample size reflective of there only being one school constructed before 1950. Furthermore, land development on the whole across Seminole County for the four time periods seemed to have been growing at a slower rate than neighboring Orange County. If provided the opportunity to examine Seminole County in the next decade, it would be interesting to see if resurgence of better connectivity and residential densities (more compact development) are occurring. However, based on the current findings, it seems that Seminole County – although legally bound by the State to conform to regulatory measures regarding growth management and school concurrency – may still be developing by its own accord.

Overall, Orange County is more in tune with the State's legislative policies, even though continual declines are seen among street connectivity indicators. Conversely, Seminole County does not seem to be following any development trends respective of the State's policy inactions. Although different patterns were found in the two case studies, the indicators within each study showed consistency between one another, validating the use of the chosen characteristics as respected means in measuring potential walkability. The methodology used in this study proves to be a beneficial resource that could be used to evaluate other communities. As mentioned, specifically in Orange County, there seems to be a resurgence of residential density occurring around newer schools. This may in part be due to policies that oversee improvements in coordination between decision makers regarding school siting and neighborhood development. Additionally, market demand may also be encouraging further production of neo-traditional developments, such as the Baldwin Park neighborhood. Development archetypes such as the new urbanism and the ideology of Smart Growth have been increasing in popularity nation-wide. With the State overseeing growth issues, and encouraging new development techniques arising, the State of Florida has the tools to develop more highly walkable and healthy communities. So how do traditional design, physical (in)activity and obesity relate? How can it provide solutions for developing safer, healthier communities?

Bridging Community Development and Public Health

Healthy physical and psychosocial behaviors have been linked to our physical (built and natural) environments. One of many components is our dependence on social interactions within the community. Limiting existence to physical sustenance (access to places) minimizes human interactions. This can be extremely detrimental to the health of individuals and a community, Seymour Sarason (1974, viii), a leading writer in the field of community psychology, has argued that "the dilution or absence of the psychological sense of community is the most destructive dynamic in the lives of people in our society" (Lucy, 1994, p. 312). A lack of psychological connection in a community in many instances is due to the lack of physical cohesion of the community. Many of the communities we see across the U.S. today are disconnected and unidentifiable, leading to places that lack interest, and are dominated by automobile travel. However, compact community development types typical of higher density and connectivity can potentially increase the opportunities for people to engage in daily interactions within the community, thus increasing social stability and healthy physical and psychological behaviors. As seen in this research study, the built environment plays a potential role in guiding decisions on whether to walk or bicycle for utilitarian travel purposes. However, there have been some inhibiting factors along the way which have reduced the possibilities for more compact development types.

Since the inception of zoning laws in response to growing industrial centers around the world, public health has proven to be a critical topic of concern. In the United Sates, the landmark case between the Village of Euclid and Ambler Realty [1] revealed just how closely land use (development) and public health are related. As a means in stymieing environmental and public nuisances (namely industrial intoxicants) near residential dwellings, the Supreme Court found in favor of separating land uses in what is now defined as Euclidean zoning[2]. This new zoning order and disconnection of land uses in many ways has contributed to what we identify

[1] Village of Euclid vs. Ambler Realty was a United States Supreme Court case argued in 1926. It was the first significant case regarding the relatively new practice of zoning, serving to substantially bolster zoning ordinances in towns nationwide across the United States. More information available at: http://supreme.justia.com/us/272/365/case.html

[2] Euclidean zoning is the separation or division of a municipality into districts, the regulation of buildings and structures in such districts in accordance with their construction and the nature and extent of their use, and the dedication of such districts to particular uses designed to serve the general welfare. More information available at: http://legal-dictionary.thefreedictionary.com/

all over the United States, as “urban sprawl.” Unfortunately, the repercussions have been destructive, both environmentally and in terms of population health (Schilling & Linton, 2005).

Addressing community livability and the health of people by introducing more compact development can provide more highly livable environments potentially alleviating patterns of suburban sprawl, reconnecting social interactions, and decreasing environmental hazards. Furthermore, developing in a more traditional manner, focusing on community-orientated approaches, can have a profound affect on the health of individuals in a community, especially children. When addressing the issue of walkability, it is not clear exactly all of the factors that influence a person’s choice to be active or not in their travel behaviors. There are some, but in many instances it is extremely difficult. Even if urban form suggests that a place is walkable; is it really? What are the factors facilitating or inhibiting behaviors in so-called “walkable environments?” Can walkability be encouraged by creating more compact developments? The bigger question may be; do people want to be physically active, specifically speaking in terms of their travel routines? The old adage of “if you build it, they will come,” is really an uncertainty. Marlon Boarnet raises an interesting point:

> Persons might choose their environments in part based on their desired level of physical activity. It does not take much imagination to believe that an avid surfer would choose to live near the beach or that a ski enthusiast would move near the mountains. Generalizing to other, more common forms of physical activity, do persons who wish to walk choose residences in pedestrian-oriented neighborhoods near parks? If so, the association between physical activity and urban form might represent a persons’ residential location choice rather than an influence of the built environment on activity (2004, p. 3).

What are the affects of (re)developing a neighborhood into a pedestrian-friendly place that encourages walking and bicycling if the residents of that community have a disinterest in living active lifestyles? These and many other questions are at the core of trying to better understand how the built environment affects population health.

One of the key features in traditional developments prior to 1950 was the institution of schools as focal points located at the center of the community. In many neighborhoods, schools were located in close proximity to parks, recreational areas and other community and civic assets. Neighborhood schools, planned with a community-oriented approach retain residents who use nearby schools for a variety of activities other than just education. Having a school at the core of the community provides a wealth of opportunities and services for both children and adults, such as parks and playgrounds, athletic facilities, health and wellness centers, libraries, and adult education opportunities. Schools also serve as places that host community events such as theater productions, local music and art festivals, community meetings, and even local farmers markets. Furthermore, a school that provides a host of services within the community limits the need for constructing additional facilities requiring funding from tax dollars (Spengler, Young, & Linton, 2007). These and other factors make schools ideal places that contribute to a sense of a place providing the social interactions that make communities healthy and enjoyable places to be. Moreover, to increase walkability of schools, it’s important for them to be located within a reasonable proximity to the neighborhoods they serve. School coordination regarding issues of size of school, site location and building design are as important if not more important than the physical elements that support the physical act of traveling to school (e.g., sidewalks, bicycle lanes, etc).

Understanding the conditions that contribute to mode choices of younger populations, particularly to school is important. Although the number of children who walk and bicycle to school has decreased dramatically, studies show that children do engage in active travel opportunities to school (Fulton, Shisler, Yore, & Caspersen, 2003). In addition to physical design elements, there are many programs and organizations which contribute to increasing the safety and walkability of environments around schools. One of the most notable programs is the Safe Routes to School program (SRTS)3. SRTS promotes walking and biking to school through education. It encourages greater enforcement of traffic laws, educating the public, and exploring ways to create safer streets for children traveling to and from school. Another notable program is the Florida Traffic and Bicycle Safety Education Program (FTBSEP)4. The FTBSEP program is jointly operated between the Department of Transportation and the University of Florida. The main goal of the organization is to administer a traffic and bicycle safety education program through workshops and certificate programs for Florida elementary and middle schools, reducing the incidence of pedestrian-vehicular accidents. Understanding travel behaviors is just one part. Addressing the impacts of the built environment is another. Together, through cooperative efforts, increasing the likelihood of active travel is possible. It is also imperative that we continue to support physical education in the classroom. Impacting a child's physical health through education in school can potentially encourage physical activity in other instances of a child's life. Studies have shown that children who are more physically active early in life tend to be more physically active later in life (Telama, Yang, Viikari, Valimaki, Wanne, & Raitakari, 2005). However, the need to encourage physical activity extends beyond the classroom. As this and other studies suggest, our environmental surroundings play critical roles, influencing the ways we live and operate in society. Understanding how to effectively design our built environments will be critical in supporting the health of populations for generations to come. This is especially true for the region of central Florida where this study takes place, as expected growth and development are predicted to skyrocket during the next fifty years.

[3] SRTS – More information available at: http://www.saferoutestoschools.org/index.shtml

[4] FTBSEP – More information available at: http://www.hhp.ufl.edu/safety/index.html

Limitations of this Study

Because this study was inherited as a continuing research opportunity, the researcher utilized previously existing data sets to conduct this study. Some data sets were unavailable for use in further investigation. This however, was not detrimental in conducting the overall research analysis for this project. In addition to data availability, there were some additional limitations pertaining to time and monetary constraints, which permitting could have yielded more in depth analyses.

Considering data availability, the methodology used two distinct measures to calculate potential walkability; street connectivity and residential density. In examining street connectivity, the researcher used the centerline of streets as a proxy in measuring potential walkability. Due to the aggregate nature of this study, the use of street networks in measuring connectivity provided a reasonable set of findings relative to general patterns of urban form and their impacts. However, a more realistic determination for walkability could have been made by examining actual pedestrian networks, which would consider elements such as sidewalks, crosswalks, speed limits, informal paths, fences, walls, crossing guards, personal safety, and lanes of traffic (Bejleri, et al., 2008, p.12).

One particular dataset that posed a limitation on this study was residential parcel data for the areas outside of the analysis zones in Seminole County, specifically the *net* calculations. The purpose for calculating the residential densities for the surrounding area of the County is to provide a comparison between what is occurring inside of the analysis areas to what is happening outside of them. Although net residential densities were calculated for the analysis zones, net residential density information for the rest of the County had not been generated. Needed information included parcel boundaries and recalculation of dwelling unit information. However, due to time constraints, generating the GIS datasets was not feasible. Remedying the residential parcel information for the areas outside of the analysis zones is important, as it examines how urban form is impacting schools within the areas where children can most likely be expected to walk and bicycle compared to the averages of what is occurring across the rest of the County.

Because this study examined development trends across four influential time periods of Florida's growth – generating assertions that policy inactions played a critical role in determining physical environments – it's important to note that no research was conducted in examining changes in redevelopment or reconstruction particularly within the analysis zones. Although a school was built during a specific development period, the findings are not necessarily representative of the conditions around the school and the neighborhood when they were first constructed. It is important to note, that land use zoning designations are variably dynamic, while street and road networks are relatively static. Over time, the different uses of land occupation (e.g., buildings, structures, open spaces) with their unique uses come and go, while streets tend to undergo minimal changes. However, in conducting this study, it is assumed that what is there now, existed there when the area was originally constructed. Researching the evolution of development across the examined time periods could potentially impact the findings of this study.

Ideally, a study of this nature requires more research and analysis than simply using a GIS for making interpretations. A final limitation in this study was the inability to conduct field audits of the subject schools. Site visits were not possible due to time and monetary constraints, but if performed could have presented more accurate findings. Key elements recommended for physical examination could include: construction of the school facility (design elements), placement and arrangement of the school on the site, street conditions around the school (design and maintenance), investigation of adjacent land uses, and safety (objective) of the school and the surrounding neighborhood.

Opportunities for Future Research

The research on the topics of physical activity and childhood obesity are extremely diverse, especially when concerning the impacts presented by the built environment. There are many arguments both for and against how the built environment, physical activity, and childhood obesity are related, but few are sufficient in making sound correlations. This is in part due to the complexities of urban environments and the behaviors of the people living within them. However, several things are for certain: Urban development has been increasingly moving to the periphery and away from urban cores, people are walking and bicycling less, and the overweight and obesity epidemic is real, placing unnecessary burdens on our society. Because we’re just beginning to realize that there may be harmful affects between the ways we develop our communities on the health of the people who inhabit them, the opportunities for future research on this and similar topics are plentiful. One particular set of data which could shine more light on the issue of childhood obesity is the availability of BMI data. This information in conjunction with other methods of investigation could help produce, more educated assumptions concerning the examination of all types of influences on a child’s weight. Although there are laws in place, protecting the safety and personal privacy of minors in research studies, there are ways to protect and keep sensitive data confidential, while still acquiring the necessary information in making more precise research evaluations. The availability of data concerning BMI levels for [well-intentioned] research use will prove to be extraordinarily beneficial for the health and well being of individuals and society as a whole.

Specifically acknowledging this study, several issues should be addressed immediately, including the data retrieval and input of the residential parcel boundaries into GIS for Seminole County. A number of other studies would also prove beneficial.

Other studies currently ongoing on this topic within the same study area (Steiner, et al., 2008) have conducted survey analysis of the number of children who walk and bicycle to school. Future research may want to consider additional surveys of the number of children who travel from school to home. Studies have shown that the number of children who travel home from school is in some instances greater than that traveling to school (Schlossberg, et al., 2006). Understanding the travel patterns of children between school and home will help to support additional theories regarding the impacts urban environments.

Another opportunity for consideration is to perform detailed field audits. Though they can be expensive and time intensive, physical interaction with the actual environment will provide more accurate interpretations of the conditions. This study utilizes only a few of the tools available in researching potentially walkability. However, other tools are available and are encouraged for use, especially if conducting field audits. In particular, the “Design Guidelines for Pedestrian-Friendly Neighborhood Schools,” prepared by the City of Raleigh, North Carolina is an appropriate resource to consider (City of Raleigh, N.C., 2008). Conducting field audits will provide additional information to help support and quite possibly negate some of the findings from this study.

When considering future research designs intended to examine evidence of causality in the relationship between the built environment, physical activity, and obesity, it is important to realize that sound conclusions can not be made based on the results of a single research study. All studies are unique and contain weaknesses. It’s encouraged that both academics and practitioners branch out to gain an understanding of other disciplines and practices that deal with health issues, development decisions, and issues of design. Having a well rounded understanding of the multitude of factors that contribute to the ways we live and function is imperative to making gainful contributions to studies such as this one.

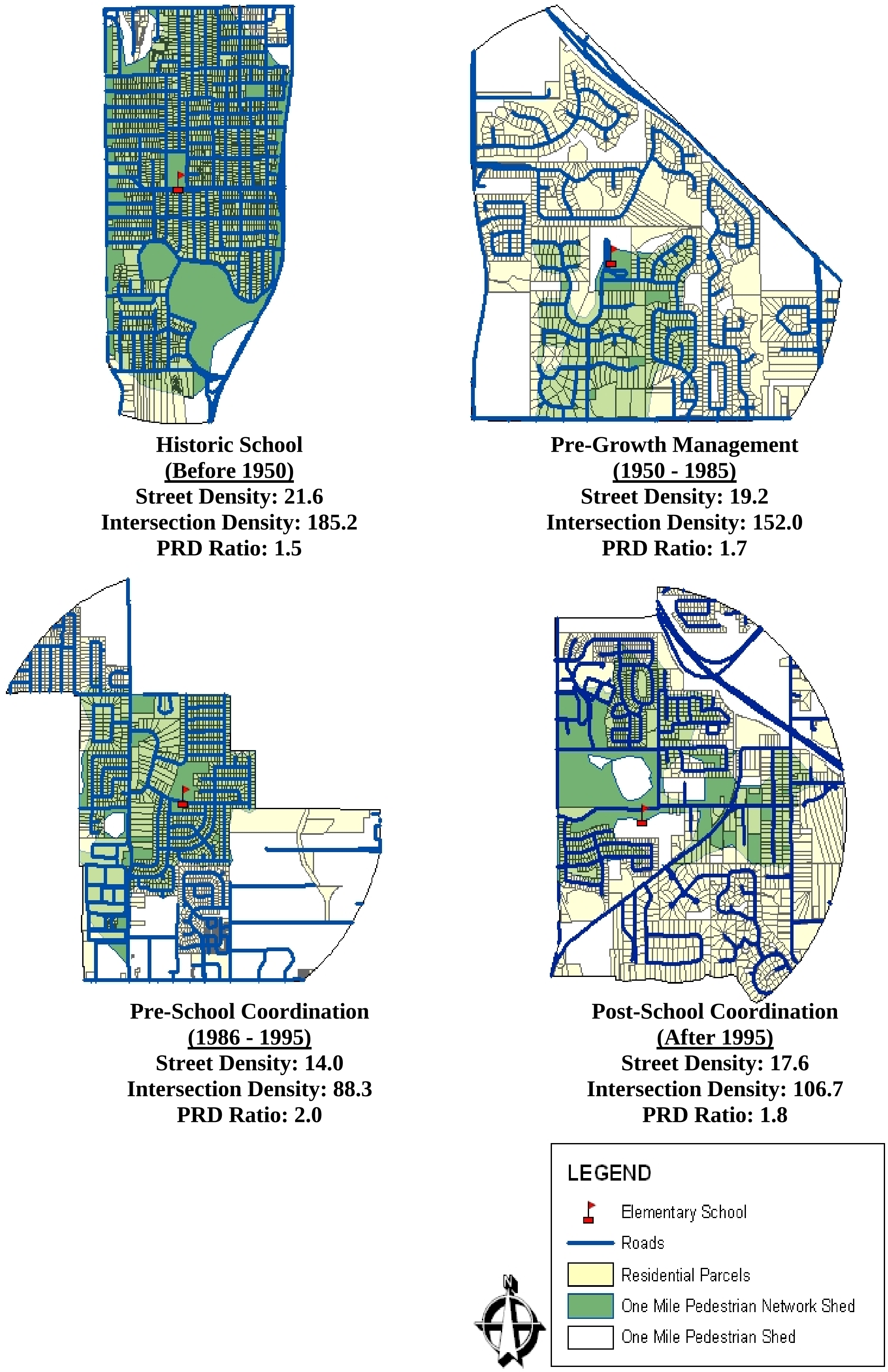


Figure 5-1.Connectivity Indicators of Sample Schools in Orange County

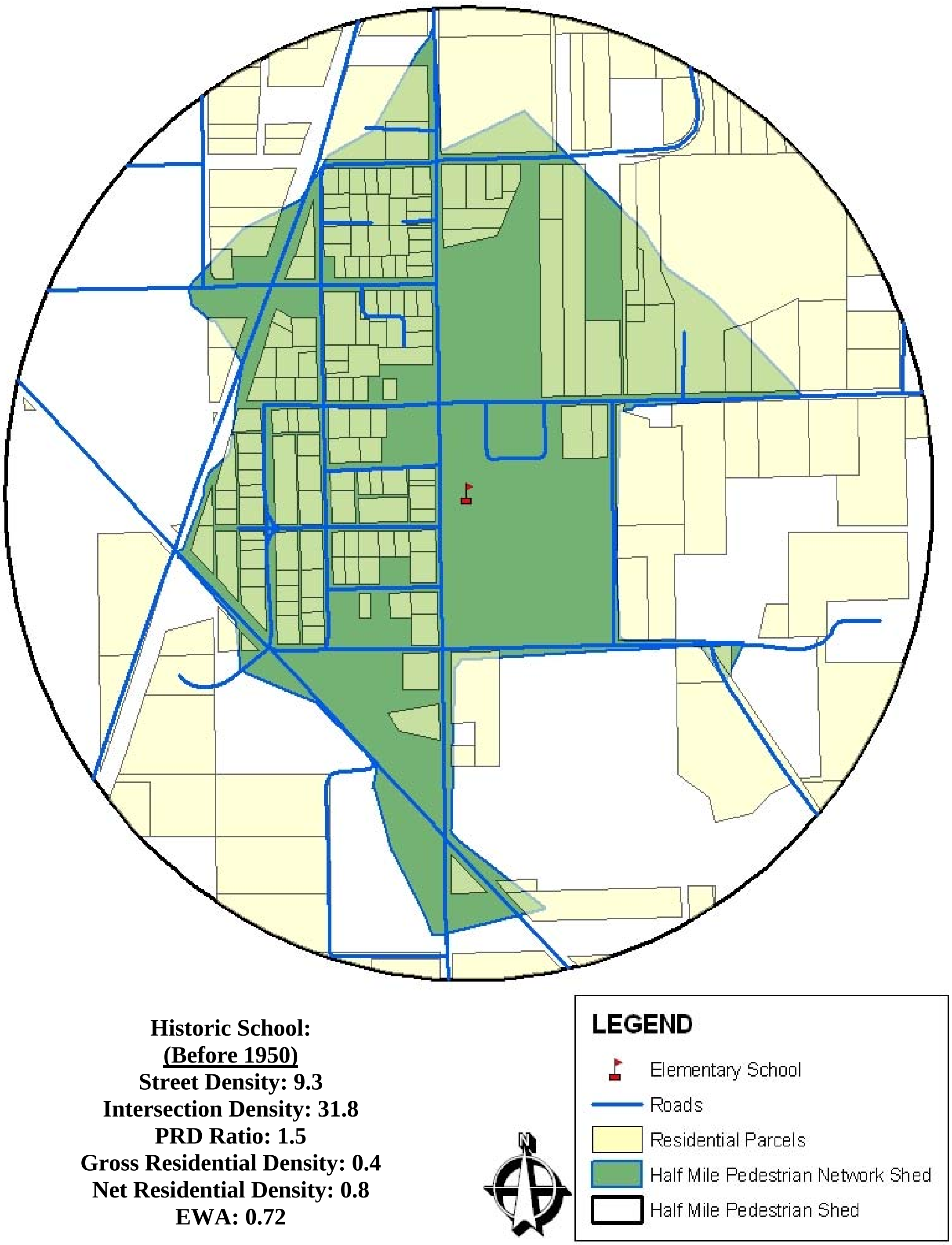
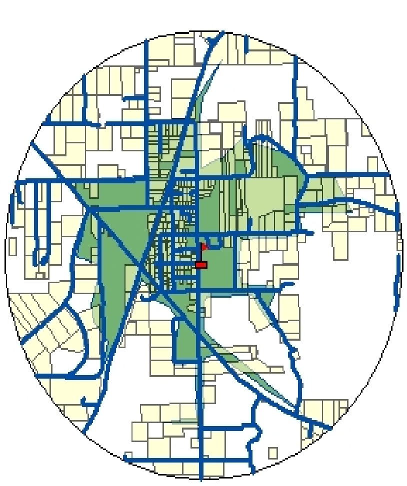
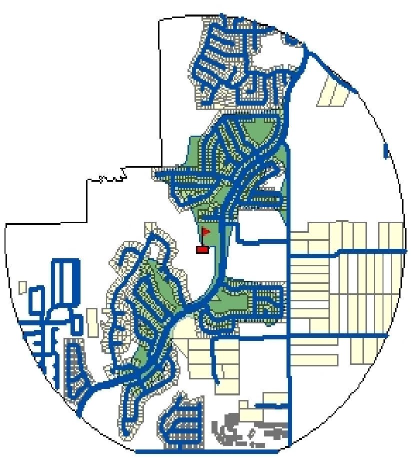


Figure 5-2. Effective Walking Area of Sample Elementary School in Seminole County

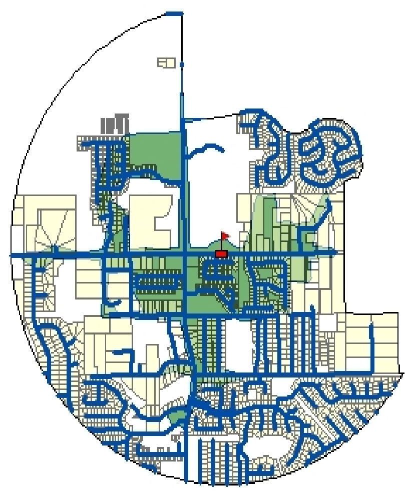


Historic School
(Before 1950)
Street Density: 13.5
Intersection Density: 62.7
PRD Ratio: 1.4

Pre-Growth Management
(1950 - 1985)
Street Density: 15.7
Intersection Density: 115.6
PRD Ratio: 2.2



Pre-School Coordination
(1986 - 1995)
Street Density: 21.0
Intersection Density: 148.4
PRD Ratio: 1.8



Post-School Coordination
(After 1995)
Street Density: 21.0
Intersection Density: 104.1
PRD Ratio: 1.6

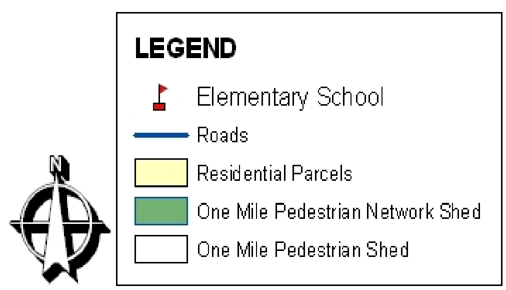


Figure 5-3. Connectivity Indicators of Sample Schools in Seminole County

LIST OF REFERENCES

1000 Friends of Florida, *Florida 2060: A Population Distribution Scenario*. Retrieved February 7, 2009, from http://www.1000friendsofflorida.org/planning/main.asp

Atash, F. (1994). Redesigning suburbia for walking and transit: Emerging concepts. *Journal of Urban Planning and Development, 120*(1), 48-57.

Aultman-Hall, L., Roorda, M., & Baetz, B. (1997). Using GIS for Evaluation of Neighborhood Pedestrian Accessibility. *Journal of Urban Planning and Development*, 123(1), 10-17.

Bejleri, I, Steiner, R.L., Provost, R.E., Fischman, A., & Arafat, A.A. (2008). *Understanding and Mapping Elements of Urban Form that Affect Children's Ability to Walk and Bicycle to School: A Case Study of Two Tampa Bay Counties*. Unpublished document, University of Florida.

Boarnet, M. & Crane, R. (2001). The Influence of Land Use on Travel Behavior: Specification and Estimation Strategies. *Transportation Research Part A: Policy and Practice*, 35(9), 823-845.

Boarnet, M.G., (2004). *The Built Environment and Physical Activity: Empirical Methods and Data Resources*. Prepared for the Transportation Research Board and the Institute of Medicine Committee on Physical Activity, Health, Transportation, and Land Use, TRB Special Report 282.

Boggs, G.H. & Apgar, R.C. (1991). Concurrency and growth management: A lawyer's primer. *Journal of Land Use and Environmental Law*, 7(1), 1–27.

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

Campbell, E.K. & Wang, Q. (2008). Pupil Transportation: Factors Affecting Mode Choice and the Amount of Parent-driven Trips to School, University of Vermont, Department of Community Development and Applied Economics, No: 09-3753. Retrieved February 24, 2009, from http://www.uvm.edu/~transctr/trbpapers/ECampbellTRBPoster09.pdf

Centers for Disease Control and Prevention (2006). NHANES data on the Prevalence of Overweight Among Children and Adolescents: United States, 2003–2006, NCHS (National Center for Health Statistics) Health E-Stat. Retrieved February 7, 2009, from http://www.cdc.gov/nchs/products/pubs/pubd/hestats/overweight/overwght_child_03.htm

Centers for Disease Control and Prevention (2007). New CDC Study Finds No Increase in Obesity Among Adults; But Levels Still High, NCHS (National Center for Health Statistics). Retrieved February 7, 2009, from http://www.cdc.gov/nchs/pressroom/07newsreleases/obesity.htm

Cervero, R. & Kockelman, K. (1997). Travel Demand and the 3Ds: Density, Diversity, and Design. *Transportation Research Design Part D*, 2(3), 199-219.

City of Raleigh, North Carolina (2008). *Design Guidelines for Pedestrian-Friendly Neighborhood Schools*. Retrieved June 16, 2008, from http://www.raleighnc.gov/publications/Planning/Guides,_Handbooks_and_Manuals/School_Design_Guidelines.pdf

Colditz, G.A. (1999). Economic costs of obesity and inactivity. *Medicine & Science in Sports & Exercise*, 31(11), S663–S667.

Cooper, A., Page, A., Foster, L., & Qahwaji, D. (2003). Commuting to School: Are Children Who Walk More Physically Active? *American Journal of Preventive Medicine*, 25(4), 273-276.

Day, K. (2009). Urban Planning for Active Living: *Who Benefits?* Publication of Planners Network, 2009. This page was last updated on: 02/09/2009 13:44:49. Retrieved February 13, 2009, from http://www.plannersnetwork.org/publications/2003_fall/day.htm

de Vries, S.I., Bakker, I., van Mechelen, W., & Hopman-Rock, M. (2007). Determinants of Activity-friendly Neighborhoods for Children: Results from the SPACE Study. *American Journal of Health Promotion*, 21(4Supp), 312-316.

Dellinger, A. & Staunton, C. (2002). Barriers to Children Walking and Biking to School in the United States. 1999. *Morbidity and Mortality Weekly Report*, 51(32), 701-704.

Dietz, W.H. (1998). Health consequences of obesity in youth: Childhood predictors of adult disease. *Pediatrics*, 101(3 Pt 2), 518-525.

Dill, J. (2004). Measuring Network Connectivity for Bicycling and Walking. Presented at the Annual Transportation Research Board meeting, Washington D.C.

Fagot-Campagna, A., Pettitt, D.J., Engelgau, M.M., Burrows, N.R., Geiss, L.S., Valdez, R., Beckles, G., Saaddine, J., Gregg, E.W., Williamson, D.F., & Narayan, V. (2000). Type 2 diabetes among North American children and adolescents: An epidemiologic health perspective, *Journal of Pediatrics*, 136(5), 664-672.

Florida Administrative Code [9J-5.025, FAC] - Public School Facilities Element for Public School Concurrency. Retrieved: January 8, 2009, from https://www.flrules.org/gateway/RuleNo.asp?ID=9J-5.025

Florida Department of Community Affairs (2009), Division of Community Planning; School Planning and Coordination, Retrieved January 8, 2009, from http://www.dca.state.fl.us/fdcp/DCP/SchoolPlanning/index.cfm

Floridians for a Sustainable Population (2006). *Population and Urban Land In Florida Projected to Double in 50 Years: Leadership and Long-Term Planning Are Needed to Protect Florida's Environment and Quality of Life*. Retrieved February 8, 2009, from http://www.flsuspop.org/docs/florida_population_facts.htm

Forsyth, A. (2003). *Measuring Density: Working Definitions for Residential Density and Building Intensity*. Design Center for American Urban Landscape, College of Architecture and Landscape Architecture, University of Minnesota, Design Brief, No. 8.

Frumkin, H., Frank, L., & Jackson, R. (2004). *Urban Sprawl and Public Health: Designing, Planning, and Building for Healthy Communities*. Washington D.C.: Island Press

Frank, L., Kerr, J., Chapman, J., & Sallis, J. (2007). Urban Form Relationships with Walk Trip Frequency and Distance Among Youth. *American Journal of Health Promotion*, 21(4Supp), 305-311.

Frank, L., Sallis, J., Saelens, B., Bachman, W., & Washbrook, K., (2005). *Travel Behavior, Environmental, & Health Impacts of Community Design & Transportation Investment*, LUTAQH: A Study of Land Use, Transportation, Air Quality, and Health, King County, Washington

Frank, L.D., Engelke, P.O., & Schmid, T.L. (2003). *Health and Community Design: The Impact of the Built Environment on Physical Activity*. Washington D.C.: Island Press.

Frank, L.D., Schmid, T.L., Sallis, J.F., Chapman, J., & Saelens, B.E. (2005). Linking Objectively Measured Physical Activity with Objectively Measured Urban Form: Findings from SMARTRAQ. *American Journal of Preventive Medicine*, 28(2S2), 117-125.

Fulton, J.E., Shisler, J.L., Yore, M.M., & Caspersen, C.J. (2003). Active Transportation to School: Findings From a National Survey. *Research Quarterly for Exercise and Sport*, 76(3), 352-357.

Goldsmith, S.A. (1992). *Reasons why bicycling and walking are not being used more extensively as travel models*. Case Study No. 1, National Bicycling and Walking Study, U.S. Department of Transportation, Federal Highway Administration, Washington D.C.

International City/County Management Association (2008). ICMA IQ Report Special Edition, Item No. E-43527 (40). Retrieved December 6, 2008, from http://icma.org/documents/SGNReport.pdf

Kahn, R. (2008). Just Eat Less and Move More, Saint Louis Behavioral Medicine Institute, *Eating Disorders News* 1(3). Retrieved November, 6, 2008, from http://www.slbmi.com/eating_disorders/ED%20News/2008/volume1issue32008.pdf

Knack, R.E. (2008). Great Streets: What makes them special? *Planning: The Magazine of the American Planning Association*, 74(1), 12-17.

Lucy, W.H. (1994). If Planning Includes Too Much, Maybe It Should Include More. *Journal of the American Planning Association*, 60(3), 305-318.

Lynch, K. (1960). *Image of the City*, Cambridge, Massachusetts: The MIT Press.

Maryland Department of Planning (2008). Managing Maryland's Growth: Smart Growth, Community Planning and Public School Construction, *Models and Guidelines*, 27(2008-001). Retrieved: January 12, 2009, from http://www.mdp.state.md.us/pdf/MG27.pdf

Ogden, C.L., Carroll, M.D., & Flegal, K.M. (2008). High Body Mass Index for Age Among US Children and Adolescents, 2003-2006. *Journal of the American Medical Association*, 299(20), 2401-2405.

Powell, D.L. (1993). *Managing Florida's Growth: The Next Generation*. Florida State University Law Review, 223(2), 223-339.

Powell, D.L. (1999). *Back to Basics on School Concurrency*. Florida State University Law Review 451(2), 451-486.

Robinson, T.N. (1999). Reducing Children's Television Viewing to Prevent Obesity: A Randomized Controlled Trial. *Journal of the American Medical Association*, 282(16), 1561-1567.

Saelens, B.E., Sallis J.F., Black, J.B., & Chen, D. (2003). Neighborhood Based Differences in Physical Activity: An Environment Scale Evaluation. *American Journal of Public Health*, 93(9), 1552-1558.

Schilling, J. & Linton, L.S., (2005). The Public Health Roots of Zoning: In Search of Active Living's Genealogy. *American Journal of Preventive Medicine*, 28(2S2), 96-104.

Schlossberg, M., Greene, J., Phillips, P.P., Johnson, B., & Parker, B. (2006). School Trips: Effects of Urban Form and Distance on Travel Mode. *Journal of the American Planning Association*, 72(3), 337-346.

Serdula, M.K., Ivery, D., Coates, R.J., Freedman, D.S., Williamson D.F., & Byers, T. (1993). Do obese children become obese adults? A review of the literature. *Journal of Preventive Medicine*, 22(2), 167-177.

Spengler, J.O., Young, S.J., & Linton, L.S. (2007). Schools as a Community Resource for Physical Activity: Legal Considerations for Decision Makers. *American Journal of Health Promotion*, 21(4Supp), 390-396.

Starnes, E., Stein, J., Crider, L., Audirac, I., & Pither, A. (1992). *Home-To-School Transportation study: Executive Summary*. Department of Urban and Regional Planning, University of Florida.

Steiner, R.L., Bejleri, I., Fischman, A., Provost, R.E., Arafat, A.A., Guttenplan, M., & Crider, L.B. (2008). *How Policy Drives Mode Choice in Children's Transportation to School: An Analysis of Four Florida School Districts*. In Publication, University of Florida.

Steiner, R.L., Bejleri, I., Wheelock, J.L., Boles, G., Cahill, M., & Perez, B.O. (2008). Understanding and Mapping Institutional Impediments to Walking and Bicycling to School: A Case Study of Hillsborough County. *Transportation Research Record*, 2074, 3-11.

Steiner, R.L., Crider, L.B., & Betancourt, M. (2006). *Safe Ways to School: The Role in Multimodal Planning*. Florida Department of Transportation Systems Planning Office. Retrieved February, 6, 2008, from http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_PL/FDOT_BD545_32_rpt.pdf

Strauss R.S., Rodzilsky, D., Burack, G., & Colin, M. (2000). Psychosocial correlates of physical activity in healthy children. *Archives of Pediatrics and Adolescent Medicine*, 155(8), 897-902.

Telama, R., Yang, X., Viikari, J., Valimaki, I., Wanne, O., & Raitakari, O. (2005). Physical Activity from Childhood to Adulthood: A 21-Year Tracking Study. *American Journal of Preventive Medicine*, 28(3), 267-273.

U.S. Department of Transportation Federal Highway Administration. (2009). *Travel Demand Management*. Retrieved February 16, 2009, from http://ops.fhwa.dot.gov/tdm/index.htm

US Census Bureau; 2007 American Community Survey, 1-Year Estimates; generated using American Factfinder; Retrieved March 7, 2008, from http://factfinder.census.gov/servlet/STTable?_bm=y&-geo_id=04000US12&-qr_name=ACS_2007_1YR_G00_S1401&-ds_name=ACS_2007_1YR_G00_&-_lang=en&-redoLog=false

Wang, G. & Dietz, W.H. (2002). Economic Burden of Obesity in Youths Aged 6 to 17 Years: 1979-1999. *Pediatrics*, 109(5), 1-6.

Wang, Y., & Lobstein, T. (2006). Worldwide trends in childhood overweight and obesity. *International Journal of Pediatric Obesity*, 1(1), 11–25.

Weight Control Information Network. (2009). *National Institute of Diabetes and Digestive and Kidney Diseases* (NIDDK). Retrieved: January 21, 2009, from http://win.niddk.nih.gov/statistics/index.htm#econ

BIOGRAPHICAL SKETCH

Jeffrey Matthew Schmucker, the son of Deborah Eckenrode Burns and Bradley William Schmucker, was born December 1978. Jeff received his Masters of Arts degree in urban and regional planning at the University of Florida in 2009. Before attending graduate school, he attained a Bachelors of Science degree in natural resources and conservation also from the University of Florida. In addition to his academic engagements, Jeff has also had the opportunity to gain valuable professional experiences having worked for several private sector architectural and design firms, non-profit organizations, and through his employment with the University of Florida where he's been able to teach and develop courses at the graduate level. Jeff's studies have primarily focused on urban and environmental design and issues regarding health and the built environment. Jeff's dedication to excellence as he pursues his planning career begins with his belief that by fostering planning and development practices that support healthy, sustainable environments, we can provide livable communities for generations to come.