A Geodesign Approach to Better Understand the Resiliency of Urban Form in the State of Florida

DCP 4290: Capstone Project in Sustainability & the Built Environment

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I. Introduction:

a. Foreword:

This research project aims to analyze the urban development patterns in the State of Florida to better understand Florida's ability to withstand long-term change. I argue that urban development in the United States is going through a third revolution to which Florida will need to adapt fairly quickly. Changes in climate, a growing population, deficiencies in transportation infrastructure and new market forces are changing the way Florida cities will look and feel in the coming years. A review of the history of urban development in the United States and the State of Florida will explain why Florida's urban form is how it is today. Using four different measures of urban resiliency and geographic information systems (GIS), this research will identify key characteristics of Florida's urban form and how those are likely to change in the coming years.

b. Key Terms:

Sustainability: The use of the word sustainability has picked up significantly over the past few years. The United Nations defines sustainability as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This definition has impacted the urban studies field significantly, however, it is not new. Daniel Burnham, in his Plan of Chicago of 1909, stated "…the aim has been to anticipate the needs of the future as well as to provide for the necessities of the present: in short, to direct the development of the city towards an end that must seem ideal, but is practical." (Urban Vision, 62). Although not new, defining and striving for sustainability became all more relevant in the past few years due to a better understanding of humanity's impact on climate and natural ecosystems. Since the majority of the world's population now lives in cities, it is utterly important to focus sustainability efforts within urban areas.

City: Jack Tager and Park Dixon Goist try to explain what a city is in their book *The Urban Vision: Selected Interpretations of the Modern American City.* They sustain that "…a precise definition of an imprecise and incalculable phenomenon may not be possible to construct." They argue that there are several definitions for what constitutes a city: some are based on arbitrary quantifications like total population and population density, others on the character and totality of manmade structures, others on the prevalence of non-farm labor, and others on the assumption that a city is a place where people seek out opportunity, choice and diversity. All these definitions may be suitable to describe any metropolis and/or megalopolis. This research project aims to dive deeper by making distinctions between real cities and car-centric pseudo-city suburban areas. While both of these may constitute the whole metropolis, each of them will have different social, economic and environmental aspects which will, in turn, impact their urban resiliency.

Resiliency: The concept of 'resiliency' began in the field of ecology and was later adapted to various fields, including urban planning and design, within what is understood as urban ecology. As Juliet Davis and Sabina Uffer explain in their report *Evolving Cities*, the term resiliency "was first theorized by ecologist C.S. Holling in a 1973 paper entitled 'Resilience and stability of ecological systems'." Holling defines ecological resiliency as "the magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that change behavior." Since we can understand urban areas and cities as ecological systems, it is therefore rightful to apply ecological resiliency concepts to them.

c. Urban Resiliency

Cities are not static; they change over time. Change can be rapid or slow, but the ability of cities to withstand change is what makes them successful and sustainable. Urban resiliency, as directly derived from ecology, has been mostly focused on the ability of cities to adapt to sudden changes, such as hurricanes, floods and earthquakes. This project, however, is primarily focused on long-term resilience, otherwise understood as sustainability. While gradual changes in this case do not necessarily mean year- or decade-long changes, they can still happen fairly quickly. Examples of gradual urban challenges include gentrification, traffic congestion and sea level rise. Davis and Uffer suggest that resilient cities are "…those that are able to reduce their environmental impact and/or in which security and risk management features are embedded in the urban fabric…" Furthermore, they argue that resilient urban form is "dense, inclusive of a diversity of building types, founded on coordinated and robust movement infrastructure and accommodating of multipurpose or 'flexible' open spaces." This project's goal is, therefore, to develop a methodology based on four key resiliency measures to test the long-term resiliency of urban areas, with Florida as its test bed.

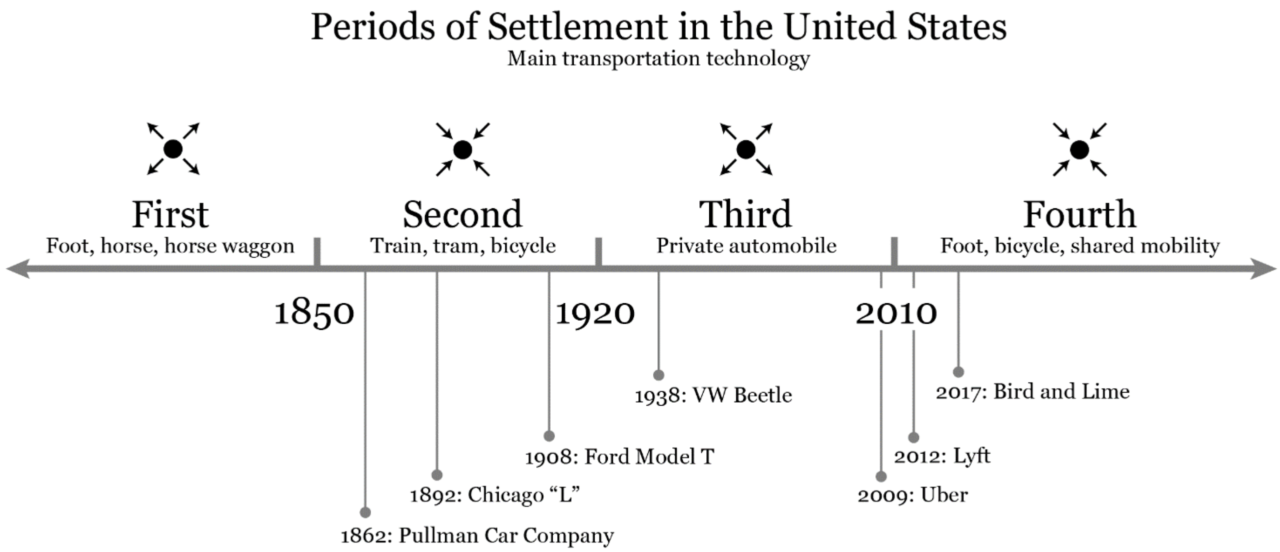
II. Literature Review

a. Urban History of the United States

Cities are an ancient phenomenon in human development; they can be traced back to Paleolithic times. Humans have clustered in cities for millennia because of all the benefits they provide. Rohit T. Aggarwala, head of Urban Systems as Sidewalk Labs, suggests that cities are constantly balancing the efficiencies or 'benefits' of density against the costs of density. According to him, the benefits of density are "lower consumption of resources, higher asset utilization and frequent physical interactions" while the costs of density include "reliance on central systems, need for courtesy and trust, and coordination and negotiation." Changes in technology and value systems during the past 200 years have made the benefits of density outweigh the costs, turning most societies from mostly rural to mostly urban.

In the United States, urban history can be divided into four periods of settlement, marked by technologies and customs which change the way in which cities and residents deal with the efficiencies and costs of density. As denoted in Figure 2.1, transportation technologies are the main drivers of settlement structure since they allow for different movements of people within and around urban areas: the first period of urban settlement accounts for the colonial times in which walking, horseback riding and the horse wagon dominate; the second period is characterized by the advent of inter- and intra-urban railroad transportation; the third period is dominated by private automobile transportation and urban regionalism; and the fourth and current period of settlement focuses on accessibility by promoting walkability, access to public transportation and adoption of smart, electric and shared mobility technologies.

Figure 2.1



Roderick McKenzie, author of the book *The Metropolitan Community,* explains that "the second period of settlement development commenced about 1850 with the expansion of the railroad." (Urban Vision, 131) During this time, railroads changed the way in which existing cities grew and new ones settled. New York and Chicago added their elevated intra-city rail lines. The East and West were finally connected with the completion of the transcontinental railroad in 1890. By this time, the United States had one third of the world's total railroad mileage (Urban Vision, 3). The flocks of European immigrants and the inner rural-urban migration that took place during this time led to a vast increase in density. Aggarwala argues that "the greatest era of urbanization in America was between the 1880s and the 1920s [because] during this time the efficiencies of density became far more valuable than they had been previously." At the same time, "the introduction of electric trolleys, elevated railroads, cable cars, subways, and steel bridges played a significant role in furthering the enlargement of the urban environs" (Urban Vision, 3). Up until this period, suburban living had been reserved for the very wealthy. However, the streetcar was "the force that made suburban living economically feasible and attractive for large numbers of city dwellers" (Urban Vision, 3). This period, labeled the Progressive Era, had such profound impacts on urban development that, even with the advent of private automobile transportation, most American cities still follow railroad development patterns.

The third period of settlement gained momentum in the 1920s when, according to Tager and Goist, "…the increased use of the automobile made it possible for even greater numbers of people to live miles from the city" (Urban Vision,189). During this period, massive infrastructure investments combined with a change in cultural norms led to the suburbanization of most of the United States. Tager and Goist suggest that suburbanites moved away from the city "…to enjoy greater contact with nature, to preserve the security of private family life, to escape changing conditions in the city, and to retain the integrity and intimacy of small community independence. Whether these ideals are actually realized in the suburbs or not, they form the mental picture upon which many have attempted to shape the 'suburban style of life'" (Urban Vision, 190). Induced by the private automobile as the leading transportation technology of the time, single-family homes with private front lawns and back yards became the standard way of living for most Americans. Private automobile transportation had a tremendous impact on the urban fabric of virtually all American cities. As McKenzie sustains, "…the boundaries of an ancient or medieval city were largely determined by the distance a man could walk in two hours. This would give a practical radius of 8 miles and a diameter of 16 miles. The introduction of the motor car would at once multiply these limits at least six times, extending the practicable radius to at least 50 miles" (Urban Vision, 135). The shift from walkable cities with rail transit to auto-oriented regions led to an era of city regionalism, where urban areas became agglomerations of various independent localities, otherwise referred to as 'metropolis' or 'megalopolis'.

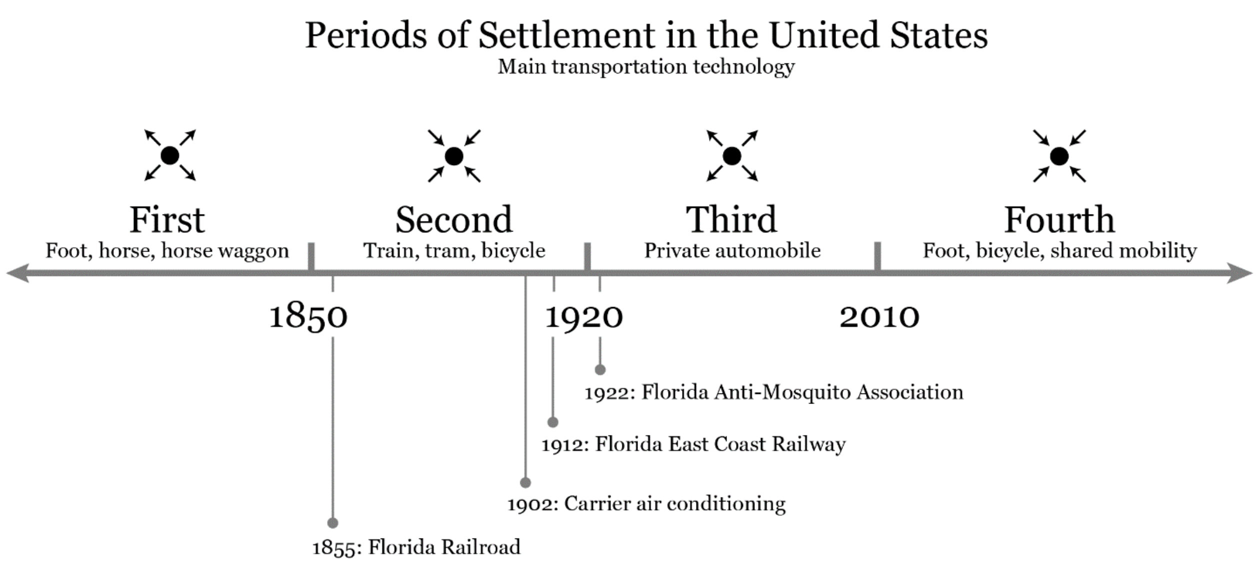
I argue that the current period of settlement is centered on walkability, public transportation investment, and smart and electric mobility solutions, all of which help mitigate problems such as traffic congestion, social inequality and environmental degradation. Characterized by a ‘return to the city movement’, today’s period is a response to the uncontrolled urban sprawl and inner-city degradation of the 20th century. It is mostly centered on re-development of inner cities, those of which were blighted during the flight to the suburbs. Daniel Sperling, professor and founding director of UC Davis Institute of Transportation Studies, suggests that “we can apply our best thinking to harness vehicle electrification, mobility sharing, and automation to create better cities, a livable planet, and a future that serves us all” (Three Revolutions, 20). Environmental, economic and social resiliency is arguably the basis of transportation and land use planning in this new, current period of settlement. The advent of electric, shared, autonomous vehicles promise to change, once again, the shape and fabric of American cities, by requiring less parking space and road space, and providing for denser and more affordable housing with quality access to on-demand transportation services.

b. Florida and the American Dream

Florida, unlike the rest of the United States, required very important infrastructure investments in hydrology in order to develop livable cities. During the second period of settlement, most of Florida was comprised of swampy, undevelopable land. The first railroad line was built between 1855 and 1861 and ran from Fernandina Beach to Cedar Key, establishing cities in dry upland and in close proximity to the rest of the continental United States. The most important railroad in terms of historical impact, however, was Henry Flagler’s Florida East Coast Railway (FEC). Completed in 1912, the FEC ran from Jacksonville to Key West, spearheading agricultural and tourism development throughout the Atlantic coast. Flagler viewed transportation infrastructure and hotel facilities as the two most important elements to realize Florida's potential for growth.

Livability in the southern sections of Florida became possible after the market adoption of air conditioning and effective mosquito control. With these innovations, permanent housing and more appealing recreational facilities became a possibility. These innovations spearheaded a new wave of growth for the entire state during the third period of settlement, when private automobiles had been widely adopted. The urban fabric of most Florida cities was therefore vastly influenced by the private automobile during the early stage of development. (See Figure 2.2) The end of World War II in 1945 brought about population growth and urban development throughout the state. By this time, suburbia was seen as the symbol of the American Dream, vastly influencing the urban fabric. As Robert Wood stated in his book *Suburbia* in the year 1958, "the most fashionable definition of suburbia today is that it is a looking glass in which the character, behavior, and culture of middle class America is displayed. When we look at suburbs we see our homes; when we look at suburbanites we see ourselves" (Urban Vision, 211).

Figure 2.2



c. Future of Florida

Florida is currently one of the deadliest states for pedestrians and bicyclists (CityLab) and one that does poorly in transit ridership. Traffic congestion is on the rise and highway expansions have been a top priority at the state's department of transportation. All these are polar opposites to the aforementioned trends characteristic of the fourth period of settlement. While many other states are investing heavily in public transport, walkability, bicycle infrastructure, and higher density development, Florida seems to be stagnated in the third period of development. How much of Florida's current urban areas will be able to cope with these changes?

Florida's urban and regional dimensions give way to a vast array of problems, including traffic congestion led by induced demand: "as highways get bigger and better, they invite more cars, destroy what undeveloped and unschematized country (or central city) remains, and require still more highways in an unending spiral" (Urban Vision, 203). This induced demand, when coped with vast car-centric suburban development, has created urban centers in the State of Florida that are neither safe nor interesting for pedestrians. With the exception of a few walkable, outdoor shopping malls such as Lincoln Road in Miami Beach, most of Florida's urban areas are strictly devoted to efficient vehicular traffic. Nathan Glazer, author of *"Why City Planning is Obsolete"* criticizes this by explaining that "the dense texture of the city is destroyed by motorcars if the streets are widened and parking lots opened up for cars. It is questionable whether we can retain city centers at all if they are adapted to private automobiles" (Urban Vision, 270). This not only affects inner-city residents who lose their public space, but suburbanites suffer as well. Traffic congestion and long commutes have their implications on public health and loss of productivity. David Riesman, author of *"The Suburban Dislocation"* suggests that "as compared with the older suburbanites who commuted by train and read the paper, did homework, or even read a book, the present and increasing tendency to travel to work by car seems aggressively vacuous and solipsistic" (Urban Vision, 198). Driving alone, as opposed to taking public transportation, requires physical and psychological effort, creates isolation with greater psychological side effects such as depression, generates vast amounts of congestion and pollution, increases the probability of accidents, and promotes a sedentary lifestyle with physical health effects such as obesity.

The social, economic, environmental and physical effects of Florida's vehicular centrism, with its effects on inner-city residents and suburbanites are less of a personal choice but a side effect of urban development patterns: "the facilities of mass transportation, except to certain to the very large cities, are not adequate for the needs of the suburban population; nor is it economically feasible to provide transportation except to certain of the more densely occupied areas. The widely scattered suburban residents must rely upon the private automobile as the principal agency of local transportation" (Urban Vision, 138). Florida's car-centric development patterns make transit and walkability unfeasible. This, in turn, has several other implications in terms of urban resiliency. The following section will explain how to test Florida's urban resiliency.

III. Measures of Resiliency

Juliet Davis, Research Fellow at the London School of Economics and Political Science, directed a research project looking at the resilience of urban form in different cities across the globe. Her findings are published in the report *Evolving Cities, Exploring the relations between urban form resilience and the governance of urban form*, where she outlines four different key measures of resiliency: physical, environmental, social and economic, with a fifth measure defined as land stewardship. This paper uses some of her measures, parameters and indicators to understand the resiliency of urban patterns in the state of Florida.

a. Physical Resiliency

The physical measure can be understood through two different indicators: (1) population density and (2) density of built form. These two indicators help frame the definition of physical resiliency, understood by Davis' team as: "Able to sustain residential populations of sufficient density to make adequate use of available infrastructure and space and to help support diversity of other allocated uses; able to provide levels of land cover that realize density without inhibiting the economic, social and cultural potentialities of the public realm; able to integrate different transport options with its streetscapes and create opportunities for a variety of street-based activities; and able to be used differently, to be converted, adjusted, extended or retrofitted in ways that continue to facilitate and enhance use in economically sustainable ways."

Population density, measured in different terms by different people, has been long associated with the vitality and diversity of urban areas. Jane Jacobs, in her infamous book *The Death and Life of Great American Cities*, suggests that the ideal density for creating diversity of uses is between 125 and 200 dwelling units per acre. For the purposes of this project, a figure of 100 or more units per acre will serve as the optimal indicator of population density.

In terms of density of built form, Davis explains that "…low levels of land coverage risk compromising not only functional diversity but also social diversity". She further assesses that "a number of recent studies have shown the effectiveness of moderately high land coverage, combined with low rise building typologies such as terraced housing, at creating a 'human scaled' fine-grained high density built form and public realm." For the purposes of this project, density of built form will be based on a minimum of 80% of lot coverage by built structures.

b. Environmental Resiliency

The environmental measure is comprised of four indicators: (1) public transportation accessibility, (2) green space accessibility, (3) school accessibility and (4) food accessibility. Environmentally resilient urban form is defined by Davis as "permeable and accessible from near and far places, and able to incorporate publically accessible green open space for recreation and the promotion of urban biodiversity."

Davis sustains that "enhancing public transport accessibility has been viewed as an important strategy for reducing energy consumption and pollution." In addition, access to public transportation has been seen as a measure of social equity and economic opportunity. For the purposes of this project, public transportation accessibility will be granted to residential parcels within a 15-minute walk to frequent transit service. Frequent transit service is defined by Seattle's Municipal Code as "transit service headways in at least one direction of 15 minutes or less for at least 12 hours per day, 6 days per week."

Green space accessibility, similarly, is granted to residential parcels within a 15-minute walk to city, county, state or national parks. For the purposes of this indicator, private beach access does not count towards green space accessibility but public beach access does. According to Davis, green spaces "accommodate numerous human activities which evolve over time… also often provide habitats for native flora and fauna and thus represent a strategy for preserving urban biodiversity.” Furthermore, she suggests that green spaces are “an important strategy for adapting to temperature increases, floods and droughts.”

School accessibility will be granted to parcels within a 20-minute walk to public high schools. Education is key for community success. Communities where schools are hard to reach affect their students’ opportunity for success. High school students, as opposed to elementary or junior high students, should be able to get to and from school independently. Resilient communities can be defined as “communities where quality public education is accessible to everyone within reasonable walking distance from home, independently of income and ability.”

Food accessibility is determined by a 15-minute walk to supermarkets and regional shopping centers as defined by the commercial parcels’ land use codes. Regional shopping centers have been identified as a parameter for food accessibility since they usually include grocery store chains. Food accessibility has been gaining relevance in the field of urban resiliency and sustainability in the United States. Many communities have been flagged as “food deserts”, where food is only accessible through fast-food chains, gas stations and convenience or corner stores. These places offer unhealthy food options which often times lead to serious health problems such as diabetes and obesity. Food deserts affect low income communities who need private automobiles or long transit commutes to reach healthy food options. A resilient community could be defined in terms of food access as one that “includes a variety of healthy foods options within reasonable walking distance”.

c. Land Stewardship

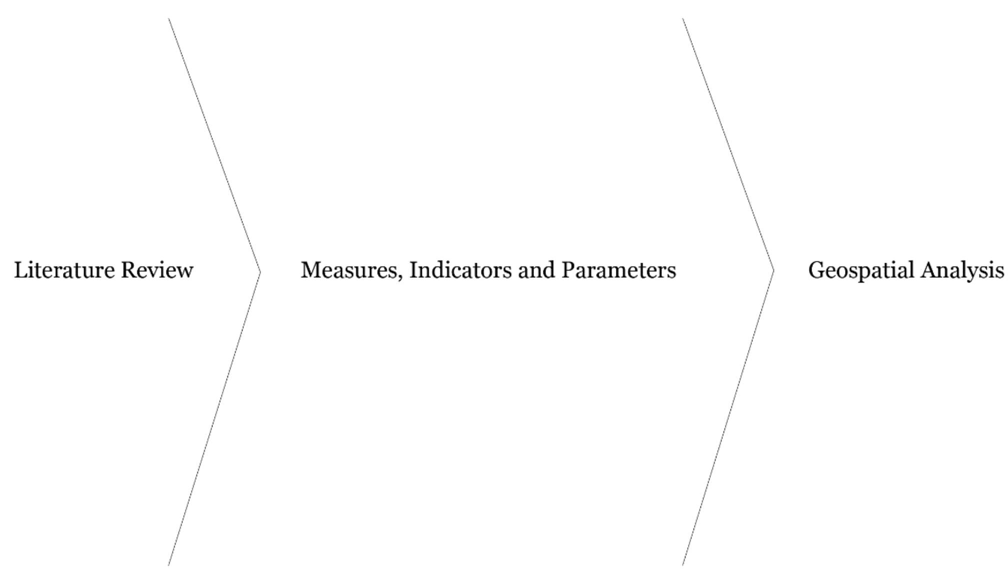
Land stewardship adds to the study of resiliency by painting a picture about who are the key players in the decision-making process guiding how Florida develops. This project distinguishes between Floridian and non-Floridian owners by looking at their declared permanent residential addresses. The proportion of acreage owned by Floridan vs. non-Floridian owners will help paint a picture about land stewardship in Florida. Resident and non-resident owners will have different motivations hence different ways of making decisions about urban development. Local owners are assumed to care about the long-term sustainability of their local community, while non-resident owners are assumed to pay attention to short-term profit margins on their real estate or have less vested interests in decision-making overall.

IV. Methodology

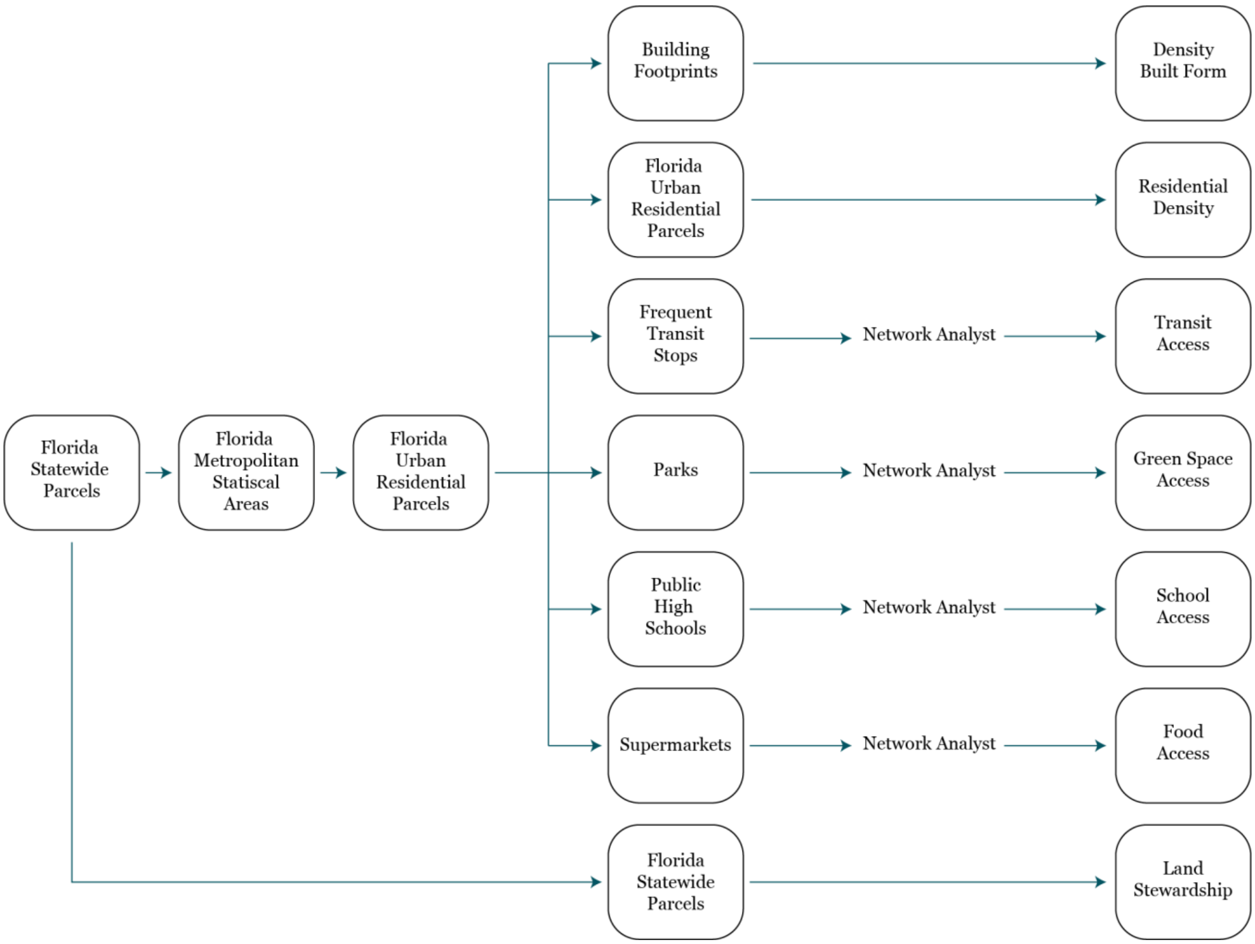
This research project used both qualitative and quantitative data to inform the current state of the urban form and urban development patterns in the State of Florida. Qualitative data was drawn from books and published papers in the fields of American history, urban planning, transportation planning, and anthropology. Quantitative data was drawn from several geospatial datasets that served to aid the qualitative data through supporting statistics produced using geographic information systems (GIS).

Four measures of urban resiliency were identified from the paper *Evolving Cities, Exploring the relations between urban form resilience and the governance of urban form* from the London School of Economics and Political Science. A literature review of qualitative data helped inform an understanding of Florida's past and current urban development trends and helped identify urban vibrancy and resiliency parameters based on the resiliency measures and indicators identified in the *Evolving Cities* paper. The geospatial data analysis produced statistics based on the identified resiliency measures and indicators in order to understand how close or far Florida's urban form is from the identified parameters.

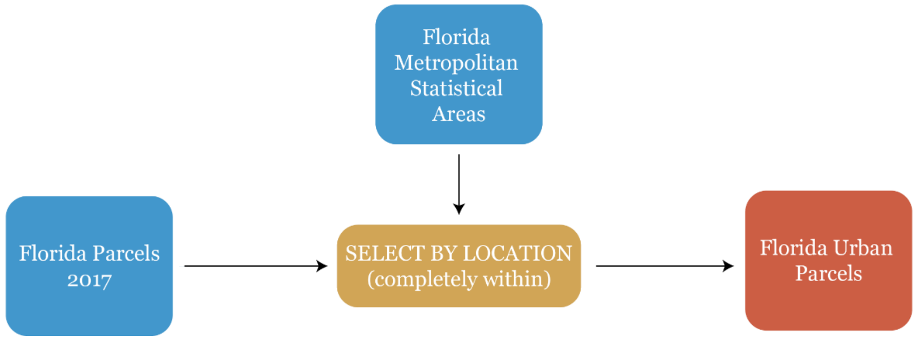
The figure below shows the methodology workflow as explained above:

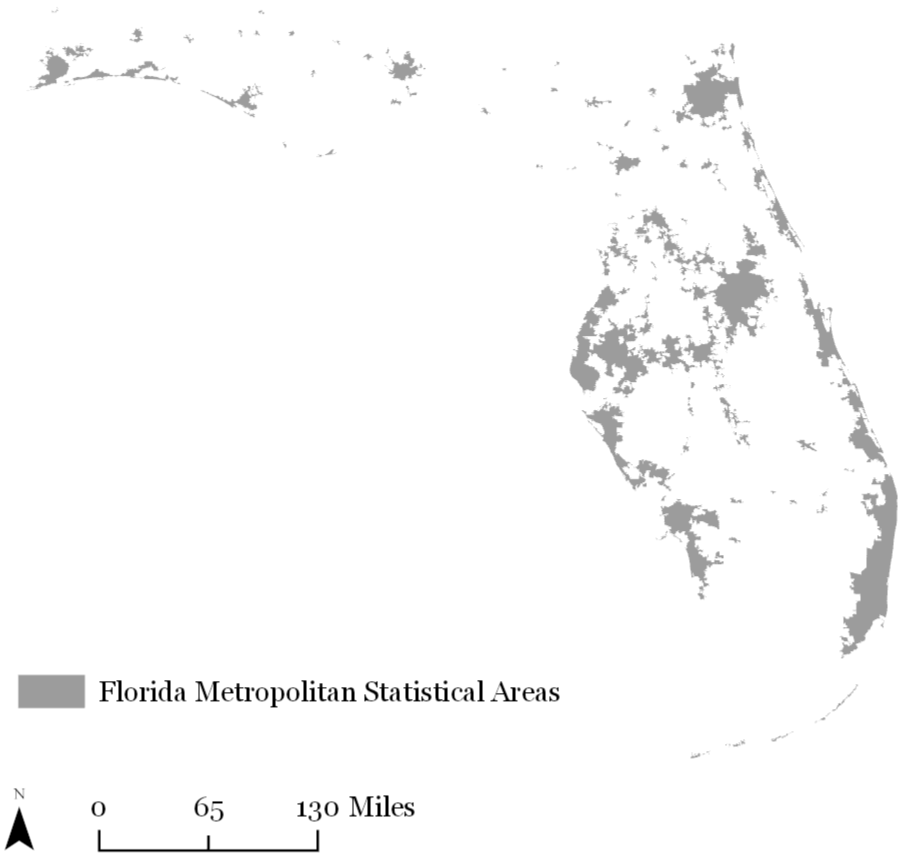


The geospatial analysis included 7 different models, which are explained in detail in the following sections. The chart below provides a simplified overview of the geospatial analysis workflow:

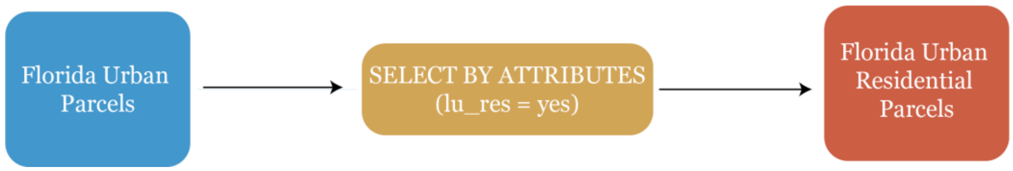


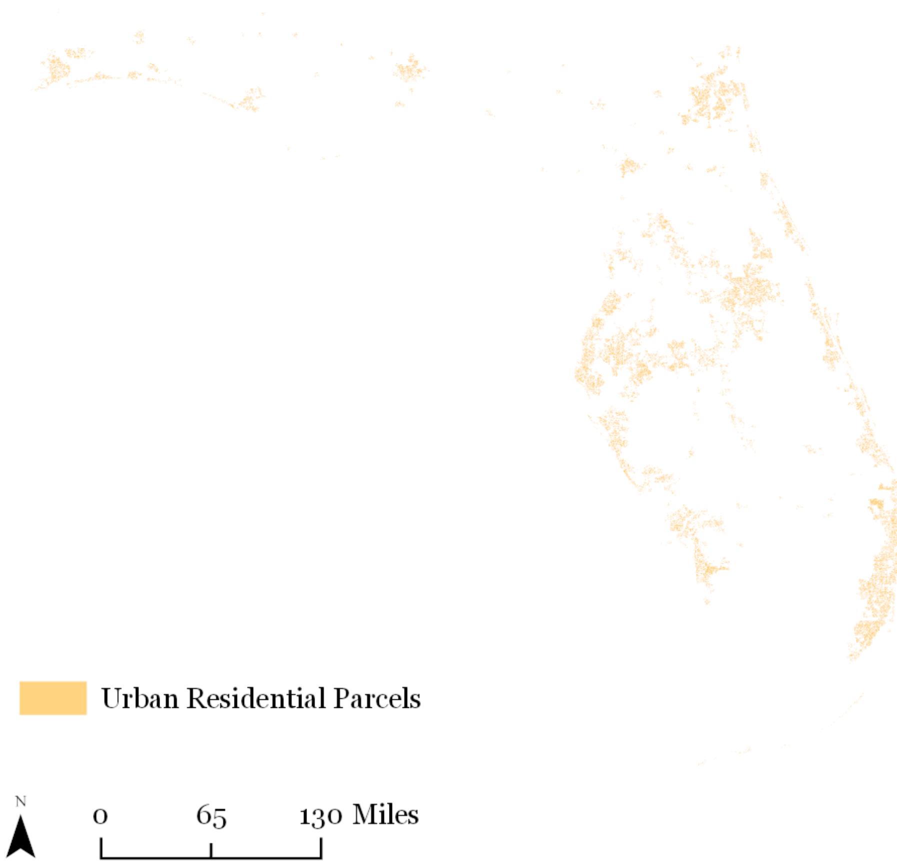
Since this research project focuses on urban resiliency measures, the first step in the geospatial analysis was to differentiate between urban and rural parcels. To do this, a *SELECT BY LOCATION* operation was performed on the statewide parcels dataset to select the parcels that were completely within urban areas, based on a dataset with 105 metropolitan statistical areas (MSAs) in the State of Florida. Once selected, these parcels were exported as a new feature class.





Once the urban parcels were distinguished from rural parcels, the second step was to perform a *SELECT BY ATTRIBUTES* operation. The statewide parcels dataset includes the field "lu_res" which indicates with a 'yes' if the parcel is considered residential. The selection formula lu_res = yes produced an output of all parcels within the 107 MSAs that are considered residential parcels. This new selection was exported as a new feature class and served as the basis for the physical and environmental geospatial analyses. Using this new ‘urban residential parcels’ dataset, a sum of the total residential units by land use code was performed using *SUMMARY STATISTICS.*

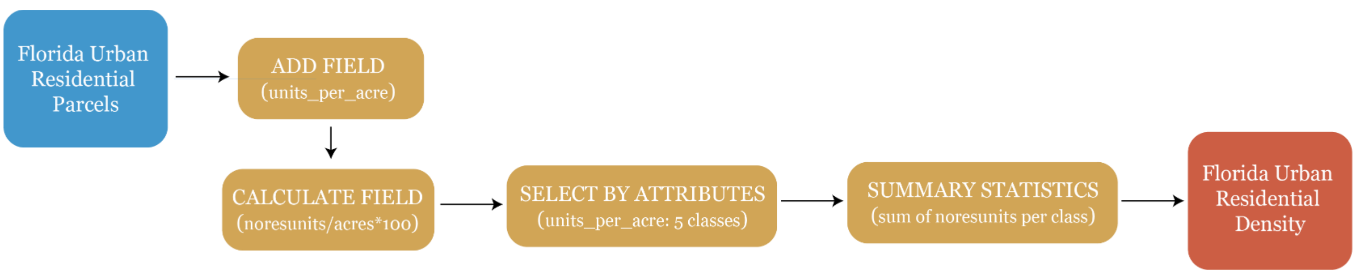




Once the urban residential parcels were identified and their attribute table cleaned up from unnecessary attributes, six indicators of resiliency were tested by performing six different geospatial analyses, based on the six different resiliency indicators. The seventh analysis was independent of these first two steps since the land stewardship indicator looks at the entirety of the state of Florida. The 7 different geospatial analyses were performed as indicated below:

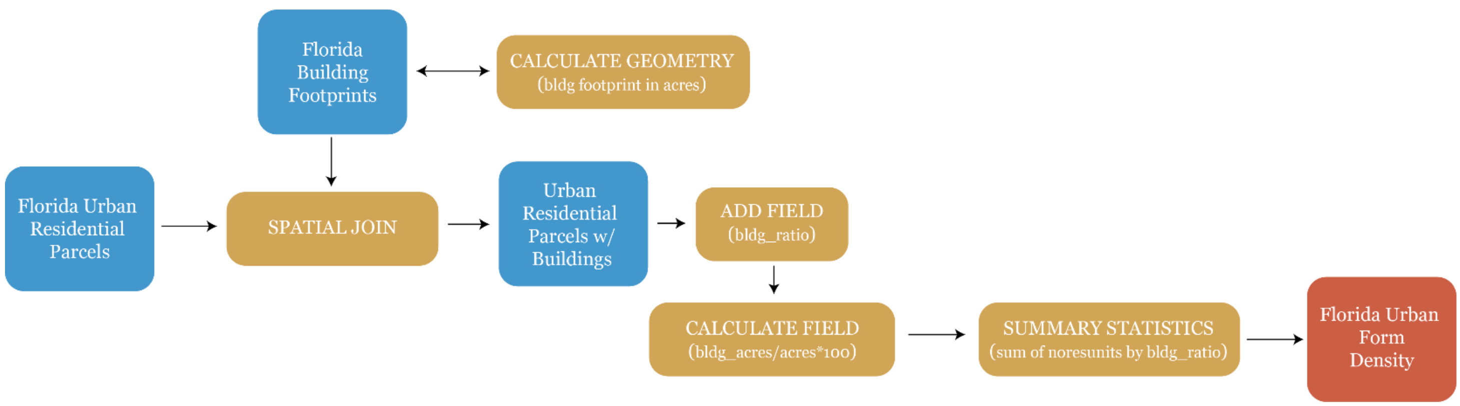
a. Residential Density:

This geospatial analysis created breaks of 'units per acre' residential densities for all urban residential parcels. In order to do this, a new field was created in the urban residential parcels dataset's attribute table and was calculated using *CALCULATE FIELD*, with the following formula: units_per_acre = noresunits/acres*100. Once this operation was completed, five different breaks of residential densities were created using *SELCT BY ATTRIBUTES* operations. These five breaks and five selections were exported as 5 different tables. Following these operations, *SUMMARY STATISTICS* was used to find the sum of residential units that would fall within each range of population density. Table 4.1 in the Appendix shows the resulting statistics from this geospatial analysis.



b. Density of Built Form:

This geospatial analysis used urban residential parcels and building footprints to find the percentage of building-to-lot coverage for each parcel. The building footprint data was far from perfect. It was not 100% complete and required some manipulation. In order to avoid excessive errors in the data, a *SELECT BY LOCATION* operation found the parcels that intersected with building footprints. This was exported as a new feature class which included all urban residential parcels from which a building footprint existed, creating a statistically significant sample size. Building footprint data did not include an area field so one was created and calculated using *CALCULATE GEOMETRY*. Once the building areas were calculated in acres, the building footprints were joined to the parcels by a *SPATIAL JOIN*. Once joined, a new field was created in the dataset and named bldg_ratio. This field was then populated by a *CALCULATE FIELD* operation using the formula bldg_acres/parcel_acres*100. Once this was populated, a *SUMMARY STATISTICS* operation generated a table with the count of residential parcels that fell within each building coverage lot ratio. This table was exported as a .csv table into Excel and grouped in 10 breaks of 10: ranging from lot coverages between 0 and 10% to lot coverages between 90 and 100%. Table 4.2 in the Appendix shows the results from this geospatial analysis.



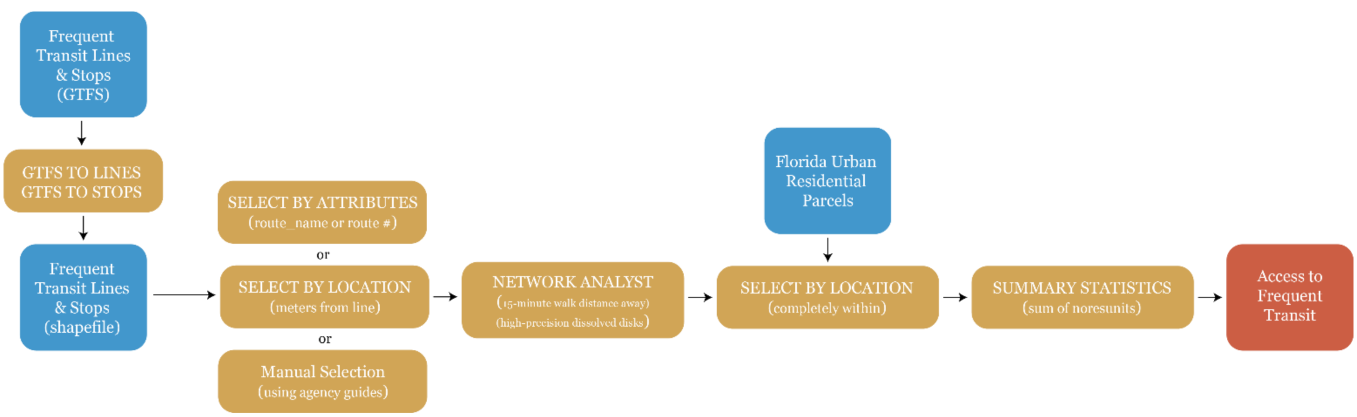
c. Frequent Transit Service Accessibility:

In order to find the urban residential parcels that are located within a 15-minute walk from frequent transit service stops, it was first necessary to manually read and calculate the transit service headways from 676 different fixed-route transit service schedules in the State of Florida. These were downloaded in PDF format from each transit agency's website. Appendix Table 4.3 shows the results of this manual tabular data analysis. Once the frequent transit service routes and stops were identified, they were imported into ArcGIS Pro using each agency's GTFS data from the Florida Transit Data Exchange database and the *GTFS TO STOPS* and *GTFS TO LINES* geo-processing tools. Once these were imported into the map, a *SELECTION BY ATTRIBUTES* was performed on the transit stops datasets that included the number or name of the line that served each stop. For the transit stops datasets that did not include this, a *SELCTION*

BY LOCATION was performed looking at transit stops that were within 10 meters of the line's polyline. For the locations where this seemed incorrect, a manual selection of transit stops was performed looking at online maps and transit stops names for reference.

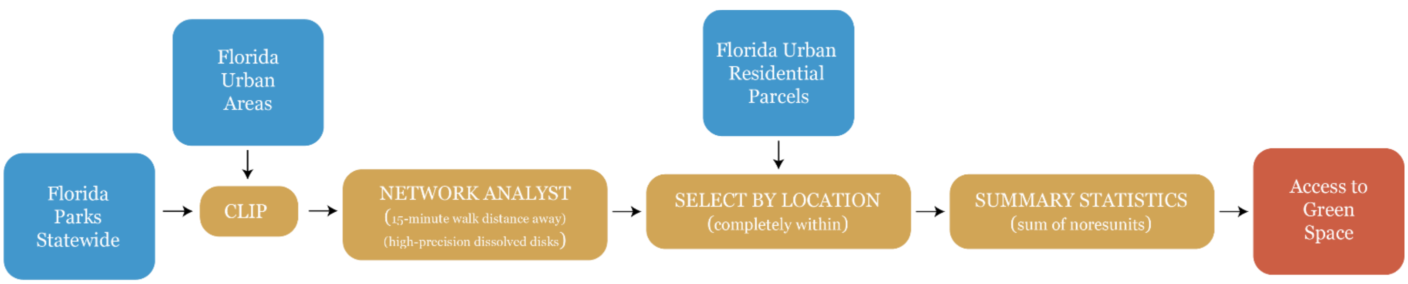
Once all transit stops were identified for the all frequent service transit lines, these were exported as a new feature class and then imported into the Network Analyst tool as Facilities. Service Areas polygons were created based on a 15-minute walking distance away from the imported Facilities, and exported as high precision, dissolved disks.

Using the service area polygons from the Network Analyst operation, a *SELECTION BY LOCATION* was performed to find the urban residential parcels that would be completely within these service areas. Once completed, the resulting selection was exported as a new feature dataset. A *SUMMARY STATISTICS* operation was performed on this dataset to find the sum of all residential units by land use code. The resulting table was then exported as a .csv table to be manipulated in Excel. Once in Excel, it was weighed against the total number of urban residential units in Florida. Table 4.4 in the Appendix shows the results from this geospatial analysis.



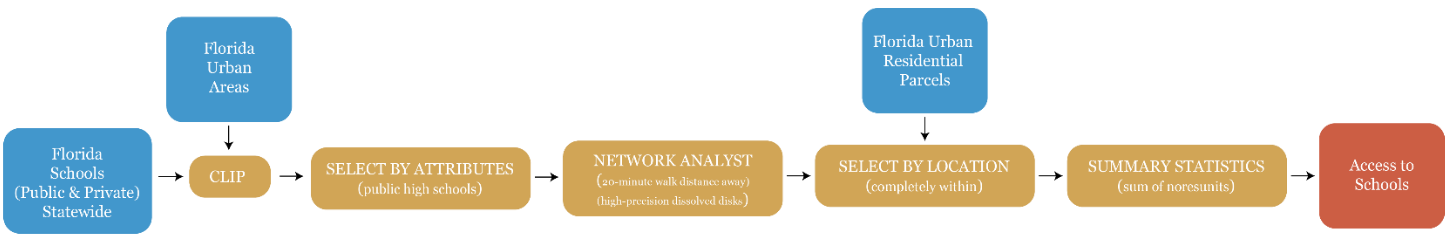
d. Green Space Accessibility:

This geospatial analysis was also performed using Network Analyst. As a first step, a *CLIP* operation was performed on the parks dataset using the MSAs polygons dataset in order to find which parks were within urban areas. The 4,000+ output parks were then imported as Facilities to the Network Analyst. Following the same settings as in the previous analysis, Service Areas from these points were generated based on a 15-minute walking distance away from the imported Facilities. The output polygons were created as dissolved discs with high precision. Once these polygons were generated, they were used to *SELECT BY LOCATION* the urban residential parcels that would be completely within these polygons. Once selected, these features were exported as a new feature class. Using *SUMMARY STATISTICS*, the total number of residential units by land use code was calculated and exported as a .csv table to be manipulated in Excel. Once in Excel, it was weighed against the total number or urban residential units in Florida. Table 4.5 shows the results from this geospatial analysis.



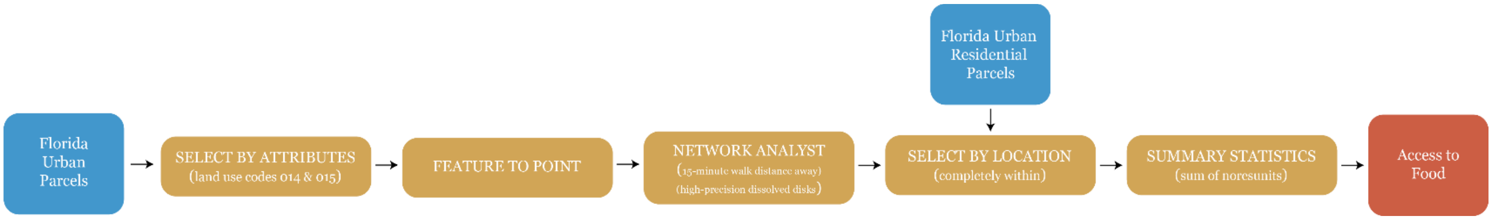
e. School Accessibility:

The first step during this geospatial analysis consisted of selecting the urban public high schools from a state-wide dataset that included all school types and levels. In order to do this, a *CLIP* operation was performed on the 'schools' dataset using the MSAs polygons. This returned an output of all urban schools in Florida. After this was completed, a *SELECT BY ATTRIBUTES* operation was performed to find the schools that are public and are considered "high" (offering grades 9 through 12). This selection was then exported as a new feature class named 'public_high_schools' and imported as Facilities to the Network Analyst. Service Area polygons were then generated using 'walking time' as the mode, with a direction away from facilities and a single cutoff of 20 minutes. The output polygons were generated using high-precision, dissolved disks. Using these Service Areas polygons, a SELECT BY LOCATION operation was performed to select the residential parcels that were 'completely within' these polygons. The resulting selection was exported as a new feature class. A SUMMARY STATISTICS operation calculated the sum of all residential units by land use code and exported as a .csv file for manipulation in Excel. These totals were weighted against the total residential units in the State to calculate the percentage of units within a 20-minute walk from public high schools. Table 4.6 in the Appendix shows the results from this geospatial analysis.



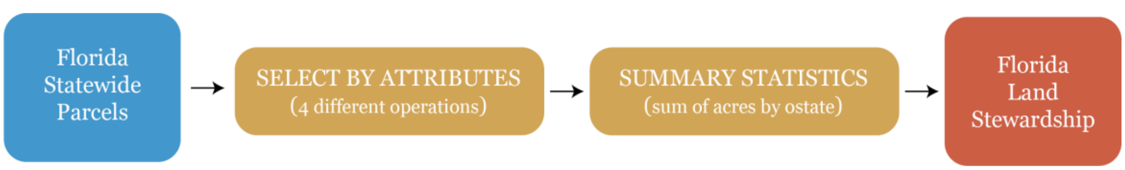
f. Food Accessibility:

This geospatial analysis also used Network Analyst to generate service areas. Using the urban parcels dataset generated in the very first step of the geospatial data analysis process, a *SELECT BY ATTRIBUTES* operation generated an output with the urban commercial parcels that included land use codes 014 and 015: supermarkets and regional shopping centers, respectively. This selection was exported as a new feature class and then turned from polygons to points through the *FEATURE TO POINT* geo-processing tool. With supermarkets and regional shopping centers depicted as points as opposed to polygons, they were added to Network Analyst as this geospatial analysis' Facilities. Service Areas polygons were generated using walking time as the mode, with a direction away from Facilities, and a single cutoff of 15 minutes. This resulted in high-precision, dissolved disks as the Service Area polygons. Using SELECT BY LOCATION, the urban residential parcels that were completely within these service areas were selected and exported as a new feature class. A table including the sum of all residential units by land use code was generated using SUMMARY STATISTICS and then exported as a .csv file to be opened in Excel. These totals were weighed against the total number of residential units in the State of Florida, which resulted in the percentage of residential units located within walking distance to food. Table 4.7 in the Appendix shows this geospatial analysis's results.



g. Land Stewardship:

Using *SELECT BY ATTRIBUTES*, Florida's statewide parcel data was split into 4 different groups according to the parcels' land use codes: residential (001-009), commercial (010-039), industrial (040-049), and agricultural (050-069). After selecting each code group, the selected features were exported as tabular data, generating four different new tables. Using *SUMMARY STATISTICS*, the total acreage by owner's state of residence was calculated for each new table. The Statistics Field was defined as the sum of acres, using the owner's state of residence as the Case Field. The resulting tables were then exported as .csv tables which could be manipulated in Excel to calculate percentages and fix any minor errors in the data. Tables 4.8 to 4.11 in the Appendix are the four resulting tables from this analysis.

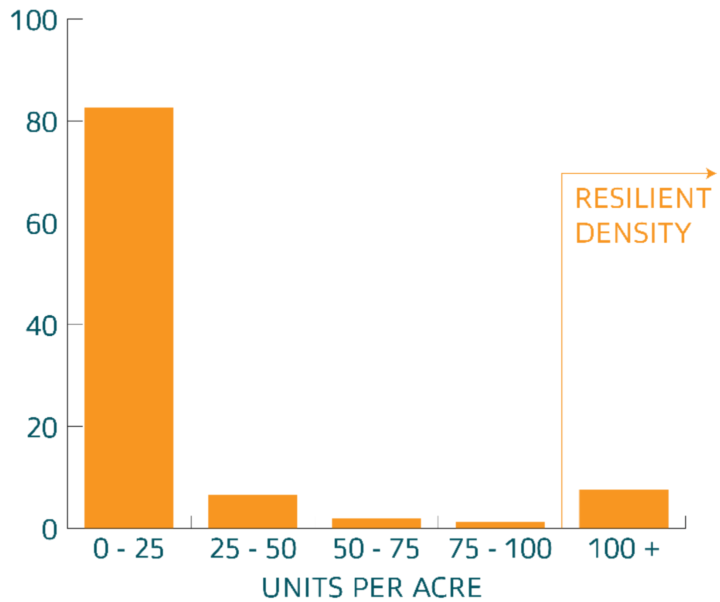


V. Results

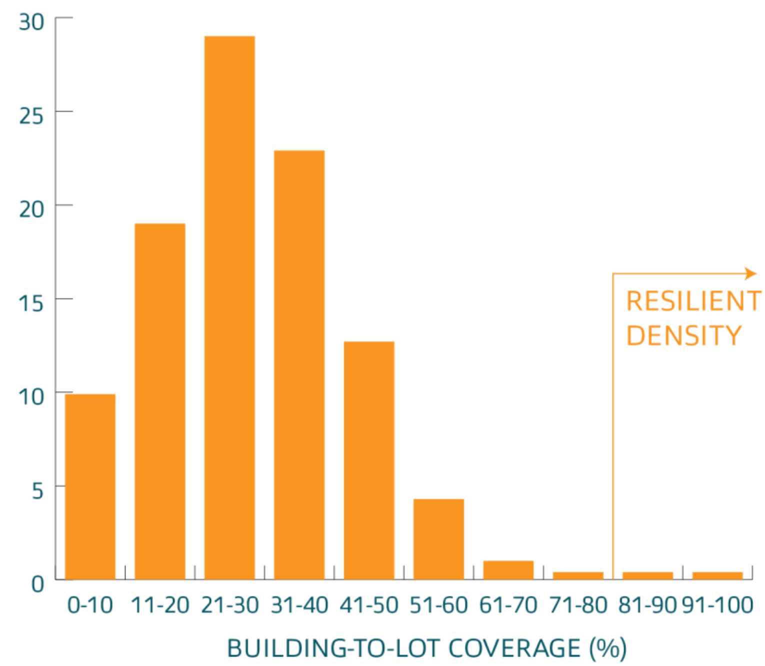
a. Statewide:

The resulting statistics based on the four identified measures of urban resiliency and the current understanding of urban form implications for resiliency in the State of Florida make it clear that there exists a wide gap between urban form resiliency ideals and the actuals. The State of Florida has a remarkably low residential density in which multi-family units reach similar residential densities as single-family units. Extremely low residential densities, coupled with low building-to-lot coverage ratios imply a big, fragmented and distant urban form. Walkability is hindered, public transportation is unfeasible, access to life services is limited without access to an automobile, social interactions are limited due to a lack of street pedestrian activity, and commercial activity is limited to shopping plazas disconnected from residential neighborhoods.

Residential density in the State of Florida is extremely low, with 82.6% of all residential units falling between 0 and 25 units per acre. Only 7.6% of residential units fall under the expected residential density of more than 100 units per acre. Car dependency, social isolation, environmental degradation, lack of access to basic services and expensive city services are all consequences of low residential density. The resiliency of Florida cities will depend on how fast they can upscale their residential density in order to prevent catastrophic climate change, resource inefficiency, increasing housing costs and worsening traffic congestion. These remarkable results show that since the vast majority of residential units fall under the lowest residential density bracket, it will cost the State of Florida vast amounts of resources and a very long time to re-develop and infill its many urban areas to bring residential density to resiliency standards. With the advent of climate change and its implications on sea level rise and storm surge, opportunities arise for re-location and re-development within Florida's urban areas.



Florida’s urban form density is also extremely low. Only 0.8% of all parcels fall within the expected lot coverage of 80% or more while 93.6% fall under a building-to-lot coverage ratio of 50% or less. This is in part due to the prevalence of single-family housing units, which usually include front and back yards, parking for two or more automobiles, and side offsets. However, these results show that multi-family buildings reach similar density of built form as single-family buildings due to zoning regulations, minimum parking requirements, minimum green space area requirements, and added amenities such as swimming pools and tennis courts. The fragmented urban form and scattered building footprints associated with subdivision development will have a tremendous impact on how Florida cities will be re-developed to reach higher urban form density. The disconnection between adjacent subdivisions will be hard to overcome, making demolition and re-construction the most feasible yet most expensive re-development strategy.



Access to frequent transit service is extremely low due to the aforementioned characteristics of residential and urban form densities. Frequent transit service availability has been increasing in the past few years, especially in cities such as Jacksonville, Tampa, Orlando and St. Petersburg. Jacksonville has added three new bus rapid transit routes with extremely good frequencies. Tampa has seen the introduction of a downtown streetcar with great service frequency but a relatively low residential coverage. Orlando has seen a great adoption of bus rapid transit connecting vast areas of the expanse metropolis and a new addition in commuter rail with increasing ridership. However, it will be a very long and expensive journey until the vast majority of Florida's urban population lives within acceptable walking distance to quality transit services. According to this research project, less than 6% of urban residential units in Florida are located within walking distance to frequent transit service. Only 4% of the 676 transit lines in the State can be considered frequent, and the median waiting time for any transit service in the State is 50 minutes, making transit unappealing, inaccessible, and too expensive. Florida will have the opportunity to make public transit accessible and interesting once it densifies its urban form to reach levels that can accommodate frequent transit service in a financially and environmentally responsible way.

Green space accessibility is one indicator that can serve as a good example for the rest of the resiliency indicators and one that paints a more resilient urban Florida overall. Access to green space is a top priority for almost all Florida cities. This is one of the reasons why most Florida cities count with departments of parks & recreation, while very few count with departments of transportation or mobility. According to this project's results, 51% of all residential units in the State are located within walking distance to green space, including public beaches. While access to green space is greater in denser neighborhoods and closer to the coasts, less dense areas and suburbs still hold acceptable green space accessibility. Densifying Florida cities to improve transit accessibility and the connectivity of their urban forms will also mean greater green space accessibility only if infill re-development happens near existing green spaces. There are great opportunities for re-development near the denser cities of the coasts, which enjoy great green space and public beach accessibility.

Only 13.6% of urban residential units in the State of Florida are located within reasonable walking distance from public high schools. This extremely low number is due to the urban form of suburban areas, where most families with children choose to live. This low number has a big burden on individuals, families and communities. Individual school attendees lose the opportunity to become independent adults and lose contact with their local community by depending on others for their most important daily transportation needs. Families suffer from tight schedules and car-dependency battles if children are dropped off by their parents; and they might suffer economically from the burden of owning a third vehicle for their teenagers' use.

Communities, in turn, dedicate significant portions of their education budgets into inefficient school transportation services.

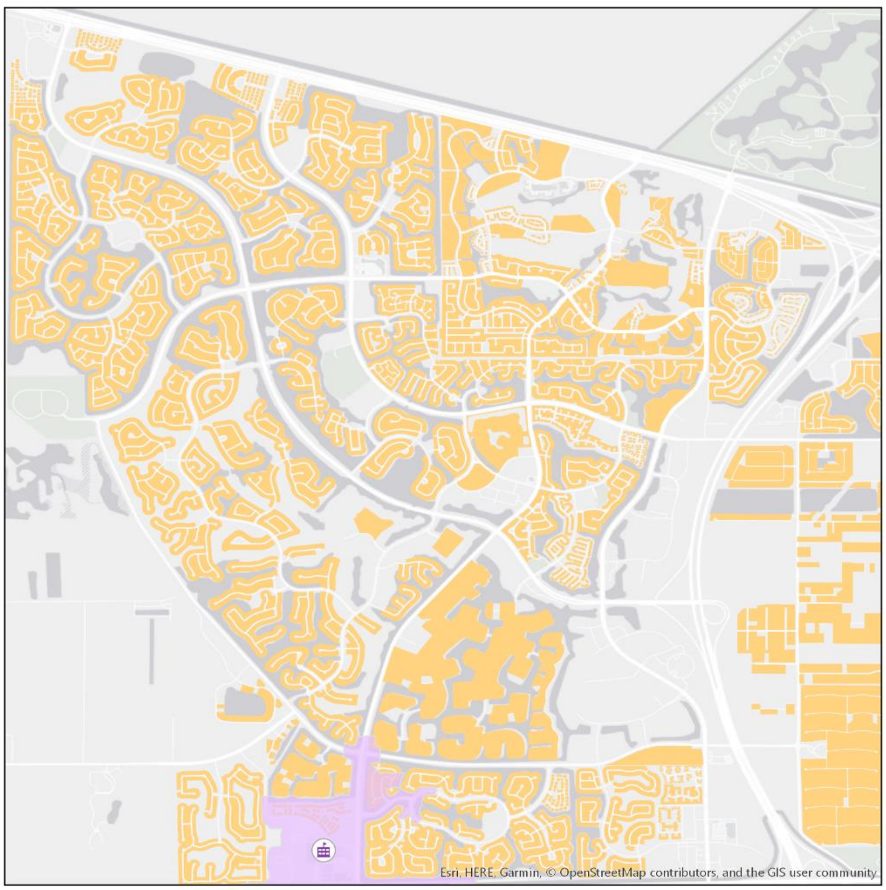
Only one third (36.6%) of Floridian residential units are located within reasonable walking distance to healthy food options such as grocery stores and supermarkets. Most families and individuals in the State of Florida therefore rely upon automobiles or long public transit commutes to satisfy their daily nutritional needs. While week-long and often-times month-long grocery purchases are common within the suburban population, the need to drive for ubiquitous daily needs such as the need for one extra milk jug or a loaf of bread has tremendous social, environmental and economic implications previously discussed in the Literature Review section of this research paper.

Land stewardship is an important indicator of urban resiliency in the State of Florida. Decisions to densify its urban form will only be achieved if resident and non-resident owners advocate for more resilient urban development policies. This research project's results show that a quarter of the acreage of residential parcels is owned by non-Floridians. These results seem to make sense since the top foreign owners are New Yorkers and Canadians, who are well-known for owning vacation homes in Florida to escape the harsh winters of the north. These owners are probably invested in keeping their properties in good shape for their vacation visits but are less likely to advocate for everyday conveniences such as better public transit accessibility. A quarter of commercial acreage is also owned by non-Floridians, in this case led by Illinoisans and New Yorkers, where many fast-food chains and big retailers are located. A quarter of industrial acreage is also owned by non-Floridians, in this case led by Georgians and Texans, most probably due to the proximity of these Southeastern states' logistics and industrial companies. Finally, a quarter of agricultural acreage is also owned by non-Floridians, in this case led by

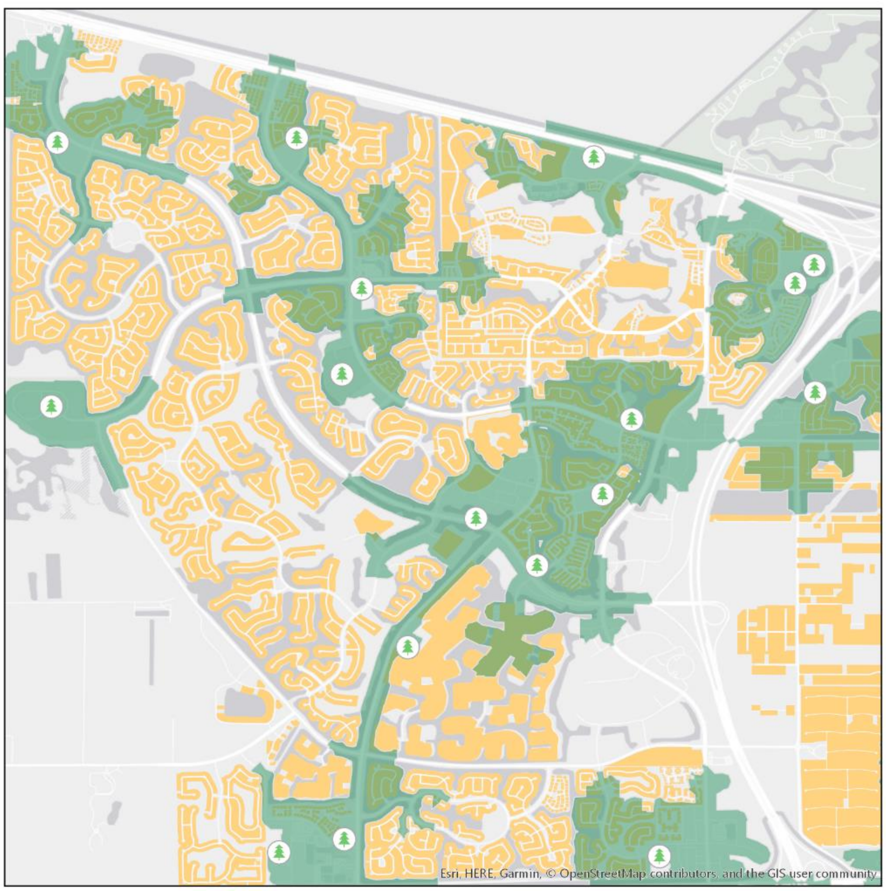
Georgians and Utahans, who own big pieces of timberland in North and Central Florida. Surprisingly, there are not severe ownership differences among these four land uses, which was unexpected. However, since Floridians can freely decide on up to 75% of their territory, this might pose a threat to future land use decisions.

b. Exurban Suburban Example (Weston, FL)

Weston, Florida is an exurban suburban city located in westernmost Broward County. Established in 1996, the City of Weston has a population of 70,944 people. Residential units are segregated by home value within gated enclaves. There are one public high school, two public junior high schools and six public elementary schools in Weston. The map below shows, in pink, a 20-minute walking radius away from Cypress Bay High. It is visible that an extremely low number of residential parcels are located within walking distance to the local high school.

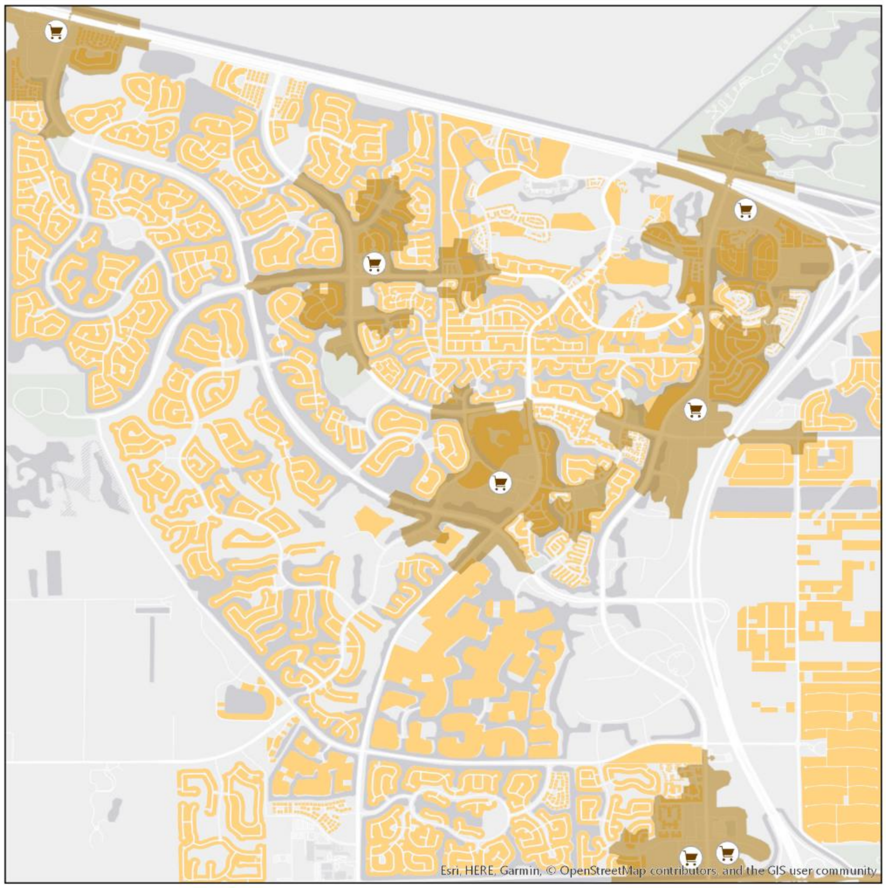


There are 17 parks in Weston. Most of them are city parks with the exception of Weston Regional Park, which attracts visitors from all over the South Florida region for sporting events. The map below shows, in green, the 15-minute walking radiuses of all parks in Weston. It is evident that the street network hinders access to green spaces. Subdivision developments, usually with one main entrance, limit the ability of pedestrians to reach nearby parks. While several residential units are indeed located across the street from city parks, residents are required to drive around the block instead of walking across the street. This problem becomes the most evident by looking at two of Weston's most populous subdivisions: Savannah and Weston Hills. Both lack 100% walking access to city parks due to the layout of their street networks.



The City of Weston, privately planned and developed, hosts five grocery stores all under the Publix brand. The map below shows, in brown, the 15-minute walking radiuses from all five

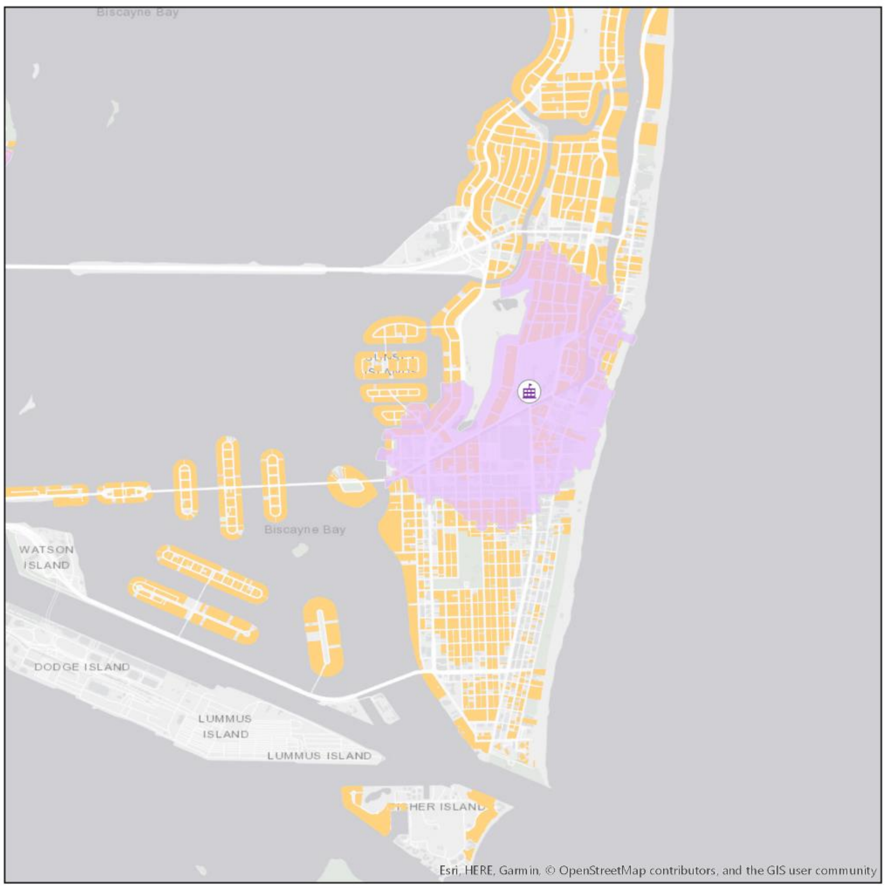
Publix grocery stores as well as two other regional shopping centers that offer smaller convenience stores. Evidently, the City of Weston was planned with the assumption that every family would satisfy their daily nutritional needs via the ownership of a private automobile. It is clear that the vast majority of residential units in Weston are located outside the range of a reasonable walk to grocery stores.



The City of Weston lacks access to frequent transit services, as do the vast majority of suburban developments in the State of Florida. One bus line from Broward County Transit reaches the City of Weston's city limits through Weston Road. The waiting time for bus line 23 is between 45 minutes and several hours in each direction.

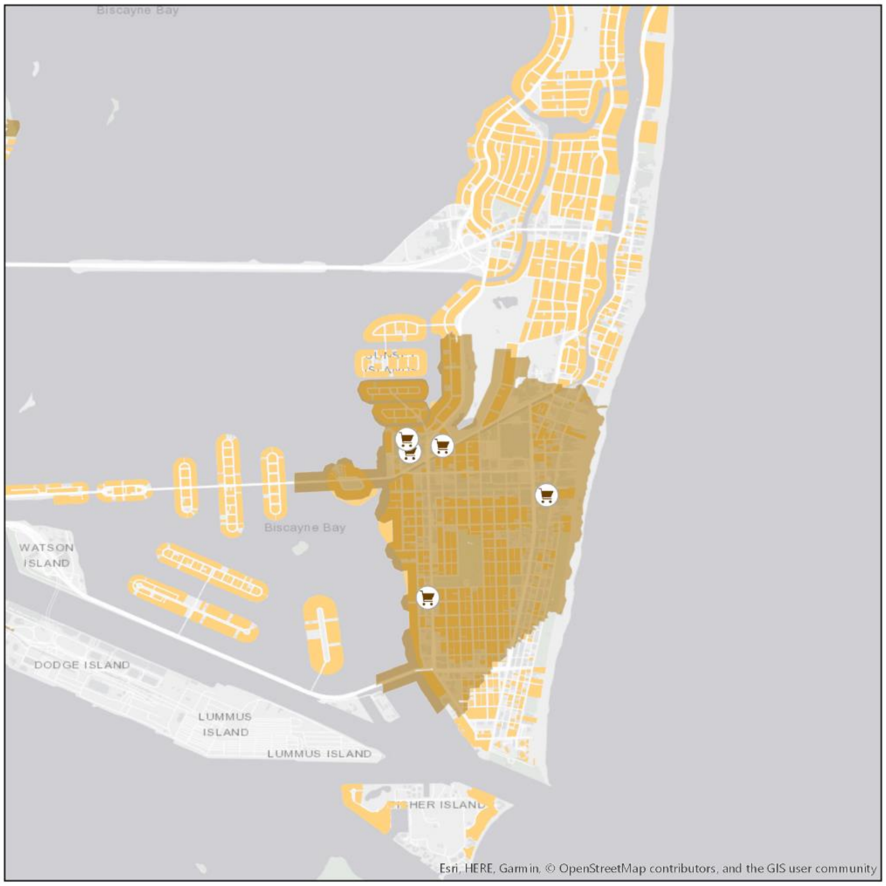
c. Walkable Urban Example (Miami Beach, FL)

Miami Beach, Florida is a walkable urban city in East Miami-Dade County. It was established in 1915 and it has a population of 92,307 people. There are one high school, two junior high schools and two elementary schools in Miami Beach. The map below shows, in pink, a 20-minute walking radius from Miami Beach Senior High. As opposed to Weston's example, Miami Beach's high school is located at the center of the city, reaching a larger number of residential units. The street grid expands the walking radius and the frequent number of street intersections make it safe and interesting to walk.

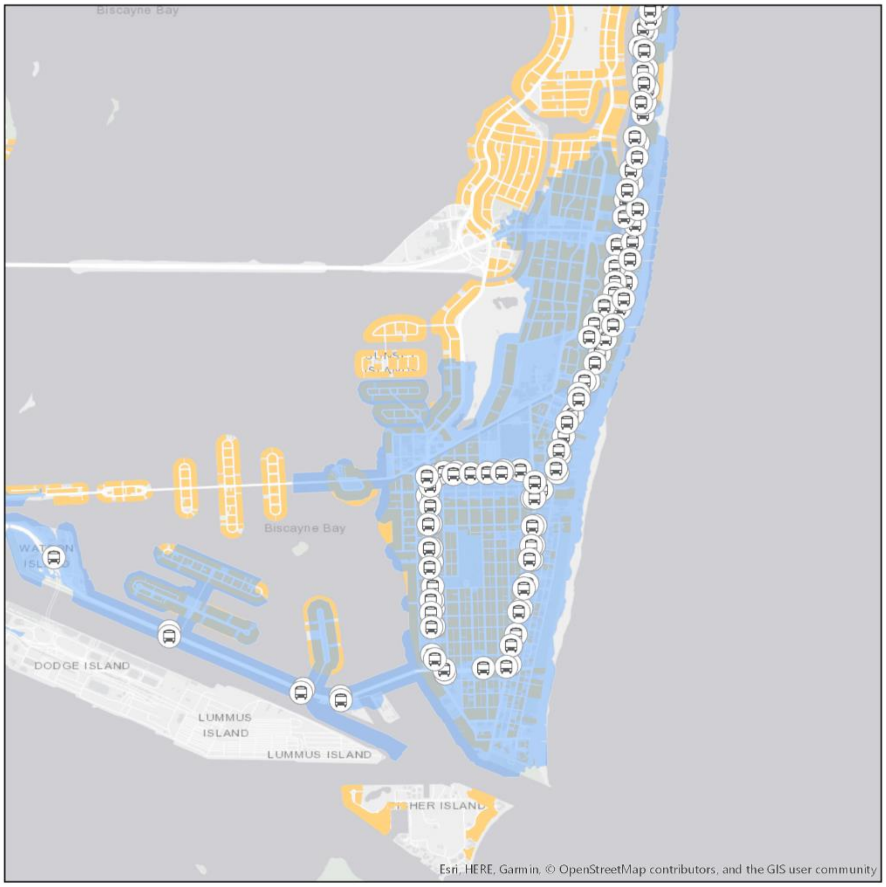


Miami Beach provides its residents with great green space accessibility, ranging from public beach access points and local city parks to islands only reachable by vessel. Because of the completeness of its street grid, its proximity to the ocean, and its number of different green space options, the vast majority of residential units in Miami Beach are located within walking distance to public green spaces. Public beach access, which has decreased in many Florida cities due to private developments, has been preserved in Miami Beach, increasing the possibility of all residents to enjoy their city. The map below shows, in green, the 15-minute walking radiuses from all accessible green spaces within Miami Beach.

Miami Beach's grocery stores reach a relatively high number of residential units within a reasonable walk due to the compact nature of Miami Beach's urban form and the connectedness of its street network. With five identified supermarkets and regional shopping centers within the city, about half of the residential units can satisfy their daily nutritional needs without the need to own a private automobile. The map below shows, in brown, the 15-minute walking radiuses from all supermarkets and regional shopping centers in Miami Beach. While it is evident that many of the city's residential parcels are located too far away from these amenities, the urban form allows for the addition of one or two new grocery stores, which, strategically placed, could potentially reach 100% of the residential parcels within walking distance.



Miami Beach is an exception in Florida in terms of frequent public transit accessibility. Two frequent transit lines serve the city, with a robust number of stops, which make it easy for most residents to reach far places within the area. Lines 112 and 119 run across the city covering both sides of the island. This is why a vast majority of the residential units in Miami Beach enjoy access to frequent transit service. The map below shows, in blue, the 15-minute walking radiuses of all frequent transit stops in Miami Beach. Evidently, the urban density, street grid and compact urban form of Miami Beach make it economically and environmentally feasible to deploy quality public transit services.


Biscayne Bay
Biscayne Bay
DODGE ISLAND
LUMMUS
ISLAND
LUMMUS ISLAND
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

VI. Conclusions

This research project serves as a starting point tool for further urban resiliency research. The state-wide nature of this project provides a bird's eye view of the State of Florida's urban form through the lens of urban resiliency and by no means can it identify variations between different urban areas. While some urban areas are compact and others widespread, this project's results show state-wide averages, which might help explain state-wide trends. This project's results are determined by the parameters identified during the literature review section of this project. Geospatial analysis models have the ability to adapt to different geographic extents and provide the opportunity to use different parameters. Further county level and urban area level research is possible using the same geospatial models utilized in this research project. Different results are to be expected, especially if parameters are to be changed.

VII. Assumptions, Limitations & Further Research

Due to the state-wide nature of this project, data accuracy is far from perfect. However, the fine-grain nature of parcel-level data is well above the expected resolution for an analysis at the state-wide level.

Time has been the main limitation concerning this research project. Even though there has been more then enough weekly time allocated specifically to working on this research project, the huge file size of the state-wide parcels feature class made imports, geographical renderings, geo-processing and exports extremely timely to execute even on a computer with 32GB of RAM installed. Some of the longest geo-processing tasks took well over 5 hours, heavily impacting this research project's timely execution.

Most of this research project's analyses were based on the state-wide parcels dataset, which, apart from taking a long time to process, is not exactly perfect. One major limitation concerning this dataset is its data structure for parcels designated as condominiums, or land-use code 004, which became a problem specifically during the residential and urban form density analyses. While single-family and multi-family residential parcels include the entire lot and the sum of all residential units within each lot, condominiums are represented as single polygons with the shape of the building, stacked on top of each other, each representing a single unit. Because of this reality, there were upwards of 12,000 residential units that were excluded from these analyses. These were excluded since they made up a very small portion of the upwards of 6 million residential units that make up Florida's urban areas.

Another data limitation, briefly mentioned in the methodology section, concerns the building footprint data. The building footprints were accessed through GitHub as part of one of Microsoft's open data initiatives. Microsoft, owner of Bing Maps, opened their computer-generated building footprint data to the public during early 2018. These computer-generated polygons are far from perfect, possibly skewing some of the data as a result. Further studies should strive to look for more reliable building footprint data if the same methodology is to be used. Even though these footprints were far from perfect, they proved to be the most reliable building footprint data available at a state-wide level for the State of Florida as of early 2019.

Using Network Analyst to find parcels within walking distance from transit stops, green spaces, schools and supermarkets allowed this project to be more accurate than if Geodesic Buffers were used instead. However, the parcel selection process might have produced unreliable results, since parcels were selected as being “completely within” as opposed to “intersecting” the polygon service areas. By scanning through random urban areas around Florida, I found “completely within” to be the most accurate representation of which parcels should be considered within the service areas generated using Network Analyst. However, my scan might have been erroneous since human work can fall prey of bias. Further research is needed to find which methodology brings about the most accurate results.

VIII. References

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IX. Appendix

Geospatial Data

Florida Parcel Data Statewide, Florida Geographic Data Library, 2017. Metadata

Parks and Recreational Facilities in Florida, Florida Geographic Data Library, 2018. Metadata.

School Facilities (Public and Private). Florida Geographic Data Library, 2017. Metadata.

Transit Stops and Routes (30 Agencies), Florida Transit Data Exchange, 2019. Metadata.

U.S. Demographics by Census Block Groups, ESRI Business Analyst Extension, 2018.

Metropolitan Statistical Areas, ESRI Business Analyst Extension, 2018.

U.S. Building Footprints, Microsoft, 2018. Metadata.

Table 4.1

UNITS_PER_ACRE	SUM_NORESUNTS	% of TOTAL
0 - 25	6366328	**82.6**
25 - 50	508762	**6.6**
50 - 75	148402	**1.9**
75 - 100	101189	**1.3**
100 +	583426	**7.6**
TOTAL	7708107	100

Table 4.2

BLDG_LOT_RATIO	COUNT_PARCELS	% of TOTAL
10	456019	**9.9**
20	874028	**19.0**
30	1330570	**29.0**
40	1052415	**22.9**
50	585589	**12.7**
60	197598	**4.3**
70	44959	**1.0**
80	20133	**0.4**
90	17098	**0.4**
100	16484	**0.4**
TOTAL	4594893	100.0

Table 4.3

Transit Agency	**Frequent Routes**	**Total Routes**	**Ratio**
Bay Town Trolley	0	8	0.0
Broward County	1	39	2.6
LYNX	5	75	6.7
Collier Area Transit	0	20	0.0
County of Volusia - Votran	0	29	0.0
Emerald Coast Rider - Okaloosa	0	10	0.0
Escambia County Area Transit	0	22	0.0
Gainesville Regional Transity Sytem	0	40	0.0
Hernando County Transit	0	4	0.0
Hillsborough Area Regional Transit - HART	5	28	17.9
Indian River County Transit - GoLine	0	15	0.0
Jacksonville Transportation Authority - JTA	4	33	12.1
Lake County Transit - LakeXpress	0	7	0.0
Lakeland Area Mass Transit - Citrus Connection	0	25	0.0
Lee County Transity - LeeTrans	0	26	0.0
Manatee County Area Transit - MCAT	0	16	0.0
Martin County Area Transit	0	4	0.0
Miami-Dade County Transit	8	101	7.9
Palm Beach County Transit - PalmTrans	0	32	0.0
Pasco County Public Transportation - PCPT	0	10	0.0
Pinellas Suncoast Transit Authority - PSTA	2	43	4.7
Sarasota County Area Transit - SCAT	0	27	0.0
South Florida Regional Transit - TriRail	0	1	0.0
Space Coast Area Transit	0	20	0.0
St Johns County - The Sunshine Bus	0	9	0.0
St Lucie County - Treasure Coast Connector	0	7	0.0
Sunrail	0	1	0.0
SunTran	0	7	0.0
Tallahassee - StarMetro	0	16	0.0
Brightline	0	1	0.0
TOTAL	**25**	**676**	**3.7**

Table 4.4

DORUC	DESCRIPTION	SUM_NORESUNTS
1	SINGLE FAMILY	107379
2	MOBILE HOMES	1561
3	MULTI FAMILY <10 UNITS	124215
4	CONDOMINIUMS	165551
5	COOPERATIVES	1730
6	RETIREMENT HOMES	642
7	MISC. RESIDENTIAL	149
8	MULTI FAMILY <10 UNITS	42632
12	MIXED USE STORE AND OFFICE	27
28	PARKING LOTS (MOBILE HOME PARKS)	671
SUBTOTAL		444557
TOTAL		7708107
% of TOTAL		**5.8**

Table 4.5

DORUC	DESCRIPTION	SUM_NORESUNTS
1	SINGLE FAMILY	2072113
2	MOBILE HOMES	65339
3	MULTI FAMILY >10 UNITS	621044
4	CONDOMINIUMS	789064
5	COOPERATIVES	22380
6	RETIREMENT HOMES	17521
7	MISC. RESIDENTIAL	1874
8	MULTI FAMILY <10 UNITS	295273
10	VACANT COMMERCIAL	10
28	PARKING LOTS (MOBILE HOME PARKS)	33051
36	CAMPS	3
48	WAREHOUSING	13
SUBTOTAL		3917685
TOTAL		7708107
RATIO		**50.8**

Table 4.6

DORUC	DESCRIPTION	SUM_NORESUNTS
1	SINGLE FAMILY	574319
2	MOBILE HOMES	11548
3	MULTI FAMILY <10 UNITS	180426
4	CONDOMINIUMS	144044
5	COOPERATIVES	2594
6	RETIREMENT HOMES	4234
7	MISC. RESIDENTIAL	650
8	MULTI FAMILY >10 UNITS	126649
28	PARKING LOTS (MOBILE HOME PARKS)	4493
SUBTOTAL		1048957
TOTAL		7708107
RATIO		**13.6**

Table 4.7

DORUC	DESCRIPTION	SUM_NORESUNTS
1	SINGLE FAMILY	1617581
2	MOBILE HOMES	74220
3	MULTI FAMILY <10 UNITS	418918
4	CONDOMINIUMS	423927
5	COOPERATIVES	14598
6	RETIREMENT HOMES	13006
7	MISC. RESIDENTIAL	1262
8	MULTI FAMILY >10 UNITS	241985
10	VACANT COMMERCIAL	10
12	MIXED USE STORE AND OFFICE	27
28	PARKING LOTS (MOBILE HOME PARKS)	15484
SUBTOTAL		2821018
TOTAL		7708107
RATIO		**36.6**

Table 4.8

AGRICULTURAL_OWNERS		
OSTATE	SUM_ACRES	% of TOTAL
FLORIDA	12146953	**76.6**
GEORGIA	898970	**5.7**
UTAH	675251	**4.3**
OTHER		**13.5**
TOTAL		100

Table 4.9

COMMERCIAL_OWNERS		
OSTATE	SUM_ACRES	% of TOTAL
FLORIDA	607926.843	**76.9**
ILLINOIS	22013.86718	**2.8**
NEW YORK	17771.74531	**2.2**
OTHER	142480.4906	**18**
TOTAL	790192.9461	100

Table 4.10

RESIDENTIAL_OWNERS		
OSTATE	SUM_ACRES	% of TOTAL
FLORIDA	10341932.9	**75.9**
NEW YORK	752927.1993	**5.5**
CANADA	416948.4781	**3.1**
OTHER	2115342.463	**15.5**
TOTAL	13627151.04	100

Table 4.11

INDUSTRIAL_OWNERS		
OSTATE	SUM_ACRES	% of TOTAL
FLORIDA	256235.9661	**76.6**
GEORGIA	10210.96078	**3.1**
TEXAS	8608.159686	**2.6**
OTHER	59398.12723	**17.8**
TOTAL	334453.2138	100