Metropolitan Areas in 1990 vs. Today- How Different Are They? An Examination of Changes in Built Form and Resident Characteristics

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Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Urban Affairs and Planning

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April 11, 2018
Alexandria, VA

Keywords: Density, Urban Form, Metropolitan Development, Suburbanization, Millennials

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ACADEMIC ABSTRACT

Anecdotal media reports have pointed towards a large shift in the residential preferences of young adults, known commonly as Millennials, towards the suburbs. There is little academic research to confirm this shift, however. A quantitative approach is used in this dissertation, with an analysis that explores changes in density over time in the context of the traditional city versus suburb distinction, as well as a potential relationship today between density and the characteristics of the residents. This includes whether the Millennial generation has any different relationships to previous generations in the same age cohort. Findings from the analysis indicate that the suburbs-city distinction is no longer relevant, and density is changing at a similar rate in both types of geographies. This suggests that density is a more appropriate metric to gauge metropolitan form changes and indicates a continued evolution of urban form theory is occurring. Findings also challenge the utility of generation theory to the planning field, as there has been little change in the relationship between density and age over time.

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ABSTRACT

The metropolitan area form has changed over time, transitioning from one central city surrounded by suburban bedroom communities to regions that possess several self-sufficient centers of activity. While these changes have occurred, metropolitan areas are commonly compared using the simple city-suburb distinction.

The changing nature of the suburbs has been discussed in terms of changes in the built environment as well as changes in the residents; most recently, anecdotal media reports have suggested that preferences of the Millennial generation (now roughly 25-to-34-year-olds) may be influencing this shift. There are two main goals of this dissertation: to explore how density has changed in the context of the overall metropolitan area, as well as to explore whether the characteristics of residents in metro areas have changed. A quantitative approach is used, with an analysis that explores changes in density over time as well as a potential relationship today between density and the characteristics of the residents, including whether the Millennial generation has any relationship to changes, if they exist.

Findings from the analysis indicate that the suburbs-city distinction is no longer relevant, and density is changing at a similar rate in both types of geographies. This suggests that density is a more appropriate metric to gauge metropolitan form changes. Further, characteristics of the population related to density have not changed since 1990, suggesting that changes in density do not have a relationship to an increase in influence by members of one generation.

ACKNOWLEDGEMENTS

I wish to thank first my husband Josh, who has continued to encourage me when I was ready to give up and has done more than his fair share of the childrearing and housework while I worked on this dissertation. Thank you as well to my son Ian, who has made completing a dissertation with a toddler quite an interesting experience.

I also want to thank my boss, Mark Obrinsky as well as my other supervisors at the National Multifamily Housing Council, who allowed me to work on this during my workday, and who all provided both financial and emotional support for this endeavor over the years. Thank you to Chris Bruen, NMHC Senior Research Analyst and Stata whiz, who no doubt saved me countless coding hours with his shortcuts.

Thank you to my committee members, who have provided a great deal of support and guidance as I worked through many iterations of my research methodology. Thank you to Adam Eckerd and Ralph Buehler as well, who took time out to go over my regression results.

Finally, I wish to thank Terry Holzheimer, who taught me that you can be a successful practitioner while continuing your education, and who even in death served as a source of inspiration. His reminder that it's alright to take a while to finish your dissertation ran in my head frequently.

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1 Introduction

Where people choose to live is one of the most important life decisions they can make; that choice can be influenced by a variety of factors—a desire to locate near family, employment, or a preference for a specific residential type. These choices have a spillover effect on the built environment, shaping overall development within a metropolitan region—employers locate offices near their employees and developers build housing where they project demand will locate moving forward. In the post-World War II era, demand for housing was greatest in the rapidly developing suburbs, leading to a change within the regional context from suburbs as traditional "bedroom communities" that depended upon a central city to integral parts of the regional economy.

Evidence of residential demand can be captured by examining household and population demographics in an area. One of the most common ways to group the population to estimate demand is by age cohort—buying preferences and behaviors can change drastically over the course of one's lifetime. Grouping into generations is an additional way to categorize the population. The living preferences of the Baby Boomers and their parents shaped the development of the suburbs, encouraging single-family development (Hanlon et al., 2010).

Much attention is currently being paid to members of the Millennial generation, due to both sheer size (they now outnumber the Baby Boomers) and age (25 to 34-years old). Media reports point to the aging of this generation into young adulthood that has also coincided with a fundamental shift in consumer behavior (McGee, 2017). These changes have been attributed partially due to the 2008 recession and partially because people are experiencing major life events later and later (Pew Research Center et al., 2012).

These two factors have led some to believe that these changes in living preferences are because today's 25-to-34-year-olds, the Millennial generation, are different than previous generations. Media reports have documented the move of the "Millennials" into the suburbs, but with different demands than members of their predecessor generations, desiring more of a mixed-use atmosphere than had previously been found in the suburbs (Greenblatt, 2017). Surveys of Millennials have reinforced these preferences for higher-density living (Lachman & Brett, 2015). Little research has been done, however, documenting whether these preferences indicated in surveys have led to actual changes in the built environment, and if there is any relationship to changes in the built environment and changes in characteristics of the residents.

Much research has already been conducted, however, to document the evolution of the suburban form over time, changing from escapes for the wealthy from the crowded unsanitary cities in the late nineteenth century to homogeneous bedroom communities for the middle class in the mid-twentieth century (Hanlon et al., 2010). Research in the past decade has also shown that some suburbs have begun to take on more characteristics like the city, with employment moving out of the city in many cases and into the suburbs where people were already living (The Urban Land Institute, 2016).

These suburbs have been broken into different typologies, including some that have been identified as higher-density, but it is unclear if this new higher-density scale is widespread in many suburbs, or if it is simply an evolution of some suburbs in the context of the overall metropolitan area (The Urban Land Institute, 2016). An examination of the built form and resident characteristics in metropolitan areas over time will yield evidence as to how the built environment and residents of cities and suburbs have changed, if at all.

1.1 Goal of the Dissertation

The goal of this dissertation research is to understand changes in residential development patterns in metropolitan areas and determine whether there is any relationship between density and characteristics of the residents, particularly the age of the residents. The research required to answer these questions requires one to delve into demographic and consumer research and metropolitan suburbanization patterns. This dissertation produces original quantitative research in support of the development of a new, substantive theory about how urban form and physical development in the metropolitan area should be viewed today, as well as how characteristics of residents, including young adults, are related to density. Are young adults more likely to live in higher-density areas? And what is meant as high-density? My goal is that upon completion of reading this analysis, readers will have a deeper understanding of how housing development is laid out in today's metropolitan areas, and how today's consumer preferences have played a role in that layout.

1.2 Definitions

Throughout this document, the terms "Millennials" is used as shorthand for today's young adults. Several definitions exist as to when Millennials were born, with Pew citing those who were born between 1981 and 1997 as members of the Millennial generation (Fry, 2015). For the purposes of this research, Millennials are defined as those who were 25 to 34 years old in 2015. Baby Boomers are defined as those born between 1946 and 1964 (Fry, 2015).

A metropolitan statistical area is defined by the United States Census Bureau as a geographic area that had at least one urbanized area of 50,000 or more inhabitants (in 2010 for the purposes of this research) (U.S. Census Bureau, 2018). Principal cities are defined by the Census Bureau as the largest city (or county in some cases) based on population in each metropolitan area, as

well as other cities that meet certain criteria related to population and employment size (U.S. Census Bureau, 2018). Suburbs are defined in this research as the counties that are within a metropolitan statistical area but are not principal cities, as well as the parts of counties outside of principal city boundaries.

1.3 Contribution of Research and Dissertation

This research was precipitated by frequent anecdotal media reports about the Millennial generation and suburbanization. Both represent major topics that must be fully understood as policymakers and planners endeavor to plan for the future. The sheer size of the Millennial generation has massive implications on buying power, particularly as they enter the age group where major life events typically occur—marriage, children, and purchasing a house. Traditionally, many people would move to "the suburbs" when these events occurred, but what does the term "suburb" mean today? While people within the field of planning may realize the limiting factors associated with using the city versus suburb distinction, that is not a thought shared widely beyond the planning practice.

The study of the Millennial generation has largely been limited to consumer research. Only recently have planning publications begun to explore the Millennial generation and the implications of this massive age cohort on elements of the planning practice. This dissertation research continues exploring those implications, as well as suggesting a new way of thinking when it comes to regional development. This will assist local governments in planning for development in the future, including how much influence to place on what the massive cohort that is the Millennial generation will want, as well as what other factors are important to consider when undertaking planning initiatives.

The results of this research suggest that density has continued to move outwards in many metropolitan areas around the United States, and as a result, planning practitioners in many jurisdictions formerly known as "suburbs" will need to recognize this density when planning in the future. This has especially important implications for transportation planning—many of the places found in this dissertation to be experiencing significant increases in density are in areas that are not well served by transit. Planners will need to be cognizant of these changes in terms of the local area, as well as the overall metropolitan region.

This dissertation research also suggests that planning theory related to the built form must continue to evolve. Original urban form theories such as Harris and Ullman (1945) depict a central activity area surrounded by other land uses, but the dissertation results suggest that many metropolitan areas have evolved beyond this layout, with most metropolitan areas containing multiple cities. The research also provides further evidence that generation theory should not be emphasized in terms of planning programs, as the regression results do not support differences between generations.

1.4 Previous Literature

The literature review chapter is divided into two different parts: theoretical background and subject matter background. The theoretical background will lay out the overall theories that have served as the foundation for the evolution of metropolitan areas in terms of urban form as well as the economy, while the subject matter background section discusses the Millennial generation as well as the overall suburbanization process.

The dissertation research was conducted using a quantitative approach, through an empiricist ontology and positivist epistemology. Quantitative methods are often employed in the empiricist ontology, because those that employ an empiricist ontology believe that objects of

study can follow set patterns that can be observed in a regular format (Porter, 1995). The positivist epistemology allows for a researcher to observe and experiment, and then use deductive and inductive reasoning to generate conclusions based on their experimentation and observations (Porter, 1995).

1.4.1 Theoretical Framework

One must understand the existing theories to generate a new theory, and both the influence that they play in forming the theoretical foundation of that new theory as well as the deficiencies that exist in those theories in terms of explaining the hypothesized phenomenon that is occurring today. Three different types of theories are important to examine for the purposes of this dissertation research: urban form, economics, and generation theory.

Regional planning theories that laid out the urban form originally developed with the central city as the focal point, examining the relationship between that central city and settlement/activity patterns of the surrounding area in a region. Metropolitan settlement patterns were originally described by the concentric zone, multiple nuclei, and sector models, which all focused on a central business district and surrounding separation of uses (Beauregard, 2007; Harris & Ullman, 1945).

The suburbs continued to evolve post World War II, and by the end of the twentieth century commuters were not simply driving from their suburban home to the central business district. Increasingly, employers began to locate in the suburbs as well, and some suburban communities began to become their own employment centers, progressing from the smaller nodes of employment that could be characterized by the multiple nuclei model (Cervero & Wu, 1997).

As development in the suburbs became more nuanced, the simplicity of the concentric zone model, sector model, and multiple nuclei model made them less appropriate descriptors for suburbs in many metropolitan areas. Instead, the city versus suburb distinction became less accepted by the planning practice, as the introduction of more people changed the composition of the suburbs.

The second part of the research relates to demographics and demand, particularly the relationship between density and age. It is important to understand consumer preferences and demographics, since they can help provide indications of where demand is headed. One method of gauging consumer demand for a product (such as housing) is to categorize people or households into groups that are likely to purchase that good. People and households can be categorized by many different characteristics, such as gender, educational attainment, or household income. One categorization that is frequently used is age. Even within that categorization, there are additional behaviors or characteristics that can be researched, including experiences at certain ages in life that contribute to behaviors later in life, or what generation or age cohort an individual belongs to. There is not widespread agreement as to the best ways to categorize people by age, or how those categories are most useful.

Generation theory posits that groups of people that are born during roughly the same time experience certain life events that help develop their beliefs which will shape their preferences and actions for the rest of their life (Howe & Strauss, 2000). These life experiences result in a common persona for members of each specific generation (Howe & Strauss, 2000). There are currently several defined generations: Baby Boomers (those born 1946 to 1964), Generation X (those born approximately 1965 to the beginning of the 1980s), and Millennials or Generation Y (those born after 1981) (Howe & Strauss, 2000).

Proponents of cohort theory (as well as general opponents of generation theory), in contrast, believe that the time period that spans an entire generation is simply too long. Cohort theory suggests that individuals are shaped by the life events that occurred as they were beginning to enter adulthood (when they were approximately 17 to 21 years old) (Meredith & Schewe, 1994). Both generation and cohort theory supporters argue that members of generations and cohorts, respectively, will always exhibit the same behaviors regardless of their age, based on their life experiences (Howe & Strauss, 2000; Meredith & Schewe, 1994).

1.4.2 Subject Matter Background

In addition to understanding the theoretical foundation of this research topic, it is also important to recognize the subject matter that exposes the relevant shortages in the current ways of thinking. There are two main subject areas that are important for exploration in this dissertation research: the state of metropolitan development patterns today, particularly in the context of suburban development; and the Millennial generation, or those currently in the roughly 18-to 34-year-old age cohort.

With the simple distinction between suburb and city less clear, there have been multiple efforts to characterize suburbs with names such as Edge Cities, Boomburbs, Metroburbs, Technoburbs, and urban realms. All these new classifications for the suburbs still described a geography at an automobile scale and focused more on the physical layout of actual buildings instead of the relationship between where people choose to live and work and why, as well as the effect that the layout of a neighborhood or community can have on an individual. There have been some attempts to design suburbs at a smaller scale with more of a focus on the individual's quality of life, however they have been met with limited success thus far.

The development of the suburbs into more nuanced geographies also coincides with the arrival of a large group of individuals into adulthood. The Millennial generation is defined by Pew Research Center as those that were born from 1981 to 1997 (Fry, 2015). There are about 80 million members of the Millennial generation, and many assertions have been made about the characteristics of members of this generation (Fry, 2015). The sheer size of this generation, and its associated buying power, makes it an attractive media and consumer research topic. In addition to anecdotal evidence and academic research, survey research has been conducted by organizations such as the Urban Land Institute, to gauge Millennial preferences for multiple topics, including housing location choice and attitudes towards employment (Lachman & Brett, 2015). These surveys have shown evidence that members of the Millennial generation are interested in living in the suburbs (Hudson, 2015).

There is much debate about whether members of the Millennial generation are one distinct generation or two distinct cohorts, or whether the behaviors that are attributed to the "new Millennial generation" are simply a manifestation of the life cycle that members of this generation are currently in (Arnett, 2015). Arnett's development of the "emerging adulthood" life cycle considers many characteristics that have been attributed to the Millennial generation (moving back into their parents' home after college, delaying marriage, and having children later) and argues that they are actually trends that have been occurring since before members of the Millennial generation became young adults (Arnett, 2015; US Census Bureau, 2015; Leonard, 2016). As these major life events have been delayed, it has led to a new life stage, emerging adulthood, that occurs when individuals first become adults at age 18 until sometime in their mid-twenties. In their late twenties individuals begin taking part in major life events such as getting married and having children. Approximately half of the Millennial generation is no

longer in the emerging adulthood stage, making their consumer preferences related to housing very important (US Census Bureau, 2015).

1.5 Research Questions

The transition of the suburbs, as well as the aging of the Millennials into adulthood leads to questions about the future of areas commonly known as suburbs going forward, and how both the built and resident composition has changed in metropolitan areas. The following research questions are explored in this dissertation to help provide explanation and context for the development of the suburbs in the future:

1. How has residential density changed over time in metropolitan areas?
    a. Is there any distinction between density in areas defined as suburbs and central cities?
2. Is there any relationship between residential density and the 25-to-34-year-old age cohort?
    a. If so, has that relationship changed over time?
    b. Are there other demographic or economic characteristics of the population that have a significant relationship with residential density?
    c. If a relationship exists between residential density and any demographic or economic characteristics, how does it compare in areas that were previously defined as suburbs and principal cities?

1.6 Organization

This first introductory chapter provides an overview of the dissertation topic and research background, as well as an outline of the dissertation organization.

Chapter 2 comprises a literature review exploring the urban form and economic theories that are necessary to understand the foundations for this dissertation research. A subject matter discussion explores the evolution of suburbanization as well as economic theory. Both explorations are necessary to understand the current state of the built environment. The literature review also includes a discussion of generation theory and consumer preference research. Justification for the methodological approach is included throughout this chapter as well.

Chapter 3 details the methodology employed in the dissertation research, explaining the quantitative approaches used to answer the research questions. The analysis in this dissertation is comprised of two parts—the first part involves the development of several residential density indexes that measure how density has changed in areas that traditionally have been known as suburbs. Part two includes a linear regression to determine whether any relationship exists between density and certain characteristics of the population, particularly the 25-to-34-year-old age cohort over time.

Following the methodology chapter, Chapter 4 presents the findings and results of both quantitative analyses. Maps from metropolitan areas around the United States are used throughout this chapter to provide illustrative evidence of the findings from the indexes.

The concluding discussion chapter delves deeper into the results and findings presented from the quantitative analysis in the preceding chapter. The findings from the literature review chapter are used to weave together the results from the quantitative analysis to develop a more complete picture of the metropolitan form and what demographics are shaping the development of that form. This chapter also provides guidance on how the findings of this dissertation research provide a contribution of new original research to the planning profession. Potential opportunities for additional research are discussed in the final chapter as well.

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2 Literature Review

2.1 Introduction

The metropolitan urban form has evolved in the United States as population and employment patterns have changed. The advent of the Industrial Revolution brought more people to the cities in search of employment, and the new population in these cities brought new challenges. Eventually people who could afford to relocate began to move out of the cities to larger houses on larger lots, known commonly as suburbs. The outflow of people first went to areas immediately adjoining the city, and as metropolitan regions became more polycentric, focused less on a primary city as the only economic engine of the regional economy, people continued to move further out.

As these areas known historically as suburbs have matured and become more developed, more research to define these areas beyond the term “suburb” has been conducted, with research in recent decades showing that the single-family centric development style is no longer the predominant land use pattern in the suburbs. Suburbs were once considered to be bedroom communities dependent on that single principal city where people would commute into work every day, but these suburbs have increasingly become their own self-sufficient centers of commerce, housing, and entertainment as well, to the point that some argue the term “suburb” has become obsolete (Marcuse, 1989).

The suburbs developed because of government and private interest initiatives that steered families towards homeownership outside of the cities. In the aftermath of World War II, the wide availability of mortgages and a baby boom led to the increase of new predominantly single-family development in the areas surrounding cities, while the cities were reserved for low-income, predominantly minority households.

The development of the suburbs coincided with the influx of the Baby Boomer generation, the largest generation at that time. They first emerged as a powerful consumer group as children in the post-World War II era, then as adults with their own families. The aging of the Millennial generation into the young adult cohort has put renewed focus on where people choose to live. Many news articles have highlighted the movements of these groups, but to date, there is little academic literature that has been written on this topic (Myers, 2016). There is also little research that answers the many questions that exist about the impact of members of the Millennial generation on the built environment as they enter adulthood, however.

This literature review explores theory related to urban form and economics, to understand how the metropolitan region has developed until this point in terms of land use. Theory related to age and consumer behavior is also explored, to inform the research surrounding whether there is any difference between the residential living patterns of the Millennial generation and earlier generations at that same age.

2.2 Urban Form, Suburbanization and the Role of Economics

One of the basic tenets of empiricism is that knowledge is continuously being gained. The timeline of defining the urban form follows this trajectory—the origins of urban planning were centered around the fundamentals of the built environment, with the goal of providing sanitary conditions for people in crowded cities. As development patterns have changed, the knowledge surrounding urban form has become more nuanced, but the basic spatial urban form theories that will be discussed in this literature review have remained important to the planning practice. Elements of each theory remain important when answering the research questions posed in this dissertation, particularly in terms of identifying new development patterns that may be occurring

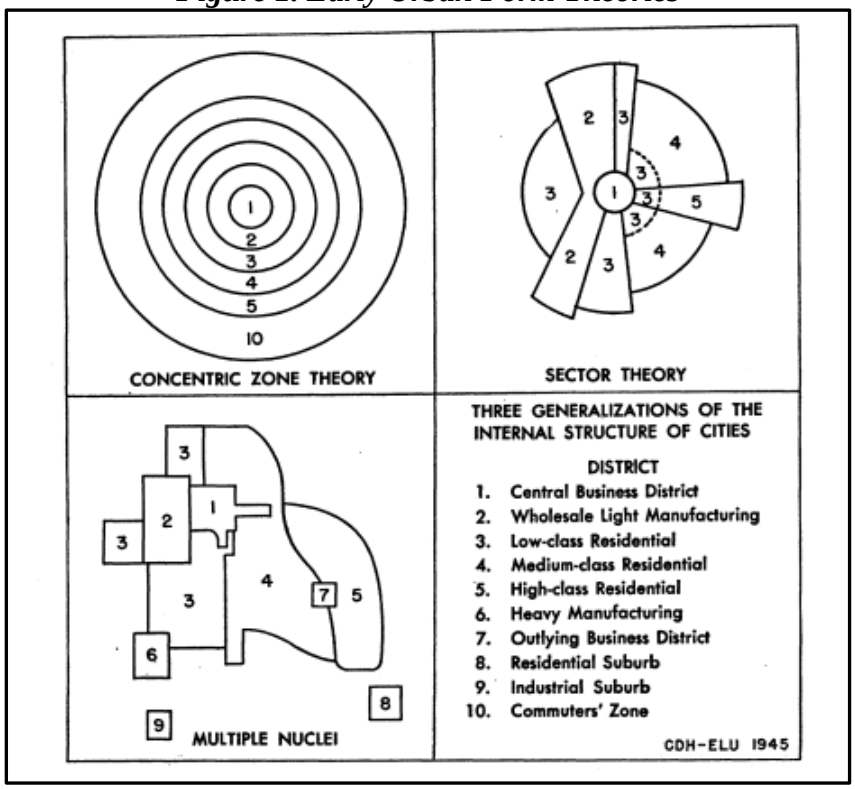
and understanding how those development patterns fit into the overall metropolitan area framework and its changes over time.

2.2.1 Original Regional Urban Form Theories

Regional urban form theories originally developed with the central city or central business district as the focal point, examining the relationship between that central city and the surrounding areas in a region. These theories described development patterns in metropolitan regions throughout the United States and when combined with various economic theories could relatively accurately describe the evolution of suburbanization in most U.S. metropolitan regions after World War II.

The concentric zone model, alternatively known as the Burgess model, can be used to describe the traditional pattern of suburban development, particularly in the post-World War II era. In the concentric zone model (see Figure 1), the central business district (the city) is surrounded by concentric rings that expand out from the core area. The furthest area from the core is where the commuters reside.

Figure 1. Early Urban Form Theories



Source: Taken from Harris and Ullman, 1945. [fair use]

Two more nuanced views of settlement patterns in the metropolitan region were Homer Hoyt's sector model and Harris and Ullman's multiple nuclei model. Hoyt's sector model separated residential areas into "high-rent" and "low-rent" areas, which were more wedge-like, with the high-rent areas clustered around existing transportation lines (Beauregard, 2007). The multiple nuclei model developed even more clearly defined delineations, arguing that there were sometimes business clusters located away from the central business district in the outer areas of the metropolitan area (Harris & Ullman, 1945).

2.2.2 The Evolution of the Suburbs

The suburbs had originally begun as places for the wealthy to escape the ills of the city (Hayden, 2003). Those that lived in the suburbs still worked in the central city, where the bulk of employment was located, however. The advent of the streetcar towards the end of the 19th

Century brought about the development of the “streetcar suburb”—residential development was located along the streetcar lines, and those that could afford to live outside the central city and commute in via the streetcar generally chose to do so (Hayden, 2003).

After World War II, the introduction of new federal programs and initiatives such as wide availability for mortgages, the mortgage interest deduction, and the development of the national highway system led to an increase in development outside of the central city (Hanlon et al., 2010; Hayden, 2003). This development was centered on increasingly large lots and was predominantly low-density (Jackson, 1985). Development also moved further and further out from the central city. Individuals who lived in the suburbs required an automobile to move from place to place, including into work in the city.

There were attempts to create planned communities in the post-World War II era that concentrated different types of land uses near one another and focused more on developing a community through a new development (such as master planned communities) via the New Town movement (Knox, 2008). Places such as Reston, Virginia and Columbia, Maryland, where development was not so spread out, included all the elements that families would need in one place. However, these towns were far outnumbered by the sprawling new development throughout the United States, and for most New Towns, the value of walkable communities would not be seen by consumers until the late twentieth century (Forsyth).

Development in the suburbs continued to evolve over time, and by the end of the twentieth century commuters were not always driving from their suburban home to the central business district. The population of the suburbs had increased, following Mieszkowski and Mills’ (1993) natural evolution theory of suburbanization. The natural evolution theory of suburbanization posits that employment is initially concentrated in a city center, but as the city

center becomes more populated, residential development will move out to farther locations, and employment will follow (Mieszkowski & Mills, 1993). Increasingly, some employers began to locate in the suburbs as well, and some suburban communities began to become their own employment centers, progressing from the smaller nodes of employment that could be characterized by the multiple nuclei model (Cervero & Wu, 1997).

These changes in suburban development patterns were due to the presence of agglomeration economies, which had developed through companies being able to take advantage of knowledge spillovers from other employers and a larger labor pool from the increased population (Rosenthal & Strange, 2004). Hoyt's economic base theory, the belief that basic employment in manufacturing jobs led to non-basic employment in the form of local goods and services that were necessary to support those basic activities, also played a role (Beauregard, 2007). The introduction of more basic activities in the suburbs led to the introduction of more non-basic activities as well.

As the concept of suburbanization became more nuanced, the concentric zone model, sector model, and multiple nuclei model that were the basics of original urban form theory all became less appropriate descriptors for suburbs in many metropolitan areas around the country. While the multiple nuclei and sector models had slightly more nuance than the concentric zone model, they still focused on the city/central business district as the core element. As employers followed population into the suburbs and supportive retail began to develop as well, the built environment in the suburbs began to resemble the original urban form theories less and less.

Criticism of these existing theories began to emerge, highlighting the change from the traditional land use patterns in these new theories. An updated urban form theory presented by Chauncy Harris, one of the original developers of the multiple nuclei model, took into account

these changes in metropolitan areas. This new theory presented patterns in relation to economic activity centers in the metropolitan area, not simply the city center (Harris, 1997).

This change in relationship to the city center played out as knowledge regarding suburbanization trends evolved. Harris and Lewis argued that as the suburbanization phenomenon continued, the dual-city metaphor of city versus suburb was less important than the issue of suburban fragmentation (Harris & Lewis, 1998). Further, Marcuse has argued that using the dual-city metaphor of city versus suburb assumes that all cities are the same and all suburbs are the same, resulting in a loss of some of the differences between the different types of suburbs (Marcuse, 1989).

The form of suburbanization described by Mieszkowski and Mills played out in metropolitan areas throughout the United States as more people and businesses moved outward and development began to sprawl. The advent of truck transportation lessened dependency on railroads in the central city (Mieszkowski & Mills, 1993; Hanlon et al., 2010). Improvements in manufacturing technology also required additional space for manufacturing that cities could not offer but was widely available in the suburbs (Hanlon et al., 2010). The Ford Motor Company, for example, relocated its operations from downtown Detroit to a large office and industrial park in suburban Dearborn (Markusen, 1987). The location of employment in the suburbs served as an additional attractant for population growth there, particularly since land costs were lower in the peripheral areas around the city, allowing for purchase of more land and housing than would be possible in the city, and commuting costs were minimal because employers were now located there as well (Alonso, 1964).

The movement of both population and employment to the suburbs helped fuel the development of agglomeration economies in suburban jurisdictions. Rosenthal and Strange cite

Marshall's three causes—labor market pooling, knowledge spillovers, and input sharing—as to why agglomeration economies, or the benefits experienced when firms locate near one another, developed (Rosenthal & Strange, 2004; Glaeser, 2007). The large population growth that was occurring in the suburbs provided a large labor pool for employers. These employers provided companies that also served as a basis for learning for their employees and employees could use that knowledge to create their own businesses. In addition to input sharing, the location of companies near each other encouraged the sharing of resources and supportive services such as airports, hotels and conference centers (Turok, 2005; Hall & Pain, 2006).

The presence of agglomeration economies that did exist in the suburbs, as well as the declining influence of cities helped fuel a change in most metropolitan areas throughout the United States from a monocentric region, with employment based in one central area, to a polycentric region, with multiple employment and business centers located in one metropolitan area. The presence of large employment centers in the suburbs negated any reasons for many people to commute into the city (Mikelbank, 2004). Increases in population and employment created demand for supportive services and retail centers in the suburbs, which in turn created even more employment opportunities in the suburbs. Not all these employment opportunities were for individuals in the middle class, however. The movement of corporate headquarters included wealthy executives, and retail stores were staffed by individuals earning lower incomes.

The massive movement of employment did not lead to a completely positive picture for the suburbs, however. While agglomeration economies and a variety of uses helped the suburbs become their own places no longer dependent on the cities, this does not mean that the physical layout of suburbs developed efficiently. The location of office jobs became more sprawled, a combination of sporadic clusters in the suburbs as well as "a more hierarchical structure of

subcentering" (Cervero & Wu, 1997). Most suburban planners emphasized a separation of land uses that were low-density and auto-dependent, meaning that jobs, retail and housing were rarely located near one another. As a result, people were driving an increasingly longer distance to work every day (Pastor et al., 2000). A study of 258 metropolitan statistical areas (MSAs) found that for 227 of the MSAs, the increase in job gains from 2001 to 2006 was accompanied by a decrease in job accessibility (Weitz & Crawford, 2012). The simple urban form theories with one central city in each metropolitan area were no longer sufficient.

2.2.3 New Suburban Typologies and Methods of Measurement

The urban planning and economic theories discussed previously help explain how the suburbs changed in terms of the regional context but did little to explain these new places specifically. Many individuals have made multiple efforts to characterize these evolved suburbs with names such as Edge Cities, Boomburbs, Metroburbs, and Technoburbs. These new terms all described relatively similar concepts, with land uses and commercial activities previously found only in cities located in these suburbs (see Table 1). Edge Cities, for example, are defined as those places with a minimum of five million square feet of office space, at least 600,000 square feet of retail space, and a larger workday population than permanent population (Garreau, 1991). Boomburbs similarly have all the elements of a city, but their physical characteristics (shopping malls and single-family detached houses) are not physically reminiscent of cities (Lang & Lefurgy, 2007).

Table 1: New Types of Suburbs

Name of Suburb	Defining Characteristics
Edge Cities	5 million sf office space 600,000 sf retail space More jobs than bedrooms People perceive as "one place"
Boomburbs	Incorporated cities with more than 100,000 people Not the core city of the metro area <10% population growth from 1970 to 2000 Census Have all the elements of a city, but their physical characteristics do not resemble them
Metroburbia	"New Metropolis" employers located outside of city with retail opportunities nearby
Technoburbs	Mix of all uses, including agricultural
New Urbanism	Mix of all uses Built to a walkable scale

Source: Hanlon, 2010; Knox, 2008; Lang & Lefurgy, 2007; Garreau, 1991; Fishman, 1987.

Some of these terms were not limited to defining the physical characteristics, however. Lang and Lefurgy (2007) also note differences in the population of Boomburbs when compared to the United States as a whole; Boomburb residents tend to be better educated and wealthier, and their households tend to be smaller.

Except for New Urbanism, all these new classifications still describe development at an automobile scale and focus more on the physical layout of actual buildings instead of the relationship between where people choose to live and work and why, as well as the effect that the layout of a neighborhood or community can have on an individual. There have been some attempts to design suburbs at a smaller scale with more of a focus on the individual's quality of life, however they have been met with limited success thus far. The New Urbanist design promotes a walkable, mixed-use neighborhood, where buildings are designed with an emphasis on how they will fit into a neighborhood (Hanlon, 2010). New Urbanism has been met with limited success because more sites have been built in greenfield locations where people cannot easily complete all of their daily activities. Knox does argue that the concept of New Urbanism

easily fits into the context of people's desires today, however, because all of the uses are located near each other (Knox, 2008).

The previous terms characterized only certain types of suburbs, and not in all metropolitan areas around the country. An alternative way to characterize the suburbs more uniformly has been to develop a classification system of the suburbs. The new typologies, presented in Table 2, use various units of analysis and measurement, and focus on different elements of suburban characteristics. In these analyses, the focus is placed more on measurement that is easily replicable across the United States and less on developing a new "type" of suburb.

Table 2: Suburban Typologies

Source	Unit of Analysis	Suburban Definition Criteria	Classifications
Brookings Institution	County	Counties outside the central city in the MSA Up to two other counties with a population greater than 100,000	City/High-Density Suburbs Mature Suburbs Emerging Suburbs Exurban
Demographia	Zip code	Density Urban form Age of housing Travel patterns	Urban Core Earlier Suburbs Later Suburbs Exurbs
Jed Kolko	Census tract	Population density Survey answers	Urban Suburban Rural
Mikelbank	Census tract	Demographic characteristics Economic/employment Government expenditures	Middle America Suburbs White Bedrooms Manufacturing Suburban Success Working Diversity Working Stability Aging Suburbs
RCLCO	Census tract	Population density Employment density Housing structure type Distance from city center	Established High-End Suburb Stable Middle-Income Suburb Economically Challenged Suburb Greenfield Lifestyle Suburb Greenfield Value Suburb

Source: Taken from The Urban Land Institute's Housing in the Evolving American Suburb.

The evolution of the suburbs has lessened the distinction between the cities and suburbs today, to the point where attempting to define suburbs, whether by period of development, density, or distance from the central city, is no longer productive (Moos & Mendez, 2015). The characterization of the suburbs has become so nuanced that the most recent typology by RCLCO includes no less than six different classifications; within each classification, there are wide variations as well.

Research by Nelson and Sanchez (1999) found that there was little evidence to further define subcategories from an overarching categorization as “suburbs”—their analysis showed that there was little difference, if any, between households in areas that had been characterized previously as “exurbs” and “suburbs”. The dissertation research, as a result, builds on this finding and is focused on the entire metropolitan area, not simply the suburbs.

2.3 Demographics and the Development of the Suburbs

Another important element of metropolitan development relates to the residents. The suburbs evolved in the way they did due in major part to the presence of the Baby Boomer generation (those born 1946 to 1964), and the choices their parents made, as well as their choices as young adults starting their families and careers (Fry, 2015).

Mostly anecdotal accounts in news stories suggest that today’s young adults are exhibiting different behaviors and preferences than members of earlier generations did when they were in the same young adult age cohort (Barkho, 2016). Some of these behaviors and preferences include living in cities, delaying marriage until later years, and choosing to live in rented apartments rather than own single-family houses. It is unclear, however, if the settlement patterns of the Millennial generation are different from the earlier generations, and if being a member of a certain generation has anything to do with where they choose to live. Are that many Millennials living in cities? If so, what about Millennials in the suburbs? Is it a city versus suburbs issue for Millennials, or do Millennials prefer a certain level of density? Examining theory on generations as well as consumer preferences can help answer these questions.

2.3.1 Generation Theory vs. Cohort Theory vs. Life Stages

It was useful to examine theory related to consumer preferences to understand how to categorize residents in the dissertation research. People can be categorized by many different

characteristics, such as gender, educational attainment, or household income. One such categorization is by age, as 19-year-olds are likely to have different life experiences impacting their buying behaviors than 55-year-olds, for example.

Even within that categorization, there are additional behaviors or characteristics that are open to interpretation—some research suggests these behaviors are tied to an individual's stage of life, while other research shows the events a group of similarly aged individuals experience within their early lifetime will influence their behaviors and consumer choices. In one scenario, today's 25-to-34-year-olds are exhibiting certain consumer characteristics because they are young adults and those behaviors may change later in life; in another scenario, the consumer choices they make will continue throughout their life span. Unpacking this distinction is important to provide context for the quantitative research in this dissertation, because it provides guidance to understand how to review results as it relates to age over time.

Economic cycles and world events play a large part in the debate between these different ways of thinking related to how to view the habits of members of age cohorts—generation theory, cohort theory, and life stage theory. Generation theory posits that groups of people that are born during roughly the same period experience certain life events that shape them throughout their life (Howe & Strauss, 2000). These life experiences, such as a war or economic recession, result in a common persona for members of each specific generation (Howe & Strauss, 2000). **Table 3: Generations**

Generation Name	Birth Years
Baby Boomers	1946-1964
Generation X	1965-Beginning of 1980s
Millennials/Generation Y	1981-1997
Generation Z	1996-Mid 2000s

Source: Fry, 2015; Howe & Strauss, 2000; Williams, 2015.

The members of each currently defined (Table 3) generation have experienced various defining life events—Baby Boomers, for example, came of age during the Vietnam War, and have been characterized as rebelling against their parents (Howe & Strauss, 2000). These situations and events are believed to have colored many elements of their lives, including their political beliefs and spending habits, as well as the way that they raise their children. Howe and Strauss (2000) argue that these beliefs existed not just when the Baby Boomers were in their early adulthood, as the Millennials are now, but have persisted throughout the Baby Boomers' entire lives. Members of the Millennial generation are generally characterized as being impacted by several major events: the attacks on the World Trade Center and the Pentagon, the wars in Iraq and Afghanistan, and the 2008 Recession (Debevec et al., 2013).

One criticism of generation theory is that the time span that distinguishes membership in different generations is too long. Generations are typically decades long, as evidenced by the 18-year span that encompasses the beginning and end of the Baby Boomer generation. Similarly, the Millennial generation is generally considered to span 16 years. A related theory, cohort theory, posits that like proponents of generation theory that groups of young adults are shaped by major life events that occur during their formative years, but they believe that the time period that spans an entire generation is simply too long, and it is more appropriate to split generations into shorter time periods (Meredith & Schewe, 1994).

Some members of the Millennial generation, for example, were only about five years old when the 2001 terrorist attacks occurred, while others were almost 20 years old in a decidedly different stage of life. Additionally, when the 2008 Recession hit, some members of the Millennial generation were 12 years old, while others were 26 years old, likely resulting in different life experiences for those two groups. Cohort theory would take this into account,

suggesting that individuals are shaped by the life events that occurred as they were beginning to enter adulthood (when they were approximately 17 to 21 years old) (Meredith & Schewe, 1994). Cohorts can be as long or as short as the events that are occurring (Meredith & Schewe, 1994).

Generation theory and cohort theory are not universally accepted, however. An alternative view is that generation theory, especially when viewed through the lens of what is occurring with the Millennial generation today, does not fully explain the shift in preferences and behaviors that is occurring today with those in their early and mid-twenties. An additional criticism of generation theory is that it lumps all the members into one category and assumes that all the members of that category will exhibit similar behaviors (Giancola, 2006). For a generation such as the Millennials, which is considered to be the most diverse generation on record, this can particularly present a problem (Howe & Strauss, 2000).

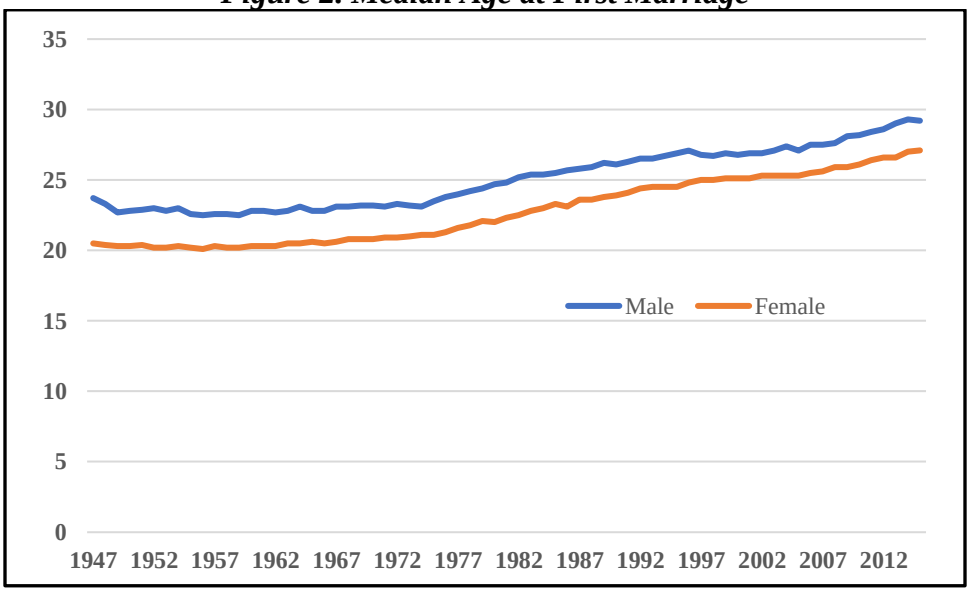
Additionally, generation theory and cohort theory both assume that it is the events that occur as members of the generation are entering adulthood that have the largest and most lasting impact on their future behaviors (Giancola, 2006). While this may be true, later events in life can have an impact on people's behaviors as well and should not be discounted when attempting to discover values and predict behaviors (Giancola, 2006).

There is an alternate theory as to the perceived changes related to the preferences and behaviors of the Millennial generation. Arnett argues that there is evidence a new life stage is occurring, called "emerging adulthood" (Arnett, 2015). Advocates of emerging adulthood argue that there has been a long-term trend in which the average age when individuals make major life decisions, such as buying a house, getting married, and having a child, has been getting gradually older (Arnett, 2015). This shift as to when life decisions are occurring has spanned multiple

cohorts as well as multiple generations, suggesting that being born in a certain year does not have a connection to these life decisions.

Data appear to reinforce this theory. The median age of first marriage has been steadily increasing (Figure 2) for decades (U.S. Census Bureau, 2016). Similarly, the median age of first-time motherhood has risen from 21 years old in 1970 to 26 years old in 2015 (Leonard, 2016).

Figure 2. Median Age at First Marriage



Source: U.S. Census Bureau.

These nuances in how to examine age groups are important when examining how the suburbs have developed. Age is just one variable by which the residents can be examined, however. Other demographic characteristics have been examined when attempting to identify residents of the suburbs.

2.3.2 Previous Consumer Choices Relating to the Suburbs

Demographics and consumer choice played a role in the increase of housing development in the suburban United States. The population boom that occurred in the aftermath of World War II, from 1946 to 1964 (the Baby Boomers), introduced a large source of demand for housing as their parents chose to move out to the suburbs with their larger families (Howe & Strauss, 2000).

Members of the Baby Boomer generation primarily chose to live in the suburbs as they became adults, fueling further demand for new development there (Knox, 2008).

For families that chose to move to the suburbs, the vast majority of them chose to purchase their homes. The homeownership rate for families increased to 63 percent in 1972, up from 44 percent in 1934 (Jackson, 1985). Most of these new homeowners located themselves in single-family housing in newly built suburbs. These new suburbs were unique (when compared with the historical central cities), with the residents described by Kenneth Jackson in *Crabgrass Frontier* as "affluent and middle-class Americans [who] live in suburban areas that are far from their work places, in homes that they own, and in the center yards that by urban standards elsewhere are enormous" (Jackson, 1985).

The choice to relocate to the suburbs was not open to everyone, however. For decades in the mid-twentieth century, the dual-city metaphor of cities versus suburbs was prevalent (Marcuse, 1989). Cities were viewed as "bad" and suburbs as "good". This idea was reinforced by both the government, private businesses, and private industry, whose leaders actively encouraged programs that encouraged the drastic change in the physical landscape of both the cities and the suburbs. Government programs encouraged the proliferation of white, middle-class households in the suburbs, while restricting the movement of minorities and the poor. The post-World War II introduction of the low-down payment mortgage by the government in the form of Veterans Administration and Federal Housing Administration loans made homeownership a reality for millions of Americans that had previously been restricted to renting their own home (Kruse & Sugrue, 2006). The ability to mass produce housing also led to the proliferation of housing in the suburbs (Hanlon et al., 2010).

Homeownership was not a reality for all demographic groups in the United States, however. The Federal Housing Administration enacted a policy of redlining, restricting the availability of mortgages for minorities (Jackson, 1985). This policy, along with the continued focus of the government and private industry on relegating renting to minorities and the cities, led to the suburbs developing as predominantly middle-class white areas (Hanlon et al., 2010). While these practices were ongoing, a policy of urban renewal was taking place in cities, demolishing neighborhoods and concentrating predominantly African Americans in high-rise buildings (Hirsch, 2006).

The effects of urban renewal in the cities also contributed to a flight of many Americans to the suburbs. Mieszkowski and Mills identify the fiscal and social problems of central cities as one set explanation as to why suburbanization took place on such a large scale in the mid-twentieth century (Mieszkowski & Mills, 1993). As urban renewal increased concentrations of poverty in the cities and removed employment opportunities, crime rates began to increase. The civil rights movement, which at times turned violent, also led many white families to leave the cities in search of a place void of racial tensions—by moving to a place without minorities (Hanlon et al., 2010; Peck, 2011). As more and more people left the cities, it diminished the tax base, reducing available services for the remaining residents and leaving even less of an incentive to remain in the city (Mieszkowski & Mills, 1993). Gradually, some suburbs began to change shape—movement of employees into the suburbs increased the need for more service jobs, and the dissolution of redlining began to open homeownership up to minorities (Hanlon et al., 2010).

While suburbs have become more diverse over time, there are still differences between some of the newer suburbs in terms of composition of households. Lang and Lefurgy note

differences in the population of Boomburbs when compared to the United States as a whole; Boomburb residents tend to be better educated and wealthier, and their households tend to be smaller (Lang & Lefurgy, 2007). Metroburbia is the result of the shift towards the service economy, which allows employers to locate outside of the central city, as well as the natural proclivity of people to accommodate to the most comfortable situation possible (Knox, 2008; Castells, 1999). People will want to have as convenient a life as possible, and employment and retail opportunities that are near their home will prove an attractive option (Knox, 2008).

2.3.3 Preferences of The Millennial Generation

The sheer size of the Millennial generation, the largest since the Baby Boomer generation, makes the choices and attitudes of the Millennial generation important to understand, because the actions of even a small portion of the generation can have a noticeable impact. The beliefs of members of this generation, just as with previous generations, will have an impact on what social values are highlighted today, as well as what becomes important in popular culture (Knox, 2008).

There are about 80 million members of the Millennial generation, and many assertions that have been made about the characteristics of members of this generation (Fry, 2015). While there have been many news articles written about the movement of Millennials into the city, and many Millennials have in fact chosen to move into cities, most Millennials live in the suburbs (Fry, 2015; Casselman, 2015). Myers explores the question of whether Millennials will begin to move into the suburbs at an even more rapid pace (Myers, 2016). His belief is that the peak year of Millennials living in cities was 2015 (Myers, 2016). Similarly, many believe that Millennials do not drive as much as earlier generations, which would impact the type of developments they

would be able to live in; recent research has found that the fewer automobile trips by Millennials is a result in a delay of major life events (McDonald, 2015).

There are different beliefs when it comes to how best to decipher the values and attitudes of those in the Millennial generation. This is further hampered by the fact that the Millennials who have entered adulthood have shown different behaviors and attitudes than previous generations did at the same age, but there have been complicating factors, namely the 2008 Recession. The recession and subsequently long recovery may be having an impact as well and may not have a long-lasting impact beyond the next few years as student loan debts are at historic highs (Nasiripour, 2017). Proponents of generation theory argue that the Millennials are a generation with preferences and behaviors that are distinguishable from previous generations when they were a similar age. Some believe that only one aspect of generation theory, the age of the generation's population, should be considered when attempting to decipher the Millennials' preferences.

Because generation theory is largely used for consumer preference research, what academic research has been conducted about the Millennial generation has focused on topics related to the purchasing preferences of this generation, such as their proclivity to own and drive automobiles (McDonald, 2015). In addition, survey research has been conducted by organizations such as the Urban Land Institute, to gauge their preferences for multiple topics, including housing location choice and attitudes towards employment. These surveys have shown evidence that members of the Millennial generation are interested in living in the suburbs (Hudson, 2015).

But members of the Millennial generation may not be content to live in the suburbs as they have developed historically. One central question, which is related to this dissertation

research, is what Millennials will want in terms of a built environment in the suburbs. Previous work by Sanchez and Dawkins (2001), conducted before the Millennials aged into the young adult cohort, suggested that policymakers should design suburbs with characteristics like cities to attract new households. These elements included a mixture of housing types and proximity to employment (Sanchez and Dawkins, 2001).

Indeed, surveys of Millennials have found that they prefer housing types that differ from the traditional single-family detached home that historically predominates the suburbs (Lachman & Brett, 2015). A recent study by Vouchlas & Ulasewicz (2015) found that when observing the spending preferences of the generation, the older Millennials preferred to purchase goods from traditional brick and mortar stores, while the younger Millennials expressed more interest in shopping online. The authors use these findings to reinforce the idea that those wishing to understand the shopping preferences of the Millennial generation should separate the members of the generation into two different age cohorts (Vouchilas & Ulasewicz, 2015).

Others feel that while it is appropriate to categorize the behaviors of the Millennial generation as different from other generations, it is not appropriate to describe all the members of the Millennial generation as being the same (Debevec et. Al, 2013). Survey research by Debevec et. al. found that when separating Millennials into two different cohorts-"younger Millennials" and "older Millennials"-the cohorts exhibited very different preferences. Younger Millennials were less likely to prioritize things like savings and sustainability than their older counterparts (Debevec et. Al, 2013). Abraham and Harrington (2015) found that Millennials are delaying homeownership due to fears about the economy and the preference for renting (although many Millennials have already purchased homes) (Debevec et. al., 2013).

Using the logic of cohort theory, there could potentially be two different cohorts that are in existence within the Millennial generation that could explain the divergence in behaviors. There was a brief recession as the oldest Millennials entered adulthood in 2001 (as well as the terrorist attacks that same year), followed by the deeper recession in 2008. The youngest members of the Millennial generation, however, have just begun entering adulthood in recent years; as a result, while their parents may have experienced the effects of the recession in 2008, their personal employment and earnings have not been shaped as deeply by the recessions as older members of the generation.

The new life stage, "emerging adulthood", likely explains better than generation or cohort theory why traditional life events such as marriage are being delayed. While the 2008 Recession may have further delayed some of these life stages, due to the presence of lagging employment in their early 20s and Millennials' higher than average student debt, they will still take part in these life events, but slightly later in life, as has been gradually occurring with previous generations at the same age. The impact of the 2008 Recession may truly have been that more Millennials enrolled in college than may have occurred if the economy were performing well, which helped further delay other major life events; the rate of college enrollment had the highest increase from in the 2007 academic year since 1968 (Fry, 2010). Members of the Millennial generation are simply continuing a preexisting trend of delaying many of the major life events that have historically happened in their early to mid-twenties to their late twenties and early thirties, and these trends have preceded the Millennial generation's entrance into adulthood.

There are different implications for important issues such as housing choice, spending patterns, and development patterns in the future, depending on whether generation/cohort theory or emerging adulthood theory are correct. Under the former scenario, consumer trends could

truly be changing drastically, resulting in fundamental changes in how people purchase goods and what they prioritize. Under emerging adulthood, consumer trends would likely be similar to previous "generations" when they were a similar age as members of the Millennial generation, albeit those trends may occur slightly later. This would require fewer changes.

2.4 Conclusion

There have been many attempts to describe the suburbs, and the one thing that is clear from all of those classifications is that Mikelbank's assertion is true. When introducing his new typologies of the suburbs, Mikelbank made the argument that it is not appropriate to think of suburbs simply as bedroom communities for the cities (Mikelbank, 2004). Kruse and Sugrue (2006) further comment that it is a danger to view metropolitan areas through that lens, as it simplifies conditions.

This chapter showed how the suburbs have evolved to a point where the distinction between cities and suburbs is likely moot; as a result, the research that follows in this dissertation will be focused on confirming this by creating a streamlined methodology that shows how in the aggregate, changes in residential density are more complicated than a simple suburb-city delineation.

Additionally, this research builds on findings that demographic characteristics play a role in suburban location, by examining demographic and economic characteristics of households in relation to density. The primary focus of this research is whether or not there is a relationship between age of residents and density, especially for the young adult cohort (known as the Millennial generation).

Much of the existing research about the Millennial generation has been geared towards gauging the generation's buying power—at almost 80 million members, the choices of this

generation will have a dramatic impact on the U.S. economy (Fry, 2015). Only recently has research begun to examine their behaviors in terms of residential choices; much of that research is focused on survey research of what Millennials would like to do, and less of what Millennials have done. This dissertation research will contribute to the latter argument—where members of the Millennial generation are located, and whether that is fundamentally different than previous generations at the same age.

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3 Methodology

3.1 Introduction

The goal of this dissertation is to explore density within the context of the metropolitan region, specifically to support the argument that the city versus suburb distinction is no longer relevant, as well as to understand the relationship between density and certain segments of the resident population. Whether the relationship between the 25-to-34-year-old age cohort (the current age of many members of the Millennial generation) and density has changed over time is of particular interest.

There were several questions that were necessary to explore to achieve the dissertation goal:

1. How has residential density changed over time in metropolitan areas?
    a. Is there any distinction between density in areas defined as suburbs and central cities?
2. Is there any relationship between residential density and the 25-to-34-year-old age cohort?
    a. If so, has that relationship changed over time?
    b. Are there other demographic or economic characteristics of the population that have a significant relationship with residential density?
    c. If a relationship exists between residential density and any demographic or economic characteristics, how does it compare in areas that were previously defined as suburbs and principal cities?

There are several types of methodological approaches that could be used: quantitative, qualitative, or mixed-methods (Creswell, 2009). This research utilized a quantitative approach with two parts. The first part of the methodology involved the development of multiple indexes to measure changes in residential density throughout metropolitan areas. The creation of a

density index allowed for a standardized approach across the United States and started everywhere from the same baseline.

The second part of the methodology requires a different approach to investigate whether any sort of relationship exists between density and certain characteristics of the population, including age. A regression analysis is commonly used to determine the existence of relationships (Tabachnick & Fidell, 2007). Regression analysis requires a bit of "art", to determine what variables need to be included to account for as many relationshipsas possible (Tabachnick & Fidell, 2007).

Data constraints and limitations strongly influenced both methodologies. Most publicly available data are focused on households and population, not buildings or real estate. The U.S. Census Bureau provides a great deal of public data on population and housing characteristics and was the main source of data for this dissertation research.

As the previous chapter discussed, many of the new suburban typologies have focused on creating a methodology using widely available datasets that are replicable across the country. The methodology used in this research was not aimed towards developing any sort of typology that could be used to characterize certain types of suburbs or geographies, but was intended to describe changes in metropolitan form occurring around the entire country.

3.2 Unit of Analysis

Determining the appropriate unit of analysis is dependent upon many factors, including the researcher's knowledge and background, the research question itself, as well as more realistic factors, such as data availability. When conducting research related to the built environment, special consideration must be paid to selecting the appropriate level of geography. Incorrect

selection could lead to skewed results, particularly in a study like this, which is so focused on the built environment.

Metropolitan statistical areas ("MSAs" or "metro areas") were chosen to be the larger unit of analysis because they have historically represented one economy. MSA definitions are published by the United States Office of Management and Budget and are updated every few years. The U.S. Census Bureau defines a metropolitan statistical area as "a core area containing a substantial population nucleus, together with adjacent communities having a high degree of economic and social integration with that core" (U.S. Census Bureau, 2018). Metropolitan areas have at least one urbanized area with a population of 50,000 or more (U.S. Census Bureau, 2018).

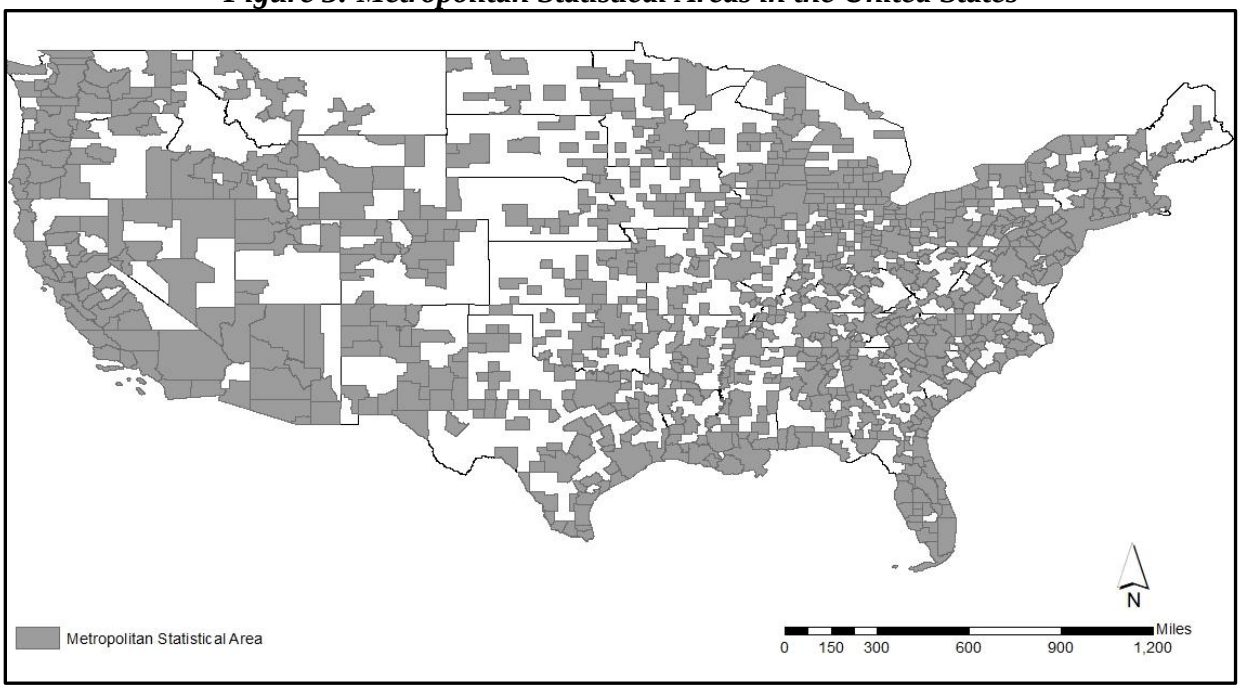
Previous literature provided guidance and support for choosing metro areas as the appropriate larger unit of analysis. Cervero and Wu showed that the concept of the metropolitan area has evolved over time to include multiple economies (Cervero & Wu, 1997). In many cases, an MSA is still a commonly used unit of analysis. The central topic of focus in this research, suburbs, required that observations be framed in the context of the overall metropolitan area, since the hypothesis being explored was that suburbs are no longer relevant. Since there are multiple suburbs located within each individual MSA, there were multiple opportunities to answer the research question (Cervero & Wu, 1997).

Each metropolitan area definition contains all the counties located within that metro area, as well as the principal cities, which are defined as the largest city in the metro area, as well as other cities that meet certain population and employment thresholds (U.S. Census Bureau, 2018). In some cases, principal cities are comprised of entire counties, such as in the case of Alexandria and Arlington, Virginia in the Washington, DC metropolitan area. In other cases, such as

Bethesda, Maryland, they are part of a larger county (Montgomery County). In all cases, however, a "Census-designated place" (CDP), a geography the Census Bureau uses to define areas that coincide with cities or towns. Although boundaries may differ slightly, because CDP boundaries are not based on legal entities, which do not change with population movements, but on organic activity based on economic and population movement (Ratcliffe). These differences should not matter for this research, as the primary goal is to determine changes in density in the overall metropolitan region, not within a principal city specifically.

The most recent metro area delineations, which were released in July 2015, were used for this analysis. The July 2015 delineations list 382 metropolitan statistical areas (U.S. Census Bureau, 2017). Figure 3 below shows the metropolitan area boundaries for the July 2015 delineations.

Figure 3: Metropolitan Statistical Areas in the United States



Source: U.S. Office of Management & Budget; U.S. Census Bureau; ESRI.

Metropolitan areas can provide a useful larger unit of analysis for comparison at the national level, but the primary goal of this dissertation research is to examine changes in density

throughout the metropolitan region. Examining only the economies and populations of each metro area at that scale are too large and varied to prove useful in answering the detailed research questions in this analysis, which require analysis of changes in housing units and residents throughout one specific metropolitan area, but on a national scale. The smaller geographies such as county, CDP, or Census tract, could be used as the unit of analysis within each metropolitan area.

Census tracts were used as the unit of analysis because they were the smallest level of geography where the data required for this dissertation research were available, and the development pattern hypothesized to be occurring are likely occurring at a level of geography that is smaller than the county or CDP. Additionally, previous research by Nelson and Sanchez has shown that population movements do not typically follow political boundaries as cities, towns, or counties (Nelson & Sanchez, 1999). Census tract boundaries, on the other hand, are based not on political boundaries but on population growth. Looking at several contiguous Census tracts together may reveal a trend not evidenced by an arbitrary legal boundary that did not likely take population movement into account.

An additional advantage to the use of Census tracts is that they are the smallest level of geography available. Focusing on the smallest unit of analysis decreases the risk of an important finding being overlooked. Giuliano and Small (1999) utilized transportation analysis zones and employment data to develop employment subcenters that were then used as the unit of analysis. In the case of their analysis, employment subcenters were the unit of analysis, with the focus of their research on the characteristics of just that type of geography, the established employment subcenter. In contrast, Redfearn (2007) aimed to determine the presence of employment subcenters by location and density, instead of assuming their existence, as Giuliano and Small

had done. To accomplish this, Redfearn utilized employment and population data by Census tract, provided by the Southern California Association of Governments. Redfearn's use of the Census tract as the unit of analysis, with the population and household data as variables to use to answer the research question, revealed that while Giuliano and Small's employment subcenters did exist, there were additional smaller subcenters. These subcenters were not captured by Giuliano and Small's analysis because while they looked at Census tracts and Transportation Analysis Zones originally, their final analysis used a larger preset unit of analysis (Redfearn, 2007).

A Census tract is defined by the U.S. Census Bureau as a subdivision of a county or county equivalent that typically has between 1,200 and 8,000 people, with a geographic area that depends upon the density of settlement (U.S. Census Bureau, 2016). While Census tract definitions are designed to stay relatively permanent over time, they can change from decade to decade (U.S. Census Bureau Geographic Products Branch). These changes can make it difficult to perform longitudinal comparisons using Census tracts as the unit of analysis, as data from the 1990 Census using Census tract definitions in 1990 would not be a one-for-one comparison with data from the 2000 Census using Census tract definitions in 2000.

The Urban Institute and Geolytics have used guidance from the U.S. Census Bureau that reveals the Census tract boundary changes over the years to create a database that allows this one-for-one comparison to take place using datasets from multiple Decennial Censuses. In the past, it was not easy to compare data at the Census tract level from several years of the Decennial Census because the definitions of some Census tracts changed in the different Decennial Censuses. This database, known as the Neighborhood Change Database, presents data at the Census tract level for several Decennial Censuses as well as the 2006-2010 American

Community Survey, using constant 2010 Census tract boundaries. The database also provides geographic identifiers for each Census tract, which allowed for Census tracts to be matched within their given city (if applicable), state, and metropolitan area. The 2015 OMB metropolitan statistical area definitions were used for this matching.

3.3 Data Sources and Software

Answering the research questions in this analysis required the use of multiple types of data, including population and household data, as well as data on the built environment. Later sections of this chapter discuss the exact data variables needed for this analysis, but they included information such as household income, the number of housing units in a structure, the total population, the age of the population, and the number of housing units in each Census tract. The U.S. Census Bureau remains the best source of publicly available data for population and household data, as well as data regarding the residential building stock. These data are available from a variety of Census Bureau surveys, including the Decennial Census and the American Community Survey.

Every ten years the U.S. Census Bureau conducts the Decennial Census. Mandated by the U.S. Constitution, the Census asks questions about every person in the United States, as well as some housing characteristics. In the past, every single housing unit in the United States received the "short form" of the Census, which asked basic questions about the names, ages, and marital status of the people in the household (U.S. Census Bureau, 2017). Until the 2010 Census, a random sample of households received the "long form" questionnaire in each decennial Census, which in addition to the short form questions included detailed questions such as the number of units in the building in which they lived, the family's household income, and ethnicity (U.S. Census Bureau, 2017).

The Census Bureau changed the format of the decennial Census in 2010—the long form survey was eliminated. Every household received the same short form questionnaire, which consisted of ten questions. These ten questions asked about the name, age, and ethnicity of the housing unit occupants, as well as whether the unit was rented or owned (Department of Commerce, 2010). Due to this change in methodology, the change in multi-unit/multifamily structures by Census tract can only be compared for the 1990-2000 period using data from the decennial Census. Additional data are available from the American Community Survey, however.

In 2005, the Census Bureau began conducting the American Community Survey, which asks questions like the questions asked in the "long form" of the previous decennial Censuses. The goal of the American Community Survey is to "provide up-to-date information about the social and economic needs" of communities (U.S. Census Bureau, 2016). The idea behind the American Community Survey was that major changes were occurring in the time between the Decennial censuses, and those changes were not being captured due to the long time horizon. In the 2000 to 2010 period, for example, there was an entire boom and bust in the housing industry that occurred after 2000 but before 2010. If the American Community Survey did not exist, the drastic changes that occurred in the late 2000s would not have been reflected in the data.

Because the American Community Survey is based on a sample of U.S. households, three-year and five-year estimates are provided at the smaller levels of geography to increase accuracy (U.S. Census Bureau, 2). These are still estimates, however, despite the attempts to increase accuracy by using averages, and a margin of error does exist for each of the observations.

The Neighborhood Change Database was used to gather the bulk of the data for this dissertation (Table 4) instead of the U.S. Census Bureau website because the Neighborhood

Change Database produces Decennial Census and American Community Survey data standardized to 2010 Census tract boundaries, something not available from the Census Bureau's website. Data were obtained from the U.S. Census Bureau's American FactFinder website for the 2011-2015 American Community Survey because those data are presented in 2010 Census tract definitions and were not available from the Neighborhood Change Database.

Table 4. Data Sources

Survey & Year	Level of Geography	Data Source
1990 Census	Census Tract (2010 Boundaries)	Neighborhood Change Database
2000 Census	Census Tract (2010 Boundaries)	Neighborhood Change Database
2006-2010 American Community Survey	Census Tract (2010 Boundaries)	Neighborhood Change Database
2011-2015 American Community Survey	Census Tract (2010 Boundaries)	American FactFinder

Source: U.S. Census Bureau; Urban Institute; Geolytics.

There are almost 70,000 Census tracts in the United States, but some Census tracts are in places that may not actually have any housing units on them. Some Census tracts from the Neighborhood Change Database are simply missing data (some tracts do not have American Community Survey data available), while other observations revealed unreliable data, such as more households earning less than $25,000 per year than total households. Missing observations were excluded from the analysis, but Census tracts with zero multifamily housing units were included. Census tracts with zero multifamily housing units were converted to a value of .01 from 0, to allow for index calculations. While a full sample would have been preferable, there were enough observations to provide reliable results.

Data analysis was conducted using Stata software. Stata provided the best software available to combine the data from the Neighborhood Change Database and American FactFinder, as well as to add whether a Census tract was in a principal city or a suburb. Data were matched in Stata using the geographic identifier for the Census tract.

For the analysis in this dissertation, spatial analysis occurred via GIS. GIS can also be used to identify unexpected patterns the researcher did not expect to observe when they began their analysis. GIS allows for the display of multiple geographic features, such as highways and natural features (rivers and mountains) in addition to whatever elements are being analyzed. Giuliano and Small (1999) use GIS to show the location of employment centers in the Los Angeles metropolitan region and the location of freeways as well. Redfearn suggests that employment subcenters tend to follow some of these features; the use of a GIS map can easily display some of these relationships for the researcher (Redfearn, 2007). This type of analysis can help the researcher determine what other variables may be important to analyze further.

The use of GIS was especially important for this analysis because it showed where residential density is physically changing in the context of the overall metropolitan region, a story that would not be nearly as compelling if told only with words. The maps used in this analysis show how density has changed within metropolitan areas and shows visually why the suburb and city distinction is no longer particularly useful.

3.4 Methodological Approach

3.4.1 Observing Changes in Density Over Time—Index Construction

The first research question centers around the issue of density and whether any trends have emerged in the metropolitan area context. Development of an index, such as a residential property price index, is a common way to measure trends (Grover & Grover, 2013). An index calculates the change in a given year compared to a baseline year. The benefit of creating an index is that it creates the same starting point for a variety of data points (Federal Reserve Bank of Dallas). This allows for a Census tract located in a city that starts off with more multifamily

units to be measured in the same manner as a Census tract located in a rural area with little or no multifamily units.

This analysis created several indexes based on residential density to see if there have been any measurable changes in density throughout metropolitan areas overall, but also in principal cities and suburbs. One common way to measure residential density is to examine the number of housing units in each unit of measurement, a similar approach to Kolko's (2015) measurement of people per acre when measuring population density. A unit of measurement could be a Census tract or an area. One unit of measurement is the number of housing units per acre (Lincoln Land Institute, 2007). The Neighborhood Change Database provides a measurement of Census tract size by square meters in the form of two variables—land area and water area. Only land area was used for this analysis because water area is undevelopable, thus density would never change for the water area variable.

There are several types of residential land uses that could be used to create the density indexes—single-family (both detached and attached) housing units, multifamily (units in buildings with either two to four or five or more housing units) and mobile homes/manufactured housing. For the purposes of this research, single-family units (both detached and attached) were considered together, while multifamily units were defined as units in buildings with two or more units. Mobile homes were not independently analyzed in this analysis, due mainly to the small count and resulting large margin of error in many cases, but they were included in the total housing units count that was included in the analysis. Indexes are created for the total housing units, as well as multifamily housing units and single-family housing units.

Choosing the wrong time period can lead to false conclusions or the overstatement of a finding (Collier & Mahoney, 1996). A recent Urban Institute analysis of household and

population trends found that the frequently cited fact that Millennials are living with their parents at a higher rate than previous generations due to the recent recession is not true; the rate of 18 to 34-year-olds (the age Millennials are today) living at home with their parents has been steadily increasing for decades (Goodman et al., 2015). To best eliminate this concern, the time period from 1990 to 2015 was analyzed, to make sure that a long enough time frame was used to capture multiple generations moving through the 25-to-34-year-old cohort.

The goal of creating the residential density indexes was to show where development has been greatest over time. Several different indexes were created for the purposes of this exercise:

1). Total Housing Unit Density (per Census tract)

2). Multifamily Density (per Census tract)

3). Multifamily Share of Total Housing Units (per Census tract)

4). Single-Family Density (per tract)

5). Single-Family Share of Total Housing Units (per Census tract)

The following calculations was used to construct the index for each year:

$$Residential\ Density\ Index_{year} = \left(\frac{x_{year}}{x_{1990}}\right) * 100$$

where *x* equals the housing unit being measured (total housing units, single-family units, or multifamily units) in terms of absolute number of units or (for single-family and multifamily housing units) share of total housing units in each Census tract, for the years 1990, 2000, 2010 and 2015.

Examining the number of housing units per acre and per Census tract yields the same results. This is because in each case, the size being compared over time stays the same; calculating the index values for the total number of housing units in each Census tract for 1990 and 2000 would yield the same index values for the total housing units per acre for 1990 and

2000. Take for example, a Census tract with a land area of five acres with 5 multifamily units in 1990 and 30 multifamily units in 2000:

$$Residential\ Density\ Index\ (per\ acre)_{2000} = \left(\frac{6}{1}\right) * 100 = 600$$

$$Residential\ Density\ Index\ (per\ Census\ Tract)_{2000} = \left(\frac{30}{5}\right) * 100 = 600$$

The indexes based off the multifamily and single-family shares were included because it is likely that the indexes using absolute numbers could lead to inflated index increases in suburban and exurban areas, where single-family development had previously been prevalent. Additionally, if many single-family units were built in addition to multifamily units, that would be captured by the total housing unit density index.

The goal of all the residential density indexes was to determine the change in residential density at the Census tract level within the metropolitan area. The previous chapter discussed the evolution of the metropolitan area, from a monocentric region to a polycentric region. The shift took place partly due to the proliferation of development in the suburbs, which originally was focused on single-family development, but towards the end of the twentieth century included other types of land uses, as employers and supportive services moved in to the suburbs. The residential density indexes provide a clearer depiction of how development patterns have evolved since 1990 and show whether there is any use in comparing suburbs and cities in any sort of context.

The residential density indexes will show where density is increasing, and in what manner. It is important to examine changes in both multifamily and single-family development, because what type of development is occurring has implications for planning practitioners. The previous chapter discussed the changing nature of suburban land use, but it is important for planners to know what type of housing is being built, particularly given traffic concerns today.

GIS was used to confirm findings from the quantitative analysis and to determine the extent of any spatial mismatch within metropolitan areas, particularly to examine how each of the density indexes changed for the Census tracts located near one another (both within suburbs and principal cities) as well as within the entire metropolitan area. Small and Song (1994) employed GIS for similar purposes in their analysis of monocentric and polycentric employment and population patterns in the Los Angeles metropolitan region. They used measures of density, in this case 20 employees per acre, as one way to identify an employment center (Small & Song, 1994). The location of these centers were then plotted on a map, which when plotted, clearly shows a corridor that extended from downtown Los Angeles to the Pacific Ocean (Small & Song, 1994).

This dissertation research focuses on analyzing density changes throughout the United States, whereas Small and Song's research focused on the Los Angeles metropolitan region. Examples of the residential density changes in two metropolitan areas (Nashville and Denver metro areas) were included in this dissertation for narrative purposes. These two metropolitan areas are not indicative of the entire United States, but as discussed previously, GIS images can provide an alternative picture of a trend that is not as clearly shown using tables and numbers.

3.4.2 Regression Analysis

The first part of the quantitative analysis was designed to answer the research question related to just changes in density throughout the metropolitan region. A separate methodology was required to answer the second research question exploring a potential relationship between residential density and demographic characteristics of metropolitan region residents.

> *Is there any relationship between residential density and the 25-to-34-year-old age cohort?*

The residential density indexes from the first part of the research provide context for answering the second research question, which combines density with population and household characteristics. A regression analysis provides the best method for determining if a relationship exists between density and age. It also requires the investigation of whether there are other characteristics that play a (possibly larger) role as well. Previous analyses have used regression analysis to examine similar questions related to suburbanization, density, the built environment, and population and household characteristics, and these previous analyses have shown that characteristics other than age are related to changes in suburban patterns (Lang & Lefurgy, 2007).

Nelson and Sanchez (1999) used such characteristics to identify patterns associated with suburban and exurban geographies. In their analysis, they used a regression analysis of characteristics including income, household size, and commute time to work to determine whether or not similar types of households cluster together in exurban and suburban areas. Similarly, research by Lang and LeFurgy (2007) into the development of suburban cities known as Boomburbs found that residents of Boomburbs were more likely to obtain higher levels of education and have higher household incomes.

Before conducting a regression analysis, an analysis using Pearson's correlation coefficient was performed, to determine if there was any correlation between density (using several different measures) and the 25-to-34-year old age cohort, as well as other household and population characteristics. The results, discussed in the next chapter, suggest that a correlation does exist, and the level of correlation has changed over time.

A correlation analysis reveals whether an association exists but does not reveal the extent of the relationship (Tabachnick & Fidell, 2007). A regression analysis predicts what one variable

(density) will be based on other variables (demographic and household characteristics). An ordinary least squares (OLS) regression was conducted using the following equation:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots \beta_p x_{ip} + \varepsilon_i$$

where *y* is the dependent variable, total housing units per acre, and the *x* values are the independent/control variables. The OLS regression was run for the years 1990, 2000, 2010 and 2015, to determine if there are any relationships between density and certain resident characteristics, and if they exist, whether there has been any change over time.

Previous academic literature was used as a baseline to choose which variables to include. Explanation for the inclusion of each variable are discussed below.

Dependent Variable

The research question centers around density and resident characteristics. The literature review presented survey results by Lachman and Brett (2015) that showed many Millennials had a preference for higher-density, mixed-use living. But those were the respondents' preferences, not necessarily their actual actions. Density was chosen as the dependent variable using the premise that supply will be located where there is demand, therefore density will change dependent upon demand. This study uses the number of total housing units per acre per Census tract as the measure of density. Previous research has used similar measures—an analysis by Kolko (2015) related to the suburbs looked at total households per square mile.

The distribution of the dependent variable observations required that the log of the variable be used in the regression analysis, resulting in the following regression equation:

$$(log)y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots \beta_p x_{ip} + \varepsilon_i$$

3.4.2.1 Independent/Control Variables

Several variables were included in the regression analysis as either an independent or control variable. Each observation in the data represents the number of units or population in each Census tract; the 25-to-34-year-old variable, for example, is the number of 25 to 34-year-olds that reside in that Census tract. A continuous variable was generated for each segment of each variable, except for the principal city variable, which is a dummy variable consisting of "0" or "1".

The bulk of the variables were included as a percentage, to reflect the share of either the total housing units, total households, or total residents. It was necessary to use a percentage to account for differences in population size by Census tract by year. It was not important for the purposes of this analysis if there were more 25-to-34-year-olds in each Census tract in a given year, it was important if the share of 25-to-34-year-olds compared to other age cohorts changed in a given year. For each of the economic and demographic characterizing variables, one portion of the share was excluded from the regression analysis, to account for collinearity issues.

Not all the variables discussed below were included in the final regression equations; for several of the variables, there was a high correlation between other variables, requiring that one of the variables be removed. The residential density was the supply side of the equation, the dependent variable; developers will build more supply if there is demand for additional supply (the independent variables). Each of the independent variables that were included in the analysis are characteristics that have been cited in previous literature as defining characteristics related to density and/or the suburbs.

Share of Each Age Cohort. One of the central elements of this research relates to age—more specifically, that members of the Millennial generation have different preferences than members of other generations at the same age. Age was included for two reasons—first, to determine

whether members of the 25 to 34-year-old age cohort have shown different behaviors over time regarding the density of where they choose to live, and second, to determine whether there was a relationship between higher-density areas and any other age groups. If members of the Millennial generation are acting differently than previous generations at the same age (25-to-34-years-old) and are moving into higher-density areas (regardless of whether or not they are in the suburbs), then there should be a positive, significant relationship between the share of 25-to-34-year-olds in each Census tract and the total housing units per acre.

*Principal City Status***.** A central part of this dissertation research relates to density and the suburbs. Like the issue explained by Nelson and Sanchez (1999) regarding the American Housing Survey and suburban/exurban status, the American Community Survey and the Decennial Census do not include a suburban indicator. The Office of Management and Budget (OMB) publishes metropolitan area definitions every few years. The most recent release (July 2015), included principal city designations for each metropolitan area (U.S. Office of Management and Budget, 2015). I created a new variable, "principal city" to delineate between Census tracts located in cities and Census tracts located in suburbs using the Census tract identification from the Neighborhood Change Database. The place code was then located for each principal city in each metropolitan area, and each Census tract located in a place with the same name as the principal city was then given a designation of "1". It was expected that Census tracts with high numbers of housing units per acre will be found in the central cities.

Educational attainment. One of the identifying characteristics of Boomburbs was that residents of Boomburbs tended to be better educated than residents of other areas (Lang & Lefurgy, 2007). It was unclear whether to expect any sort of positive or negative relationship with density, but the variable was included because educational attainment, along with household income, is used

by many practitioners (both public and private) to gauge potential residential demand going forward in areas.

Race/ethnicity. Historically, the suburbs were racially homogenous areas and cities tended to have residents of various races and ethnicities (Hanlon, 2010). The literature review pointed to suburbs becoming more heterogeneous in recent decades. If historical norms persist, however, it is expected that there would be a positive relationship between density and Hispanic residents and density and black/African American residents.

Household Income. A mix of residential structure types would likely result in a mix of incomes, in contrast with a traditional bedroom suburb consisting of single-family detached housing (Hanlon, 2010). It was expected that higher-density Census tracts would have a mixture of household incomes, because they would likely be more evolved suburbs with a mixture of land uses and housing types.

Commute Time to Work. Jobs have followed households into the suburbs over time, but traffic has continued to worsen, as one's house and place of employment are not necessarily located in the same suburb (Cervero & Wu, 1997). The average time it takes to commute to work has increased for many who live in the suburbs (Calthorpe & Fulton, 2001). It was expected that there would be a positive relationship between density and the shorter commute times, and a negative relationship between density and the longer commute times.

Share of Multifamily Housing Units. Multifamily housing units are by their nature, higher-density than single-family housing units. The first part of the dissertation research answered the question of whether the share of multifamily housing units has changed in the areas known as the suburbs has changed over time, while the regression analyzed the relationship between density and multifamily housing. It was expected that there would be a positive relationship between

density and multifamily housing, since multifamily units are by their nature higher-density than single-family units.

Share of Single-Family Housing Units. It was expected that there was a significant, negative relationship between the share of single-family units and the total housing units per acre per Census tract, since single-family units are by nature less dense than multifamily.

Tenure and Vacancy Status. Rented units can be in single-family or multifamily units. It is possible that it is not the built environment that is changing, but that more units in the suburbs are rented instead of owned. It is unclear, however, whether there would be a relationship between tenure and density, because whether a housing unit is rented or owned does not have anything to do with the built environment. Similarly, whether or not a housing unit is vacant should not have any relationship with density.

The next chapter provides the results and findings of both parts of the dissertation research. Each part is intended to inform the other, with the first part of the research showing how residential density has changed over time in metropolitan areas. Once those changes in density have been observed via the residential density indexes, that knowledge can be used when examining the potential relationship between density and the residents.

3.5 Data Constraints and Limitations

There are several limitations that the data presented that must be discussed. Data were only available in aggregated form, so instead of observations at the household, housing unit or person level, the number of occurrences in a certain category for each Census tract was the unit of observation—the number of 25-to-34-year-olds in a Census tract, for example.

The main focus of the regression analysis required the use of age variables. The age of householder variable was the preferred metric, because it would have excluded those who are

living with their parents (and likely not responsible for choosing where they live). That variable was not available in the Neighborhood Change Database, however, so the age of population was used, which does include those living with their parents.

3.6 References

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4 Results and Findings

The goal of this chapter is to report findings and results from the two quantitative analyses—the analysis of how the residential built environment has changed and the analysis of the relationship between the built environment and its occupants. The findings and results answer the main research questions—has the metropolitan form, particularly the suburbs, changed in recent years in terms of residential land use, and is there any relationship between residential density and the characteristics of its residents, especially age?

The first part of this chapter reports the various index results and details how residential density has changed over time in the context of the overall metropolitan area as well as how residential density in and surrounding principal cities has changed; the goal of the second part is to explore whether there is any sort of relationship between density (in the form of total housing units per acre) and the characteristics of residents, and if a relationship exists for any demographic or economic characteristics, how it has changed over time. The implications of these results are discussed in the following chapter.

4.1 Changes in Residential Density Over Time

The change in residential density in metropolitan areas was analyzed by creating indexes using three different measures—total housing units, total multifamily units, and total single-family units. For the total housing units index, the total number of units per Census tract was measured. In the case of the multifamily and single-family indexes, both the number of units per Census tract and the share of the total housing units were measured. These indexes show both the magnitude of changes in density across metropolitan areas as well as where within metropolitan areas those changes in residential density have occurred.

4.1.1 Total Housing Units Index

Table 5 below shows the summary statistics for the total housing units density index, revealing how the overall trends in the number of housing units per Census tract changed from 1990 to 2015. All index values are 100 for the 1990 total housing units density index because the number of housing units in each Census tract in 1990 was used as a baseline. Index values for 2000, 2010, and 2015 all compare the number of total housing units in that Census tract in that particular year to the number of total housing units in that Census tract in 1990.

Table 5: Summary Statistics, Total Housing Units Density Index

		Total Housing Units Density Index			
Index Year	**No. of Obs.**	**Min.**	**Max.**	**Mean.**	**Std. Dev.**
1990	68,119	100.00	100.00	100.00	0.00
2000	68,119	2.34	22,500.00	125.67	166.12
2010	68,119	0.13	49,300	180.35	499.41
2015	68,119	0.13	50,600	189.09	544.43

Source: U.S. Census Bureau; Urban Institute; Geolytics.

The table shows clear outliers for 2000, 2010, and 2015 in terms of the minimum and maximum index values and the mean value steadily increased from 100.00 in 1990 to 189.09 in 2015. The standard deviation values suggest that there were some Census tracts where the number of housing units drastically increased compared to the number of housing units that existed there in 1990.

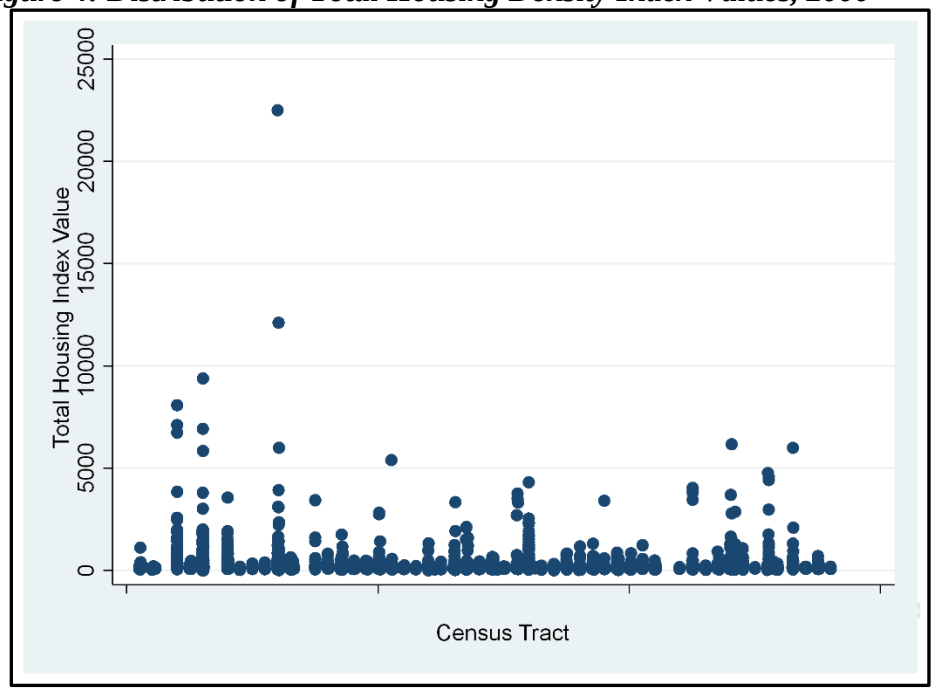
Indexes were calculated to understand changes in density relative to the individual location, so it is important to understand the reason behind the massive increase in index value for these Census tracts, as well as just how much of an impact they have on the summary statistics. It was useful to examine both the outliers as well as the summary trends without the outliers included, because a few outliers could potentially mask the fact that there has been relatively little change in density over time for the clear majority of Census tracts.

The Census tract with the maximum value for the total housing unit density index (22,500) in 2000 was in Broward County, Florida, defined by the U.S. Office of Management and Budget as a suburban area in the Miami-Fort Lauderdale-West Palm Beach, FL metropolitan area. The number of housing units in that Census tract rose from six in 1990 (0.01 housing units per acre) to 1,350 housing units in 2000 (2.95 housing units per acre). Most of those housing units were single-family units in both 1990 and 2000.

The largest index value in 2010 was found in suburban Ada County, Idaho, part of the Boise City metropolitan area, where the total number of housing units rose from 38 in 2000 to 2,465 units in 2010. The bulk (90.7 percent) of those additional housing units (2,236) were single-family units. The index rose significantly from 760 in 2000 to 49,300 in 2010, with the total density per acre increasing from 0.02 residential units per acre to 1.33 residential units per acre. The 2015 maximum index value (50,600) was in the same Census tract in Idaho, with a density increase to 1.36 units per acre. While the Ada County Census tract was still the largest index value overall because the increase in total housing units was still large compared to 1990, the number of total housing units rose little between 2010 and 2015, increasing by only 65 housing units.

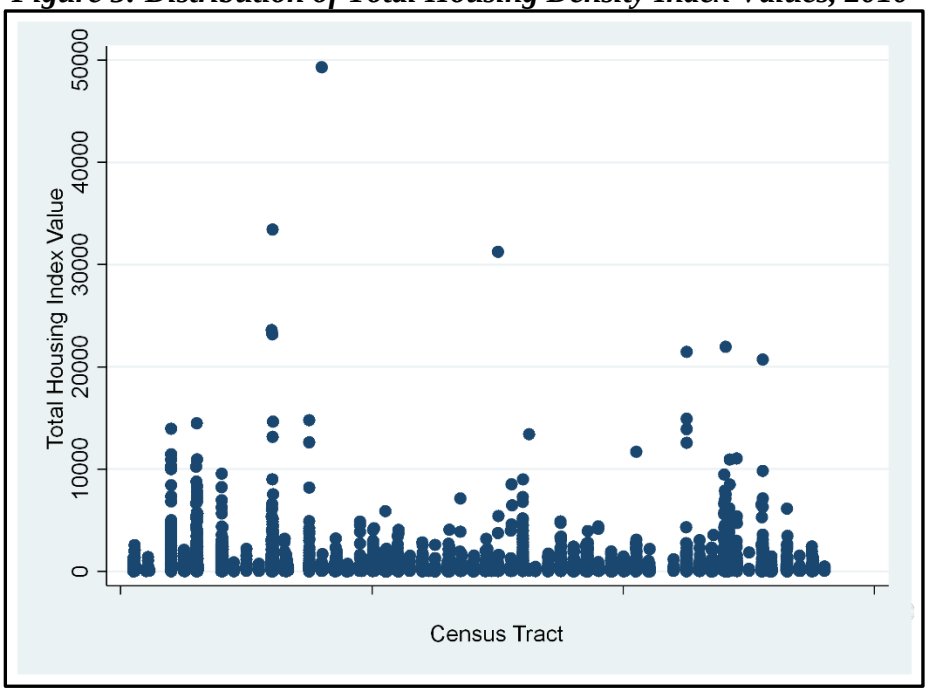
Figures 4 through 6 below show that there are clearly multiple outliers such as the Ada County Census tract in the total housing value indexes—in 2000, the 95th percentile index value was 187.18, while the maximum value was 20,500. Examining just the 3,406 Census tracts with an index value above 187.18 (the top 5 percent), the mean index value increased to 393.47. The average number of housing units for those Census tracts increased from 537.78 in 1990 to 1,423.33 in 2000. These outliers are distributed between Census tracts located in principal cities and suburbs similarly to the overall distribution of Census tracts in the dataset.

Figure 4: Distribution of Total Housing Density Index Values, 2000



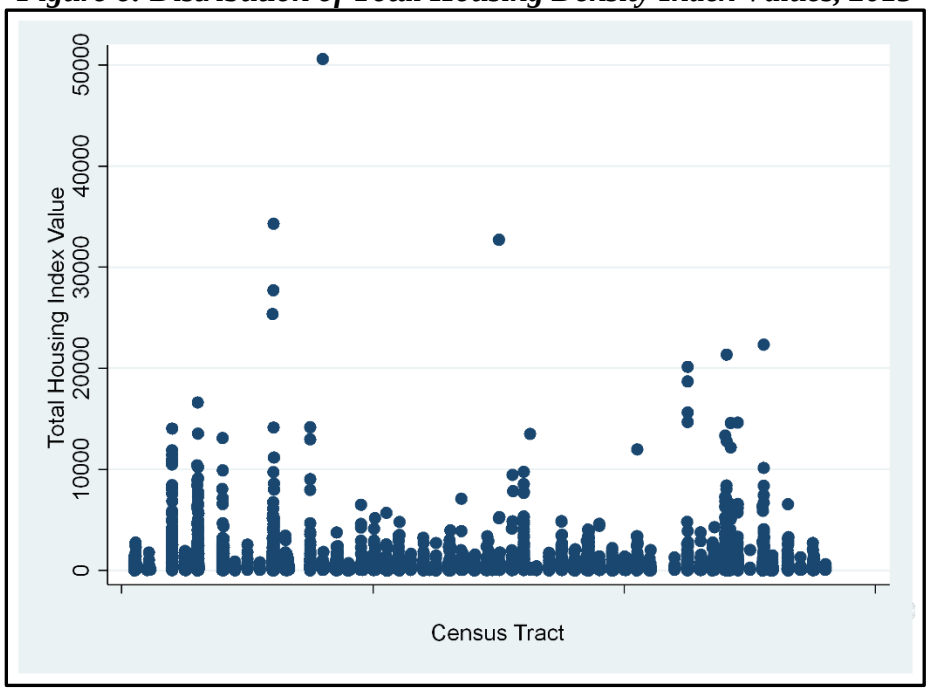
Source: U.S. Census Bureau; Urban Institute; Geolytics.

Figure 5: Distribution of Total Housing Density Index Values, 2010



Source: U.S. Census Bureau; Urban Institute; Geolytics.

Figure 6: Distribution of Total Housing Density Index Values, 2015



Source: U.S. Census Bureau; Urban Institute; Geolytics.

When the top 5th percentile of values are excluded from each year to account for these outliers, a clearer picture emerges. Table 6 below shows the summary statistics when index values in the top 5th percentile of all index values for each year are excluded. The values show a steady increase for all the values except for the 10th percentile values, which gradually decreased over time. The distribution excluding the top five percent is much more even, with the 90th percentile values all below 200. The number of Census tracts below the top 5th percentile located in principal cities changed little from 40,746 in 2000 to 40,683 in 2015.

Table 6: Summary Statistics, Total Housing Units Index (Excluding Top 5th Percentile)

Index Year	No. of Obs.	10th Percentile	50th Percentile	90th Percentile	Mean	Std. Dev.
2000	64,713	94.65	106.34	137.75	111.58	19.32
2010	64,713	91.46	111.90	184.53	127.48	50.41
2015	64,713	90.58	112.72	194.54	130.39	55.81

Source: U.S. Census Bureau; Urban Institute; Geolytics.

The average number of housing units per acre for the values excluding outliers rose from 3.08 units per acre in 1990 (for all housing units, since the index values were all 100) to 3.57 units per acre in 2015. This suggests that while residential density has been increasing overall, it is not increasing at a rapid rate for most areas.

4.1.1.1 Changes Over the Entire Period

The summary statistics provide insight on the general trends, but they do little to inform more detailed trends that may be occurring, as the examination of outliers indicate. An additional way to analyze the data is to examine how density in tracts has changed over time, and whether there were any geographic differences.

For about one-third of the Census tracts (22,840), the total housing stock density index increased over all four periods. Over one-quarter (30 percent) were in a principal city, and the largest number of Census tracts with increases in density over the entire period were located in California, Florida, New York and Texas. This is mainly due to the size of these states—the state with the smallest number of units that consistently increased, for example, was the District of Columbia (31 tracts), which only has 173 Census tracts in the analysis; Texas (1,750 tracts), for comparison, had 4,785 Census tracts.

On a percentage basis, the states with the most Census tracts where overall housing increased over all periods were Idaho (54 percent), followed by Washington (52 percent), Oregon (51 percent), Utah, Maine, North Carolina, and Vermont (48 percent each).

The average number of housing units per acre rose from 1.84 in 1990 to 2.72 in 2015 for Census tracts that had consistent increases, much lower than the 3.08 units per acre in the overall dataset, but a faster increase. Census tracts in principal cities began with a higher density than Census tracts located in suburbs, increasing from 4.51 units per acre in 1990 to 6.38 units per

acre in 2015 in principal cities and increasing from 0.72 units per acre in 1990 to 1.18 units per acre in suburbs.

Over three-quarters of Census tracts (76.9 percent) had more housing units in 2015 than in 1990. Only slightly more than half (56.1 percent) off Census tracts had a higher index value in 2015 than 2010, however. For 2,735 Census tracts (4 percent), the total housing stock density index decreased over all four periods. Ohio had the most Census tracts with a continuous decrease (243), followed by Michigan (207), Texas (195), Illinois (187), and Pennsylvania (178).

4.1.1.2 Changes within Metropolitan Areas

It is important to analyze where the changes in density occurred within the metropolitan area as well as the scale that density changes occurred. The literature review chapter discussed the shift in the suburban form, and the city versus suburb distinction is still a commonly used comparison method. This research endeavors to explore whether that is still a useful comparison. Table 7 shows the difference in summary statistics between Census tracts located in principal cities and suburbs for the 2000, 2010, and 2015 indexes. In most cases, there is fewer than a 30 basis points (bps) difference in the summary statistics between the two typologies. This suggests that analyzing changes in residential density by simply distinguishing between principal cities and suburbs is not useful.

Table 7: Summary Statistics for Total Housing Units Index, Principal Cities vs. Suburbs

	10th Percentile		50th Percentile		90th Percentile		Mean		Std. Dev.		No. of Obs.	
	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb
2000	91.44	97.19	102.81	110.40	145.32	153.96	122.02	127.81	142.6	178.45	25,181	42,938
2010	87.69	94.71	107.27	118.00	209.81	243.12	172.18	185.14	524.26	484.19	25,181	42,938
2015	86.23	94.21	107.38	119.54	225.10	259.1	181.57	193.5	580.87	521.83	25,181	42,938

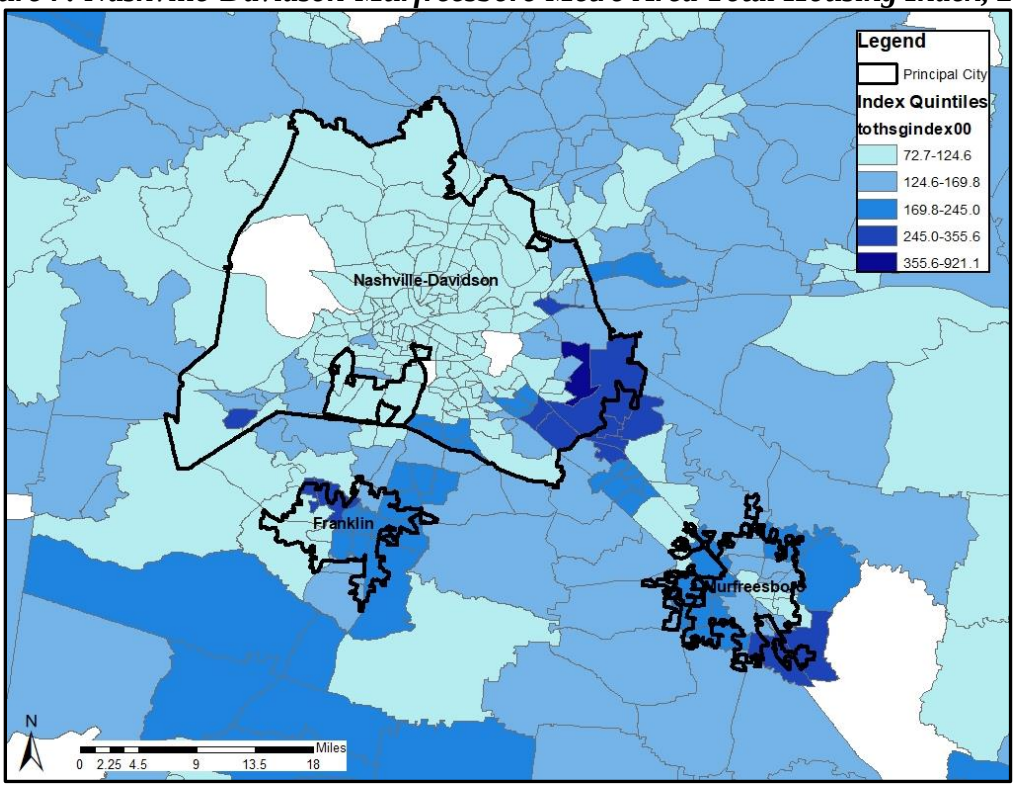
Source: U.S. Census Bureau; Urban Institute; Geolytics.

The change in density was similar for suburbs and principal cities, although the starting point was different. The average number of units per acre for Census tracts in suburban areas

rose from 1.28 units per acre in 1990 to 1.55 units per acre in 2015, while the average number of units per acre rose from 6.13 units per acre to 6.84 units per acre.

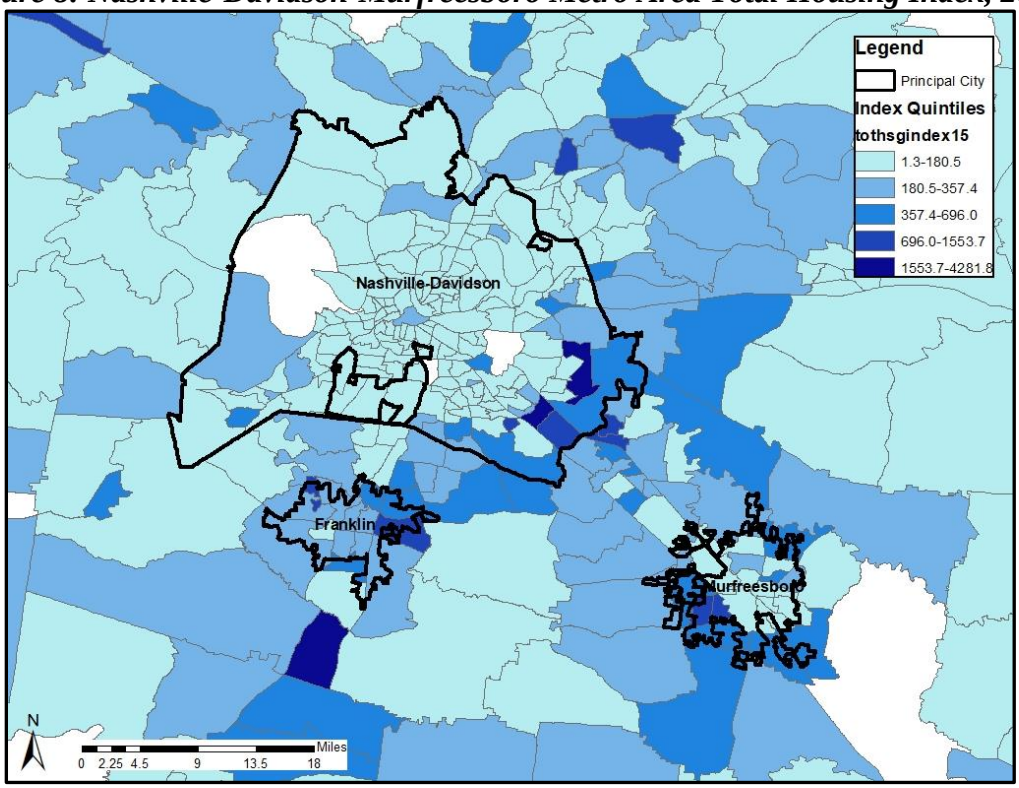
Further evidence of the variation of the magnitude of changes in density is shown by examining the distribution of total housing index values in metropolitan areas using GIS. Figures 7 through 10 show the change in the total housing index in the Nashville metropolitan area and the Denver metropolitan area. Index values in each map are color coded by quartiles, with the darkest tracts representing the highest index values. In both cases, whether a tract was in a principal city did not provide any sort of indication as to how density would change over time in that tract. In the case of the Nashville metro area, the Census tract with the largest index value was within the principal city in 2000; by 2010 and 2015, those Census tracts were located outside the principal city. For the Denver metro area, those Census tracts were all located outside the principal cities for all three years.

Figure 7: Nashville-Davidson-Murfreesboro Metro Area Total Housing Index, 2000



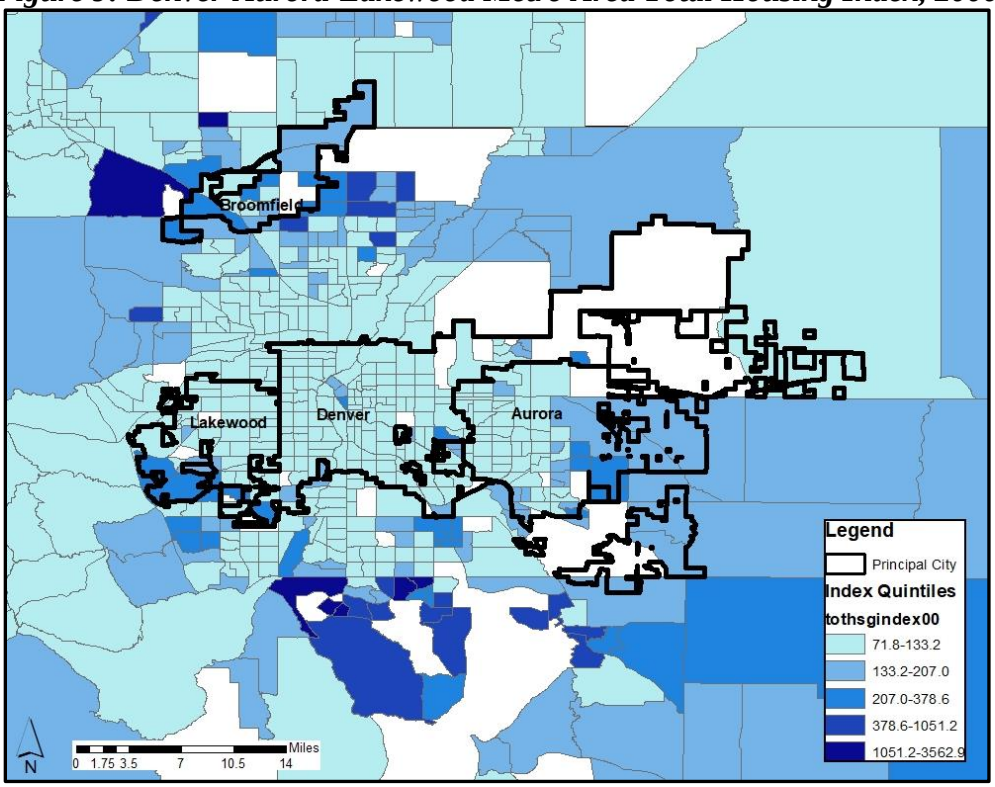
Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

Figure 8: Nashville-Davidson-Murfreesboro Metro Area Total Housing Index, 2015



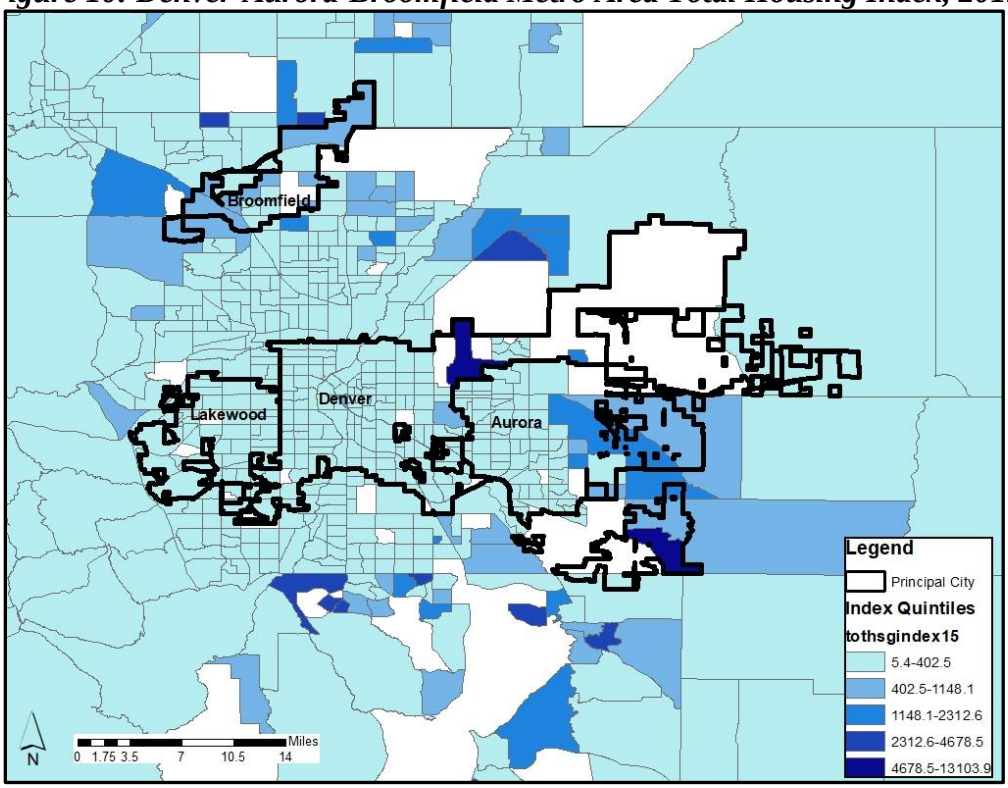
Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

Figure 9: Denver-Aurora-Lakewood Metro Area Total Housing Index, 2000



Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

Figure 10: Denver-Aurora-Broomfield Metro Area Total Housing Index, 2015



Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

Both the Nashville and Denver metropolitan area maps also highlight a related trend found in many metropolitan areas across the country in this analysis—the change in density varied tremendously from Census tract to Census tract in a given political boundary. This is a trend found throughout many of the metropolitan areas in this analysis. Montgomery County, Maryland, for example, had a total housing index value of 1,327.56 in 2000 for one Census tract in Germantown (7003.04), which is in the northern section of the county, but had a total housing index value of 121.38 for a Census tract in Silver Spring (7014.17), an established principal city that adjoins Washington, DC, located in the same county.

Just as political boundaries contained multiple levels of density, observing just Census tracts in one political boundary could miss a larger trend. Looking at the Denver and Nashville metropolitan areas, for example, clusters of Census tracts with similar levels of total housing index values are evident; those clusters in many cases transcend political boundaries.

Density in terms of total housing units changed to varying degrees. For a small portion of the Census tracts in the dataset, the number of housing units rose dramatically. In most cases, however, there was a gradual increase in density. The overall rate at which density changed was similar in both principal cities and suburbs, and there was not an even pattern across the board in either type of geography.

4.1.2 Single-Family Indexes

The total housing density index gives an indication of how the overall residential built environment has changed over time, but one central question in this research necessary to understand the metropolitan form is whether the suburbs have changed over time to include the shift from a traditionally single-family dominant layout. The change in single-family density was

captured in two ways- through both absolute numbers (single-family housing density index) as well as the percentage of the total housing units (single-family housing share density index).

Table 8 shows the summary statistics for both single-family indexes. The mean index value for both the number of units and the share increased from 1990 through 2015, with the average single-family density index values much higher in 2010 and 2015 than the average single-family share density index values. The maximum values were higher in the absolute number indexes. This may be a function of the fact that the share is bounded at 100 percent, whereas the absolute numbers can go much higher.

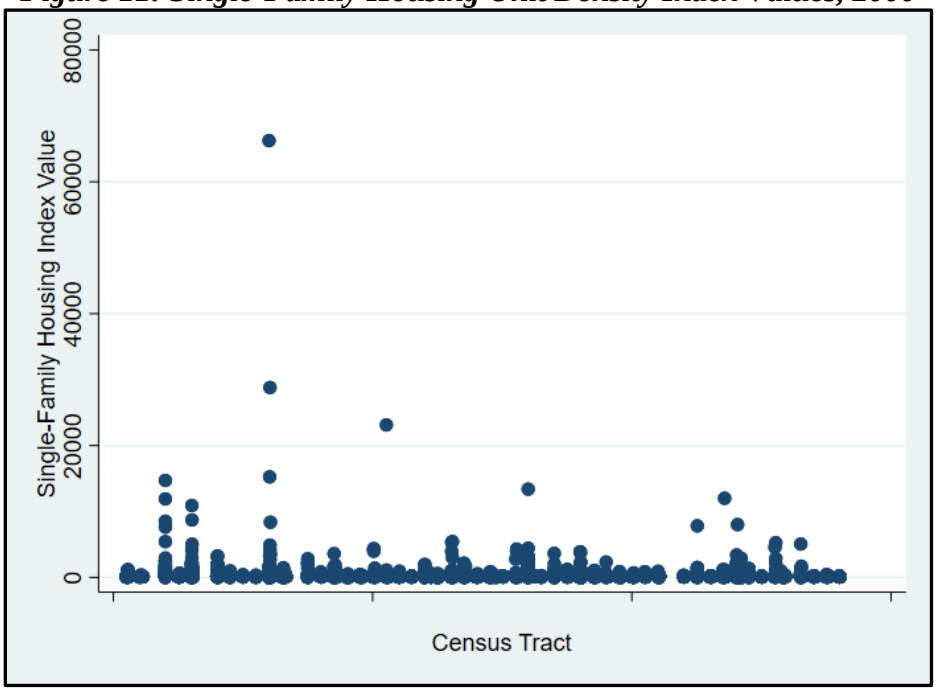
Table 8: Summary Statistics, Single-Family Density Indexes

		Single-Family Housing Unit Density Index				Single-Family Housing Unit Share Density Index			
Index Year	**No. of Obs.**	**Min.**	**Max.**	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**Mean**	**Std. Dev.**
1990	68,119	100	100	100	0	100	100	100	0
2000	68,119	0	66,250.00	134.73	350.17	0	8,043.35	106.06	59.73
2010	68,119	0	70,800.00	202.15	701.82	0	7,478.86	110.58	88.90
2015	68,119	0	73,300.00	212.53	764.66	0	12,060.27	110.84	103.64

Source: U.S. Census Bureau; Urban Institute; Geolytics.

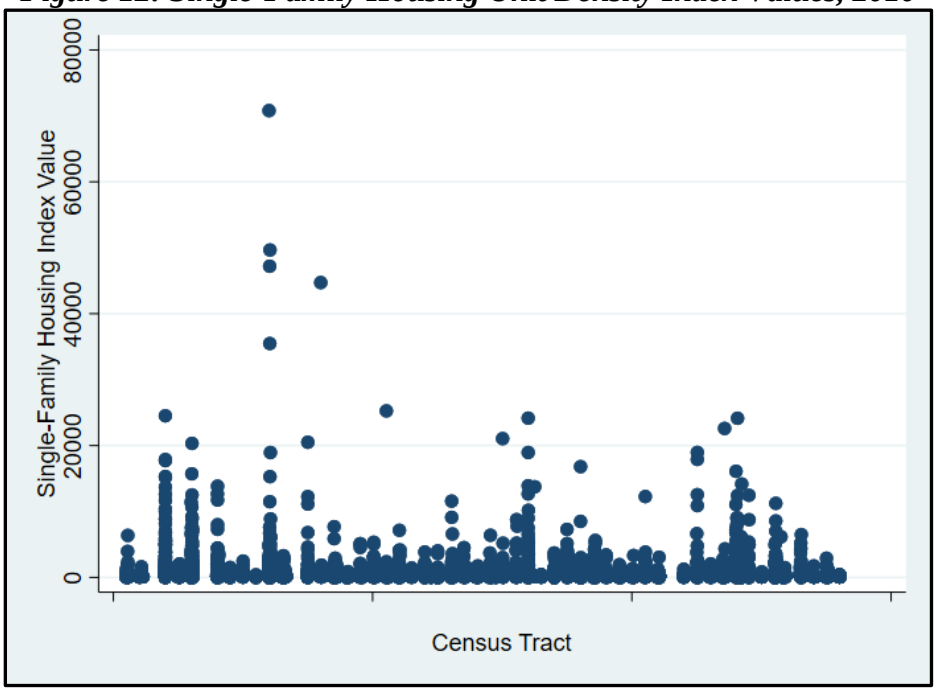
Like the total housing unit density index described previously, both the maximum values for both the total single-family housing unit and single-family housing unit share density indexes suggest there were outliers for 2000, 2010 and 2015, as shown in Figures 11 through 16.

Figure 11: Single-Family Housing Unit Density Index Values, 2000



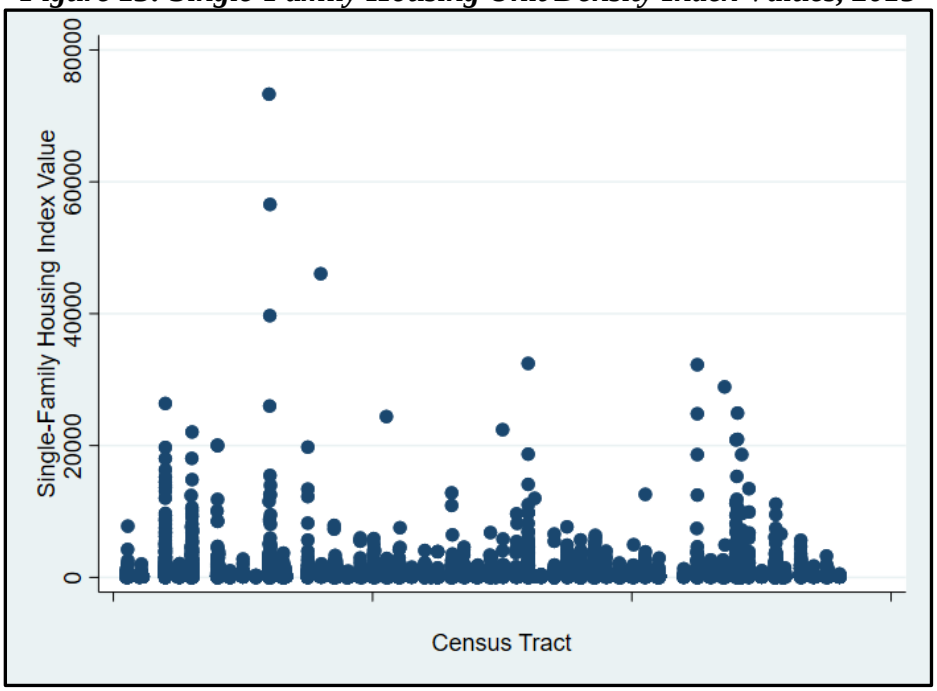
Source: U.S. Census Bureau; Urban Institute; Geolytics.

Figure 12: Single-Family Housing Unit Density Index Values, 2010



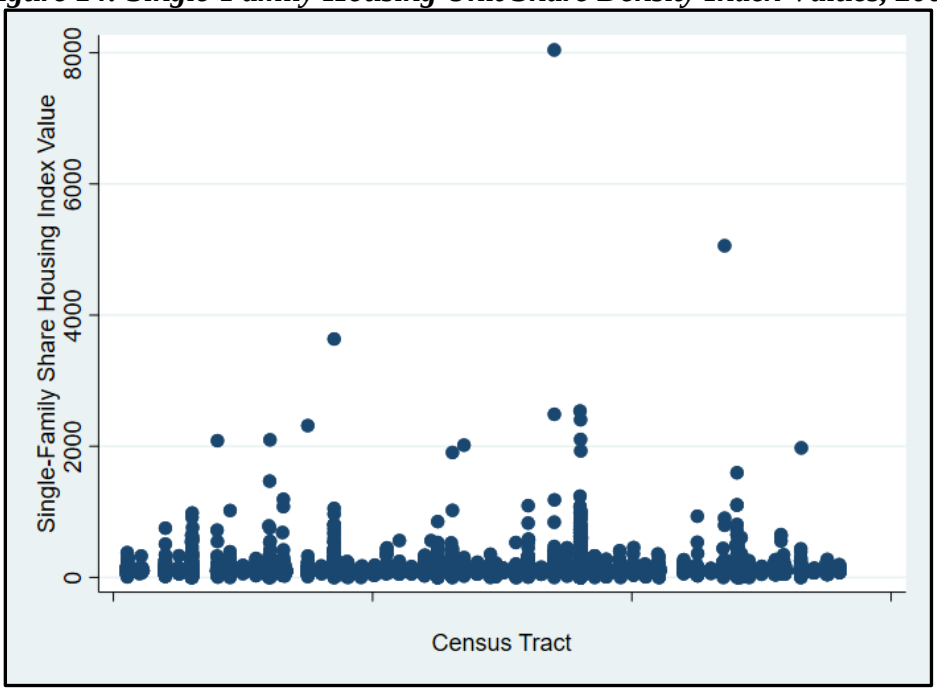
Source: U.S. Census Bureau; Urban Institute; Geolytics.

Figure 13: Single-Family Housing Unit Density Index Values, 2015



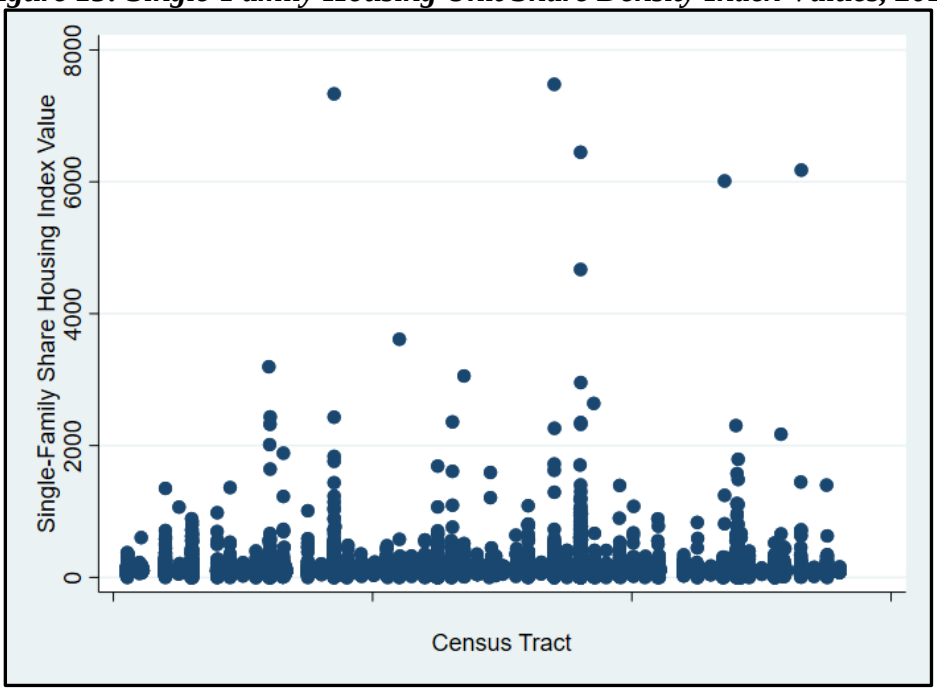
Source: U.S. Census Bureau; Urban Institute; Geolytics.

Figure 14: Single-Family Housing Unit Share Density Index Values, 2000



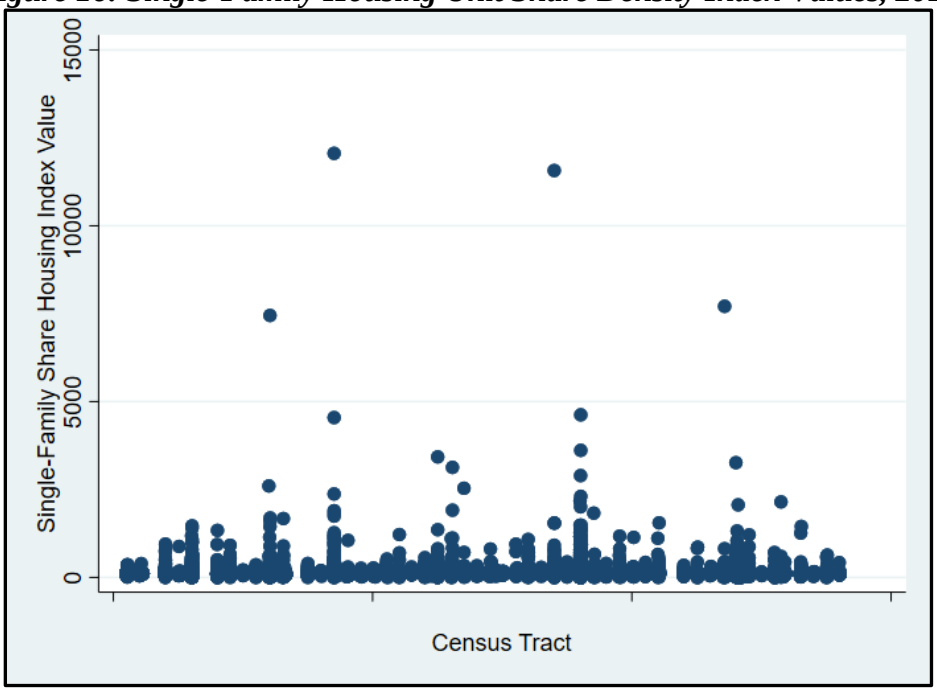
Source: U.S. Census Bureau; Urban Institute; Geolytics.

Figure 15: Single-Family Housing Unit Share Density Index Values, 2010



Source: U.S. Census Bureau; Urban Institute; Geolytics.

Figure 16: Single-Family Housing Unit Share Density Index Values, 2015



Source: U.S. Census Bureau; Urban Institute; Geolytics.

Analysis of the total housing units index previously showed that a low starting number of units was the main reason for the outlier index values, and a similar trend was evident in the single-family indexes. The Census tract with the highest single-family index value in 2000 was

in Broward County, Florida, where the number of single-family units rose from two in 1990 to 1,325 in 2000. That same tract had the highest index value in 2010 and 2015. The highest total housing index value in 2000 was also in this Census tract. The rate of growth slowed considerably from 2000 to 2015, like in the case of the total housing index outliers, increasing by only 91 units from 2000 to 2010, and by only 50 units from 2010 to 2015.

While approximately two-thirds of single-family density index outliers were in suburban Census tracts, approximately two-thirds of single-family share density index outliers were located in principal city Census tracts. The Census tract with the highest single-family share index value in 2000 and 2010 was in Jersey City, New Jersey. The total number of single-family units rose from six in 1990 to 219 in 2000 and 223 in 2010, but the share rose from less than one percent in 1990 to 26.71 percent in 2000. By 2010, the share was down to 24.83 percent, despite the small increase in single-family units. The Census tract with the highest single-family share index value (12,060.27) in 2015 was in Cook County, Illinois. The number of single-family units only rose from one in 1990 to 79 in 2015, but the share rose from less than one percent in 1990 to 15.02 percent in 2015.

The exclusion of the top fifth percentile of index values (see Table 9) results in much smaller standard deviations than in the overall summary statistics, but the exclusion of outliers had more noticeable impacts on the mean single-family index value than the mean single-family share index value.

Table 9: Summary Statistics Excluding Top 5th Percentile of Values, Single-Family and Single-Family Share Indexes

Single-Family Housing Unit Density Index						
Index Year	No. of Obs.	10th Percentile	50th Percentile	90th Percentile	Mean	Std. Dev.
2000	64,713	93.66	108.64	146.81	114.40	25.12
2010	64,714	89.68	116.27	267.59	134.33	61.44
2015	64,714	89.50	116.91	214.07	137.31	66.45
Single-Family Share Housing Unit Density Index						
Index Year	No. of Obs.	10th Percentile	50th Percentile	90th Percentile	Mean	Std. Dev.
2000	64,714	88.10	101.00	113.88	100.44	13.35
2010	64,713	83.12	102.04	122.82	101.84	19.16
2015	64,713	82.58	102.14	123.20	101.92	19.03

Source: U.S. Census Bureau; Urban Institute; Geolytics.

4.1.2.1 Changes Over the Entire Period

The single-family indexes, like the total housing unit indexes, did not consistently increase over the entire period for the entire dataset. For the overall single-family density index, 20,178 Census tracts (29.6 percent) increased in 2000, 2010 and 2015. Over one-quarter (26.3 percent) of those tracts were in principal cities. Over one-third of the tracts (38.2 percent) were in the Southern Census region, which includes Texas, Oklahoma, Arkansas, Louisiana, Mississippi, Alabama, Tennessee, Kentucky, West Virginia, Virginia, Maryland, District of Columbia, Delaware, North Carolina, South Carolina, Georgia, and Florida. California had the most Census tracts in this category (1,738), followed by Texas (1,500) and Florida (1,158).

The single-family density index decreased from 1990 through 2015 for 1,544 Census tracts. Almost half (48.3 percent) of these were in a principal city. Like the total housing index, the number of Census tracts with a higher index value than the preceding period steadily decreased—there were 53,250 Census tracts with single-family index values in 2000 that were

higher than 1990; there were 37,699 Census tracts with single-family index values higher in 2015 than 2010.

The single-family share index values increased for all four time periods for a much smaller percentage than the single-family index values—only 11.0 percent. The single-family share density index increased all four years in 7,536 Census tracts and decreased for 3,377 Census tracts. Almost one-third (31.5 percent) of the tracts that continuously increased were in the South, followed by 27.8 percent in Midwest and 20.5 percent and 20.1 percent in the West and Northeast, respectively. The distribution between principal cities and suburbs was similar to the overall distribution in the dataset.

4.1.2.2 Changes Within Metropolitan Areas

A comparison of the total housing units index found that there was minimal difference in the summary statistics between index values for Census tracts located in principal cities and suburbs from 2000 to 2015. Table 10 shows similar summary statistics for the single-family density and single-family share density indexes. Within the suburban Census tracts, the mean single-family density share increased at a slightly slower pace than Census tracts in the principal cities. The mean share of single-family units in suburban Census tracts rose from 71.2 percent in 1990 to 73.5 percent in 2015, while the mean share of single-family units in principal city Census tracts rose from 55.3 percent in 1990 to 57.2 percent in 2015.

In the single-family density indexes, the mean value of Census tracts located in both the principal cities and suburbs increased at a similar pace, but on a per-unit basis, density increased faster in principal cities. The mean number of single-family units per acre in suburban Census tracts rose from 0.72 units per acre to 0.90 units per acre compared to an increase from 1.89 units per acre in 1990 and 2.20 units per acre in 2015 in principal cities.

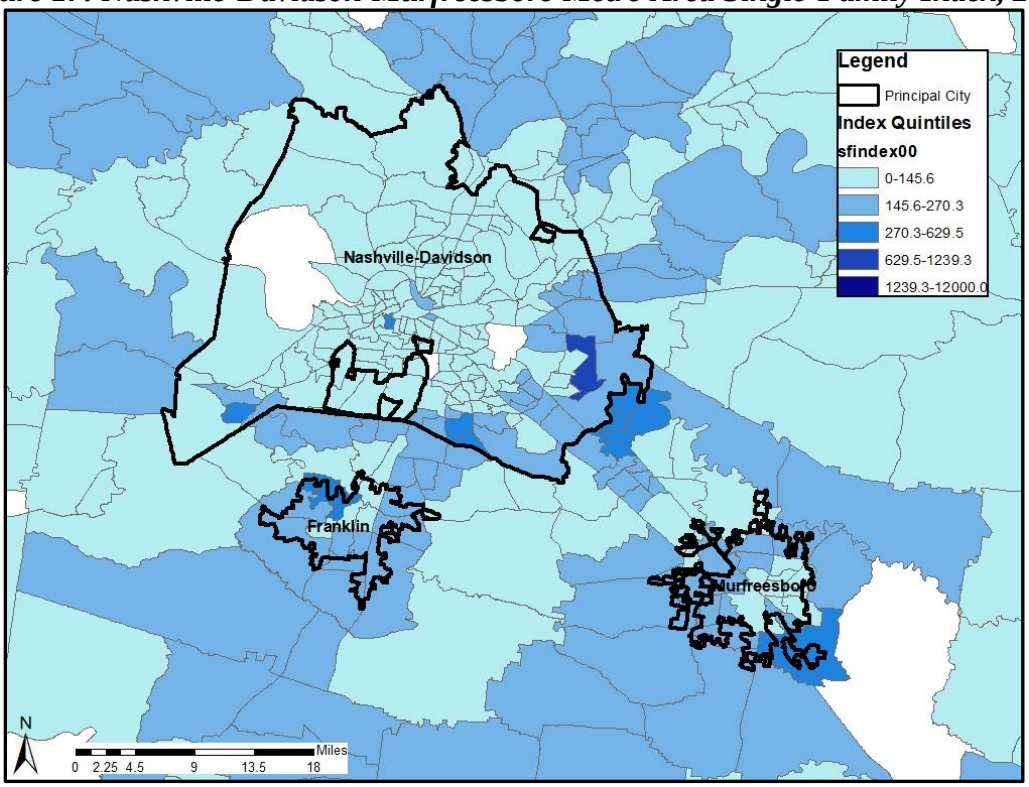
Table 10: Summary Statistics of Principal and Suburban Census Tracts, Single-Family Indexes

	Single-Family Housing Units Index									
	Min.		Max.		Mean		Std. Dev.		No. of Obs.	
Index Year	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb
2000	0.00	0.00	23,128.57	66250.00	136.28	133.81	261.69	392.9	25,181	42,938
2010	0.00	0.00	47,200.00	70800.00	202.70	201.83	747.09	673.87	25,181	42,938
2015	0.00	0.00	46,060.00	73,300	212.79	212.37	799.29	743.61	25,181	42,938
	Single-Family Housing Units Share Index									
	Min.		Max.		Mean		Std. Dev.		No. of Obs.	
Index Year	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb
2000	0.00	0.00	8,043.35	2,487.37	111.47	102.88	90.75	28.33	25,181	42,938
2010	0.00	0.00	7,748.86	6,177.69	118.49	105.94	133.08	45.75	25,181	42,938
2015	0.00	0.00	12,060.27	7,450.00	119.03	106.03	157.86	48.61	25,181	42,938

Source: U.S. Census Bureau; Urban Institute; Geolytics.

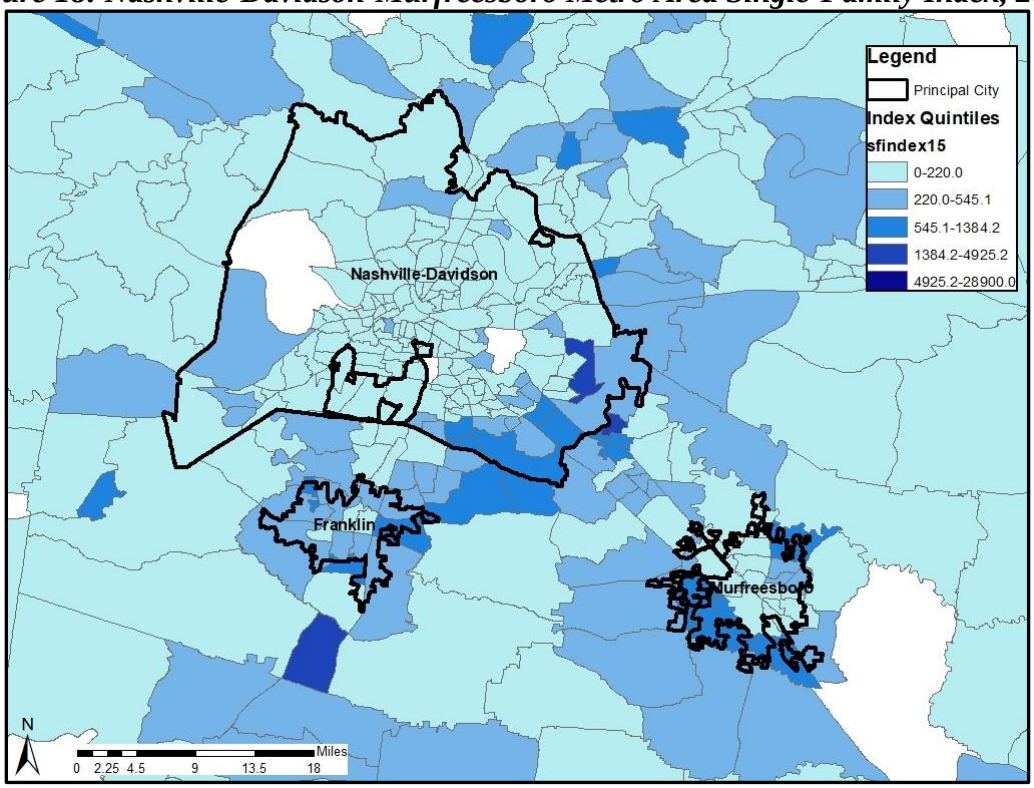
The summary statistics for both the single-family and single-family share indexes also show that there is a wide variation between the minimum and maximum values for both principal cities and suburbs. This, along with similar mean values for both types of geographies, suggests that like the total housing unit indexes, the simple principal city-suburb distinction is not representative of current density trends in metropolitan areas. Figures 17 through 20 show this through the single-family density index values in Nashville and Denver.

Figure 17: Nashville-Davidson-Murfreesboro Metro Area Single-Family Index, 2000



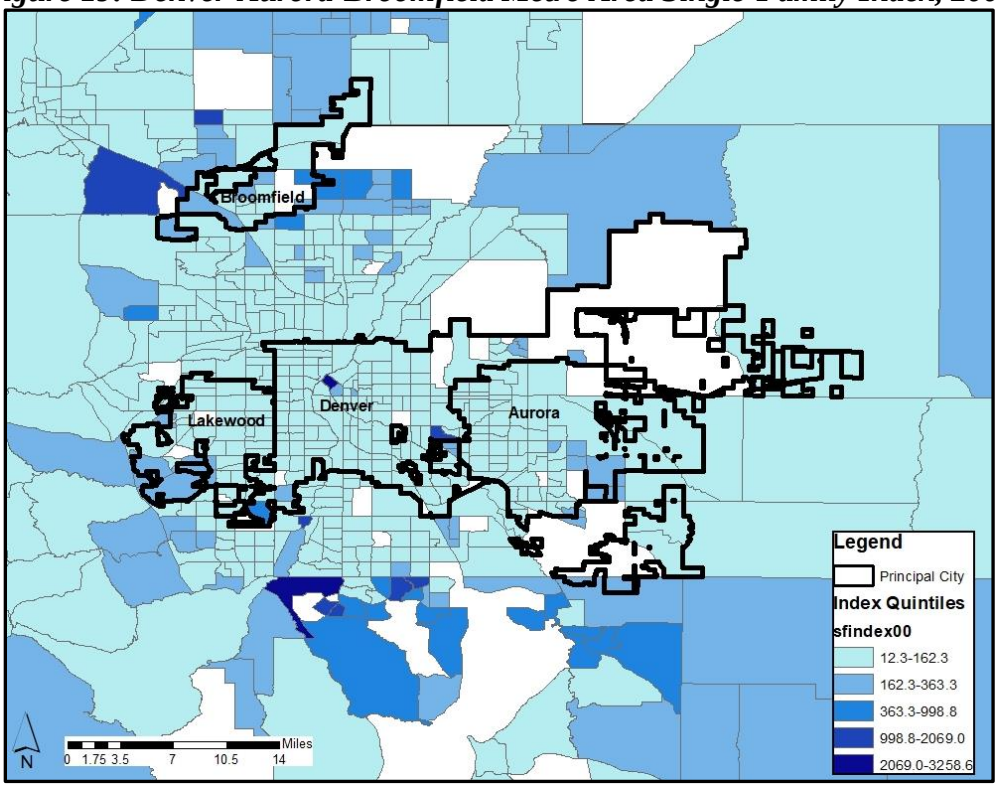
Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

Figure 18: Nashville-Davidson-Murfreesboro Metro Area Single-Family Index, 2015



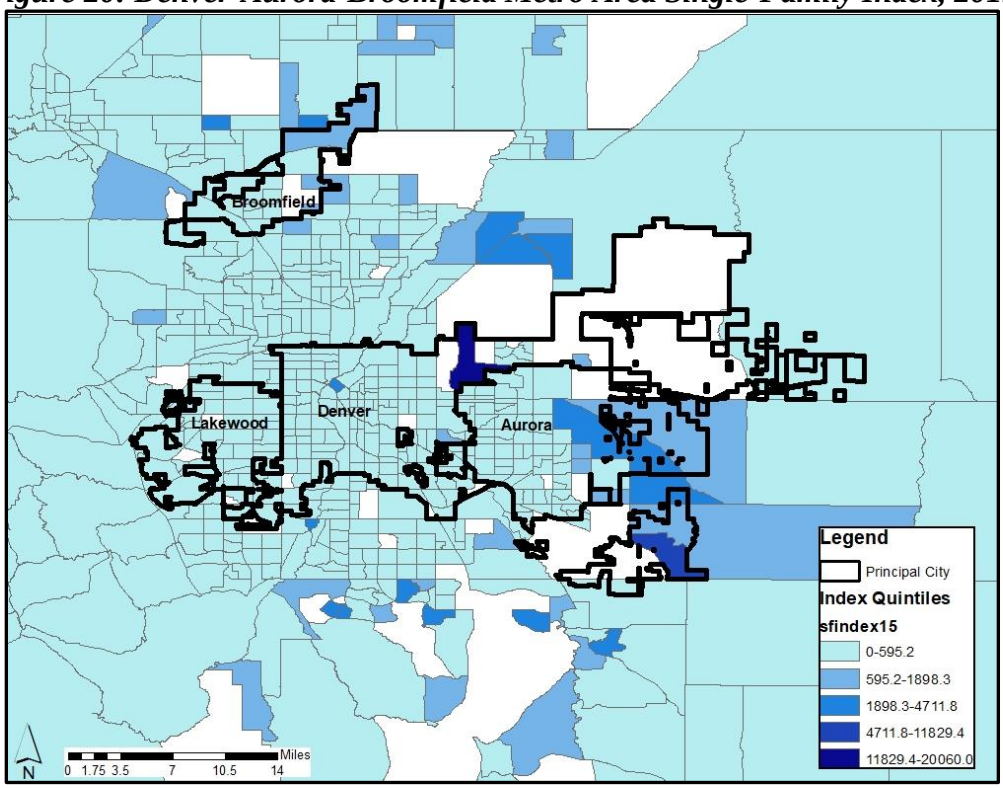
Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

Figure 19: Denver-Aurora-Broomfield Metro Area Single-Family Index, 2000



Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

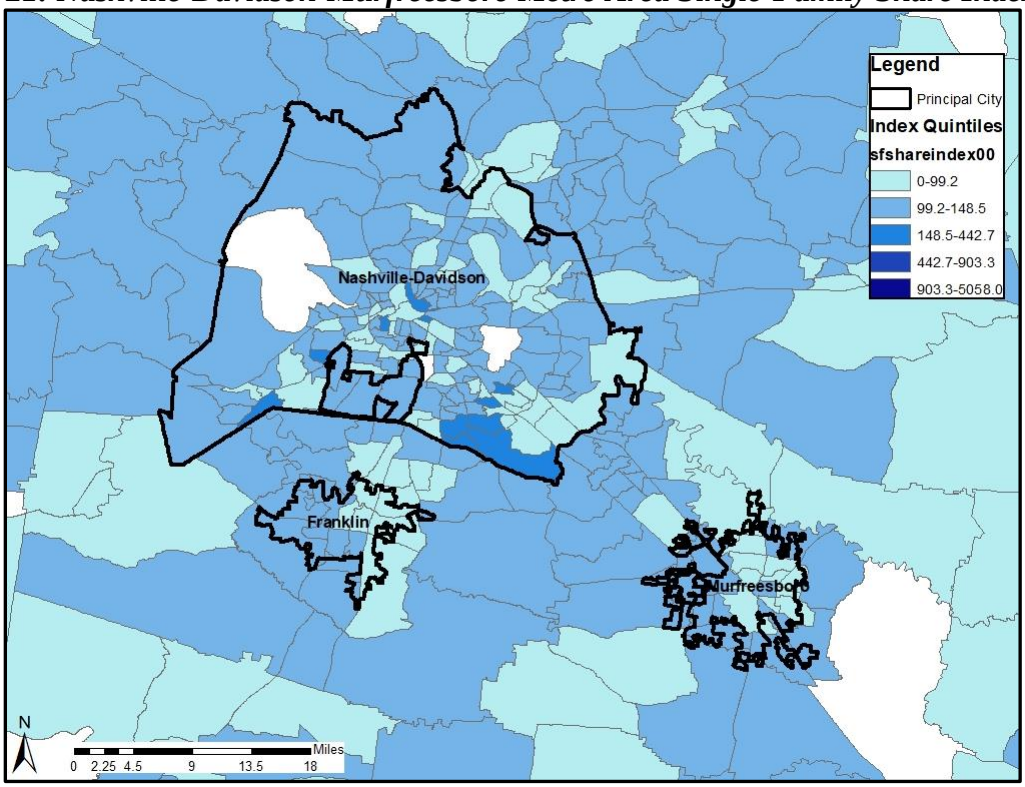
Figure 20: Denver-Aurora-Broomfield Metro Area Single-Family Index, 2015



Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

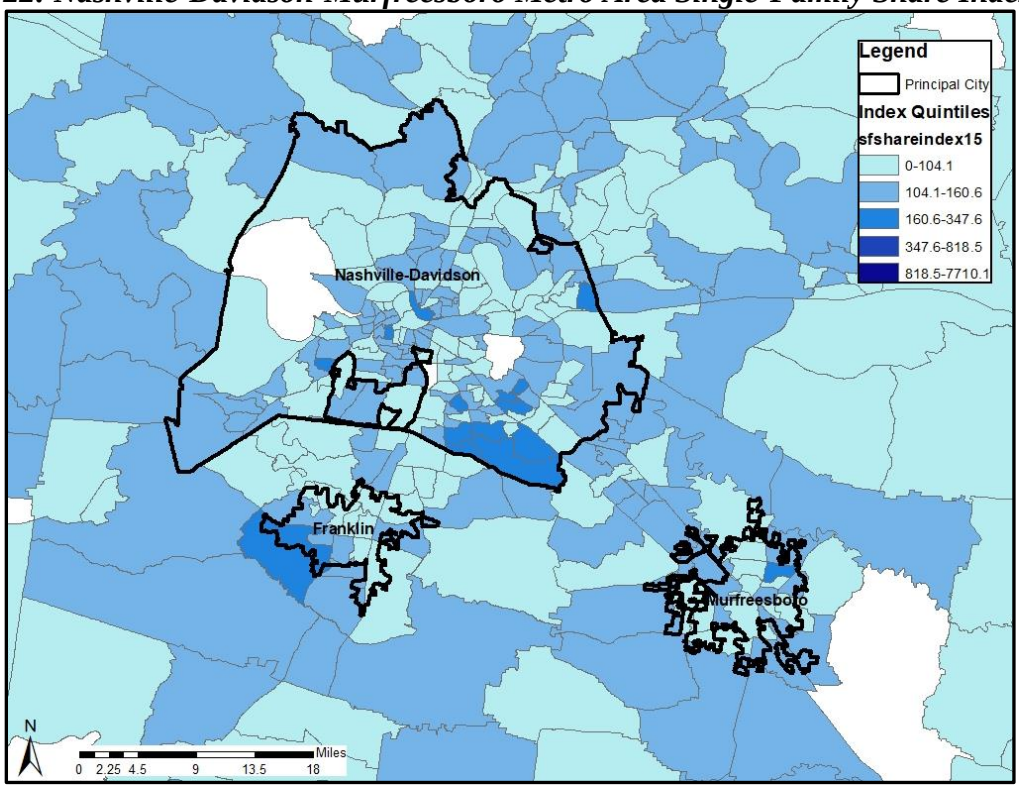
The distribution of single-family share index values does not have the same distribution as the single-family index values, as shown in Figures 21 through 24. There are several higher index values within the middle of the principal cities in both metropolitan areas, while in the case of the single-family index, the higher values were located near the outer edges of the principal cities.

Figure 21: Nashville-Davidson-Murfreesboro Metro Area Single-Family Share Index, 2000



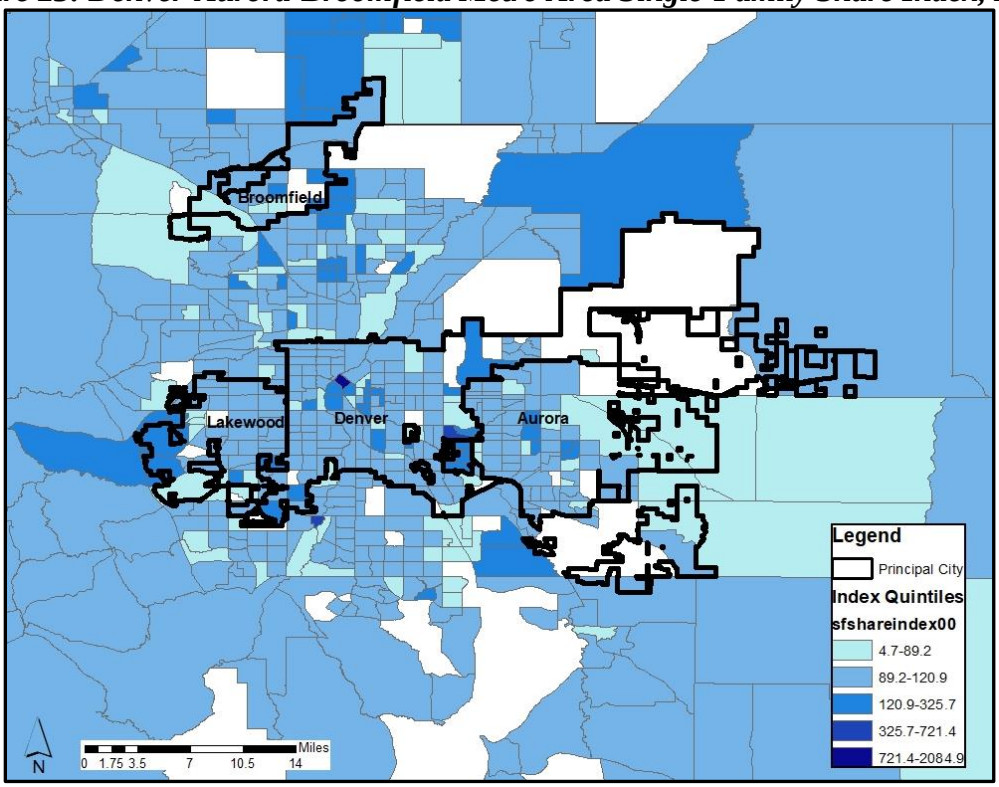
Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

Figure 22: Nashville-Davidson-Murfreesboro Metro Area Single-Family Share Index, 2015



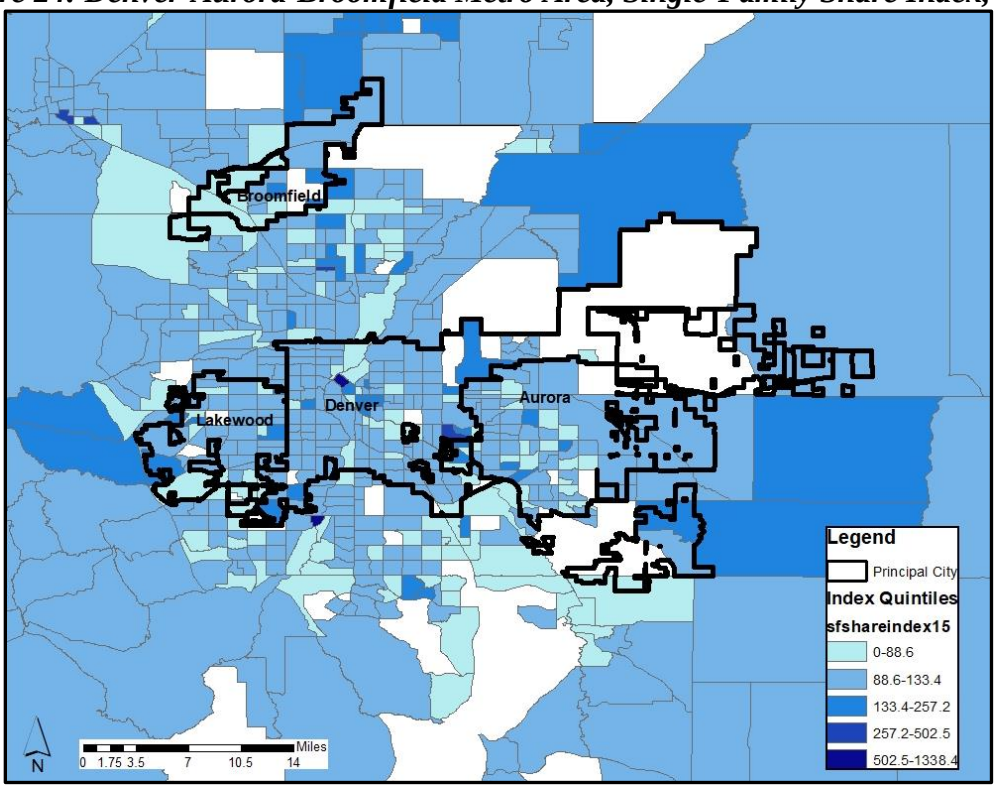
Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

Figure 23: Denver-Aurora-Broomfield Metro Area Single-Family Share Index, 2000



Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

Figure 24: Denver-Aurora-Broomfield Metro Area, Single-Family Share Index, 2015



Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

4.1.3 Multifamily Indexes

As with the single-family indexes, it was necessary to determine where the multifamily indexes have increased (or decreased), and how the share of multifamily units in each tract has changed over time. It was also necessary to compare the changes for the multifamily indexes to the changes for the total housing unit indexes and single-family indexes

Table 11 shows the summary statistics for the multifamily housing unit density index and the multifamily share index. The mean value was much higher for the multifamily index compared to the multifamily share index.

Table 11: Summary Statistics, Multifamily Density Indexes

		Multifamily Housing Unit Density Index				Multifamily Housing Unit Share Density Index			
Index Year	No. of Obs.	Min.	Max.	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.
1990	68,119	100.00	100.00	100.00	0.00	100.00	100.00	100.00	0.00
2000	68,119	0.00	143,900.00	178.88	955.46	0.00	29,574.93	126.68	301.62
2010	68,119	0.00	174,000.00	346.93	2,404.08	0.00	27,455.97	146.97	457.63
2015	68,119	0.00	187,400.00	412.83	3,009.12	0.00	29,559.10	157.05	510.25

Source: U.S. Census Bureau; Urban Institute; Geolytics.

In each case, there were outliers, as evidenced by the large maximum values, like the total housing and single-family indexes. Also like the single-family density index, the outliers in the multifamily index appear to be so large due to a low number of multifamily units in 1990. The Census tract with the highest index value in 2000 was in Maricopa County, Arizona, northeast of Phoenix (increase from one multifamily unit in 1990 to 1,439 in 2000); the 2010 maximum index value was in Brazoria County, Texas (one to 1,740); the 2015 maximum was in the same county, having gained an additional 134 units by 2015.

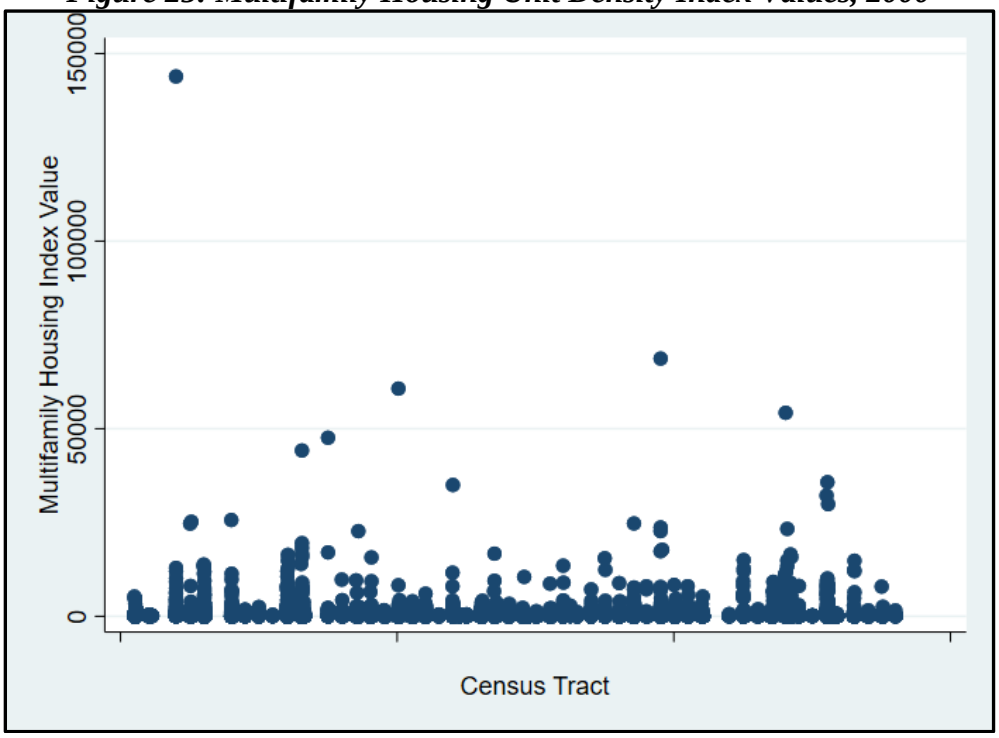
The multifamily share index value in both 2000 and 2015 was greatest in a Census tract located in Plano, Texas, a principal city in the Dallas-Fort Worth metropolitan area. The increase was greatest because over 1,000 multifamily units were built in the period between 1990 and

2000, while only 50 single-family units were built in that Census tract during the same period. A slight decline in multifamily units was recorded in that Census tract from 2010 to 2015.

The Census tract with the highest multifamily share index value for 2010 was not located in a principal city, however. The Census tract, located in the Springfield-Franconia area of Fairfax County, Virginia, rose from 95 multifamily units in 2000 to 1,113 multifamily units in 2010. During that period, the number of single-family units decreased from 316 units in 2000 to 18 in 2010, a variation likely larger than any sampling error.

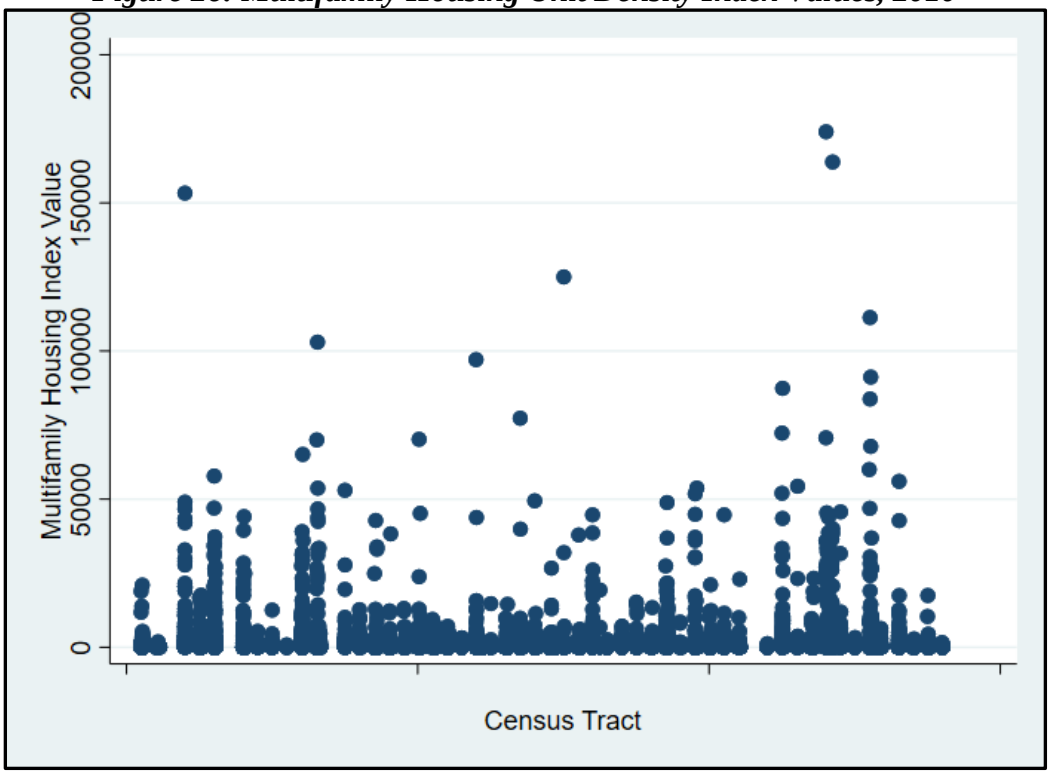
Figures 25 through 30 show the distribution of both the multifamily and multifamily share index values for 1990, 2000, 2010 and 2015. Like the total housing index and the single-family indexes, there are some clear outliers present in each index year.

Figure 25: Multifamily Housing Unit Density Index Values, 2000



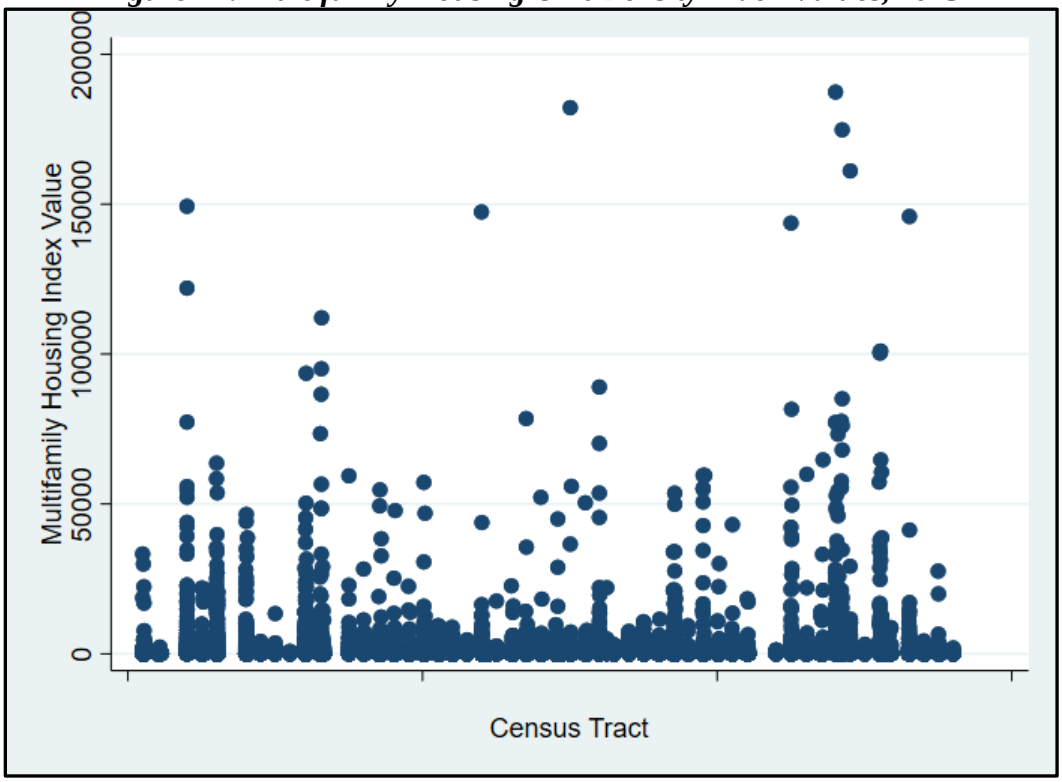
Source: U.S. Census Bureau; Urban Institute; Geolytics.

Figure 26: Multifamily Housing Unit Density Index Values, 2010



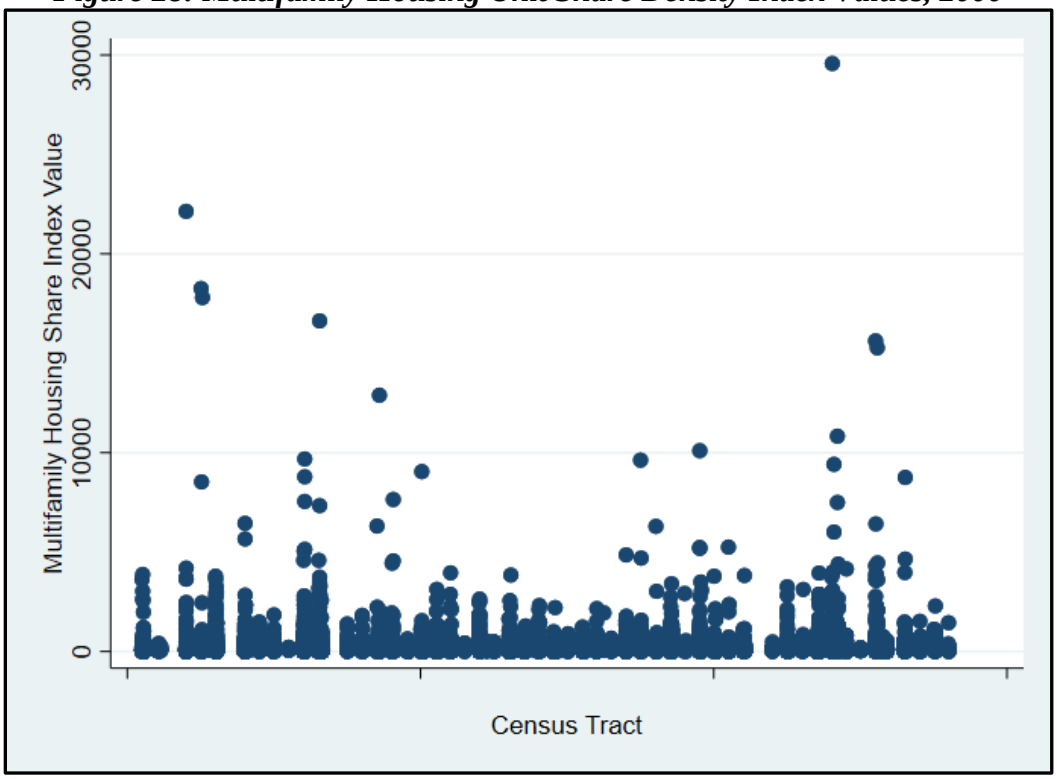
Source: U.S. Census Bureau; Urban Institute; Geolytics.

Figure 27: Multifamily Housing Unit Density Index Values, 2015



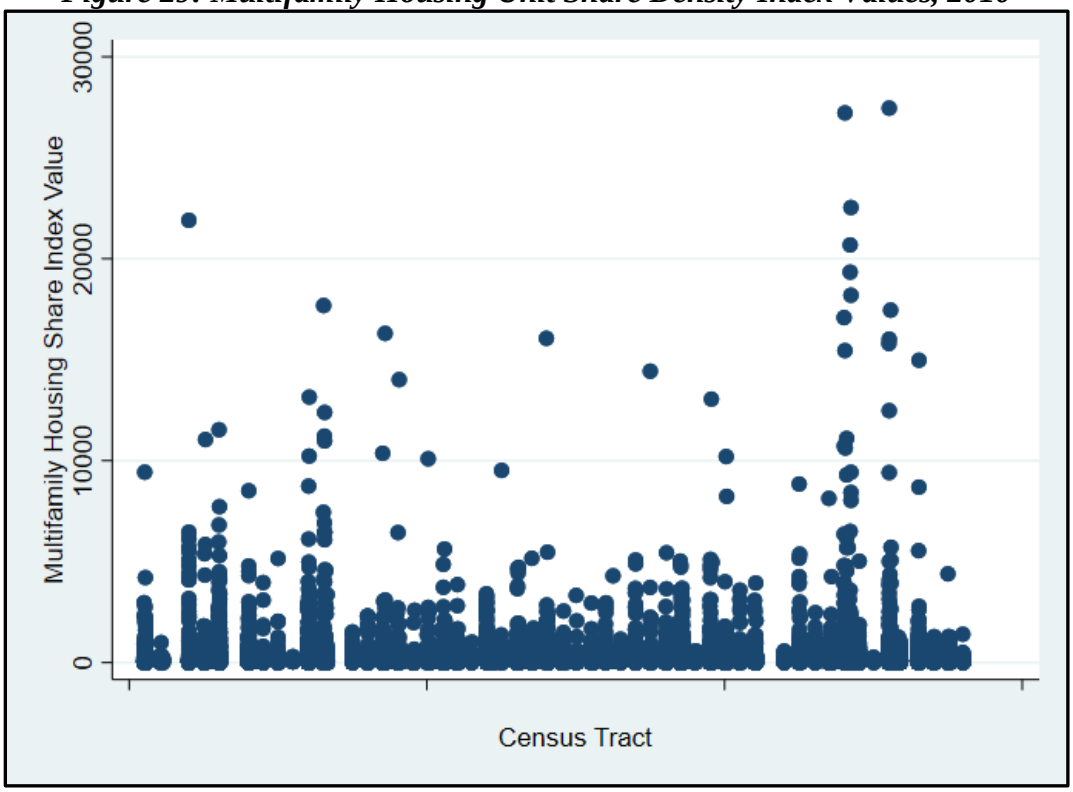
Source: U.S. Census Bureau; Urban Institute; Geolytics.

Figure 28: Multifamily Housing Unit Share Density Index Values, 2000



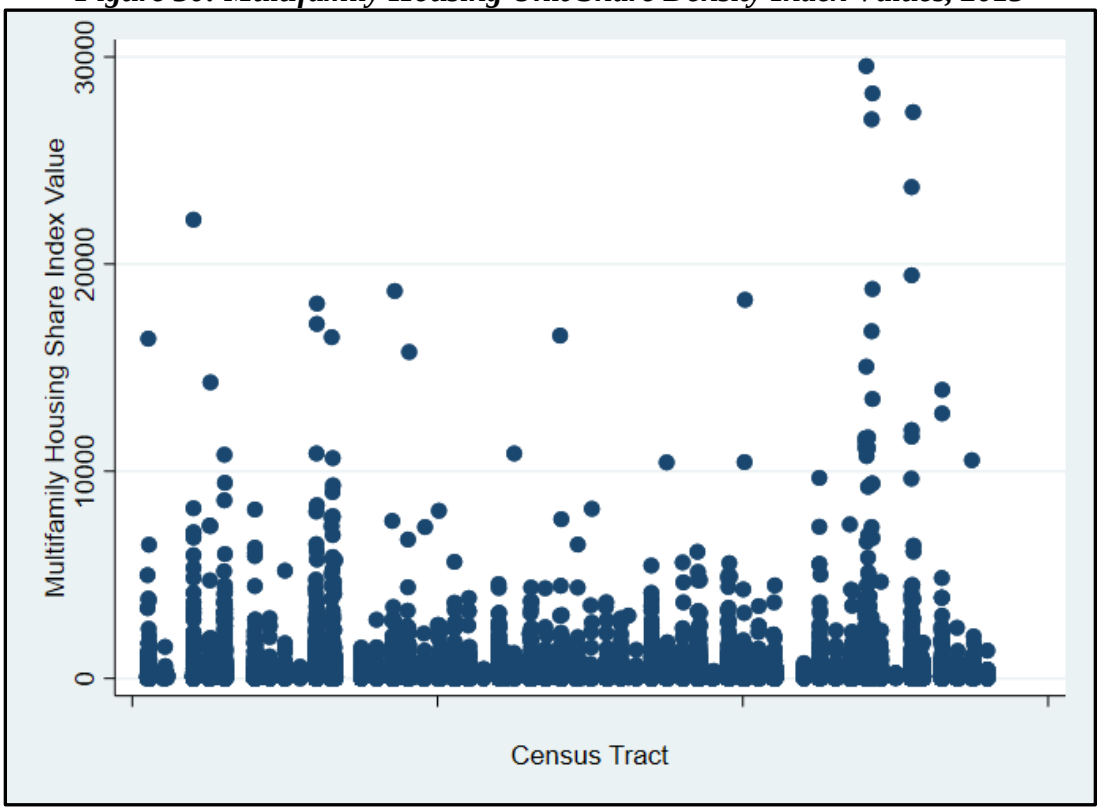
Source: U.S. Census Bureau; Urban Institute; Geolytics.

Figure 29: Multifamily Housing Unit Share Density Index Values, 2010



Source: U.S. Census Bureau; Urban Institute; Geolytics.

Figure 30: Multifamily Housing Unit Share Density Index Values, 2015



Source: U.S. Census Bureau; Urban Institute; Geolytics.

Almost three-quarters of the top fifth percentile (73.0 percent) multifamily index values were in suburban Census tracts; by 2015, it had fallen slightly to 70.7 percent of the multifamily index values. The change was much more drastic for the multifamily share index, falling from 76.3 percent of suburban Census tracts in 2000 to 62.2 percent in 2015.

4.1.3.1 Changes Over the Entire Period

The multifamily density index increased steadily during the entire period from 1990 to 2015 for a small portion of the dataset (13.9 percent). Most of these tracts were in suburban areas (62.0 percent). This is roughly half the number of Census tracts that increased during the same period for the total housing unit index and each of the single-family indexes. The number of Census tracts where the multifamily share index consistently increased was even less (5,035). Almost two-thirds (64.9 percent) of these Census tracts were in the suburbs.

For 2,997 Census tracts the multifamily density index decreased from 1990 through 2015, while there was a consistent decline in the multifamily share index in 4,510 Census tracts. For many of the Census tracts where the index fell from the preceding time, it was due to a small number of multifamily units (under ten in the entire Census tract in many cases) being lost completely from the stock. Possible reasons for this could include a physical explanation such as the units being demolished or renovated into a single-family house, or a statistical explanation from margin of errors between samples. In all cases for multifamily, less than half were Census tracts located in a principal city.

Overall, the density gradually increased for multifamily units. The average number of multifamily units per acre rose from 1.84 multifamily units per acre to 2.08 multifamily units per acre. This varies by principal city vs. suburbs, however. The average rose from 0.51 units per acre to 0.61 units per acre in suburban areas, while increasing from 4.11 units per acre to 4.58 units per acre in principal cities.

4.1.3.2 Changes Within Metropolitan Areas

Table 12 shows the summary statistics for Census tracts in principal cities and suburbs for both the multifamily density indexes and the multifamily share density indexes. Like the single-family and single-family share density indexes, the multifamily and multifamily share density indexes both show similar trends in terms of maximums and mean values.

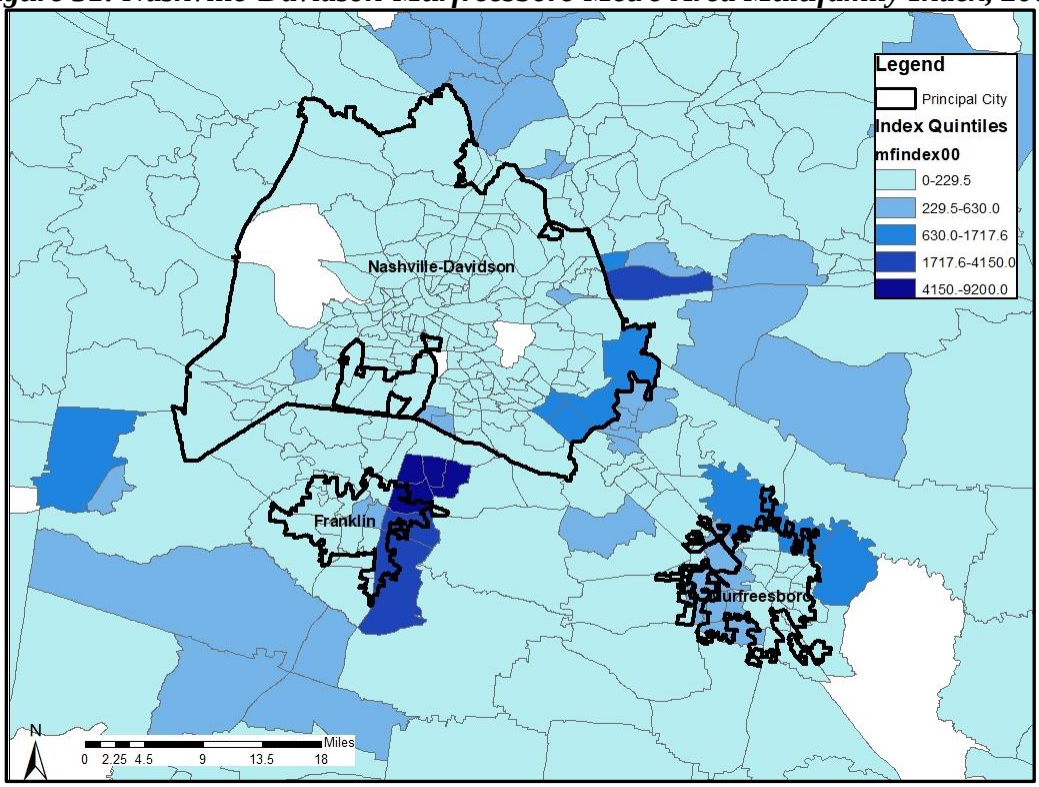
Table 12: Summary Statistics, Multifamily Indexes by Principal City Status

	Multifamily Housing Units Index									
	Min.		Max.		Mean		Std. Dev.		No. of Obs.	
Index Year	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb
2000	0.00	0.00	68,700	143,900	159.97	189.96	735.62	1,063.31	25,181	42,938
2010	0.00	0.00	163,800	174,000	309.46	368.91	2,114.99	2,558.23	25,181	42,938
2015	0.00	0.00	174,800	187,400	374.46	435.33	2,888.10	3,216.26	25,181	42,938
	Multifamily Housing Units Share Index									
	Min.		Max.		Mean		Std. Dev.		No. of Obs.	
Index Year	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb	Principal City	Suburb
2000	0.00	0.00	29,574.93	22,138.46	117.77	131.91	264.00	321.54	25,181	42,938
2010	0.00	0.00	27,219.78	27,455.97	135.11	153.92	410.92	482.8	25,181	42,938
2015	0.00	0.00	29,559.10	48,238.04	142.12	165.82	455.59	539.55	25,181	42,938

Source: U.S. Census Bureau; Urban Institute; Geolytics.

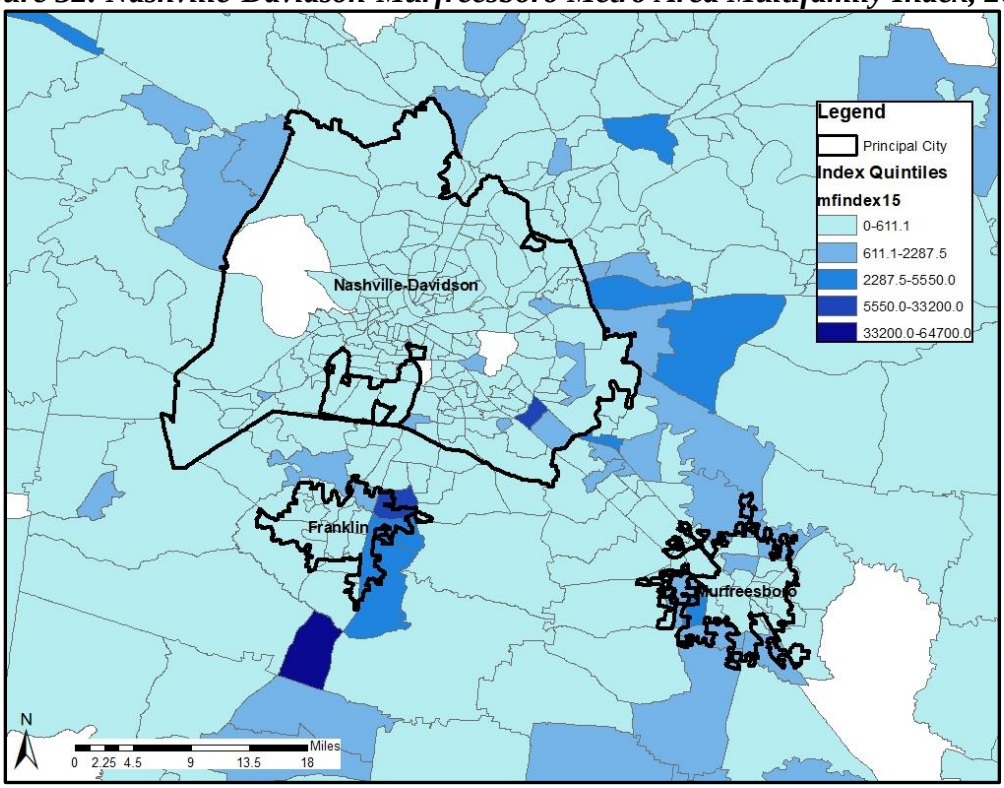
While there was little difference between the summary statistics for Census tracts located in suburban and principal cities overall, the suburban statistics were clearly higher on all accounts, indicating that a large part of the multifamily growth was in Census tracts defined as located in suburban areas. Figures 31 through 34, however, show that like the single-family and total housing indexes, the story is more nuanced in terms of changes in multifamily density related to tracts in suburbs and principal cities. The largest increases in multifamily density (in absolute numbers) were evident both in principal cities and suburbs in the Nashville and Denver metropolitan areas, and often clustered in areas that were not easily distinguished as principal cities or suburbs. Some of the largest increases in index values were located on both sides of political boundaries, such as in the case of Franklin, Tennessee.

Figure 31: Nashville-Davidson-Murfreesboro Metro Area Multifamily Index, 2000



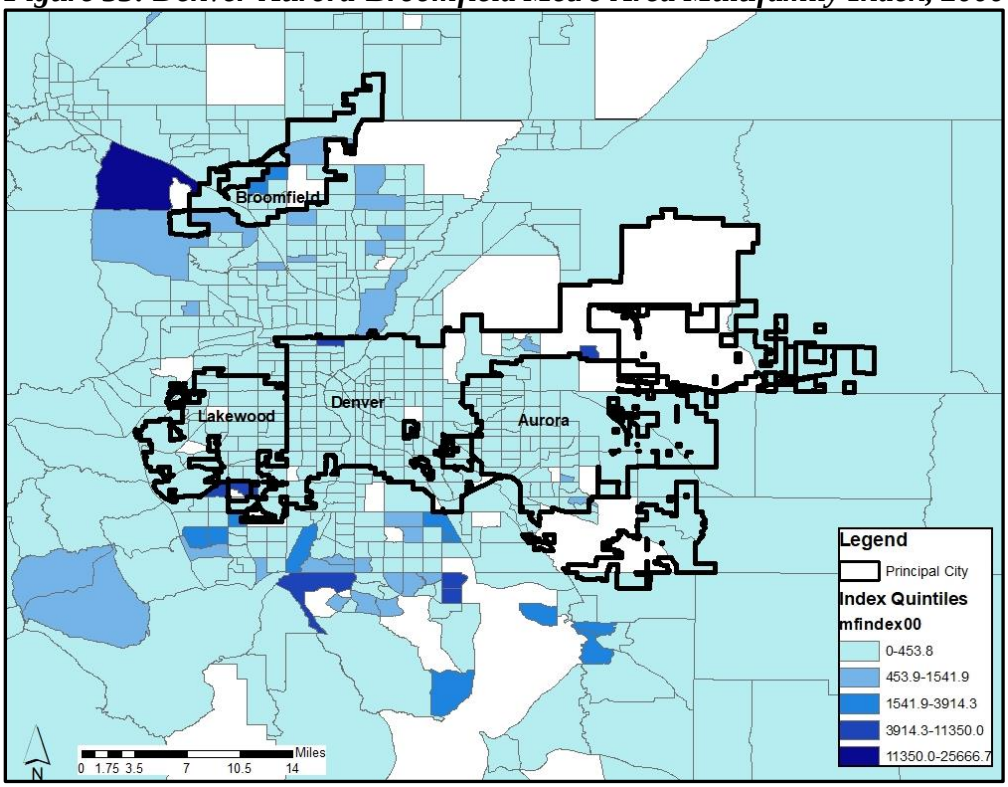
Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

Figure 32: Nashville-Davidson-Murfreesboro Metro Area Multifamily Index, 2015



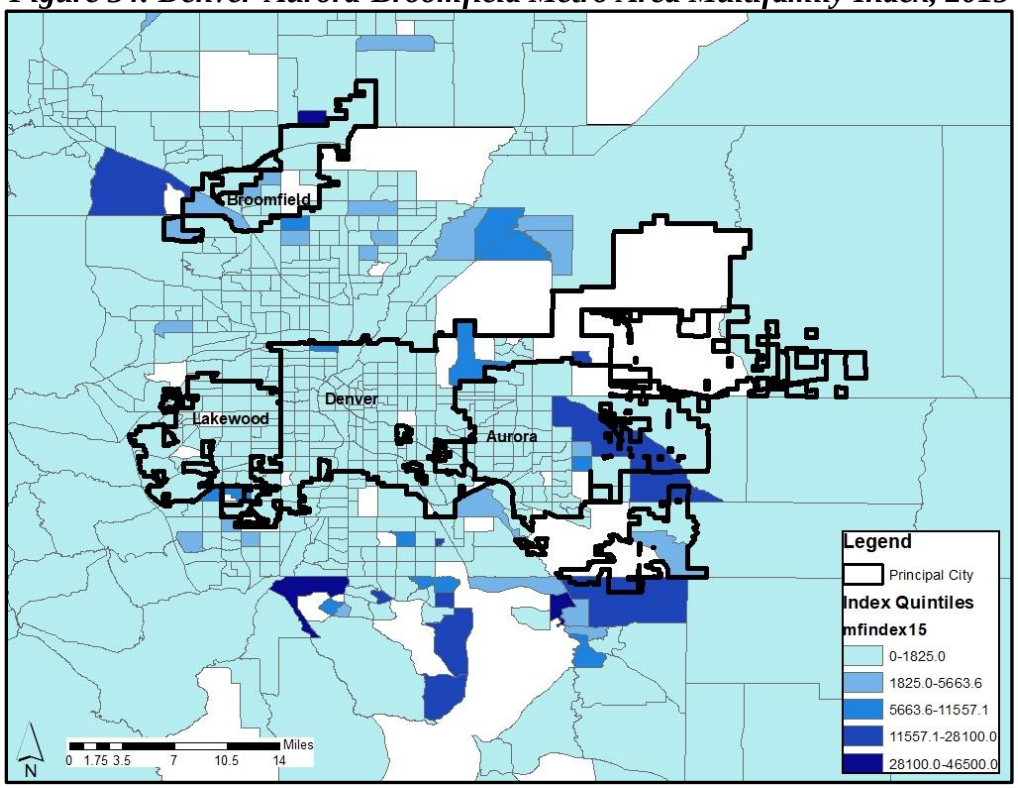
Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

Figure 33: Denver-Aurora-Broomfield Metro Area Multifamily Index, 2000



Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

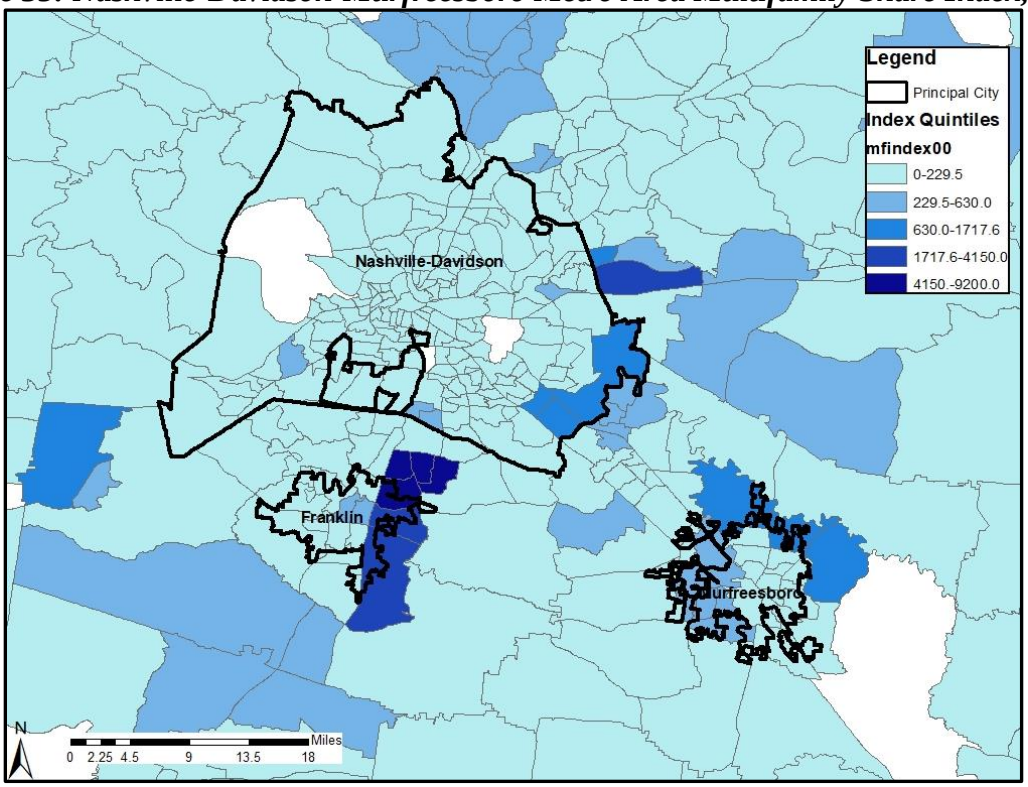
Figure 34: Denver-Aurora-Broomfield Metro Area Multifamily Index, 2015



Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

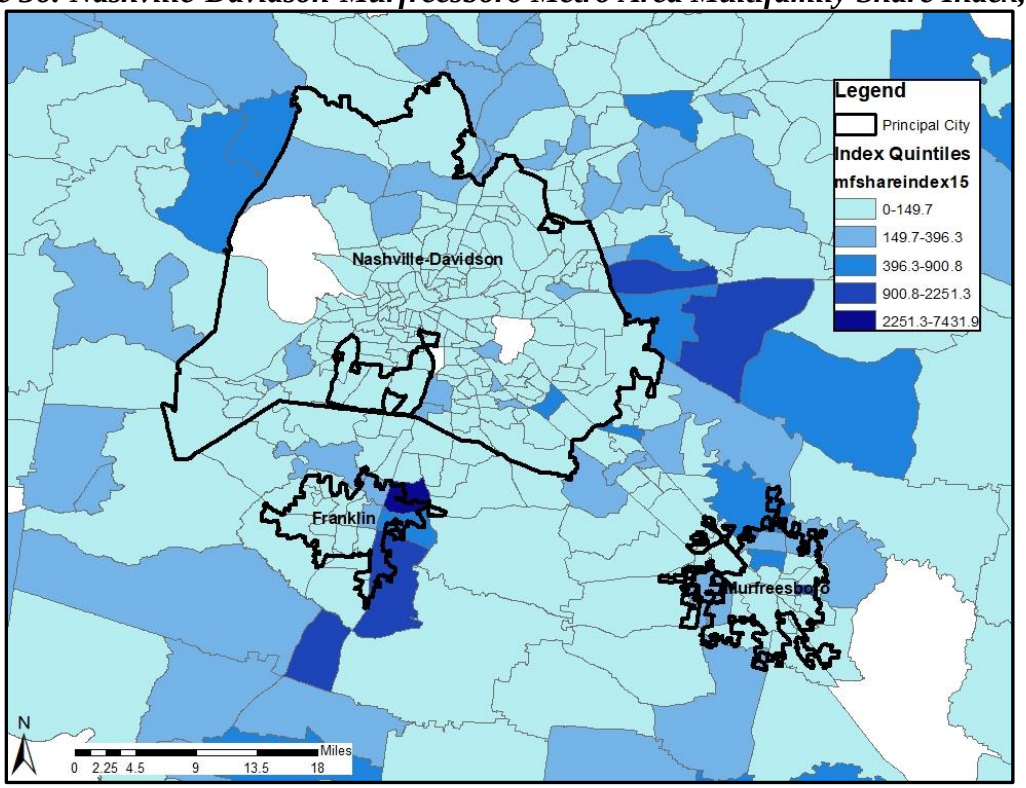
The change in multifamily share was most drastic in many suburbs, as shown in the Nashville and Denver metro areas (Figures 35 through 38). While this does not indicate that multifamily development was greatest in the suburbs, it does indicate that the overall composition of the type of housing was changing there.

Figure 35: Nashville-Davidson-Murfreesboro Metro Area Multifamily Share Index, 2000



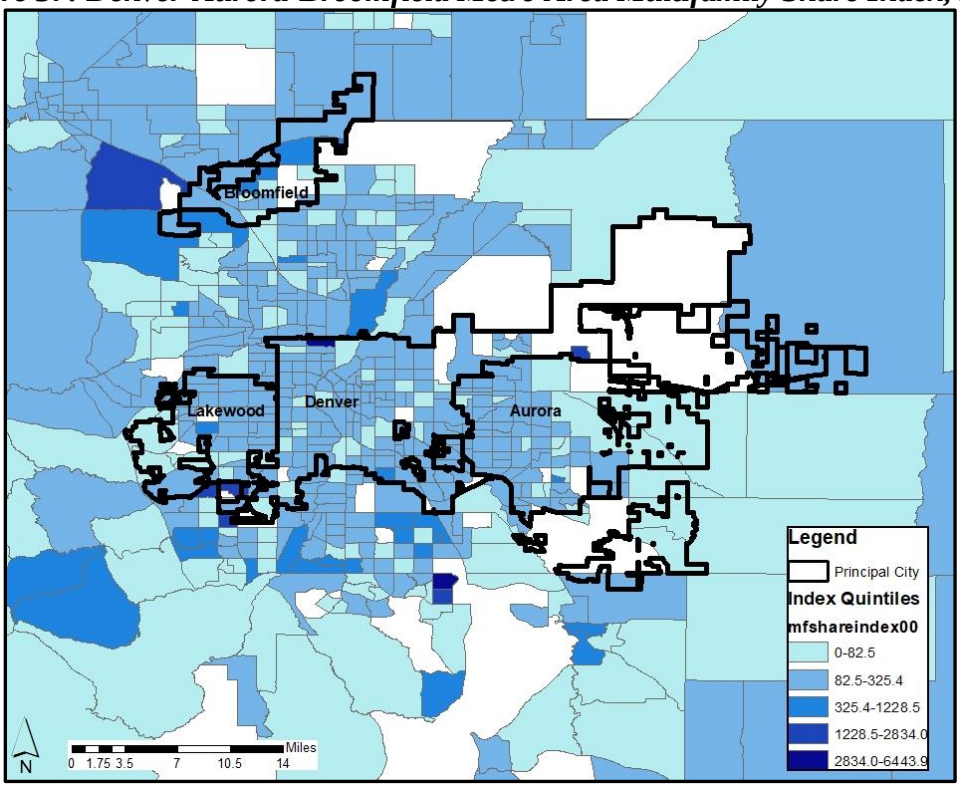
Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

Figure 36: Nashville-Davidson-Murfreesboro Metro Area Multifamily Share Index, 2015



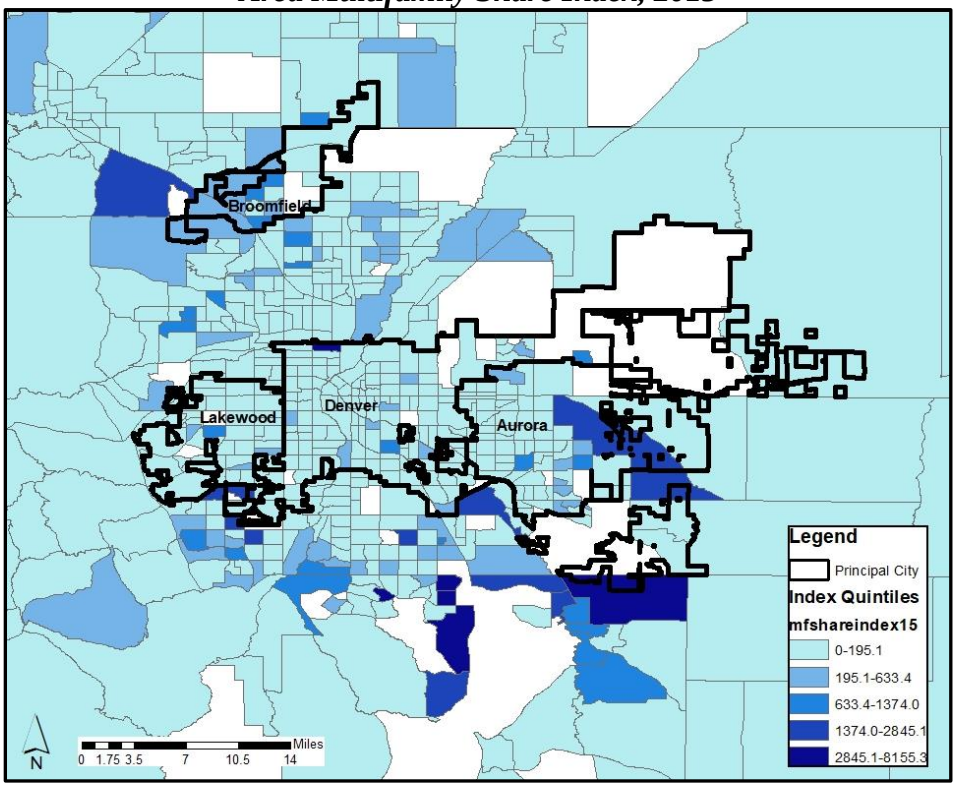
Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

Figure 37: Denver-Aurora-Broomfield Metro Area Multifamily Share Index, 2000



Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

Figure 38: Denver-Aurora-Broomfield Metro Area Multifamily Share Index, 2015



Source: U.S. Census Bureau; Urban Institute; Geolytics; ESRI.

4.2 The Relationship Between Residential Density and the Population

The previous section of this chapter presented results that showed how the residential built environment in the metropolitan area has changed from 1990 to 2015. This section presents results as to how the population and household composition of the residential built environment has changed over time, in particular the 25 to 34-year-old age cohort. While age was the biggest focus of the research, other demographic and economic characteristics were considered, because previous research into the suburbs found that certain characteristics (such as educational attainment) were evident when researching suburban development.

As discussed in the methodology chapter, first, the data were analyzed for each of the four years to determine whether there is any sort of correlation between the percentage of 25 to 34-year-olds in each Census tract, location in a principal city, and density. The presence of a correlation indicates that further analysis is necessary.

The correlation analysis provides an indication of how much certain variables are related, while the regression analysis will provide an indication of how much those variables predict density. The regression analysis will also determine whether there are additional characteristics beyond age that are important to understand which people live where.

4.2.1 Summary Statistics and Diagnostics

Tables 13 through 16 below present the summary statistics for the data used in both the correlation analysis and the regressions. The regression analysis required the transformation of the dependent variable (the number of housing units per acre) into the log of the total housing units per acre, to gain a normal distribution.

Table 13: Summary Statistics, 1990

Variable	Min.	Max.	Mean	Std. Dev.	No. of Obs.
% Pop. 25-34 Years Old	0.00	0.59	0.18	0.05	68,119
% Pop. Under 18 Years Old	0.00	0.73	0.25	0.07	68,119
% Pop. 18-24 Years Old	0.00	0.98	0.10	0.07	68,119
% Pop. 35-44 Years Old	0.00	0.51	0.15	0.03	68,119
% Pop. 45-54 Years Old	0.00	0.31	0.10	0.03	68,119
% Pop. 55-64 Years Old	0.00	0.36	0.09	0.03	68,119
% HH with HH Inc. $25,000-$49,999	0.00	1.00	0.34	0.08	68,119
% HH with HH Inc. $50,000-$74,999	0.00	0.70	0.15	0.08	68,119
% HH with HH Inc. $75,000-$99,999	0.00	0.40	0.05	0.05	68,119
% HH with HH Inc. Greater than $100,000	0.00	0.87	0.04	0.07	68,119
% Workers Who Use Public Transit	0.00	0.89	0.05	0.11	68,119
Principal City	0.00	1.00	0.37	0.48	68,119
New England	0.00	1.00	0.05	0.22	68,119
Middle Atlantic	0.00	1.00	0.14	0.35	68,119
East North Central	0.00	1.00	0.17	0.37	68,119
West North Central	0.00	1.00	0.07	0.26	68,119
South Atlantic	0.00	1.00	0.18	0.39	68,119
East South Central	0.00	1.00	0.06	0.24	68,119
West South Central	0.00	1.00	0.11	0.31	68,119
Mountain	0.00	1.00	0.07	0.25	68,119
% Workers Who Commute 25-44 Min.	0.00	0.70	0.22	0.10	68,119
% Black/African American Pop.	0.00	1.00	0.11	0.22	68,119
% Hispanic Pop.	0.00	1.00	0.09	0.16	68,119
% Pop. With Some College	0.00	0.58	0.19	0.06	68,119
% Pop. With Associate's Degree	0.00	0.37	0.06	0.03	68,119
% Renters	0.00	1.00	0.32	0.20	68,119
% Vacant Units	0.00	0.91	0.10	0.10	68,119

**=Dependent Variable*

Source: U.S. Census Bureau; Urban Institute; Geolytics.

Table 14: Summary Statistics, 2000

Variable	Min.	Max.	Mean	Std. Dev.	No. of Obs.
% Pop. 25-34 Years Old	0.00	0.57	0.14	0.05	68,119
% Pop. Under 18 Years Old	0.00	0.57	0.25	0.07	68,119
% Pop. 18-24 Years Old	0.00	0.98	0.10	0.07	68,119
% Pop. 35-44 Years Old	0.00	0.41	0.16	0.03	68,119
% Pop. 45-54 Years Old	0.00	0.53	0.13	0.03	68,119
% Pop. 55-64 Years Old	0.00	0.40	0.09	0.03	68,119
% HH with HH Inc. $25,000-$49,999	0.00	0.96	0.29	0.08	68,119
% HH with HH Inc. $50,000-$74,999	0.00	1.00	0.19	0.06	68,119
% HH with HH Inc. $75,000-$99,999	0.00	0.41	0.10	0.06	68,119
% HH with HH Inc. Greater than $100,000	0.00	1.00	0.12	0.12	68,119
% Workers Who Use Public Transit	0.00	0.85	0.05	0.11	68,119
Principal City	0.00	1.00	0.37	0.48	68,119
New England	0.00	1.00	0.05	0.22	68,119
Middle Atlantic	0.00	1.00	0.14	0.35	68,119
East North Central	0.00	1.00	0.17	0.37	68,119
West North Central	0.00	1.00	0.07	0.26	68,119
South Atlantic	0.00	1.00	0.18	0.39	68,119
East South Central	0.00	1.00	0.06	0.24	68,119
West South Central	0.00	1.00	0.11	0.31	68,119
Mountain	0.00	1.00	0.07	0.25	68,119
% Workers Who Commute 25-44 Min.	0.00	0.66	0.23	0.10	68,119
% Black/African American Pop.	0.00	1.00	0.13	0.23	68,119
% Hispanic Pop.	0.00	1.00	0.12	0.19	68,119
% Pop. With Some College	0.00	0.69	0.21	0.06	68,119
% Pop. With Associate's Degree	0.00	0.29	0.06	0.03	68,119
% Renters	0.00	1.00	0.31	0.21	68,119
% Vacant Units	0.00	0.99	0.09	0.09	68,119

**=Dependent Variable*
Source: U.S. Census Bureau; Urban Institute; Geolytics.

Table 15: Summary Statistics, 2010

Variable	Min.	Max.	Mean	Std. Dev.	No. of Obs.
% Pop. 25-34 Years Old	0.00	1.00	0.13	0.06	68,116
% Pop. Under 18 Years Old	0.00	0.64	0.24	0.07	68,116
% Pop. 18-24 Years Old	0.00	1.00	0.10	0.08	68,116
% Pop. 35-44 Years Old	0.00	1.00	0.14	0.04	68,116
% Pop. 45-54 Years Old	0.00	0.78	0.15	0.04	68,116
% Pop. 55-64 Years Old	0.00	1.00	0.12	0.04	68,116
% HH with HH Inc. $25,000-$49,999	0.00	1.00	0.25	0.09	68,113
% HH with HH Inc. $50,000-$74,999	0.00	1.00	0.18	0.06	68,113
% HH with HH Inc. $75,000-$99,999	0.00	0.82	0.12	0.06	68,113
% HH with HH Inc. Greater than $100,000	0.00	1.00	0.16	0.11	68,113
% Workers Who Use Public Transit	0.00	1.00	0.05	0.11	68,109
Principal City	0.00	1.00	0.37	0.48	68,119
New England	0.00	1.00	0.05	0.22	68,119
Middle Atlantic	0.00	1.00	0.14	0.35	68,119
East North Central	0.00	1.00	0.17	0.37	68,119
West North Central	0.00	1.00	0.07	0.26	68,119
South Atlantic	0.00	1.00	0.18	0.39	68,119
East South Central	0.00	1.00	0.06	0.24	68,119
West South Central	0.00	1.00	0.11	0.31	68,119
Mountain	0.00	1.00	0.07	0.25	68,119
% Workers Who Commute 25-44 Min.	0.00	0.00	0.00	0.00	0
% Black/African American Pop.	0.00	1.00	0.13	0.23	68,116
% Hispanic Pop.	0.00	1.00	0.15	0.21	68,116
% Pop. With Some College	0.00	1.00	0.21	0.06	68,116
% Pop. With Associate's Degree	0.00	0.40	0.07	0.03	68,116
% Renters	0.00	1.00	0.30	0.20	68,119
% Vacant Units	0.00	1.00	0.12	0.10	68,119

**=Dependent Variable*
Source: U.S. Census Bureau; Urban Institute; Geolytics.

Table 16: Summary Statistics, 2015

Variable	Min.	Max.	Mean	Std. Dev.	No. of Obs.
% Pop. 25-34 Years Old	0.00	1.00	0.14	0.06	68,115
% Pop. Under 18 Years Old	0.00	0.64	0.23	0.07	68,115
% Pop. 18-24 Years Old	0.00	1.00	0.10	0.08	68,115
% Pop. 35-44 Years Old	0.00	0.52	0.13	0.03	68,115
% Pop. 45-54 Years Old	0.00	1.00	0.14	0.04	68,115
% Pop. 55-64 Years Old	0.00	1.00	0.13	0.04	68,115
% HH with HH Inc. $25,000-$49,999	0.00	1.00	0.24	0.08	68,110
% HH with HH Inc. $50,000-$74,999	0.00	1.00	0.18	0.06	68,110
% HH with HH Inc. $75,000-$99,999	0.00	1.00	0.12	0.05	68,110
% HH with HH Inc. Greater than $100,000	0.00	1.00	0.22	0.16	68,110
% Works Who Walk to Work	0.00	1.00	0.03	0.06	68,108
% Workers Who Use Public Transit	0.00	0.93	0.06	0.12	68,108
Principal City	0.00	1.00	0.37	0.48	68,119
New England	0.00	1.00	0.05	0.22	68,119
Middle Atlantic	0.00	1.00	0.14	0.35	68,119
East North Central	0.00	1.00	0.17	0.37	68,119
West North Central	0.00	1.00	0.07	0.26	68,119
South Atlantic	0.00	1.00	0.18	0.39	68,119
East South Central	0.00	1.00	0.06	0.24	68,119
West South Central	0.00	1.00	0.11	0.31	68,119
Mountain	0.00	1.00	0.07	0.25	68,119
% Workers Who Commute Less than 25 Min.	0.00	1.00	0.56	0.17	68,109
% Workers Who Commute 25-44 Min.	0.00	1.00	0.55	0.31	68,108
% Black/African American Pop.	0.00	1.00	0.14	0.22	68,115
% Hispanic Pop.	0.00	1.00	0.16	0.21	68,115
% Pop. With Some College	0.00	1.00	0.21	0.06	68,113
% Pop. With Associate's Degree	0.00	1.00	0.08	0.03	68,113
% Renters	0.00	1.00	0.33	0.20	68,119
% Vacant Units	0.00	1.00	0.12	0.11	68,119

**=Dependent Variable*
Source: U.S. Census Bureau; Urban Institute; Geolytics.

4.2.2 Correlation Analysis

The main research question is that whether there is a relationship between the 25 to 34-year-old age cohort and density. A correlation analysis using the main variables—density (total housing units per acre), the percent of 25 to 34-year old residents in each Census tract and whether a Census tract is in a principal city will indicate whether there is any relationship between any of those variables. The results are shown in Table 17 below.

Table 17: Pearson's Correlation Coefficient

	1990			*2000*			*2010*			*2015*		
	% 25-34-Year-Olds	**Tot. Hsng. Per Acre**	**Principal City**	**% 25-34-Year-Olds**	**Tot. Hsng. Per Acre**	**Principal City**	**% 25-34-Year-Olds**	**Tot. Hsng. Per Acre**	**Principal City**	**% 25-34-Year-Olds**	**Tot. Hsng. Per Acre**	**Principal City**
% 25-34-Year-Olds	1.00			1.00			1.00			1.00		
Tot. Hsng. Per Acre	0.21	1.00		0.31	1.00		0.31	1.00		0.34	1.00	
Principal City	0.23	0.32	1.00	0.29	0.32	1.00	0.31	0.32	1.00	0.34	0.32	1.00

Note: All coefficients significant at $p<0.05$.
Source: U.S. Census Bureau; Urban Institute; Geolytics.

The results from the correlation analysis suggest that there is some sort of relationship between the share of 25-to-34-year-olds in each Census tract, the total number of housing units per acre in each Census tract, and whether a Census tract is located in a principal city.

For over half (52.8 percent) of Census tracts not located in principal cities, the percentage of 25-to-34 year-olds rose from 2010 to 2015, compared to 55.4 percent of Census tracts located in principal cities. This is compared to 44.8 percent of principal city Census tracts and 35.7 percent of non-principal city Census tracts from 2000 to 2010 and 15.9 percent of principal city Census tracts and 8.0 percent of non-principal city Census tracts from 1990 to 2000.

In 697 Census tracts the percentage of 25-to-34-year-olds increased in all four years; 69.7 percent of those were located in a principal city. In the principal city Census tracts, the Middle Atlantic had the most Census tracts (96), followed by the East North Central (90). For the non-principal city tracts, the South Atlantic region had the most tracts with an increase in the percentage of 25-to-34-year-olds over all four time periods.

4.2.3 OLS Regression

Building upon the correlation analysis, a regression analysis helped gauge how much individual variables influence residential density. A multiple linear regression was chosen given the fact that the dependent variable, the number of housing units per acre per Census tract, was continuous. Regressions were run for each of the four years—1990, 2000, 2010 and 2015.

Several adjustments needed to be made to the equations—an adjustment for potential heteroskedasticity was also included. It is important to note that the dependent variable in all four years was the log of the total number of housing units per acre in each Census tract. It was necessary to exclude some variables due to a high correlation with other variables. Tables 18 through 21 below show the results of the multiple linear regression for the years 1990, 2000, 2010 and 2015.

Table 18: Regression Results for Variables Predicting Density, 1990

Variable	*B*	*SE B*	β
% Pop. 25-34 Years Old	-2.55*	0.20	-0.06*
% Pop. Under 18 Years Old	-4.57*	0.18	-0.14*
% Pop. 18-24 Years Old	-1.99*	0.16	-0.06*
% Pop. 35-44 Years Old	-7.99*	0.27	-0.13*
% Pop. 45-54 Years Old	-11.83*	0.29	-0.15*
% Pop. 55-64 Years Old	-1.67*	0.41	-0.02*
% HH with HH Inc. $25,000-$49,999	1.96*	0.11	0.07*
% HH with HH Inc. $50,000-$74,999	5.98*	0.14	0.23*
% HH with HH Inc. $75,000-$99,999	7.21*	0.27	0.16*
% HH with HH Inc. Greater than $100,000	3.00*	0.17	0.09*
% Workers Who Use Public Transit	3.55*	0.09	0.18*
% Workers Who Walk	-4.92*	0.17	-0.14*
Principal City	0.89*	0.01	0.20*
New England	-0.14*	0.03	-0.01*
Middle Atlantic	0.53*	0.03	0.08*
East North Central	0.22*	0.02	0.04*
West North Central	-0.39*	0.03	-0.05*
South Atlantic	-0.13*	0.02	-0.02*
East South Central	-0.36*	0.03	-0.04*
West South Central	-0.31*	0.03	-0.04*
Mountain	-0.39*	0.03	-0.05*
% Workers Who Commute 25-44 Min.	3.51*	0.10	0.16*
% Workers Who Commute Less than 25 Mi	3.40*	0.08	0.25*
% Black/African American Pop.	1.05*	0.03	0.11*
% Hispanic Pop.	1.37*	0.05	0.10*
% Pop. With High School Diploma	-1.95*	0.14	-0.08*
% Pop. With Some College	2.19*	0.15	0.06*
% Pop. With Associate's Degree	-2.61*	0.28	-0.03*
% Pop. With Bachelor's/Graduate Degree	-1.69*	0.11	-0.11*
% Multifamily Units	2.44*	0.06	0.29*
% Renters	2.07*	0.09	0.19*
R^2	0.63		

*$p<.05$.

Source: U.S. Census Bureau; Urban Institute; Geolytics.

Table 19: Regression Results for Variables Predicting Density, 2000

Variable	***B***	***SE B***	**β**
% Pop. 25-34 Years Old	-4.05*	0.19	-0.10*
% Pop. Under 18 Years Old	-5.93*	0.16	-0.19*
% Pop. 18-24 Years Old	-4.97*	0.15	-0.17*
% Pop. 35-44 Years Old	-6.38*	0.31	-0.09*
% Pop. 45-54 Years Old	-8.47*	0.30	-0.13*
% Pop. 55-64 Years Old	-15.44*	0.40	-0.21*
% HH with HH Inc. $25,000-$49,999	0.17	0.13	0.01
% HH with HH Inc. $50,000-$74,999	1.81*	0.14	0.05*
% HH with HH Inc. $75,000-$99,999	5.88*	0.18	0.15*
% HH with HH Inc. Greater than $100,000	3.28*	0.08	0.17*
% Workers Who Use Public Transit	3.28*	0.11	0.18*
% Workers Who Walk	-4.39*	0.18	-0.12*
Principal City	0.88*	0.01	0.20*
New England	0.01	0.03	0.00*
Middle Atlantic	0.61*	0.03	0.10*
East North Central	0.17*	0.02	0.03*
West North Central	-0.58*	0.03	-0.07*
South Atlantic	-0.01	0.02	-0.00
East South Central	-0.31*	0.03	-0.04*
West South Central	-0.45*	0.02	-0.07*
Mountain	-0.48*	0.03	-0.06*
% Workers Who Commute 25-44 Min.	2.78*	0.09	0.13*
% Workers Who Commute Less than 25 Mi	2.55*	0.07	0.19*
% Black/African American Pop.	1.36*	0.03	0.15*
% Hispanic Pop.	1.97*	0.04	0.18*
% Pop. With High School Diploma	-0.71*	0.11	-0.03*
% Pop. With Some College	2.23*	0.15	0.06*
% Pop. With Associate's Degree	0.44	0.37	0.01
% Multifamily Units	2.29*	0.06	0.28*
% Renters	1.51*	0.09	0.15*
R^2	0.62		

*$p<.05$.

Source: U.S. Census Bureau; Urban Institute; Geolytics.

Table 20: Regression Results for Variables Predicting Density, 2010

Variable	*B*	*SE B*	β
% Pop. 25-34 Years Old	-1.32*	0.16	-0.04*
% Pop. Under 18 Years Old	-3.39*	0.14	-0.11*
% Pop. 18-24 Years Old	-3.29*	0.13	-0.12*
% Pop. 35-44 Years Old	-2.20*	0.22	-0.04*
% Pop. 45-54 Years Old	-4.76*	0.2	-0.09*
% Pop. 55-64 Years Old	-6.76*	0.25	-0.13*
% HH with HH Inc. $25,000-$49,999	0.16	0.11	0.01
% HH with HH Inc. $50,000-$74,999	-0.34*	0.12	-0.01*
% HH with HH Inc. $75,000-$99,999	-0.19	0.14	-0.01
% HH with HH Inc. Greater than $100,000	0.88*	0.12	0.05
% Workers Who Use Public Transit	0.89*	0.06	0.05
% Workers Who Walk to Work	-1.91*	0.14	-0.06
Principal City	0.93*	0.01	0.21
New England	-0.03	0.03	-0.00
Middle Atlantic	0.48*	0.02	0.08*
East North Central	0.15*	0.02	0.03*
West North Central	-0.64*	0.03	-0.08*
South Atlantic	-0.06*	0.02	-0.01*
East South Central	-0.58*	0.03	-0.07*
West South Central	-0.65*	0.02	-0.10*
Mountain	-0.49*	0.03	-0.06*
% Black/African American Pop.	1.77*	0.03	0.19*
% Hispanic Pop.	2.31*	0.04	0.23*
% Pop. With High School Diploma	-0.66*	0.13	-0.03*
% Pop. With Some College	2.45*	0.13	0.07*
% Pop. With Associate's Degree	-0.18	0.19	-0.00
% Pop. With Bachelor's Degree	1.94*	0.09	0.17*
Multifamily Share	3.24*	0.05	0.40*
% Renters	-0.52*	0.08	-0.05*
% Vacant Units	-3.71*	0.08	-0.18*
R^2	0.61		

**p<.05.*

Source: U.S. Census Bureau; Urban Institute; Geolytics.

Table 21: Regression Results for Variables Predicting Density, 2015

Variable	*B*	*SE B*	β
% Pop. 25-34 Years Old	-0.42*	0.16	-0.01*
% Pop. Under 18 Years Old	-3.29*	0.15	-0.10*
% Pop. 18-24 Years Old	-2.06*	0.13	-0.08*
% Pop. 35-44 Years Old	-0.14	0.23	-0.00
% Pop. 45-54 Years Old	-3.22*	0.23	-0.05*
% Pop. 55-64 Years Old	-4.96*	0.25	-0.09*
% HH with HH Inc. $25,000-$49,999	-0.07	0.12	-0.00
% HH with HH Inc. $50,000-$74,999	0.03	0.13	0.00
% HH with HH Inc. $75,000-$99,999	-0.63*	0.17	-0.02*
% HH with HH Inc. Greater than $100,000	0.89*	0.10	0.07*
% Workers Who Use Public Transit	1.38*	0.06	0.08*
% Workers Who Walk to Work	-3.69*	0.16	-0.10*
Principal City	0.84*	0.01	0.19*
New England	0.07*	0.03	0.01*
Middle Atlantic	0.76*	0.02	0.13*
East North Central	0.25*	0.02	0.04*
West North Central	-0.60*	0.03	-0.08*
South Atlantic	0.03	0.02	0.01
East South Central	-0.60*	0.03	-0.07*
West South Central	-0.57*	0.02	-0.08*
Mountain	-0.43*	0.03	-0.05*
% Workers Who Commute Less than 25 Min.	0.90*	0.05	0.07*
% Workers Who Commute 25-44 Min.	0.31*	0.02	0.05*
% Black/African American Pop.	1.62*	0.03	0.17*
% Hispanic Pop.	1.82*	0.04	0.19*
% Pop. With High School Diploma	-2.94*	0.09	-0.15*
% Pop. With Some College	1.27*	0.12	0.04*
% Pop. With Associate's Degree	-1.18*	0.19	-0.02*
Multifamily Share	3.08*	0.05	0.38*
% Renters	-0.37*	0.09	-0.04*
% Vacant Units	-3.79*	0.08	-0.19*
R^2	0.61		

*$p<.05$.

Source: U.S. Census Bureau; Urban Institute; Geolytics.

Age. There was a negative relationship between density and the 25-to-34-year-old age cohort in 1990, 2000, 2010, and 2015. The coefficient was negative for all the age cohorts in all four regressions as well.; The share of 35-to-44-year-olds was not significant in the 2015 regression. The higher the percentage of members of each age group in the Census tract, the fewer the number of housing units in that Census tract. For example, if the percentage of 25-to-34-year-old residents was 56% in 2000, it would be expected that there would be fewer housing units per acre than if the percentage of 25-to-34-year-olds was 40%.

Household Income. The coefficients were significant and positive for all income levels in 1990. The share of households with an income of $25,000 to $49,999 was not significant in the 2000, 2010, and 2015 regressions. The share of $75,000 to $99,999 variable in 2010 and the share of $50,000 to $74,999 in 2015 were not significant, either. The household income variables that were significant had some of the highest beta coefficients, indicating the percentage of households earning a given income distribution has some of the highest influence on density.

Method of Transportation to Work The share of workers in each Census tract that drive a car to work needed to be excluded in all four regressions due to a high correlation with other variables. In all four regressions, the coefficient for the share of workers who used public transportation to commute to work was significant and positive, and the coefficient for the share of workers who walk to work was negative. The share of workers who worked at home was not included in any of the regressions due to issues with the data. Data issues made it difficult to draw many conclusions from transportation variables, but higher uses of public transportation are associated with higher-density Census tracts.

Length of Commute Time. Similarly, the length of commute was not included in the 2010 regression due to issues with the variables. Three options were available in the Neighborhood

Change Database and American Factfinder—workers whose commute was under 25 minutes, workers whose commute was 25 to 44 minutes, and workers whose commute was 45 minutes or greater (excluded in the analysis). The share of workers who commute less than 25 minutes cohort and the share whose commute was 25 to 44 minutes was significant and positive in the 1990, 2000 and 2015 regressions. The beta coefficients were highest for these variables—0.19 for the commute less than 25 minutes in the 2000 regression. Only the coefficients for share of multifamily units in the Census tract and principal city status were higher.

Structure Type. The share of multifamily housing units in each Census tract indicated a positive relationship with density in all four regressions. In all four regressions, the beta coefficient for the multifamily share was the highest coefficient for all variables included. The single-family share was excluded in all four regressions due to high multicollinearity with other variables.

Census Division. Not all Census regions were significant in all four years. In 1990, all coefficients were significant at the 95 percent confidence interval. Coefficients were negative in the West North Central, West South Central, and Mountain divisions, indicating that a Census tract's location in one of these divisions lowers the density. In 2000, 2010 and 2015, coefficients for the New England, Middle Atlantic and East North Central were all positive, except for the New England division in the 2010 regression, which was not significant. All other coefficients were negative, except for the South Atlantic division in the 2015 regression, which was not significant. Results from the regression suggest that there may be some geographic diversity between density trends.

Principal City Status. Like the share of multifamily units in each Census tracts, whether a Census tract was in a principal city was significant in all four years, with one of the highest beta

coefficients in each regression. This indicates that Census tracts located in areas defined as principal cities are associated with higher density than areas defined as suburbs.

Educational Attainment. Several of the education attainment variables, including the percent of Census tract population that had earned either a bachelor's, graduate, and/or professional degree as their highest education level, were collinear with other variables in many of the regressions and were excluded. The share of population with some college was significant and positive in all four regressions; the share of population with a high school diploma was included in all four regressions, with a significant negative coefficient. The share of the population with an associate's degree was able to be included in all four regressions but was only significant in the 1990 and 2000 results. The percent of residents with a bachelor's degree or higher was not able to be included in the 2000 or 2015 regressions; the coefficient was significant and negative in the 1990 regression, but by the 2010 regression, the coefficient was significant and positive. These results indicate that the higher the share of less educated residents in a Census tract, the lower the density of the Census tract. Results for the higher educated (bachelor's degree or higher) cohort are not substantial enough to indicate any patterns.

Race/Ethnicity. The share of residents that were white was excluded from each of the regression analyses due to a high multicollinearity with other variables. In all four regressions, the coefficients for both the share of Census tract residents that were Hispanic or Black/African Americans were significant at the 95 percent confidence interval and positive, indicating that residential density increases as the share of Black/African American and Hispanic residents in each Census tract increases.

Tenure/Vacancy Status. The share of renter households was significant and positive in all four regressions, indicating that the more renter households in a Census tract, the higher the density.

The beta coefficient for this variable was one of the highest coefficients included in each of the regressions, except for the 2010 regression. The variable for the percent of vacant housing units was only able to be included in the 2010 and 2015 regressions due to a high vif score in the other two regressions. The result was significant with the highest negative beta coefficient in both the 2010 and 2015 regression, however. This indicates that at least in later years, the higher the share of vacant units in a Census tract, the lower the residential density.

4.3 Conclusion

Regression results for the housing-related variables (structure type, tenure) provided expected results; more multifamily units and more renter-occupied households are associated with higher density. This is unsurprising given that multifamily housing by its nature is more dense (more units per acre).

Clear trends are less evident when examining the relationship between demographic characteristics and residential density, however. While the correlation coefficient found a positive relationship between the percentage of 25-to-34-year-olds in a given Census tract and density, further analysis showed that the relationship was actually negative. This is likely due to the influence of other explanatory variables besides age. This finding, combined with the results from the housing unit density indexes, suggests that changes in overall density should be the focus when attempting to understand metropolitan areas, not simply one demographic group. The following chapter delves into the implications of these findings.

5 Discussion & Conclusion

The goal of this dissertation research was to examine whether there have been changes in metropolitan areas, in terms of both the built environment and the residents. The results from the housing unit density indexes suggest a continued evolution of the metropolitan area, while the results from the regression analyses suggest that in the face of this evolution, the relationship between density itself and characteristics of the population has changed little. Simply viewing metropolitan areas through a city-suburb lens does not capture these changes. Density is increasing throughout metropolitan areas, but not at an even rate.

The first two parts of this chapter tie together the literature review with the results of the density index as well as the regression results. The third part of this chapter further delves into the implications of the findings towards planning theory and suggests alterations to the presentation of planning theory in the academic setting. Finally, the implications of the findings to the planning profession as well as opportunities for further research are discussed.

5.1 The Evolution of the Metropolitan Area

The first research question for this dissertation delved into whether there was any change in residential density over time in metropolitan areas. A related question was whether there was any distinction between density in Census tracts defined as suburbs and those defined as cities. The literature review chapter provided context for researching these questions, discussing the evolution of the suburbs, from bedroom communities where folks attempted to escape the ills of crowded cities, to areas with concentrations of white, middle-class families.

More recent academic research has found that the term suburb is no longer representative of one type of geography, that different types of suburbs have emerged (The Urban Land Institute, 2016). Marcuse (1989) noted that simply delineating between cities and suburbs was no

longer useful, but this distinction is still a common practice today. Harris and Lewis (1998) argued that the dual-city metaphor of the city and suburb was less important than the issue of suburban fragmentation. The results from this research further indicate that both these ideas are true. Residential density in metropolitan areas has evolved to the point where using the terms cities and suburbs is no longer helpful to understanding the metropolitan form. Instead, a fundamental shift should be made, to view metropolitan areas as places where development and employment are located throughout the region.

5.1.1 The Change from Monocentric to Polycentric Regions is Complete in Many Metropolitan Areas

The geography of employment and population centers has changed in many metropolitan areas. The U.S. Census Bureau defines a principal city as the largest city in the metropolitan area, as well as additional cities that meet certain population or employment centers (U.S. Census Bureau, 2018). In most metro areas, there are multiple principal cities—the Nashville metropolitan area includes three (U.S. Office of Management & Budget, 2015). These new employment centers are not always located near the original city center, which has resulted in sporadic clusters (Cervero & Wu, 1997). This shift in employment centers means that building trends would change as well—new “cities” and “suburbs” would develop, and locations further out would become more realistic options for housing. Additionally, the development of supportive services in these new employment and population centers (such as retail) brings individuals of a variety of incomes. A variety of housing options are necessary for these residents of varying income levels, and it would be reasonable to expect that the type of housing would be diversifying throughout the metropolitan area as a result.

Sanchez and Dawkins (2001) recommended that planners include elements of the cities in the suburbs, such as a mixture of housing types and employment. The index results in this

research suggest that the residential mix is in fact changing in many areas commonly known as suburbs. Some of the largest changes in both the multifamily and multifamily share density indexes were found in Census tracts in areas defined as suburbs. As the results chapter discussed, observing the changes in residential density using maps for the Nashville and Denver metropolitan areas showed that the change in residential density was not even across the metropolitan area, and there were increases in the multifamily density indexes in many suburban Census tracts. This is a trend that was found in multiple metropolitan areas throughout the United States.

5.1.2 Density is a Relative Term

The indexes provided further results that indicated the makeup of the suburbs has changed in terms of multifamily versus single-family units, but overall density has not changed tremendously. For many of the Census tracts located in areas that are traditionally characterized as suburbs, the multifamily indexes increased at a faster rate than the single-family indexes. The results from the total housing indexes also showed that some of the largest increases in density took place in suburban areas, but even with those increases, on a per acre basis, the density was relatively low. The average number of total housing units per acre in suburban Census tracts increased from 1.28 in 1990 to 1.55 in 2015.

The fact that overall, density is not increasing quickly has multiple implications. Cervero and Wu (1997) discuss the impact of the changing metropolitan form and the lengthening of commute times. If changes in density continue in a similar pattern without local governments planning for these changes, traffic congestion would likely worsen in existing areas, and could move further out.

The indexes considered how density has changed relative to the existing housing stock; therefore, places that had little density to begin with would see a larger effect than places with an existing high density. This was done on purpose, because the research topic in this dissertation was to examine changing densities—a higher-density place likely already has many of the attributes of a principal city, and therefore changes there would not be as noticeable. Density in principal cities and suburbs changed at a similar rate despite the different starting points, again reinforcing the idea that the city-suburb designation is not useful.

5.1.3 Political Boundaries Are Meaningless

Census tracts coincide with political boundaries such as cities and counties but allow for analysis at a finer grained geography than the county or city. This is important because many political jurisdictions have areas with very different characteristics. Census tracts are one of the only metrics that allows for analysis below the overall political boundaries. Results from the index analysis show that the magnitude of changes in density are varied throughout many political boundaries.

The Nashville and Denver maps also showed that while there were clusters of Census tracts where the density indexes were increasing quickly, those clusters of tracts were not neatly inside or outside the political boundaries. This reinforces the assertion by Nelson and Sanchez (1999) that political boundaries have little to do with development patterns.

The permeability of political boundaries further suggests the importance of coordination between local governments. In the Nashville metro area, the city of Franklin is one example where the housing density increased both within the city boundaries and outside. Local planners need to be cognizant of the growth on both sides of the boundary to understand the impact on both jurisdictions.

These changes in the built environment do not come without changes to the resident population as well. The first part of the research informed how density has changed in the context of the metropolitan area and found that density is gradually increasing throughout metropolitan areas. As this density has moved outward, though, have identifying characteristics of residents changed?

5.2 Characteristics of Residents and Households and the Relationship with Density

The impetus for this research was anecdotal reports about the Millennial generation, and speculation that members of the Millennial generation were going to change the face of the suburbs. Some previous survey results showed evidence that members of the Millennial generation were interested in living in the suburbs, but it was unclear whether that was true, and whether those movements if they were occurring, were having any impact (Hudson, 2015). The second research question for this dissertation was designed to explore this potential relationship between density and the age distribution of households:

1. Is there any relationship between residential density and the 25-to-34-year-old age cohort?
    a. If so, has that relationship changed over time?
    b. Are there other demographic or economic characteristics of the population that have a significant relationship with residential density?
    c. If a relationship exists between residential density and any demographic or economic characteristics, how does it compare in areas that were previously defined as suburbs and principal cities?

To answer this question (and the related sub-questions), it was necessary to investigate whether other relationships exist as well. The results suggest that the face of the suburbs is

changing, but it is not because of members of the Millennial generation. While the correlation coefficients showed that there was a relationship between the percentage of 25-to-34-year-olds and density in Census tracts, further research through the regression analysis found a more complicated relationship between age of residents and density.

Metropolitan areas were the focus of the study, not suburbs specifically, but it was important to explore whether any differences exist between areas known as suburbs and areas commonly known as principal cities. Regressions were attempted for Census tracts in suburbs and principal cities separately, with similar results. The final regressions suggest that there is a positive relationship between density and whether a Census tract is located in a principal city.

5.2.1 The Relationship Between Young Adult Residents and Density

The 25-to-34-year-old age cohort was chosen to be studied because the bulk of the Millennial generation was in that age cohort at the time of many of the anecdotal news reports. The 25 to 34-year-old cohort comprised 14.2 percent of the entire United States population in 2000; in 2010, it was 13.3 percent; by 2015, it had increased slightly to 13.7 percent, as the Millennials continued to age into the cohort (U.S. Census Bureau 2, 2018). In the regression results, the coefficient for the percent of 25-to-34-year-olds in each Census tract was negatively associated with density in all years. Less important is the sign of the coefficient, but the fact that the relationship between age and density did not change over the entire time period. This indicates that as density has changed throughout the metropolitan area, the behaviors of the Millennial generation have had no different impact than recent generations did at the same age.

There are two caveats to these findings—the first is that age of householder was not able to be used, so individuals living with their parents were included in the analysis. It is possible that if the age of householder was able to be used, they might provide even more insight into the

relationship between density and 25-to-34-year-olds over time. Additionally, there is an issue of composition; there were fewer 25-to-34-year-olds in 1990 than there were in 2000 and 2010, which may also have an impact. Absolute numbers were not used, however, because there was a concern that absolute numbers would cloud the regression results.

The regression results also yielded similar coefficients for other age groups, suggesting that there was no distinct difference in the relationship between density and young adults aged 25-to-34 and density and other age groups. This reinforces the idea that when gauging demand, practitioners should not focus too much on one demographic group.

5.2.2 The Relationship Between Other Demographics and Density

Previous academic research regarding the suburbs found additional characteristics to be important when categorizing the residents (Lang & Lefurgy, 2007). While the suburbs were not the specific focus, some of these characteristics, such as educational attainment, were included in the regression analysis. The regression results showed that some of these other variables such as tenure and household income had a significant relationship with density. One finding consistent across almost all of the variables examined was that the relationship between each variable and density did not change over the entire time studied.

The various variables suggest that there are a variety of factors that influence density, which make sense given the fact that higher-density places are associated with a larger mix of people from different backgrounds. The literature review established that many minorities were relegated to living in the cities due to government practices (Hayden, 2003). One of the most clear-cut findings from the regression suggests that higher shares of minorities (African Americans and Hispanic residents) are associated with higher levels of density.

It is unclear, however, whether these minorities are associated with living in cities, specifically, and data suggest that this may not be the case. Most Census tracts located in suburbs (69.4 percent) experienced an increase in the percent of African American residents from 1990 to 2000; a similar increase was seen from 2000 to 2010 (44.2 percent) and from 2010 to 2015 (52.6 percent). For 11.5 percent of the suburban tracts, the share increased steadily from 1990 through 2015. This is in comparison to 13.1 percent of principal city Census tracts during the same time period.

There was an increase in the share of Hispanic residents in over three-quarters (77.6 percent) of suburban Census tracts from 1990 to 2000; similar trends existed in the 2000 to 2010 period (69.7 percent) and the 2010 to 2015 period (60.3 percent). For over one-quarter (27.4 percent) of suburban Census tracts, the share of Hispanic residents increased over the entire 1990-2015 time period, almost exactly the same percentage of principal city Census tracts (27.8 percent).

Kruse and Sugrue (2006) previously highlighted this change in the racial makeup when writing about how the suburbs have changed from stereotypical communities comprised of residents of the same race and economic background. An opportunity for future research would be to focus on the socioeconomic situation for these minority residents, as it would provide a clearer picture of desegregation of race and poverty throughout metropolitan areas.

5.3 Theoretical Implications

5.3.1 Changes to the Urban Form Theory

The residential density indexes suggest that many of the theories related to the process of suburbanization are still accurate today. The natural evolution theory of suburbanization posits that employment is initially concentrated in a city center, but as the city center becomes more

populated, residential development will move out to farther locations, and employment will follow (Mieszkowski & Mills, 1993). Harris' (1997) updated urban theory, that presented patterns in relation to economic activity centers in the metro area, not just the city center, also applies. While the dissertation research did not delve into the employment aspect, the changes in density suggest that the fundamentals of this theory are occurring.

The results from this dissertation research indicate that an equal emphasis should be placed on the process behind suburbanization and changes in density when teaching urban planning theory, not just the issue of cities versus suburbs as places. The index results show that density is increasing in metropolitan areas, and future planning practitioners should be educated regarding how metropolitan areas are changing in terms of development patterns, particularly because they will be the people to help guide those development patterns.

5.3.2 Generation Theory vs. Emerging Adulthood- What is Right?

It was necessary to delve into the existing literature surrounding the Millennial generation and generation theory in order to understand the potential impact on the dissertation research. Generation theory posits that groups of people that are born during the same time period will be shaped by certain life events for the entirety of their lives (Howe & Strauss, 2000). As a result, members of different generations will behave differently because they have different life events that shape them.

The regression results preliminarily seem to confirm claims that generation theory is not particularly useful, particularly in terms of its utility to the planning profession, and likely should not be included in curriculums for planning programs. The influence of the Millennial generation should not be overstated in planning programs, but instead the importance of analyzing overall demographics in a given area could be taught. The scope of this dissertation research, however,

is not broad enough to prove or disprove generation theory itself. The regression results do suggest that local planners and private developers should not concentrate their efforts on the behaviors of members of one group, because as density continues to increase, a variety of demographics are represented in the resident base.

There are elements from the literature review that cannot be ignored, however, even though the regression results suggest there is not an anomalous relationship between the 25-to-34-year-old age cohort in the 2015 regression. The median and average age at which major life events occur has been increasing for many decades, as discussed in the literature review. The emerging adulthood theory, however, may be more accurate.

The cohorts that the ages are divided into makes it difficult to confirm or disprove the emerging adulthood theory. The median age at which individuals get married has been increasing, however the age has always fallen in the 25-to-34-year-old cohort, therefore the changes in the emerging adulthood theory would not appear in the data.

It is not important to confirm or deny the emerging adulthood theory in this dissertation, however; under that theory, there is no meaningful change in consumer behavior between the same age cohorts in different decades, just a few years' difference as to when those behaviors occur.

5.4 Planning Practice Implications

The results from this dissertation research suggest that individuals need to change their entire way of thinking regarding metropolitan areas—they are not simply a city or series of cities and their suburbs, but a region with scattered employment centers and residents. Density is moving out of the cities and further out, and individuals need to acknowledge changes that come with density in all forms.

The indexes clearly show that in many parts of the United States, density is continuing to spread further away from the central city, and while density is increasing, it is not increasing at an incredibly rapid rate, and it is spreading further outward. As density continues to spread, it will be necessary for planners to be cognizant of development patterns to combat sprawl, but also to be mindful of infrastructure and traffic complications due to development.

Practitioners, both private and public, also need to avoid putting too much stock in one group of individuals- members of the Millennial generation are one portion of a large population. The regression results clearly showed that the relationship between the 25-to-34-year-old cohort and density has not changed over time, but the changes in density seen in the indexes clearly exceed any influence of one specific group.

5.5 Opportunities for Further Research

It was not possible to obtain commercial data as part of this dissertation research. This research addresses the concept of residential density, however many of the anecdotal media reports mentioned in the introduction discussed the introduction of more mixed-use developments in the areas previously known as the suburbs. While this research moved forward the relationship between density and the built environment, additional data related to commercial (retail and office) land uses would add an additional element to the story. In addition, the data from the Geolytics/Neighborhood Change Database looked at the age of the population, not the age of householder. As was noted in the literature review chapter, a significant number of young adults aged 25 to 34 are living at home with their parents. Obtaining data regarding the age of householders would result in a stronger and more clear explanation regarding the movement of the Millennial generation.

5.6 Conclusion

The goal of this dissertation was to explain how metropolitan areas have continued to evolve and provide a description of the current built environment and the people who live there, as well as provide a quantitative rationale for this description. This research was prompted by anecdotal media reports that suburbs are changing, and members of the Millennial generation are part of the reason for that change. Results show that a much more complicated story exists.

The findings from this dissertation suggest that the reason for the change in the suburbs is a longer-term trend—places are becoming denser, which is unsurprising given the context that the literature review suggests. It is important not to think about the suburbs becoming denser, but to consider the fact that metropolitan areas are gradually adding density, and density is spreading further out as development patterns change in those metropolitan areas.

Results also indicate that Millennials are not solely responsible for the changes in density that are occurring throughout metropolitan areas. A relationship does exist between members of the 25-to-34-year-old cohort and density, however a relationship also exists between members of other age cohorts and density, as well as other demographic and economic characteristics. This relationship with density is not unique to Census tracts in suburbs or cities.

This dissertation purposefully did not attempt to classify suburbs or cities or any types of metropolitan areas; instead, the goal was to show an emerging fundamental shift that is occurring in the metropolitan form for most of the country. Metropolitan areas are not simply cities and suburbs; places are becoming more heterogenous in terms of the built environment and the population across the metro areas.

5.7 References

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6 Appendix A

Table A- 1: Variables Used from Urban Institute/Geolytics Variables, 1990

Variable Name	Neighborhood Change Database Variables
Multifamily Units	ttunit39+ttunit49+ttunit59
Less than HS Diploma	educ89+educ119
High School Diploma (or Equivalent)	educ129
Some College	educ159
Associate's Degree	educa9
Bachelor's Degree or Graduate Degree	educ169
Under 18 Years Old	child9n
18 to 24 Years Old	ythpop9
25 to 34 Years Old	fem299+fem349+men299+men349
35 to 44 Years Old	fem449+men449
45 to 54 Years Old	fem549+men549
55 to 64 Years Old	fem649+men649
65 Years or Older	pers65p9
White	shrnhw9n
African American/Black	shrnhb9n
American Indian/Alaskan Native	shrnhi9n
Asian/Pacific Islander/Hawaiian	shrnha9n
Other	shrnho9n
Hispanic	shrhsp9n
Uses Public Transportation	trvlpb9n
Walks to Work	trvlot9n
Work at Home	wkhome9
Travels to Work by Car	auto9
Less than 25 Min Commute	commut29
25 to 44 Min Commute	commut49
45 Min Commute or Greater	commutx9
Household Income Less than $25,000	whh59+whh109+whh159+whh259+bhh59+bhh109+bhh159+bhh259+ihh59+ihh109+ihh159+ihh259+ahh59+ahh109+ahh159+ahh259+ohh59+ohh109+ohh159+ohh259
Household Income $25,000-$49,999	whh359+whh509+bhh359+bhh509+ihh359+ihh509+ahh359+ahh509+ohh359+ohh509
Household Income $50,000-$74,999	whh759+bhh759+ihh759+ahh759+ohh759
Household Income $75,000-$99,999	whh1009+bhh1009+ihh1009+ahh1009+ohh1009
Household Income $100,000+	whhmxa9+bhhmxa9+ihhmxa9+ahhmxa9+ohhmxa9
Single-Family Units	ttunit19+ttunit29
Owner Households	ownocc9
Renter Households	rntocc9
Total Housing Units	tothsun9
Total Population	trctpop9
Total Vacant Units	vachu9

Source: Urban Institute/Geolytics, Neighborhood Change Database.

Table A- 2: Variables Used from Urban Institute/Geolytics Variables, 2000

Variable Name	Neighborhood Change Database Variables
Multifamily Units	ttunit30+ttunit40+ttunit50
Less than HS Diploma	educ80+educ110
High School Diploma (or Equivalent)	educ120
Some College	educ150
Associate's Degree	educa0
Bachelor's Degree or Graduate Degree	educ160
Under 18 Years Old	child0n
18 to 24 Years Old	ythpop0
25 to 34 Years Old	fem290+fem340+men290+men340
35 to 44 Years Old	fem440+men440
45 to 54 Years Old	fem540+men540
55 to 64 Years Old	fem640+men640
65 Years or Older	pers65p0
White	shrnhw0n
African American/Black	shrnhb0n
American Indian/Alaskan Native	shrnhi0n
Asian/Pacific Islander/Hawaiian	shrnha0n
Other	shrnho0n
Hispanic	shrhsp0n
Uses Public Transportation	trvlpb0n
Walks to Work	trvlot0n
Work at Home	wkhome0
Travels to Work by Car	auto0
Less than 25 Min Commute	commut20
25 to 44 Min Commute	commut40
45 Min Commute or Greater	commutx0
Household Income Less than $25,000	thy0100+thy0150+thy0200+thy0250
Household Income $25,000-$49,999	thy0300+thy0350+thy0400+thy0450+thy0500
Household Income $50,000-$74,999	thy0600+thy0750
Household Income $75,000-$99,999	thy01000
Household Income $100,000+	thy01250+thy01500+thy02000
Single-Family Units	ttunit10+ttunit20
Owner Households	ownocc0
Renter Households	rntocc0
Total Housing Units	tothsun0
Total Population	trctpop0
Total Vacant Units	vachu0

Source: Urban Institute/Geolytics, Neighborhood Change Database.

Table A- 3: Variables Used from Urban Institute/Geolytics Variables, 2010

Variable Name	Neighborhood Change Database Variables
Multifamily Units	ttunit31a+ttunit41a+ttunit51a
Less than HS Diploma	educ81a+educ111a
High School Diploma (or Equivalent)	educ121a
Some College	educ151a
Associate's Degree	educa1a
Bachelor's Degree or Graduate Degree	educ161a
Under 18 Years Old	child1an
18 to 24 Years Old	ythpop1a
25 to 34 Years Old	fem291a+fem341a+men291a+men341a
35 to 44 Years Old	fem441a+men441a
45 to 54 Years Old	fem541a+men541a
55 to 64 Years Old	fem641a+men641a
65 Years or Older	pers65p1a
White	minwht1an
African American/Black	minblk1an
American Indian/Alaskan Native	minami1an
Asian/Pacific Islander/Hawaiian	minapi1an
Other	minoth1an+mrapop1an
Hispanic	shrhsp1an
Uses Public Transportation	trvlpb1a
Walks to Work	trvlot1an
Work at Home	wkhome1a
Travels to Work by Car	auto1a
Less than 25 Min Commute	commut21a
25 to 44 Min Commute	commut41a
45 Min Commute or Greater	commutx1a
Household Income Less than $25,000	thy0101a+thy0151a+thy0201a+thy0251a
Household Income $25,000-$49,999	thy030a1+thy0351a+thy0401a+thy0451a+thy0501a
Household Income $50,000-$74,999	thy0601a+thy0751a
Household Income $75,000-$99,999	thy01001a
Household Income $100,000+	thy01251a+thy01501a+thy2001a+thym201a
Single-Family Units	ttunit11a+ttunit21a
Owner Households	ownocc1a
Renter Households	rntocc1a
Total Housing Units	tothsun1a
Total Population	trctpop1a
Total Vacant Units	vachu1a

Source: Urban Institute/Geolytics; Urban Institute Database.

Table A- 4: Variables Used from 2011-2015 American Community Survey Tables

Variable Name	American Community Survey Table
Multifamily Units	B25024
Less than HS Diploma	B15003
High School Diploma (or Equivalent)	B15003
Some College	B15003
Associate's Degree	B15003
Bachelor's Degree or Graduate Degree	B15003
Under 18 Years Old	B01001
18 to 24 Years Old	B01001
25 to 34 Years Old	B01001
35 to 44 Years Old	B01001
45 to 54 Years Old	B01001
55 to 64 Years Old	B01001
65 Years or Older	B01001
White	B03002
African American/Black	B03002
American Indian/Alaskan Native	B03002
Asian/Pacific Islander/Hawaiian	B03002
Other	B03002
Hispanic	B03002
Uses Public Transportation	B08006
Walks to Work	B08006
Work at Home	B08006
Travels to Work by Car	B08006
Less than 25 Min Commute	B08303
25 to 44 Min Commute	B08303
45 Min Commute or Greater	B08303
Household Income Less than $25,000	B19001
Household Income $25,000-$49,999	B19001
Household Income $50,000-$74,999	B19001
Household Income $75,000-$99,999	B19001
Household Income $100,000+	B19001
Single-Family Units	B25024
Owner Households	B25003
Renter Households	B25003
Total Housing Units	B25024
Total Population	B01003
Total Vacant Units	B25004

Source: U.S. Census Bureau.

Table A- 5: Sources for Geography Variables

Variable Name	Method
Acres	Conversion of arealand (in square meters) from Neighborhood Change Database
Tract Number	2010 Census tract definition
Census Division	https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf
Principal City/Suburb	https://www.census.gov/geographies/reference-files/time-series/demo/metro-micro/delineation-files.html
Metropolitan Statistical Area	https://www.census.gov/geographies/reference-files/time-series/demo/metro-micro/delineation-files.html

Source: U.S. Census Bureau; Urban Institute; Geolytics.