Land Use Efficiency in Fairfax City, Virginia Through Per Acre Property Tax Analysis

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ABSTRACT

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This thesis explores the efficiency of sprawl land use patterns in Fairfax City, VA. Over the last 100 years, local, state, and federal land use policies have created an auto-oriented environment known as sprawl. Literature suggests that sprawl is more expensive to build and maintain than more compact development patterns, so localities must ensure that their development patterns produce enough property tax revenue to cover costs. Calculating property tax per acre allows localities to determine how productive each acre of land is, and which types of land uses are the most productive for each acre of land that they use. In Fairfax City, detached single-family homes and properties that used a considerable amount of land for surface parking lots were significantly less productive per acre with respect to tax revenue than more compact land uses such as attached single-family housing and the City's Old Town. Fairfax City should reexamine its land use policies and zoning ordinance which currently emphasizes sprawl over traditional development.

1. INTRODUCTION

Every day most Americans get to the majority of their destinations by car. American settlement and travel patterns are a result of a human environment built around the use of automobiles. The suburbs and personal car ownership have been considered elemental parts of the United States economic and social dominance on the world stage. However, when considering the economic strength of these suburbs, local governments must examine the costs and revenues of their land use patterns.

This research will attempt to determine whether the current land use patterns that are common throughout the U.S. are an efficient and sustainable use of land for local governments. Although suburbia is considered the physical embodiment of prosperity, research has shown that it is more costly to build and maintain while also bringing in less revenue than more compact development patterns. By measuring property tax revenue by each acre's output rather than each property's gross revenue, a local government can determine which land uses are the most financially productive. Using 3D mapping technology in the City of Fairfax, Virginia, this research will examine the per acre tax returns with the expectation that:

1. Gross tax revenue will be highest in shopping centers,
2. Per acre tax revenue will be highest in Old Town Fairfax,

3. The difference between the Old Town per acre tax revenues and that of traditional sprawl land uses will be statistically significant.

In doing so, Fairfax City will be able to use this analysis to make future land use choices to ensure that their revenue can keep up with their costs.

This research will only cover property tax revenues in the City of Fairfax. Sales tax revenues, which are associated with a geographic location, are not included. The analysis of property tax revenue per acre uses the most recent assessment values provided by the City and does not consider land use in the surrounding County or the region at large. The research presented here is intended to be used as a tool, but not the only tool, to judge land use decisions in Fairfax City.

2. LITERATURE REVIEW

This section reviews literature related to this mapping project. Because of the complexities of land use decisions and consequences in the United States, this section will be split into five subsections. Although this research is focused on tax revenues, many land use decisions were made before current decisionmakers were born. Therefore, in order to examine revenues, it is necessary to first address how and why the existing built environment, namely sprawl, emerged, before considering whether sprawl is financially efficient.

2.1 The Suburbs

2.1.1 Definition of "Sprawl"

"Sprawl" is a common but ambiguous term used to describe suburban settlement patterns. It is sometimes referred to as "urban sprawl" as a description for whole metropolitan regions, or "suburban sprawl" when specifically discussing the suburbs. Many of the sources used in this research reference "sprawl" but do not clearly define what they mean when they use the term. As the term can have somewhat various but similar definitions, it will be defined as it will be used throughout this paper. All sources using the word "sprawl" will be inferred as using the following definition.

Sprawl describes a geographically continuous human settlement pattern surrounding metropolitan centers in which there is little to no physical separation or distinction between towns. It is characterized by four basic physical arrangements:

1. *Separation of uses*: Residential, commercial, and industrial uses are all separated from each other. Often different types of residential uses, such as apartments and single-family homes, are separated and different types of commercial uses, such as office from retail, are separated,.
2. *Single-family neighborhood pods*: Neighborhoods consisting of only single-family detached housing located in pods with limited roadways in or out. These pods often are distinctly separated from each other which can be seen on the ground or by air.
3. *Business Districts of strip malls*: Areas where people shop or do business, activities that might be located on a Main Street, are located in strip malls in which low-lying buildings are fronted by a parking lot.
4. *Hierarchical road system of feeder and collector roads*: Instead of a gridded street system found in cities, neighborhood pods feed into collector roads that feed into arterial roads which sometimes feed into highways.[1] The hierarchical system allows for only a limited number of routes to get from Point A to Point B and reduces traffic through residential neighborhoods.

This definition is similar to the ones found in *Suburban Nation* (pages 5-7) and *Happy City* (pages 46-47). Sprawl may take many forms, but these four physical

[1] Leigh Gallagher, *The End of the Suburbs* (New York, NY: Penguin Group, 2013), 42.

arrangements will dominate, leading to auto-orientation in which "automobile use is a prerequisite to social viability."[2]

2.1.2 Suburbanization

The suburbs that encompass large swaths of the United States did not occur naturally and are sometimes an extreme variation to historic settlement patterns. Most towns, villages, and cities built before World War II followed a traditional development pattern that had been used for thousands of years. Traditional neighborhoods started at a cultural center; in ancient Greek cities this was the agora; in small towns it is Main Street.[3] Surrounding the center was a street network, often gridded, made of narrow streets and small blocks that allowed for a variety of route options.[4] The buildings were often mixed-use, and there was a mix of uses along each block.[5] Most things a resident needed in their daily lives existed within a five-minute walk.[6] This close knit grid came about organically from the needs of residents, who, prior to the automobile, had to walk to every destination.[7]

The change to the traditional development pattern began as transportation technology changed, but a desire to move away from the city had built up before that. Thomas Jefferson and the Romantic Movement preferred nature to cities.[8] Architects and

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[2] Andres Duany, Elizabeth Plater-Zyberk, and Jeff Speck, *Suburban Nation: The Rise of Sprawl and the Decline of the American Dream*, 1st ed. (New York, NY: North Point Press, 2000), 14.
[3] Duany et al., *Suburban Nation*, 15. Charles Montgomery, *Happy City: Transforming Our Lives Through Urban Design*, First (New York, NY: Farrar, Straus and Giroux, 2013), 19.
[4] Duany et al., *Suburban Nation*, 15-16.
[5] Ibid., 16.
[6] Ibid., 15.
[7] Gallagher, *The End of the Suburbs*, 30-31.
[8] Dennis R. Judd and Todd Swanstrom, *City Politics*, 9th ed. (New Jersey: Pearson Education, Inc., 2015), 150-151.

thinkers throughout the 1800s and 1900s sought alternative living arrangements to "evil" cities in the form of Frank Lloyd Wright's Broadacre City, Le Corbusier's Radiant City, the Garden City movement, and the City Beautiful movement.[9] As cities industrialized, these intellectual movements emerged and gained a following by presenting an idyllic life where "homes were integrated with nature" and separated from factories.[10] It was not hard to see why those movements caught hold; industrial cities were overcrowded, without modern sewage systems, covered in factory pollution, susceptible to disease, and had a constant "'intolerable'" smell.[11]

As transportation technology advanced, the option to live just outside the city arrived, first in the form of the steam ferry and later the railroad; those who could afford to commute moved outside the city center.[12] With homes separated from factories, "life expectancies rose significantly" giving momentum to anti-city intellectual movements.[13] The electric streetcar, popularized in the 1890s, "increased the amount of land available for residential use by […] 900 percent" by "tripling the distance" of possible commutes.[14] Around the trolley stations popped up middle-class suburbs, known as streetcar suburbs, in which homes and shops were within walking distance of the station and each other, since once residents got off the streetcar the only mode of transportation was their feet.[15] The streetcar suburban homes were often single-family homes either built close together

[9] Ibid., 152.
[10] Ibid., 151.
[11] Gallagher, *The End of the Suburbs*, 29.
[12] Judd and Swanstrom, *City Politics*, 151.
[13] Duany et al., *Suburban Nation*, 10.
[14] Judd and Swanstrom, *City Politics*, 152.
[15] Gallagher, *The End of the Suburbs*, 30.

on small lots or as rowhouses in order to make walking quicker.[16] Then the automobile, specifically the mass produced and affordable Model T, embiggened possible commuting distances even more.[17]

New transportation technology made dispersed settlement patterns possible, but sprawl as it is today was built by federal, state, and local policies and regulations in the post-war period. Soon after the introduction of the automobile, American transportation transformed to ensure that everyone could get everywhere by car. Electric streetcar systems were systematically bought up by a conglomerate made up of car, oil, and rubber companies and replaced with buses in order to "promote automobile sales" as an alternative to mass transit, for which the those companies were later convicted of criminal conspiracy by the U.S. Supreme Court.[18] However, the streetcar had become somewhat inefficient when it was made to share road space with cars.[19] City streets had previously been used by pedestrians, streetcars, horses, and everything in between, until auto clubs, political action groups of drivers and car dealers, lobbied local governments to create jaywalking laws.[20] The auto clubs hired engineers to promote transportation designs favoring auto transportation, and in 1928 a conference held by Commerce Secretary Herbert Hoover published a set of traffic regulations influenced by the auto clubs that was quickly adopted by cities across the country.[21]

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[16] Ibid., 30-31.
[17] Judd and Swanstrom, *City Politics*, 154.
[18] Jeff Speck, *Walkable City: How Downtown Can Save America One Step at a Time* (New York, NY: North Point Press, 2012), 141-142.
[19] Montgomery, *Happy City*, 74.
[20] Ibid., 69-71.
[21] Montgomery, *Happy City*, 72.

At the 1939 World's Fair, a General Motors exhibit called 'Futurama' presented a Broadacre City and Radiant City inspired futuristic model city in which wide, high speed "superhighways" carried cars between distant skyscraper destinations.[22] In 1956, the National Defense Highway Act put the superhighway idea into action. The new highways had two main purposes: one was to move military and civilians in case of a Cold War nuclear attack, and the second was to link major metropolitan areas in order to stimulate the economy.[23] The new highway system would also allow for the decentralization of U.S. urban areas, a policy that the Eisenhower administration pushed following its view "that suburbs were superior to cities" echoing Henry Ford's proclamation that "'we shall solve the problems of the city by leaving the city.'"[24] Ninety percent of the more than 41,000 mile interstate highway system would be paid for by the federal government.[25] In urban areas, the highways were constructed through impoverished minority (mainly African-American) residential areas, to avoid more profitable commercial land, on the premise of slum clearance which left millions temporarily homeless.[26] Highways were often built on waterfronts, separating downtowns from those waterfronts and making them inaccessible to people.[27] Famously, construction of the Embarcadero Freeway on the San Francisco waterfront was protested and uncompleted; the part of the highway that

[22] Ibid., 73.
[23] Judd and Swanstrom, *City Politics*, 192.
[24] Ibid., 192.
[25] Duany et al., *Suburban Nation*, 8.
[26] Judd and Swanstrom, *City Politics*, 193.
[27] Judd and Swanstrom, *City Politics*, 193.

had been built was eventually torn down and the location of the originally planned highway is now the location of the Wharf and other San Francisco landmarks.[28]

Other countries built highway systems at the same time; however, in Western Europe highways only lead between cities and are not built through them, while U.S. highways not only cut through cities, but commercial and residential development exists alongside the highways in between the cities.[29] Europeans also used gasoline taxes to fund their mass transit systems while the U.S. gasoline tax was directed to the highway system; gas tax revenue was not even allowed to be allocated for mass transit funding until 1975.[30] Today, the federal government pays four times more to support auto-oriented transportation than it does for mass transit.[31]

The federal highway policies effectively worked in conjunction with federal housing policies to promote suburban investment and development. The Great Depression and World War II had led to a housing crisis as soldiers returned home from war and the baby boom began.[32] The Federal Housing Administration (FHA) and the Veterans Administration (VA) created new mortgage programs with low down payments and long-term loans in order to encourage home purchases.[33] The FHA and VA would insure home loans made by banks, making lending to prospective homebuyers extremely low risk.[34] However, the programs instituted by the FHA and VA discouraged renovation

[28] Ibid., 193.
[29] Duany et al., *Suburban Nation*, 87.
[30] Judd and Swanstrom, *City Politics*, 193.
[31] Speck, *Walkable City*, 143.
[32] Judd and Swanstrom, *City Politics*, 155.
[33] Ibid., 186-187.
[34] Judd and Swanstrom, *City Politics*, 185.

of existing housing or construction of non-single-family housing.[35] It was therefore cheaper to build or buy a new single-family home in the suburbs than it was to renovate or rent a city apartment.[36] Since the federal government put all its resources into suburban development, the FHA "did not insure a single dwelling in Manhattan" for the first twelve years of its existence.[37]

The housing policies worked to restart the housing market. By 1950, housing starts were 15 times higher than in 1944.[38] The suburban preference of those policies was not only based in anti-city cultural thought, but also in a theory of ethnic segregation.[39] The FHA believed, as did much of the housing industry, that segregated neighborhoods would better retain their land values, or as they put it in their guidelines to banks: "'If a neighborhood is to retain stability, it is necessary that properties shall continue to be occupied by the same social and racial classes.'"[40] Banks were threatened that any neighborhood that had a non-white household would not receive federal mortgage insurance and advised developers to legally segregate their new housing subdivisions.[41] In 1950, the FHA was forced to rescind its racial recommendations, but the housing industry continued its legal discrimination until the Housing Act of 1968.[42]

At the same time as African-Americans were being blocked from moving to the suburbs, federal urban renewal projects forced many to move into low-quality public

[35] Duany et al., *Suburban Nation*, 8.
[36] Judd and Swanstrom, *City Politics*, 156.
[37] Ibid., 187.
[38] Ibid., 155.
[39] Ibid., 187.
[40] Ibid., 188-189.
[41] Ibid., 189.
[42] Ibid., 189-190.

housing. Slum clearance intended to bulldoze traditional neighborhoods that were considered too crowded and rundown and replace them with new public housing that would be built in what urban theorist Jane Jacobs called "pretended order."[43] In the first decade "less than one-fifth" of those displaced by slum clearance could be housed by the new public housing units that were supposed to replace the cleared housing and only one percent of the urban renewal funds were used for relocation assistance.[44] Because slums were being razed, there was less affordable housing on the market, and those displaced either moved to other slums or were forced into public housing.[45] The large, often segregated, public housing developments, known as 'the projects', were restricted to people who could not afford market rate housing, concentrating poverty.[46] Any tenants whose incomes increased past a certain point were evicted, effectively guaranteeing that the projects would remain pockets of highly concentrated poverty.[47] The buildings were not only "shoddily built," but they were also located away from "desirable parts of the city" and surrounded by impoverished slums.[48] Many were built on Le Corbusier's Radiant City "towers in the park" model, resulting in high-rises surrounded by grass lawns but no "'place to get a cup of coffee or a newspaper.'"[49] Residents of minority, primarily black, neighborhoods found it nearly impossible to receive bank loans to improve their homes or finance a home purchase as banks deemed those neighborhoods

[43] Jane Jacobs, *The Death and Life of Great American Cities*, First (New York, NY: Vintage Books, 1992), 15.
[44] Ibid., 183.
[45] Ibid., 183.
[46] Ibid., 183.
[47] Ibid., 183.
[48] Ibid., 183.
[49] Jacobs, *The Death and Life of Great American Cities*, 22, 15.

too risky in a practice known as 'redlining.'[50] Federal policy had destroyed existing black neighborhoods and restricted them from moving out of impoverished areas while at the same time subsidizing white flight to the segregated suburbs.[51] In cities and suburbs throughout the country, the resulting structure of these federal policies has been cemented in a local government code known as zoning.

2.1.3 Zoning

On the third page of the introduction of the seminal urban planning book *Suburban Nation*, Duany, et al. write:

> *The problem is that one cannot easily build Charleston anymore, because it is against the law. Similarly, Boston's Beacon Hill, Nantucket, Santa Fe, Carmel—all of these well-known places, many of which have become tourist destinations, exist in direct violation of current zoning ordinances. Even the classic American main street, with its mixed-use buildings right up against the sidewalk, is now illegal in most municipalities. Somewhere along the way, through a series of small and well-intentioned steps, traditional towns became a crime in America.*[52]

That traditional development is illegal under most current zoning codes is a common theme in urban planning publications. Although Duany, et al. describe them as

[50] Judd and Swanstrom, *City Politics*, 191.
[51] Ibid., 196.
[52] Duany et al., *Suburban Nation*, xi.

"well-intentioned," and some of them are, other literature describes their origins and continued use as one steeped in racism and classism. Zoning remains the most powerful shaper of the built environment in the U.S.

During the Industrial Revolution, European cities began separating factories from the rest of the city, resulting in an increase in life expectancy.[53] In 1916 New York City put in place the first zoning code after Fifth Avenue residents campaigned to protect their neighborhood from the migration of the working class, who would bring higher population densities and immigrants.[54] Retailers supported the new zoning laws that would protect their businesses from encroaching "industrial interests."[55] The main goal of this zoning was to preserve land values by separating desirable uses from undesirable uses.[56] The New York code was adopted by other city governments "virtually verbatim," making little or no adjustments based on the needs of their city.[57] In 1926, the Supreme Court ruled that the town of Euclid, Ohio was within its rights as a municipality to impose restrictive zoning in order to protect residential neighborhoods.[58]

The result is known as Euclidean, or single-use, zoning.[59] A single-use zoning code separates each type of land use from each other. Initially only incompatible uses were separated, but eventually almost every use became separate.[60] Commercial is separated from housing, and different types of commercial or housing are separated from

[53] Duany et al., *Suburban Nation*, 10.
[54] Judd and Swanstrom, *City Politics*, 266.
[55] Montgomery, *Happy City*, 66.
[56] Judd and Swanstrom, *City Politics*, 266.
[57] Ibid., 267.
[58] Ibid., 267.
[59] Gallagher, *The End of the Suburbs*, 40-41.
[60] Duany et al., *Suburban Nation*, 10.

each other so, for example, an area with apartments will not have single family homes, and vice versa.[61] American zoning codes have defined around 600 different types of land uses.[62] Not only are uses strictly segregated, but zoning codes dictate how buildings can be built. Setbacks require a certain distance between the street and the building, height limits are imposed, building materials are required or banned, and there can be minimum lot area requirements. Codes determine the width of roads, the height of curbs, and the distance between intersections.[63] These zoning codes are long (the Zoning Ordinance of the City of Fairfax is 303 pages), complex, and extremely detailed. While some of the zoning restrictions protect residents, such as laws banning lead paint, many were designed either under the assumption that mixing two types of uses might negatively affect health or to protect property values by excluding undesirable people.[64] Separating residential neighborhoods from industrial uses, the first law separating usage, is often no longer necessary as most modern industrial facilities are no longer a public health risk.[65]

Before long the FHA required single-use zoning ordinances as a prerequisite for a neighborhood to qualify for its mortgage programs, prioritizing sprawl development over alternatives and resulting in a post-war housing boom with built-in separation of uses.[66] Prior to the Civil Rights Act, this FHA requirement made it easy to deny African-American neighborhoods funds since their inner-city neighborhoods did not have zoning codes and they were refused access to suburban neighborhoods that received federal

[61] Ibid., 10.
[62] Speck, *Walkable City*, 120.
[63] Montgomery, *Happy City*, 280.
[64] Duany et al., *Suburban Nation*, 10.
[65] Ibid., 11.
[66] Gallagher, *The End of the Suburbs*, 40.

funds.[67] Single-use codes were soon exported from the suburbs to cities without much adaptation.[68] Through their zoning codes, communities were able to legally create barriers using 'exclusionary zoning' to keep out people with lower incomes by banning housing types such as apartments or duplexes.[69] Other requirements, such as large-lot zoning that requires a minimum lot size that makes the neighborhood more expensive, are "effective devices" for economic segregation.[70]

Zoning codes usually focus on use, based on numbers and ratios, creating property values from formulas such as Floor Area Ratio.[71] The codes are often downloaded from Municode, a downloadable online zoning code.[72] They protect existing uses, make it easy to challenge new developments, and make it expensive for developers to build new projects that even slightly violate the required zoning.[73] By prohibiting traditional development and segregating uses, federal, state, and local governments have shaped nearly every American town and city around the models of sprawl.[74] Zoning codes also require a minimum parking allotment for each use which, aside from separation of uses, has had the greatest effect on land use.

2.2 Parking

Suburbia, with its separation of uses, usually has a place to park a car at each one of those various uses. As with the creation of the suburbs themselves, these often large

[67] Ibid., 42-43.
[68] Speck, *Walkable City*, 121.
[69] Montgomery, *Happy City*, 67.
[70] Judd and Swanstrom, *City Politics*, 269.
[71] Duany et al., *Suburban Nation*, 176.
[72] Montgomery, *Happy City*, 281.
[73] Judd and Swanstrom, *City Politics*, 268.
[74] Montgomery, *Happy City*, 280-281.

and free parking lots were not the result of market preference, but rather government policies based not in scientific studies, but in loose theories. Because, on average, a car will be parked 95 percent of the time, car storage is vitally important no matter if car usage is high or low.[75] In order to deal with the issue of where to store cars, local governments mandated that each land use provide its own parking. These minimum parking requirements are sections of local zoning codes that require "all new buildings to provide ample on-site parking" in order to "satisfy the expected peak demand" for parking.[76]

Most of the information in Section 2.2 will come from *The High Cost of Free Parking*, an exhaustive study of American parking policies by UCLA professor Donald Shoup. This section will focus on how minimum parking requirements were created and their effect on local land use.

2.2.1 Creation of Parking Requirements

There are three parts of zoning codes: permitted uses (e.g., residential or commercial), permitted bulks (e.g., height limits and setbacks), and minimum off-street parking requirements.[77] When car use increased early in the 20th century, it became more and more difficult for drivers to find parking spaces on the curb. Cities concluded that the market failed to supply enough parking, so in order to solve increased parking demand from any new developments, local governments required the development to build their

[75] Donald Shoup, *The High Cost of Free Parking* (New York, NY: Routledge, 2017), 6.
[76] Ibid., 2.
[77] Shoup, *The High Cost of Free Parking*, 25.

own off-street parking.[78] This solution was based on the idea that parking is free; however, pricing curb parking would have created a supply and demand market whereas mandating free parking resulted in a commons, not a market (see Section 2.2.4).[79]

To address this perceived parking shortage, cities decided to supply the amount of parking that would be needed during maximum parking occupancy, otherwise known as peak demand.[80] The minimum parking requirement is then set at the maximum observed occupancy.[81] Shoup is very critical of any parking demand calculations because he insists that they do not calculate demand for parking but instead calculate demand for *free* parking.[82] Peak demand for a land use is often determined by the Institute of Transportation Engineers *Parking Generation* report.[83] The report uses studies of suburban sites with free parking and "no public transit," but many of the reported peak demands are based on a small number of studies; almost a quarter are based on a single study.[84] These peak demands are surely inflated because the parking is free and there are no alternatives to driving; therefore it is not truly 'peak demand' but demand for free parking at the busiest time in suburban areas.[85] They are also influenced by the fact that in these suburban areas, there is no supply shortage that would decrease demand.[86]

[78] Ibid., 8.
[79] Ibid., 8.
[80] Ibid., 24.
[81] Ibid., 24.
[82] Ibid., 8.
[83] Ibid., 31.
[84] Ibid., 32.
[85] Shoup, *The High Cost of Free Parking*, 32, 36.
[86] Ibid., 62.

The result is parking requirements that "are frequently over-estimated."[87] Parking lots are created with the busiest day of the year in mind, which leaves spaces empty most of the time.[88] Even during the busiest hour of the year, nearly half of all American shopping center parking lots are never more than 85% full.[89] If the minimum requirement is based on the 20th busiest hour of the year would mean that spaces would be unused for 99% of the year and only be full for 20 hours a year.[90] However, if those spaces are not even being used at the busiest hour of the year, parking would still be oversupplied during peak occupancy.[91] The result is that there are 500 million empty parking spaces in the U.S. at any one time, according to a 2010 study.[92] Requiring sites to provide parking spaces that will only be used a couple hours each year is a "spectacularly bad investment" and a poor use of land, according to Shoup.[93]

The American Planning Association has found that there are 662 land uses for which local governments across the U.S. require parking.[94] When deciding on the requirement, ordinances base the amount of spots on a feature of the development, of which 216 have been defined, such as square footage, number of hospital beds, number of fuel nozzles, and number of nuns.[95] Four parking spaces for every 1,000 square feet of floor space is considered the golden rule for minimum parking requirements, but a

[87] Ibid., 83.
[88] Ibid., 138.
[89] Ibid., 81.
[90] Ibid., 85.
[91] Ibid., 86.
[92] Speck, *Walkable City*, 121.
[93] Shoup, *The High Cost of Free Parking*, 87.
[94] Ibid., 76.
[95] Shoup, *The High Cost of Free Parking*, 77.

transportation study of Home Depot store parking lots found no correlation between a store's square footage and its peak parking demand.[96]

It is repeated instances like this that encourage Shoup to often refer to parking policy as a 'pseudoscience.' Chapter Three of *The High Cost of Free Parking* is even entitled "The Pseudoscience of Planning for Parking." A survey of parking requirements found 66 cities had a total of 27 different requirements for funeral parlors, "and 20 of those cities had a requirement that no other city had."[97] Multiple studies found that the oversupply of spaces and sometimes seemingly random land use requirements had "no justification" and were "not founded on empirical analysis."[98] The *Parking Generation* report greatly influenced the ideas behind peak parking demand and is used to justify requirements, but the implementation of actual "parking requirements are unknown" and often these regulations are simply "'handed down' from one community to another" resulting in what Shoup refers to as policy resulting from "a collective hunch."[99] It is then left to developers to challenge the parking requirements to prove that they are in excess of what will actually be needed, an expensive process that many developers are not willing to do.[100]

The continued misdiagnosis of a parking shortage as a lack of enough parking spaces, and the solution of minimum parking requirements is also a result of local politics and neighborhood complaints.[101] Oversupplying parking spaces ensures that new

[96] Ibid., 31, 34.
[97] Ibid., 78.
[98] Ibid., 83, 28.
[99] Ibid., 27-28.
[100] Ibid., 53.
[101] Shoup, *The High Cost of Free Parking*, 175.

developments do not create spillover into adjacent neighborhoods, allowing politicians and planners to avoid criticism.[102] Requiring parking works as a political and planning solution because the costs to both consumers and the government is hidden.[103] Parking lots are also considered drivers of business, often an argument against removing requirements, but "building more parking spaces will not result in increased [customer] traffic volumes and, subsequently, in increased sales at centers."[104] There is "no clear evidence from aggregate statistical studies" that removing parking requirements would limit businesses economic health because the market would supply the demanded parking.[105] The result of the political incentives and pseudoscience requirements is "a shopping list of requirements for every land use" that are difficult to change and, as will be discussed in the rest of Section 2.2, are expensive to build, take up significant space, and have drastic external effects on communities.[106]

2.2.2 Cost

Shoup uses creative analogies throughout his book to make his points. In the preface he compares free parking requirements to cities requiring that all fast food restaurants include fries with every hamburger. To the consumer the fries are free, and expected, but fries have a cost to produce and that cost is passed on to every customer whether or not they eat the fries.[107] A comprehensive parking study done by the Victoria Transport Policy Institute found that, as of 2015, in the U.S. a parking space in a surface

[102] Ibid., 41.
[103] Ibid., 89.
[104] Ibid., 86.
[105] Ibid., 92-93.
[106] Ibid., 111.
[107] Shoup, *The High Cost of Free Parking*, Xxxviii.

lot costs between $5,000-$10,000 per space to build, an above-ground parking structure averaged $24,000 per space, and an underground structure costs $34,000 per space.[108] Shoup does his analysis on fifteen parking structures built on the UCLA campus and found that the average cost was $22,500 per space in 2002 dollars.[109] That is, a new structured parking space in 2002 cost 17% more than a new car.[110] Shoup's breakdown of costs based on this average is what this paper will use to show the significance of the cost of building parking.

At $22,500 a space, a parking structure becomes expensive fast. In order to pay the debt service on a 40-year loan at 4% interest, UCLA would have to pay $94 a month per space.[111] The addition of maintenance costs, higher for structures than surface lots, costs UCLA an additional $33 per space each month, bringing the total monthly cost per space up to $127.[112] However, a parking structure is predicted to have a lifespan of 40 years, whereupon it will need significant maintenance requiring an entirely new loan immediately after the previous one has been paid off.[113] $127 a month for a parking spot that is only used by commuters at an office costs $5.77 a day for a 22-day work month.[114] Ninety-five percent of U.S. car commuters park free at work, and overall American

[108] Todd Alexander Litman and Eric Doherty, "Transportation Cost and Benefit Analysis: Techniques, Estimates and Implications Second Edition (2009)" Chapter 5.4 Parking Costs (Victoria Transport Policy Institute, March 16, 2019), https://www.vtpi.org/tca/tca0504.pdf, 7.
[109] Shoup, *The High Cost of Free Parking*, 186.
[110] Ibid., 210.
[111] Ibid., 191.
[112] Ibid., 191.
[113] Ibid., 192.
[114] Shoup, *The High Cost of Free Parking*, 212.

drivers in 2002 "[paid] for parking on only 1% of their trips".[115] And, as previously stated, "many parking spaces are vacant much of the time."[116]

If most parking is free and parking also costs a significant amount to build, the question arises: how is it being paid for? The simple answer is it is not. In cities that do charge for parking, "parking fees are often insufficient to cover the debt service" and they cannot even "meet day-to-day operating costs."[117] The true payment is that "96 to 99 percent of the cost of parking was hidden in higher prices for everything else."[118] These higher prices in nearly every transaction mean that everyone is paying for parking whether or not they use it, therefore subsidizing drivers who are not required to pay directly for their parking space.[119] This subsidy is so significant that removing it for workplaces would have the same effect on commuters as raising the gasoline tax by $4.44 a gallon.[120]

2.2.3 Space

A single parking space averages about 330 square feet of a parking lot, including backup space and driving lanes.[121] One acre can hold 130 of these 330 square foot spaces in a surface parking lot.[122] To show how much land parking can use when minimum parking is required, Shoup uses various requirements from around the country. This paper will recreate similar examples using the City of Fairfax Zoning Ordinance Article 4.2.E

[115] Shoup, *The High Cost of Free Parking*, 211, 217.
[116] Ibid., 210.
[117] Ibid., 83.
[118] Ibid., 206.
[119] Ibid., 170.
[120] Ibid., 214.
[121] Ibid., 37.
[122] Ibid., 645.

'Parking ratio requirements.' All of these calculations are for surface lots, as they are the cheapest option and can be seen in full in Appendix A; a few are included in Table 1. Developers could cut the amount of land needed by building a parking structure, but as covered in Section 2.2.2, structured parking is extremely expensive and difficult to pay for. None of these calculations include landscaping as required by Article 4.5.7. A Fairfax City restaurant is required to have five spaces for every 1,000 square feet of floor space resulting in a parking lot 1.65 times the size of the building. This is the same as the requirement for tobacco stores, medical offices, shopping centers, and convenience stores among other land uses. This means that in order to build a restaurant with a surface lot, a developer would need to secure an additional 1,650 square feet for every 1,000 square feet of floor space they want in their restaurant. A restaurant with a dance floor requires 10 spaces per 1,000 square feet, giving it a parking lot 3.3 times the size of the building. Some requirements are lower, such as art galleries that require lots that are 82.5% the size of the building. Others are much larger such as funeral homes, mentioned in Section 2.2.2, where lots are 6.6 times the size of the building, or the highest ratio - auction houses where lots are 16.5 times the size of the building. Residential and other uses are determined by bases other than floor area but have similar parking impact. A 30-unit townhouse development with two parking spaces required per unit would have 20% of its land taken up by parking.[123]

[123] Calculated with average 2,500 sq. ft. per townhouse, no front yard or backyard included.

Table 1: Parking Lot to Building Size Ratio[124]

USE TYPES/ USE GROUPS	GENERAL REQUIREMENTS	Spaces per 1000 sqft. floor space	Parking lot size (sqft.)	Parking lot: Building ratio
Auction houses	5 spaces per 100 sq. ft. of floor area	50	16500	16.5
Funeral homes	1 space per 50 square feet of floor space in funeral service rooms	20	6600	6.6
Adult uses	1 space per 100 sq. ft. of floor area	10	3300	3.3
Restaurants w/ dancing and entertainment	1 space per 100 sq. ft. of floor area	10	3300	3.3
Day care centers	5 spaces per 1,000 sq. ft. of floor area	5	1650	1.65
Nursery schools	5 spaces per 1,000 sq. ft. of floor area	5	1650	1.65
Convenience stores	1 space per 200 sq. ft. of floor area	5	1650	1.65
Office, medical	1 space per 200 sq. ft. of floor area	5	1650	1.65
Restaurants or food service	1 space per 200 sq. ft. of floor area; none for outdoor dining and service areas	5	1650	1.65
Shopping centers	1 space per 200 sq. ft. of floor area	5	1650	1.65
Tobacco and smoke shops	1 space per 200 sq. ft. of floor area	5	1650	1.65
Animal care facilities	1 space per 250 sq. ft. of floor area	4	1320	1.32
Office, general	1 space per 300 sq. ft. of floor area	3.3	1089	1.089
Art gallery or studio	1 space per 400 sq. ft. of floor area	2.5	825	0.825

Since so much land is required to be committed to parking, traditional development becomes almost impossible because there is no way to build a group of stores without building a mall or strip mall.[125] Developers will try to find ways to cut

[124] Zoning Ordinance: City of Fairfax.
[125] Shoup, *The High Cost of Free Parking*, 135.

costs elsewhere instead of challenging parking requirements. Often, they decide to build a one-story building covering about 40% of the ground, limiting the amount of parking they would need to build.[126]

The spatial results can be extreme. Car storage often occupies twice as much land as the buildings it serves.[127] With one parking spot for each worker, as is often the case, office buildings usually have 1.5 times more space for employees' cars as office space for the employees themselves.[128] In Olympia, Washington, buildings occupied only 26% of the land while parking took up more than half.[129] In Buffalo half of downtown is taken up by parking alone.[130] American parking takes up more land than the interstate highway system.[131] With at least three parking spaces for every car, it is no wonder that the total parking area in the U.S. combined is about the size of Connecticut.[132]

2.2.4 Results of Parking Minimums

When governments require parking minimums they end up "planning cities for cars, not people."[133] The idea was "a drive-in utopia" with easy access to everything a person would need.[134] In reality, mandating parking "wastes money, degrades urban design, increases impervious surface area, and encourages the overuse of cars."[135]

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[126] Shoup, *The High Cost of Free Parking*, 134.
[127] Ibid., 165.
[128] Ibid., 81.
[129] Ibid., 134-135.
[130] Ibid., 131.
[131] Ibid., 210.
[132] Ibid., 217.
[133] Ibid., 43.
[134] Ibid., 65.
[135] Ibid., 23.

Section 2.2.3 covered how much space a single required parking lot can take up. When every building has parking lots with larger footprints than the buildings themselves it spreads activities farther and farther apart.[136] Low densities make alternative transportation methods (bus, bicycle, walking) both more difficult and more expensive.[137] Whereas higher densities make it easy to get places on foot or public transit, thereby reducing the need for cars, lower densities makes "cars more necessary."[138] The parking is ample and free, increasing its attractiveness, but when the dispersed landscape requires driving, it creates "increased vehicle travel [which] also increases traffic congestion."[139] By increasing mobility by automobile, parking minimums have nearly eliminated mobility by any other method.[140]

The plethora of parking lots disrupts "the built fabric of the city."[141] When buildings are on the sidewalk, people can see into the store and are invited in by what they see, but when the building is surrounded by parking, a pedestrian has to wade through an "uninviting, even hazardous" parking lot.[142] The conveyed message is that only drivers are welcome at the store, but that is a cromulent business model because there are no pedestrians to serve.[143] Parking structures are not much better than surface lots; in order to cut costs they are built as cheaply as possible with little to no landscaping. Motorists will park there because they are looking for the cheapest parking,

[136] Shoup, *The High Cost of Free Parking*, 93.
[137] Ibid., 57.
[138] Ibid., 59, 93.
[139] Ibid., 93.
[140] Ibid., 93.
[141] Ibid., 111.
[142] Ibid., 107.
[143] Ibid., 108.

not the prettiest, but pedestrians are left with long, blank concrete walls that destroy the "ambience of a street."[144]

The attraction of a downtown area is in its abundance of activities packed into a small, easily accessible place.[145] The variety of activities signals that it is a place to stay and spend some time.[146] People are willing to "ride public transit or pay for parking" in order to get there and then walk once they are there.[147] Both Jacobs and Speck write that people are willing to walk as long as the walk is both interesting and purposeful. A high density Central Business District (CBD) creates a place that can check both those boxes, but when parking lots reduce the density it loses those "essential features that make it attractive."[148] Without the density, the CBD becomes a place that has made driving easier, but less interesting and therefore walking is "more difficult and less rewarding."[149] People do not go places to park, they desire to be somewhere they can do things, but "long distances between widely spaced buildings" and "large parking lots in an area reduce the desire to be there."[150] Achieving Le Corbusier's goal that "'wide avenues must be driven through the centers of our towns'" and that "'vast and sheltered public parking places'" would be created left urban areas with towers in the parking lot rather than towers in the park.[151] The signal these cities send is "that the environment is not a place

[144] Shoup, *The High Cost of Free Parking*, 108.
[145] Ibid., 161.
[146] Ibid., 161.
[147] Ibid., 161.
[148] Ibid., 159.
[149] Ibid., 162.
[150] Ibid., 131.
[151] Ibid., 103.

for people."[152] In essence, a CBD has a choice: more parking and less place, or more place and less parking.[153]

The difference in choice can be seen in the CBDs of San Francisco and Los Angeles, or in U.S. cities versus their European counterparts. Whereas Europeans "require density and limit parking," "Americans require parking and limit density."[154] In Los Angeles, high off-street parking requirements sends development outward, sprawling the city.[155] The mix of suburban parking measures with a city's population density gives Los Angeles the worst traffic in the U.S.[156] Los Angeles's parking minimums are 50 times higher than San Francisco's parking maximums, and it is no coincidence that downtown San Francisco is more attractive than downtown Los Angeles[157] This is a result of San Francisco believing that "no great city is known for its abundant parking supply."[158] By insisting on plentiful parking lots, many American cities and towns have chosen a path that is "antithetical to creating a vibrant community" and once they have committed to it create "transportation problems by precluding virtually any means of travel other than driving, even to nearby destinations."[159]

Not only do parking minimums distort the way communities are built physically, but when parking is free and plentiful, it distorts the way people make decisions about their transportation. Basic microeconomics is the theory of supply and demand: when

[152] Shoup, *The High Cost of Free Parking*, 103.
[153] Ibid., 162.
[154] Ibid., 122.
[155] Ibid., 165.
[156] Ibid., 165.
[157] Ibid., 121.
[158] Ibid., 136.
[159] Ibid., 137.

demand goes up supply goes up, when demand goes down supply goes down. There is also a third component of supply and demand economics, price. Supply and demand meet at a price point where supply at a certain price can meet demand. If supply is higher than demand, the price will drop, and if demand is higher than the supply the price will rise. Planners observed a parking demand that outstripped the supply and then attempted to balance it without using prices.[160] This provision of a free commodity creates a whole new market balance in which supply cannot meet the never-ending demand, but at the same time the supply is so high that the effective market price of parking is zero.[161]

This unlimited demand becomes a market phenomenon known as 'induced demand,' in which offering a good for free creates a demand for that good. Studies show that adding capacity to existing roads and highways "causes people to drive more."[162] This counterintuitive result makes sense once it is looked at more deeply. The main restrictions on travelling by car are money cost and time cost, but when cost is free then the only restriction is time represented by traffic.[163] Once new lanes are built, there is less traffic and therefore less time cost.[164] Motorists can drive faster and reach their destinations quicker.[165] The absence of tolls or parking fees means driving is already essentially free, and with new driving lanes it becomes fast, so people who would have stayed home or used other forms of travel now drive.[166] With longer commutes now

[160] Shoup, *The High Cost of Free Parking*, 8.
[161] Ibid., 8.
[162] Duany et al., *Suburban Nation*, 88-89.
[163] Ibid., 91.
[164] Ibid., 89-90.
[165] Shoup, *The High Cost of Free Parking*, 194.
[166] Ibid., 194.

easier, "people are willing to live farther and farther from their workplace."[167] Induced demand means that increased roadway capacity does nothing to reduce traffic in the medium term if that roadway is free to use.[168] On average "every new mile of roadway that you build will typically be 40% filled up with new trips immediately, and 100% full within four years.[169]

Increasing free parking supply induces demand the same way as widening roadways. By increasing the space available to park, thereby making it easier to park, more people are willing to drive.[170] Demand that already existed for parking is "inflated by the prevalence of free parking."[171] The majority of people have experienced induced demand in their own lives: there are many trips where one might consider whether or not to drive depending on the presence or absence of easy parking. A basic example is a shopper at a large strip mall. The shopper parks in front of Target and once done shopping at Target, walks back to their car and then drives over to Macy's 1,000 feet away. It was only a 1,000-foot walk, not far and easily walkable on the sidewalk in front of the buildings. If there were no parking spaces available or if a cost was associated with moving spots, the shopper would have walked. However, because there are plenty of open parking spots in front of the Macy's, the shopper, and most people, will drive instead of walk. That is induced demand.

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[167] Duany et al., *Suburban Nation*, 89.
[168] Ibid., 88.
[169] Jeff Speck, *Walkable City Rules: 101 Steps to Making Better Places* (Washington, D.C.: Island Press, 2018), 64.
[170] Shoup, *The High Cost of Free Parking*, 194.
[171] Ibid., 94.

Induced parking demand works hand in hand with induced travel demand creating a feedback loop (Figure 1). With more parking spaces, more people will drive creating traffic, which is solved by building more driving lanes. Once the lanes are added, more people will drive increasing demand for parking spaces, which is solved by requiring more parking spaces. With more parking spaces, more people will drive creating traffic, which is solved by building more driving lanes. And on and on.[172] When the current parking requirement does not meet demand, a new requirement can meet it until the inevitable increase of demand for cars increases demand for free parking.[173]

[172] Shoup, *The High Cost of Free Parking*, 57.
[173] Ibid., 171.

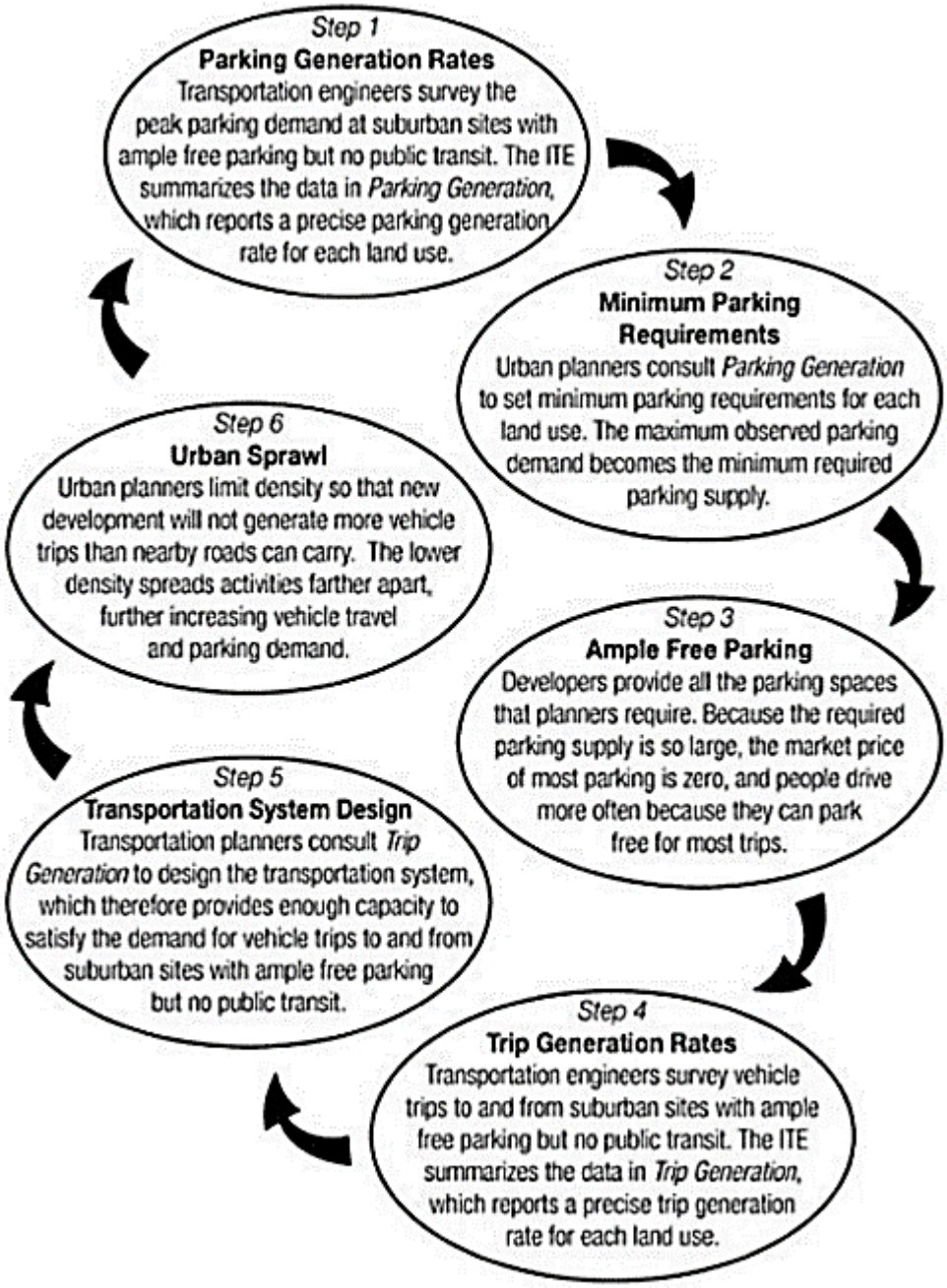

Figure 1: Cycle of planning for free parking [174]

[174] Shoup, *The High Cost of Free Parking*, 58.

Once minimum parking requirements are implemented, this "vicious cycle" is difficult to slow or stop because it orients "travel habits toward solo driving."[175] Shoup likens free parking to free cigarettes: more people would smoke if cigarettes were free and that habit would be difficult to break, even if cigarettes were suddenly no longer free.[176] Minimum parking requirements, with their combination of induced demand and domination of the built environment, "seriously skew travel choices."[177]

People choose "their travel decisions only on the prices they personally face."[178] When driving and parking is free, driving becomes much cheaper than any other form of transit and drivers believe they are saving money by driving.[179] Much like a situation in which a buffet offers free chocolate, but charges for everything else, people will likely only consume chocolate instead of eating a balanced meal.[180] The availability of free parking reduces the cost of driving by an average of $0.22 a mile.[181] The subsidy changes based on distance, with "the largest subsidy per mile [for] the shortest vehicle trips."[182] These parking subsidies keep the cost of driving low and makes solo driving the cheapest form of travel.[183] When everyone can drive cheaply it "reduces the perceived price of owning a car and leads to increased vehicle ownership."[184] The U.S. had 1.2 vehicles per

[175] Shoup, *The High Cost of Free Parking*, 94, 96.
[176] Ibid., 97.
[177] Ibid., 9.
[178] Ibid., 199.
[179] Ibid., 212.
[180] Ibid., 36.
[181] Ibid., 215.
[182] Ibid., 9.
[183] Ibid., 171.
[184] Ibid., 165.

licensed driver in 2002.[185] Eighty-seven percent of trips in the U.S. were made by car in 2001 whereas only 8.6% were made by walking and only 1.5% were made by public transit.[186] These numbers are a direct result of parking policies that ensure that 95% of Americans park free at work.[187]

Parking lots spread the CBD out so that "a car is needed to get to most places," further skewing travel toward driving.[188] The combination of factors that lead to heavy car use also lead to heavy traffic congestion.[189] Low cost of vehicle use, where "'the public provides the road, and, to use it, you must bring the car'" is encouraged by infrastructure spending that is fronted by the federal government.[190] The current auto-oriented transportation system is so engrained in most American cities and towns that "we have tailored our housing, employment, and shopping patterns to the plentitude of free parking."[191] If the parking requirements had never been implemented, it is likely that Americans would "own fewer cars and use them more judiciously."[192] In fact, higher density places create a different demand for parking all together where people own fewer cars and use different means of transport.[193] Parking requirements to meet the free parking demand become a "self-fulfilling" prophecy ensuring everyone drives everywhere.[194]

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[185] Shoup, *The High Cost of Free Parking*, 172.
[186] Ibid., 32.
[187] Ibid., 211.
[188] Ibid., 93.
[189] Ibid., 93.
[190] Ibid., 170-171.
[191] Ibid., 91.
[192] Ibid., 594.
[193] Ibid., 96.
[194] Ibid., 594.

By insisting on free parking everywhere, most U.S. towns have distorted not only transportation choices, but also land use.[195] Section 2.2.3 shows how parking requirements regularly result in parking lots that are often bigger than their buildings which is "a major cause of modern urban form" known as sprawl.[196] Buildings are often too small to afford a garage, so they are surrounded by surface lots to satisfy the parking requirement in the cheapest way possible.[197] Although the parking lot, usually private, may only be used for a few hours every day, it has an effect on its surroundings all the time.[198] Shoup claims that "architects now design buildings to serve the parking requirements" because certain types of buildings are no longer tenable or legal under parking ordinances.[199] For example, in Southern California if office building projects were allowed a 34% reduction in the parking requirement, it would allow the buildings to increase in size by 42%.[200]

Parking requirements make it difficult and sometimes impossible to convert buildings to new uses. Older buildings often cannot provide enough parking for new uses because they do not have enough land.[201] Without this flexibility, they can become unusable, and many towns and cities have demolished older buildings to make room for parking lots.[202] Brownfield sites can be impossible to redevelop because they do not have

[195] Shoup, *The High Cost of Free Parking*, 169.
[196] Ibid., 135.
[197] Ibid., 139.
[198] Ibid., 139.
[199] Ibid., 141.
[200] Ibid., 146.
[201] Ibid., 97-98.
[202] Ibid., 156.

room for the required parking unless a variance is given to the current parking requirement.[203]

All the required land for parking consumes space that could be used for housing, contributing to affordable housing issues.[204] When garages are required, they can dictate the number of housing units that can be built on a site.[205] Likewise, zoning codes that require adding additional spaces for additional apartment units often result in developers building "fewer but larger apartments," reducing the amount of land needed for surface parking.[206] Since additional units result in more provided parking, but larger units do not, housing densities drop.[207] Requiring just one space per apartment in Oakland reduced density by 30%.[208] Oftentimes the allowed number of units cannot be fit onto the same piece of land as the required parking spaces, forcing developments to build parking instead of housing.[209]

While minimum parking requirements reduce the supply of housing and restrict development, they also raise costs. The construction of the parking facility, in addition to maintenance, insurance, property tax, and more must be paid for.[210] Because there are usually no parking fees to pay for these costs, they are passed on to the facility owner who passes them to the tenants in higher rents and common area fees who then charge

[203] Shoup, *The High Cost of Free Parking*, 158.
[204] Ibid., 133.
[205] Ibid., 142.
[206] Ibid., 144-145.
[207] Ibid., 144-145.
[208] Ibid., 145.
[209] Ibid., 152.
[210] Ibid., 141.

customers higher prices whether or not they use the parking lot.[211] As shown in Section 2.2.2, these costs are not low: in an Los Angeles apartment development the required parking increased the cost of construction by $35,000 per apartment, totaling a 25% increase in the project's cost.[212] In Palo Alto, a low-income housing project saw a 38% increase to construction costs from the city's parking requirement, even though that parking requirement had been reduced.[213] In San Francisco, an off-street space increased the cost of a single-family house by $47,000 and in Oakland the requirement of one space per apartment mentioned above increased housing costs by 18%.[214] Increased construction costs combined with the lower supply, both caused by parking requirements, "inevitably increase rents" and "significantly raise housing prices."[215] If the required parking was removed in San Francisco, "24% more San Francisco households could afford to buy houses."[216]

The limitations on housing supply and higher costs have a negative impact on affordable housing. When subsidized housing units are required to provide parking, it not only limits the number of units that can be built, but it also raises the price point of the affordable housing.[217] In these projects, "a substantial part of the subsidy for low-income housing pays for parking spaces."[218] Shoup argues that for cities with minimum parking

[211] Shoup, *The High Cost of Free Parking*, 141.
[212] Ibid., 148.
[213] Ibid., 150.
[214] Ibid., 145.
[215] Ibid., 143.
[216] Ibid., 146.
[217] Ibid., 153.
[218] Ibid., 167.

requirements "free parking has become more important than affordable housing."[219] Parking requirements can also block renters from becoming owners in conversion of rental units to owned condominiums, such as in Los Angeles where the parking requirements increase from apartments to condos, a requirement which oftentimes cannot be met on limited land.[220]

Most studies on parking since 2005 begin with a study of *The High Cost of Free Parking*. Shoup is cited by multiple sources used in this paper. He argues that "off-street parking requirements, far more than interstate highways, have spurred the dominance of the automobile in urban transportation."[221] Parking policy based in "planning cities for cars, not people" has extreme negative externalities.[222] However, he does not argue for an elimination of cars or parking facilities as they are both necessary parts of a transportation system. Instead, he believes that eliminating parking requirements and letting the market decide how much parking is necessary, and at what price, will result in better land use and transportation decisions.

2.3 Criticisms of Sprawl

Sections 2.1 and 2.2 illustrate how sprawl consumes an enormous quantity of land and was not created from market preference, but rather from federal, state, and local government policies that favored cars over traditional development patterns. As Shoup puts it, it "was not immaculately conceived, and it does not result from consumer

[219] Shoup, *The High Cost of Free Parking*, 153.
[220] Ibid., 157.
[221] Ibid., 210.
[222] Ibid., 43.

preferences in a fair market."[223] There are many people who do want a big house and a big yard, but "'only one in ten say they would prefer a suburban neighborhood with houses only'" according to one survey.[224] Considering that a single point on a Walk Score, measuring the walkability of a neighborhood, can raise real estate prices by $500 to $3,000, it is not a reach to suggest that that survey is a fairly accurate assessment of market preferences.[225]

As previously mentioned, the policies have led to auto-orientation, in other words an environment where the only viable way to get around is by personal automobile. Alternative transportation options can be extremely inconvenient to the point of being impossible and walking can be highly dangerous. Auto-orientation, caused by separation of uses and parking requirements, has negative consequences, some of which have been mentioned in previous sections. Among the most common criticisms of sprawl are hours spent driving, degradation of the environment, car crashes, and deteriorating social scene.

In the U.S. more than 90% of commuters drive to work each day at an average of 51 minutes a day, amounting to about 15,000 to 18,000 miles per year.[226] The costs of this commuting add up, an average American family spends 48% of its income on housing and transportation combined.[227] However, for lower income families, it is almost 60%, and many spend more on transportation than housing.[228] In addition to commuting, separation of uses requires nearly all trips be taken by car with more than 70% of all car

[223] Shoup, *The High Cost of Free Parking*, 65.
[224] Speck, *Walkable City*, 27.
[225] Ibid., 26.
[226] Gallagher, *The End of the Suburbs*, 94.
[227] Ibid., 100.
[228] Ibid., 100.

trips shorter than two miles.[229] The necessity of automobile trips makes significantly less housing truly affordable when transportation costs are factored in.[230]

Climate change is a hot button issue, and Americans are a major culprit of carbon emissions. Motor vehicles are the biggest producers of carbon dioxide and produce about half of all U.S. air pollution.[231] When the built environment requires automobile use for nearly all transportation, it automatically raises the amount of pollution produced per person. This can be seen in carbon maps that show carbon emissions per square mile vs. ones that show emissions per household. Whereas the per square mile maps show cities as the greatest polluters while suburban and rural areas are the least in a graduated color scheme, the per capita maps flip the colors because city dwellers individually pollute less than suburbanites (Figure 2).[232] That is, walkable places pollute much less than auto-oriented places on a per person basis.[233] A walkable built environment has a greater impact on lowering carbon dioxide emissions than any LEED certified building or electric car.[234] In addition to air pollution is the massive quantity of land taken up by impervious surfaces, namely wide roads and expansive parking lots. Pavement often collects oil drippings with toxic metals and other polluting liquids.[235] Increasing the amount of impervious surfaces decreases the amount of soil that can absorb water from rainfall.[236] When it rains, instead of the soil absorbing some of the toxins and the

[229] Montgomery, *Happy City*, 191.
[230] Gallagher, *The End of the Suburbs*, 101.
[231] Duany et al., *Suburban Nation*, 95.
[232] Speck, *Walkable City Rules*, 56-57.
[233] Ibid., 57.
[234] Ibid., 56-57.
[235] Shoup, *The High Cost of Free Parking*, 198.
[236] Ibid., 198.

resulting dispersal having a negligible effect on the environment, these toxins are swept up in stormwater runoff and poured into local bodies of water.[237] In addition, the impervious surfaces collect more stormwater than local environments can handle which can cause extensive erosion and flash flooding.[238]

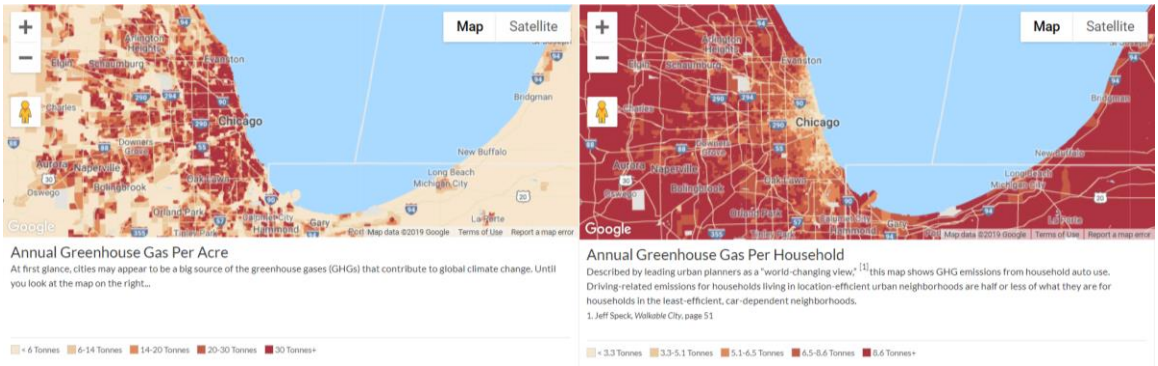

Figure 2: Carbon Emissions Maps by the Center for Neighborhood Technology. Carbon emissions are higher per acre in Chicago vs. its suburbs, but per capita the suburbs produce the most greenhouse emissions.[239]

Another often cited criticism of sprawl is that it is dangerous, even deadly to live in. This is because, in the U.S., around 45,000 people die in automobile accidents every year, and even more are injured.[240] In 2004 that was 14.5 deaths per 100,000 population.[241] More walkable cities had lower rates (San Francisco 2.5) than more

[237] Shoup, *The High Cost of Free Parking*, 198.
[238] Ibid., 198.
[239] *H+T® Greenhouse Gas Emissions* (Center for Neighborhood Technology), accessed November 30, 2019, https://htaindex.cnt.org/compare-greenhouse-gas/.
[240] Duany et al., *Suburban Nation*, 119.
[241] Speck, *Walkable City*, 45.

sprawled out cities (Atlanta 12.7), and rural areas had higher death rates than cities.[242] The link between sprawl and traffic deaths is strong. Sprawl has longer blocks than traditional development, and doubling block size results in a tripling of traffic fatalities.[243] Increasing the width of a street from 24 feet to 36 feet makes that street four times more dangerous.[244] For every additional mile of arterial roadway, a community's fatal auto accidents increases by 20%.[245] Long blocks, wide streets with wide lanes, and an abundance of high speed arterial roadways in the hierarchical street system are all major components of sprawl's auto-oriented transportation plan. The roads in sprawl are designed "for speeds well above the posted limit" in accordance with engineering standards.[246] The idea is that wider roads with less roadside obstacles allow for drivers to correct errors and are therefore safer, but because people drive at a speed they feel comfortable, they will drive 50 miles per hour on a road that has a posted speed limit of 25 miles per hour because it is designed to be safe at 50 miles per hour.[247] The higher the speed of a car in an accident the higher the likelihood of injury or fatality, especially in pedestrian collisions in which a doubling of speed from 20 mph to 40 mph increases fatalities by 1,700%.[248] According to many critics, these statistics and their link to the suburban transportation system make the suburbs some of the most dangerous places in America.

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[242] Speck, *Walkable City*, 45-47.
[243] Ibid., 165.
[244] Duany et al., *Suburban Nation*, 68.
[245] Gallagher, *The End of the Suburbs*, 84.
[246] Speck, *Walkable City*, 169.
[247] Ibid., 172.
[248] Ibid., 172.

Less tangibly, the suburbs make people feel more isolated. Suburbanites go everywhere by car and are therefore rarely in a position to spontaneously interact with other people.[249] In order to have informal communal interactions, neighborhoods need a low-stakes public space which sprawl does not provide.[250] Spontaneous interaction is important for personal and community health.[251] Without these interactions people can have difficulty making new friendships and are not presented with new and different perspectives, resulting in a stagnant "social evolution" and an echo chamber of their existing beliefs.[252]

Families can also suffer from auto-centric lifestyles. Commuters with a one hour one-way commute spend 500 hours a year, or twelve work weeks, in their car commuting.[253] People often buy larger houses for the benefit of their family but replace family time with the resulting longer commute.[254] Long commutes can bring anxiety, stress, and physical ailments.[255] And then there is a study that found that families in which one spouse had a commute longer than 45 minutes were 40% likelier to divorce.[256]

Social isolation and family strife caused by sprawl is felt most by children and the elderly, members of society who cannot drive. The suburbs are considered safe for families with large yards for kids to play, but sprawl means that children are almost completely reliant on their parents for transportation until they are sixteen or

[249] Duany et al., *Suburban Nation*, 60.
[250] Ibid., 60.
[251] Gallagher, *The End of the Suburbs*, 92.
[252] Duany et al., *Suburban Nation*, 59-60.
[253] Ibid., 124-125.
[254] Gallagher, *The End of the Suburbs*, 97-98.
[255] Ibid., 97.
[256] Montgomery, *Happy City*, 55.

seventeen.[257] Children are "unable to practice at becoming adults" with "the complete loss of autonomy they suffer in suburbia" and dependence on their parents makes them "frozen in a form of infancy."[258] Alternatives to parent chauffeurs are long and dangerous walks or bike trips, or getting in a stranger's Uber. In lieu of that, children are stranded in subdivisions, isolated from others and often bored.[259] The large yards for play can go unused without enough other kids to play with. Where traditional neighborhoods had local parks for kids to play, sprawl sometimes replaces them with sports complexes out of walking distance; "nearly two-thirds of parents say there is no place for their children to play within walking distance of home."[260]

Suburban neighborhoods are not stimulating for young people, they are too homogeneous and unchallenging for kids who are maturing.[261] Teenagers in such an idle environment are "prone to social and emotional problems."[262] Teens in suburbs are more likely to be anxious or depressed than their urban peers.[263] They are also more likely to drink and use hard drugs.[264] At the same time sprawl took over the landscape, teenage suicides tripled with national teenage suicide rates that are much higher in the suburbs than in cities.[265] The same isolation and dependence that plagues teens is also suffered by seniors. Once they lose the ability to drive, senior citizens become immobile and either

[257] Gallagher, *The End of the Suburbs*, 90.
[258] Duany et al., *Suburban Nation*, 116-117.
[259] Ibid., 120.
[260] Montgomery, *Happy City*, 188.
[261] Duany et al., *Suburban Nation*, 120.
[262] Montgomery, *Happy City*, 60.
[263] Ibid., 60.
[264] Ibid., 60.
[265] Duany et al., *Suburban Nation*, 120.

must rely on others to drive them around or move out of their longtime home in order to be able to complete daily activities.[266] The rise of retirement homes is partially an outcome of the elderly not being able to function in an auto-centric environment.[267]

These criticisms of sprawl are valid and have statistical evidence to back them up. However, they are often ineffective arguments against sprawl. Local governments respond to voters who overlook social ills, are ignorant of the underlying causes of traffic deaths, and may want a better environment as long as it does not change their way of life. Voters do not understand that building more road lanes results in more traffic or the negative externalities of parking requirements. The social and environmental consequences of sprawl seem abstract, but parking and travel lanes are tangible. These criticisms fail because they are not good enough to convince publicly elected officials to challenge the status quo. Looking at sprawl's inefficiency of land use such as how it negatively impacts local finances, or how alternative development patterns may correct fiscal imbalances, may be enough to encourage the eradication of outdated zoning ordinances.

2.4 Expenditures

This research focuses on the land use impacts of auto-centric planning, and so it must be reiterated how much land is used for cars in places that build their transportation system around the automobile. A car "requires 20 times more space than" a person using

[266] Duany et al., *Suburban Nation*, 123.
[267] Ibid., 123.

alternative modes of transportation.[268] Automobile transportation systems consist of both roads and parking, and when the mode share of automobiles is increased by 10%, there is an expected increase in parking of 2.53 m^2 per person and a decrease of 1,700 people per km^2. That is, when more people use their cars to get around, there will be more parking built and less concentration of people and activities in an area.[269] Auto-centric places require a "significant" portion of their land to be devoted to cars rather than other uses, and the sprawling out of people and activities means extensive road networks are being provided.[270] Concerns about the maintaining this massive auto-oriented infrastructure system have been raised since the mid-2000s as much of the post-World War II infrastructure neared the end of its lifecycle.[271] "Growing fiscal stress" on local governments has resulted in 69 public authorities, municipal special districts, and general-purpose local governments filing for bankruptcy nationally since 2010.[272] The assertion that "revenues aren't keeping pace with the bills" means that both infrastructure expenditures and revenues should be examined.[273] Although this research is focused on revenues, those revenues are only necessary to pay for the expenditures. This section will

[268] Christopher McCahill and Norman Garrick, "Automobile Use and Land Consumption: Empirical Evidence from 12 Cities," *Urban Design International* 17, no. 3 (2012): 221–27.
[269] McCahill and Garrick, "Automobile Use and Land Consumption."
[270] Ibid.
[271] Eric Kelderman, "ROADS, BRIDGES, DAMS IN U.S. FALLING APART: THE COST OF MAINTAINING INFRASTRUCTURE HAS FAR OUTSTRIPPED THE WILL TO PAY FOR IT, EXPERTS SAY.," *Wisconsin State Journal*, January 21, 2008, sec. Front.
[272] "Bankrupt Cities, Municipalities List and Map" (Governing.com, n.d.), https://www.governing.com/gov-data/municipal-cities-counties-bankruptcies-and-defaults.html.
Keith Ihlandfeldt and Kevin Willardson, "Local Public Services Costs and the Geography of Development: Evidence from Florida Counties," *Journal of Regional Science* 58, no. 1 (January 2018): 5–37, https://doi.org/10.1111/jors.12333.
[273] Kelderman, "ROADS, BRIDGES, DAMS IN U.S. FALLING APART."

explore whether sprawl increases infrastructure expenditures and therefore the impending maintenance expenditures.

Ladd's (1992) paper was one of the more influential early analyses of the relationship between population density and its fiscal impacts on public services after the 1974 study *The Costs of Sprawl*. *The Costs of Sprawl* was not included in this research because the many criticisms of its methodology have caused it to become a questionable citation. Ladd found a U-shaped pattern in which spending decreases and then increases with density.[274] Her model saw the lowest spending at 250 people per square mile with "costs of providing public services increase[ing] with population density."[275] This analysis suggests that urban populations, over 500 people per square mile, face increasingly higher costs than rural places, specifically those at the bottom of the U graph around 250 people per square mile. Ladd's methodology is inherently flawed as an analysis of sprawl since it uses county population data to establish population density. Any additional population to a county would increase its overall population density regardless of where that population resides. This means that the overall population density of a county could be 1,000 people per square mile with the population not being geographically compact creating geographically extended public services. She was attempting to study the impacts of how close people lived together might affect public

[274] Helen Ladd, "Population Growth, Density and the Costs of Providing Public Services," *Urban Studies* 29, no. 2 (April 1992): 273–95, https://doi.org/10.1080/00420989220080321.
[275] Ibid.

service costs, but by using countywide population density this study does not answer how compact areas affect spending.[276]

Holcombe and Williams (2008) statistically calculated the relationships between population density and local government spending per capita, with the note that sprawl and population density are similar but not the same thing, so their research "looks at the issue of sprawl only indirectly."[277] They did not find a relationship between population density and overall per capita expenditures for cities with populations under 500,000.[278] For cities with populations greater than 500,000 they found that increased population density increased total per capita spending.[279] Section 2.4 is more concerned with infrastructure expenditures and Holcombe and Williams found strong relationships between population density and both highway and sewer per capita costs. Higher density was shown to reduce highway and sewer per capita expenditures for cities under 250,000, with the strongest relationship being between population densities and highway expenditures.[280] The relationship "goes away for the largest cities" which have populations over 500,000.[281]

Carruthers and Ulfarsson's (2008) study looks at "a more precise measure of density as persons per developed land area."[282] They found that increasing density and

[276] Kurt Paulsen, "The Effects of Land Development on Municipal Finance," *Journal of Planning Literature* 29, no. 1 (February 2014): 20–40, https://doi.org/10.1177/0885412213497982.
[277] Randall G. Holcombe and DeEdgra W. Williams, "The Impact of Population Density on Municipal Government Expenditures," *Public Finance Review* 36 (May 2008): 359–73.
[278] Ibid.
[279] Ibid.
[280] Ibid.
[281] Ibid.
[282] Paulsen, "The Effects of Land Development on Municipal Finance."

developing less area would result in billions of dollars of savings annually in public service expenditures.[283] When places are built at lower densities, the costs for services such as roads, parks, education, and police increase.[284] When the amount of land that has been developed decreases, thereby making the service areas smaller, services such as fire, police, sewer, roads, libraries, and education cost less, with the highest impact on roadways.[285] For places that are built more densely, there is less space to service and costs are lowered, especially for centralized facilities that might need to be "replicated" in order to cover more ground.[286] Carruthers and Ulfarsson projected that if the average American county was built 25 percent more densely, they would save about $1.18 million annually in 2002 dollars.[287] The annual savings in 2002 dollars for a county that was servicing 25 percent less total area was calculated at about $2.13 million.[288] Those savings doubled when calculated for 50 percent denser and 50 percent less total area.[289] With many infrastructure projects funded through borrowing mechanisms, savings at a long term interest rate of 5 percent could save the average county nearly $75 million in 2002 dollars in loan repayments alone if they were 25 percent denser and serviced 25 percent less total area.[290] Carruthers and Ulfarsson argue that their results "indicate that sprawl is not efficient from the standpoint of public finance."[291] Their results suggest that

[283] John I. Carruthers and Gudmundur F. Úlfarsson, "Does 'Smart Growth' Matter to Public Finance?," *Urban Studies* 45, no. 9 (August 2008): 1791–1823.
[284] Ibid.
[285] Carruthers and Ulfarsson, "Does 'Smart Growth' Matter to Public Finance?"
[286] Ibid.
[287] Ibid.
[288] Ibid.
[289] Ibid.
[290] Ibid.
[291] Ibid.

even small increases in density can result in public expenditure savings, and "even small decreases in expenditures represent tens of billions of dollars" nationally.[292]

Holcombe and Williams differ from Ladd in their methodology in that they only use places with populations greater than 50,000 "where most of the concern for sprawl is centered."[293] They then categorize those communities into similar sized groups as opposed to the broader classifications of Ladd. Carruthers and Ulfarsson likewise differ from Ladd in only studying developed areas rather than whole counties. Ladd's U-shaped pattern may exist; Holcombe and Williams found a decrease in expenditures from populations of 50,000 to populations of 250,000 and then an increase in cities with populations over 500,000. However, because Ladd study uses rural numbers it is not the best study of the effects of sprawl on total public expenditures.

Speir and Stephenson (2002) focus on water and sewer costs rather than total government expenditures. They looked at the effects of separation between houses or lot size, separation between housing developments or tracts, and distance from developments to water and sewer centers and found that lot size had the largest effect on water and sewer costs.[294] When lot size increases, the street frontage of the lot increases thereby increasing "the length of water distribution and sewer collector mains needed."[295] The larger lots cost more to serve than the smaller lots they studied, with an increase of lot size from 0.25 acre to 1 acre resulting in almost double the cost of providing water and

[292] Paulsen, "The Effects of Land Development on Municipal Finance."
[293] Holcombe and Williams, "The Impact of Population Density on Municipal Government Expenditures."
[294] Cameron Speir and Kurt Stephenson, "Does Sprawl Cost Us All?," *Journal of the American Planning Association* 68, no. 1 (March 31, 2002): 56–70.
[295] Ibid.

sewer services.[296] Doubling the lot size from 0.25 to 0.5 increased costs by an average of 30%.[297] Increases in separation of tracts and distance from centers also increased costs, but increase of lot size was found to be the "most cost-sensitive spatial attribute."[298] Since large lot size is common in sprawl, and minimum lot sizes are often mandated by zoning ordinances, Speir and Stephenson results suggest that sprawl style single-family neighborhoods significantly increase water and sewer costs. The effects of lot size on water and sewer costs results in residents in more compact areas subsidizing "water and sewer services for those in more sprawling" areas.[299] In many places, regardless of how much water is used by a household, "users in less compact spatial patterns will pay less than their true cost of service, while users in more compact patterns will pay more."[300] Speir and Stephenson conclude that sprawl drives "up the total cost of providing water and sewer services."[301]

Ihlandfeldt and Willardson (2018) use a statistical analysis to determine how the developed area of a county, its concentration of buildings, and the type of buildings affects its infrastructure costs in both rural and urban counties in Florida. Single-family homes were found to be the least concentrated and all housing became more spatially dispersed from 1995-2013.[302] They found that urban area expansion, which came mostly

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[296] Ibid.
[297] Ibid.
[298] Ibid.
[299] Speir and Stephenson, "Does Sprawl Cost Us All?"
[300] Ibid.
[301] Ibid.
[302] Keith Ihlandfeldt and Kevin Willardson, "Local Public Services Costs and the Geography of Development: Evidence from Florida Counties," *Journal of Regional Science* 58, no. 1 (January 2018): 5–37, https://doi.org/10.1111/jors.12333.

from single-family homes, increased expenditures on streets and roads.[303] Economies of density is the theory that "concentrating the existing number of buildings and having a large number of buildings within concentrated areas" will result in "savings on public infrastructure costs."[304] Ihlanfeldt and Willardsen saw economies of density play an important role in the differences in expenditures in urban counties, and conclude that "concentrating economic activity [geographically] creates cost savings especially in the provision of public infrastructure."[305]

Ford (2010) compares seven different suburban (single use, single-family housing, surface parking lots, and hierarchical road systems) and traditional neighborhood development (mixed use, gridded street network, and on-street parking) scenarios in a study for the EPA.[306] Ford's scenarios showed that even if the suburban developments were built at the density of the traditional neighborhoods they would still require "twice as much land."[307] The suburban developments required more pavement because of the amount of traffic funneled to "a small number of collectors and arterials" and wider shoulders in order for emergency vehicles to navigate the only routes available if they become blocked.[308] The traditional neighborhoods therefore required "an average of 42% less impervious area per unit than" the suburban development scenarios.[309] In

[303] Ibid.
[304] Ibid.
[305] Ihlandfeldt and Willardson, "Local Public Services Costs and the Geography of Development."
[306] Jonathan Ford, "Smart Growth & Conventional Suburban Development: An Infrastructure Case Study Completed for the EPA" (Morris Beacon Design, January 13, 2010), https://www.epa.gov/sites/production/files/2014-07/documents/mbd-epa-infrastructure.pdf.
[307] Ibid.
[308] Ibid.
[309] Ibid.

addition, the residential lot size in the main single-family neighborhood scenario was about four times the size of its traditional neighborhood scenario counterpart.[310] The infrastructure cost savings ranged from 32% to 47% per unit because the suburban scenarios required "far-reaching infrastructure systems to serve lower-density development."[311]

Smart Growth America's "Building Better Budgets" (2013) paper reviewed case studies from around the U.S. on local government's costs and revenues related to sprawl. They found that "in case after case, localities determined that smart growth development would reduce costs" for upfront infrastructure, roads and sewer/water, by 38% on average.[312] Of their case studies, one of which is Ford (see above), a few points are notable. Champaign, IL could cut upfront infrastructure costs by $52 million over 20 years, or 42%, by switching to a smart growth development that would require half the land.[313] A California study found that suburban development would cost about $32 billion more than traditional development over 40 years.[314] The state of Maryland "would save approximately $1.5 billion per year statewide on new road construction through 2030" by "following a smart growth approach" to development.[315] The smart growth approach would cut the need for new highways by 20% and new local streets by

[310] Ibid.
[311] Ibid.
[312] William Fulton et al., "Building Better Budgets," May 2013, https://smartgrowthamerica.org/resources/building-better-budgets-a-national-examination-of-the-fiscal-benefits-of-smart-growth-development/.
[313] Ibid.
[314] Ibid.
[315] Ibid.

62.5%.[316] Savings on maintenance costs were $12 million a year statewide for local roads, and $6.5 million a year for highways.[317] The report also cites multiple instances of traditional development patterns resulting in savings in "public services such as police, ambulance, and fire service costs."[318] The savings on these services averaged 10%, but could be up to 75% or 80%, because in traditional development "service vehicles drive fewer miles."[319]

Slack (2002) finds that the literature suggests that low-density sprawl raises the cost of providing public services.[320] However, Paulsen (2014) finds that the literature is more ambiguous. Although water and sewer provision exhibit economies of density, he says that research on the effects of economies of density of other types of public services such as public safety and education is "limited and inconclusive.[321] He also cautions that any study of the costs of sprawl are only studies of the expenditures of sprawl, since expenditure data, not cost data, is what is available.[322]

Qin et al. (2018) studied the cost of infrastructure repair in the City of Fairfax, Virginia, and offer an optimization study built on earlier crowdsourcing research[323]. The cost of maintaining the public walkway infrastructure, even when crowdsourced

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[316] Ibid.
[317] Ibid.
[318] Ibid.
[319] Fulton et al., "Building Better Budgets."
[320] Enid Slack, "Municipal Finance and the Pattern of Urban Growth," *Commentary - C.D. Howe Institute*, no. 158–160 (February 2002), http://search.proquest.com/docview/216600765/.
[321] Paulsen, "The Effects of Land Development on Municipal Finance."
[322] Ibid.
[323] Rice et al. "Position validation in crowdsourced accessibility mapping."", "Quality assessment and accessibility applications of crowdsourced geospatial data", Qin et al., "Geocrowdsourcing and accessibility for dynamic environments."

condition reporting is used to reduce costs, is substantial. This cost is demonstrably higher in locations with low-density sprawl, where walkways infrastructure is more extensive.

The review of the literature here suggests that hard infrastructure such as water, sewer, and roads exhibit economies of density and therefore will be more expensive to build if stretched out over conventional sprawl development patterns. It is possible that other public services such as public safety, education, parks, etc. may also become more costly in sprawled patterns. There is limited to no literature available that directly addresses infrastructure maintenance costs and their relation to sprawl; however, logic would suggest that if new infrastructure costs more in sprawl versus compact settlement patterns, then so would maintenance.[324] If revenues keep up with costs, then savings are generally irrelevant. However, determining the most cost-efficient development pattern is important because "of the growing fiscal stress that local governments have experienced in recent years."[325] That stress can be attributed to the "steadily growing burden of infrastructure maintenance costs" as infrastructure built in the post-WWII boom years nears the end of its lifecycle.[326] Ihlanfeldt and Willardsen suggest future research into "whether and how local government revenues are affected by the geography of development" in order to get a complete picture of the fiscal impacts of development patterns.[327] Section 2.5 will review the limited literature related to development patterns

[324] Fulton et al., "Building Better Budgets."
[325] Ihlandfeldt and Willardson, "Local Public Services Costs and the Geography of Development."
[326] Ford, "Smart Growth & Conventional Suburban Development."
[327] Ihlandfeldt and Willardson, "Local Public Services Costs and the Geography of Development."

and tax revenues in an attempt to give a more complete picture of the effects of sprawl on the fiscal health of localities.

2.5 Revenues

Property tax is the "primary mechanism" used to raise revenue by local governments.[328] In most places throughout the U.S., and in Fairfax City, the amount that is paid in property tax is a rate on the total combined value of land and the structures built on it. For example, the 2019 Fairfax City property tax rate was $1.075 for every $100 of property value.[329] So the owners of a property that is valued at $600,000 would have to pay $6,450 in property taxes. Localities have a finite amount of land, and because the majority of local revenue comes through property tax, land is their most valuable resource. In order to maintain fiscal viability, local governments must ensure that their land use is financially productive. The literature reviewed here will discuss whether or not sprawl is the ideal mechanism for greater property tax revenues.

The additional costs of low-density development are often considered to be offset by high assessment values, and therefore high property taxes, in single-family neighborhoods.[330] Dekel (1994) calculates the required assessment values that would cover the public service costs at different development densities in the case of Regina, Canada.[331] He calculated the assessment value that could be expected at different

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[328] Soji Adelaja and Manly Miles Building, "Optimal Density for Municipal Revenues" (American Agricultural Economics Association Annual Meetings, Portland, OR: Federal Reserve Bank of St Louis, 2007), 35, https://search-proquest-com.mutex.gmu.edu/docview/1697468915?accountid=14541&rfr_id=info%3Axri%2Fsid%3Aprimo.
[329] SOURCE
[330] Gabriel P. Dekel, "Housing Density: A Neglected Dimension of Fiscal Impact Analysis," *Urban Studies (Routledge)* 32, no. 6 (June 1995): 935–52, https://doi.org/10.1080/00420989550012726.
[331] Ibid.

densities against the required assessment values to find the break-even point at which property taxes would meet costs.[332] The expected and required assessments per hectare had an inverse relationship; as expected assessments per hectare rose with density the required assessments per hectare fell.[333] Low densities may have higher assessments per dwelling unit, but Dekel found that the assessment that would be required to recover the costs is significantly higher than existing assessments, rejecting the idea that higher assessment values in low-density places can recoup costs.[334] In Dekel's words "assessed values of lower-density development per hectare are not as high as values per hectare in higher-density areas."[335] In addition, lower densities result in a higher "divergence of revenues from costs."[336] Every single neighborhood studied showed higher costs than revenues.[337] Dekel claims that because of the inverse relationship, high-density neighborhoods that operate with a budget surplus subsidize low-density neighborhoods that operate at a loss.[338]

Adelaja and Chaudhuri (2007) attempt to determine the optimal lot size that maximizes property values and therefore property tax revenues.[339] Using data from Meridian Township in Ingham County, Michigan, their model determined that peak property value existed at properties sized 1.00 acres and 0.49 acres, with 0.49 being the

[332] Ibid.
[333] Ibid.
[334] Ibid.
[335] Ibid.
[336] Dekel, "Housing Density."
[337] Ibid.
[338] Ibid.
[339] Adelaja and Building, "Optimal Density for Municipal Revenues."

higher peak.[340] The average lot size allowed in Meridian by the zoning code was 0.8 acres.[341] An average lot size of 0.49 acres would increase lot density suggesting "that greater density than the current standard would yield greater municipal property tax revenue than the current density."[342] They suggest that these results indicate that local governments should be aware of the optimal lot size for peak property values as it is likely below the minimum lot size standard set in local zoning codes.[343]

As discussed in Section 2.2, density in cities is often cut down to make way for parking and auto-oriented transportation networks, and parking is one of the most defining traits of sprawl. Blanc et al. (2014) researched the effects of parking lots on local government property tax revenue in six midsized U.S. cities: Arlington, VA; Berkeley, CA; Cambridge, MA; Hartford, CT; Lowell, MA; and New Haven, CT. They looked at the change in downtown area, or CBD, land use from 1950 to 2009, specifically the building, surface parking, and structured parking footprints. Arlington, Berkeley, and Cambridge all had total surface parking footprints under 7% of the total CBD area and a positive change in building footprint (buildings took up more square feet per acre in 2009 than 1950).[344] Hartford, Lowell, and New Haven all had parking footprints over 13% of the CBD and negative change in building footprint.[345] Those three cities also had a much greater percentage change in parking footprint and more structured parking than

[340] Ibid.
[341] Ibid.
[342] Ibid.
[343] Ibid.
[344] Bryan P. Blanc et al., "Effects of Urban Fabric Changes on Real Estate Property Tax Revenue: Evidence from Six American Cities," *Transportation Research Record: Journal of the Transportation Research Board* 2453, no. 1 (January 1, 2014): 145–52.
[345] Ibid.

Arlington, Berkeley, and Cambridge.[346] While the land use of surface parking ranged from 3% to 15% of total land, the tax revenue from the surface parking ranged from only 1.6% to 6.9% of total revenue.[347] Lowell had 15.4% surface parking which returned 3.8% of its total property tax revenue and Arlington had 6.5% surface parking which returned 1.8% of its tax revenue.[348] Surface parking returned much less in tax revenue than it took up in space; in Hartford each 1% of land used for surface parking returned 0.46% in tax revenue.[349] In contrast, buildings had a far higher return in tax revenue than land occupied.[350] Buildings contributed no less than 87% of tax revenue, and in some cases it was more than 97%.[351] However, at most buildings occupied 29% of the total CBD.[352] In every case, buildings provided a much higher return in tax revenue than parking did.[353] In Hartford, every unit of land used for buildings contributed 10 times as much tax revenue as the same unit of land used for surface parking, and in Arlington the contribution was 20 times more.[354] Property taxes derived from assessment values lead to the discrepancy, because the land value of a building is significantly higher than parking.[355] This creates an opportunity cost of using land for parking, "for the three cities with the largest increase in parking, the potential additional tax revenue is at least 20% higher than the

[346] Ibid.
[347] Ibid.
[348] Ibid.
[349] Ibid.
[350] Ibid.
[351] Ibid.
[352] Ibid.
[353] Blanc et al., "Effects of Urban Fabric Changes on Real Estate Property Tax Revenue."
[354] Ibid.
[355] Shoup, *The High Cost of Free Parking*, 175.

existing land use configuration in the CBDs."[356] Likewise, Shoup found that reducing the parking requirement in Oakland, CA by 34% would increase property tax revenues by 37%.[357] "Hartford had the largest increase in surface parking of any of the cities in the study" but reverting back to the land use configuration of the 1950s would give them $21 million more in tax revenue each year.[358] Blanc et al. concludes that there is a "substantial consequence of parking that consumes a large proportion of land" in the form of significant loss in potential tax revenue.[359]

McMillan (2016) concludes that since property tax revenue is higher for non-parking land uses, places that rely more heavily on local property tax are less likely to sprawl.[360] In Blanc et al. Arlington, Berkeley, and Cambridge all had about 97% of their revenue from non-parking uses whereas Hartford and New Haven which had 87.8% and 88.85% respectively (Lowell was at 95.3% because of "a very low rate of taxation on surface parking).[361] McMillan looked at American cities and then compared them to the Canadian cities of Calgary and Edmonton using data from Burchfield et al. "Causes of Sprawl." He found that reliance on governmental transfers, funding from state or federal governments, and therefore the implication of "a lower cost of local government services to local residents" promoted sprawl.[362] Calgary and Edmonton had more reliance on

[356] Blanc et al., "Effects of Urban Fabric Changes on Real Estate Property Tax Revenue."
[357] Shoup, *The High Cost of Free Parking*, 148.
[358] Blanc et al., "Effects of Urban Fabric Changes on Real Estate Property Tax Revenue."
[359] Ibid.
[360] Melville L. McMillan, "Municipal Revenue Generation and Sprawl: Implications for the Calgary and Edmonton Metropolitan Regions Derived from an Extension of 'Causes of Sprawl' (Technical Paper)," *The School of Public Policy Publications; Calgary* 9 (December 2016), http://dx.doi.org.mutex.gmu.edu/10.11575/sppp.v9i0.42613.
[361] Blanc et al., "Effects of Urban Fabric Changes on Real Estate Property Tax Revenue."
[362] McMillan, "Municipal Revenue Generation and Sprawl."

property taxes than the U.S. cities in the study which reduced their sprawl "relative to what it would have been if their public finance mimicked that of the typical U.S. metro region in the data."[363] A different approach to local finance in the U.S. cities that emphasized property tax revenue generation would encourage local governments to favor denser development styles that would reduce sprawl by about one-quarter.[364]

2.5.1 Revenue per Acre

At this point it is time to cover the literature that this project will be based on: per acre tax revenue analysis from Urban3, an urban planning consulting firm. Much like Dekel who looked at financial productivity by hectare, Urban3's per acre analysis divides the gross tax revenue of each property by the property's acreage.[365] Take the example property above that is valued at $600,000 and pays $6,450 in property taxes. If this property sits on 2 acres it would generate $3,225 per acre, but if the property was only 0.5 acres it would generate $12,900 per acre. Instead of comparing property to property, per acre analysis compares acre to acre.[366] In this way, a comparison of different types of development becomes apples to apples.[367] All local governments are "constrained by the land they can develop" so by doing a per acre revenue analysis they can see how to get the most of their most valuable, but finite, resource: land.[368]

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[363] Ibid.
[364] Ibid.
[365] Peter Katz, "The Missing Metric" 29, no. 4 (August 2013), https://www.questia.com/magazine/1G1-340636601/the-missing-metric.
[366] Speck, *Walkable City Rules*, 22-23.
[367] Joe Minicozzi, "Thinking Differently About Development," *Government Finance Review*, August 2013.
[368] Joshua McCarty, "Mapping the Effects of Parking Minimums," Strong Towns, November 20, 2017, https://www.strongtowns.org/journal/2017/11/20/mapping-the-effects-of-parking-minimums.

Katz's (2013) article in *Government Finance Review* magazine explores a per acre analysis done on Sarasota City and Sarasota County. Figure 3 shows the per acre tax revenue of different building types. The first three are averages of those building types, the remaining categories are the yields from specific buildings or centers. Apartment buildings (Multi-family) and single-family homes in the city yield double the property taxes per acre of homes in the county.[369] Single-family homes, a staple of sprawl, are the least productive building type at $8,211, but the shopping centers, another sprawl staple, don't do much better. The big-box shopping center (number 4) is new and sits on 21 acres, but only makes $163 more per acre than the average city of Sarasota single-family home.[370] Of the other shopping centers, only the 32-acre upscale Southgate mall (number 8) brings in more than double the tax revenue per acre of single-family residential.[371] This expansive development, large shopping centers surrounded by parking and roads and single-family neighborhoods, is expensive to service, as detailed in Section 2.4. Who is paying the bill if commercial development is barely providing more revenue than a house?

[369] Katz, "The Missing Metric."
[370] Ibid.
[371] Ibid.

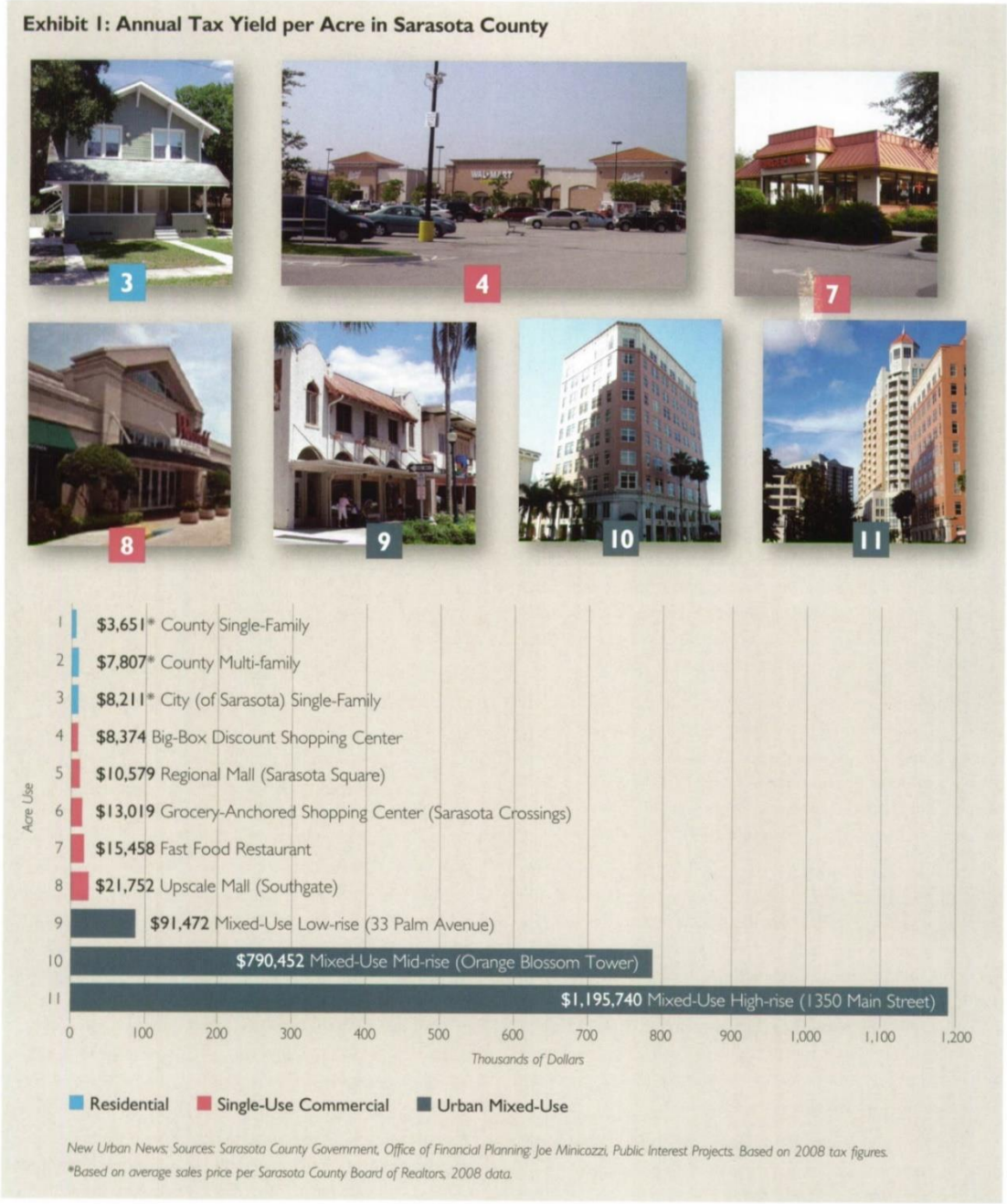

Figure 3: Per-acre tax revenue of building types in Sarasota, FL [372]

[372] Katz, "The Missing Metric."

The bottom of Figure 3 stands out as the per acre revenues skyrocket. All three of these buildings are mixed-use, meaning they mix commercial with residential or offices. The low-rise (number 9) building is only two stories, one retail and one office, but per acre generates $90,000 per year in property taxes, more than four times that of the upscale mall and eleven times more than the big-box shopping center.[373] The ten floor mid-rise mixed use building (number 10) generates nearly $800,000 per acre in property taxes with retail, condos, and offices, over 74 times as much per acre as the regional mall.[374] Then there is the mixed-use high-rise (number 11) which at 17 stories of retail and condos generates $1.2 million per acre, or 13.5 times the property tax revenue of all the other non-mixed-use building types put together.[375]

The numbers are staggering. The high-rise development generates 142 times the per acre tax revenue of the big-box shopping center.[376] Urban3 has found similar numbers across at least 30 jurisdictions in 10 states.[377] In Asheville, N.C. a six-story mixed-use building produced over thirteen times the tax revenue per acre than the Walmart on the edge of town.[378] The "Building Better Budgets" report surveyed similar studies and found that, on average, more compact development produced ten times the tax revenue per acre conventional sprawl.[379] Their survey includes a Nashville, TN scenario in in which a brownfield development would generate 42 times the tax revenue per acre as a suburban

[373] Ibid.
[374] Katz, "The Missing Metric."
[375] Ibid.
[376] Ibid.
[377] Minicozzi, "Thinking Differently About Development."
[378] Montgomery, *Happy City*, 263.
[379] Fulton et al., "Building Better Budgets."

greenfield development.[380] In Raleigh, NC a six-story downtown building generates 50 times the revenue per acre as an average Walmart.[381]

These studies continually show "that mixed-use developments in urbanized areas generate property tax revenue at a much higher rate than do single-use developments in more suburban locations."[382] Joe Minicozzi, the principal of Urban3, and Katz urge local governments to calculate a return on investment for development projects using per acre analysis. In the Sarasota example, the high-rise building and two other adjacent downtown buildings containing 197 residential units and retail sitting on 1.9 acres would pay off the costs of infrastructure built to serve them in three years.[383] In comparison, a garden style apartment complex in Sarasota with 357 residential units sitting on 30 acres would take 42 years to pay back the costs of infrastructure built to service it.[384] The 30 acres requires more horizontal infrastructure than the downtown buildings which, as discussed in Section 2.4, is more expensive.[385]

Considering that a road will likely need to be paved again every 20 years, that revenue generation is unsustainable.[386] Katz contends that "few would argue that government should be subsidizing forms of private development that are known to generate public costs far in excess of the tax revenue they will generate over their useful lives."[387]

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[380] Ibid.
[381] Ibid.
[382] Katz, "The Missing Metric."
[383] Katz, "The Missing Metric."
[384] Ibid.
[385] Ibid.
[386] Speck, *Walkable City Rules*, 22.
[387] Katz, "The Missing Metric."

What makes Urban3's analysis unique is that they present the per acre calculations in a 3D map.

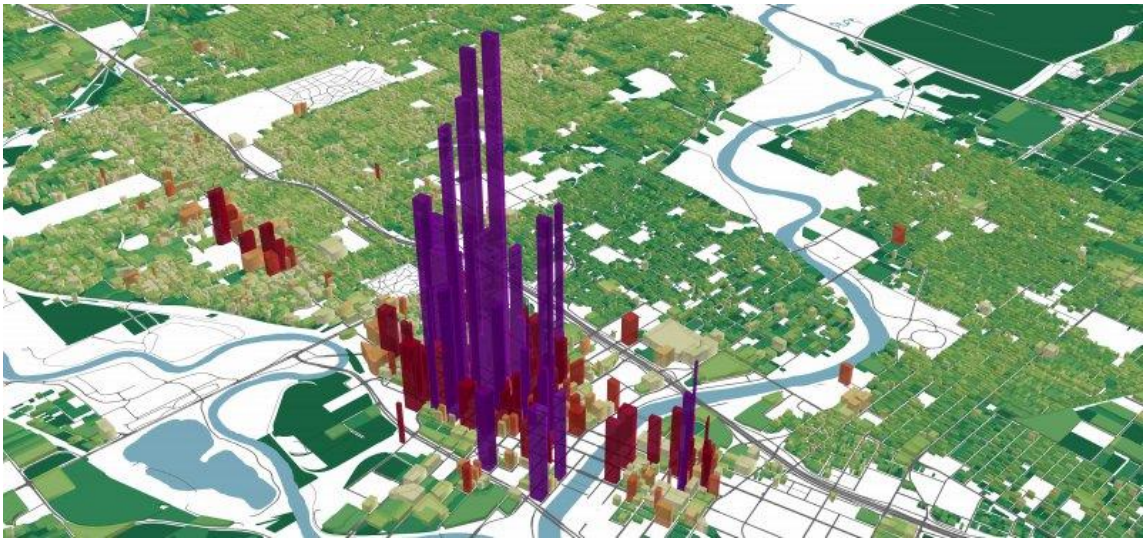

Figure 4: Map of Des Moines, IA with 3D height of each parcel representative of its tax revenue per acre [388]

Figure 4 is a 3D map by Urban3 depicting per acre tax revenue in Des Moines, IA. This map shows the parcels with the highest per acre tax revenue in both the most vertical 3D columns and in purple, while the lowest revenue earners are in low-lying green. In an article for Strong Towns, Urban3's Joshua McCarty discusses these maps and the influence parking has on per acre tax revenue. The downtown in Figure 4 is "the most compact, 'urban' pattern of development and corresponds to the most potent taxable properties."[389] Figure 5 shows a main street area with black demarcating buildings and red signifying parking lots.

[388] McCarty, "Mapping the Effects of Parking Minimums."
[389] Ibid.

Figure 5: Main Street area showing parking (red) and buildings (black)

390

Compare that with Figure 6 that shows the same main street's tax revenue per acre.

[390] McCarty, "Mapping the Effects of Parking Minimums."

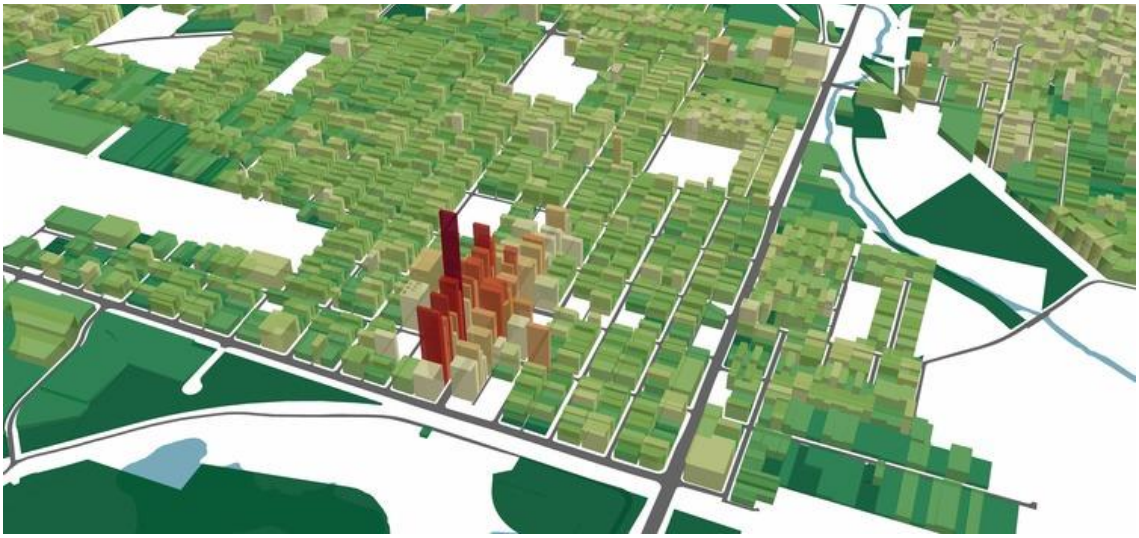

Figure 6: Main Street area per acre tax revenue in 3D [391]

The main street of this town easily generates the most tax revenue per acre. These are the areas that in Figure 5 show a lot of black densely packed together. To the north of the main street in Figure 5 is an area with large red parking lots surrounding smaller black buildings, likely either a shopping center or office park. The same area in Figure 6 does not stand out from the surrounding single-family neighborhoods. Figure 7 and Figure 8 show a "decidedly auto-oriented" shopping center around a cloverleaf exit with similar low per acre return of buildings surrounded by large parking lots.[392]

[391] Ibid.
[392] McCarty, "Mapping the Effects of Parking Minimums."

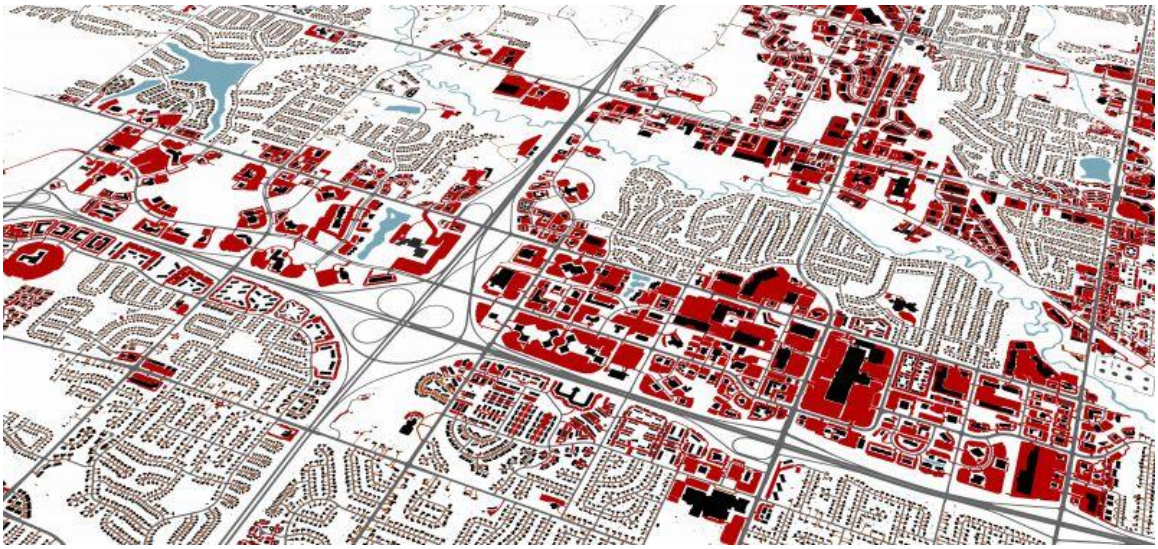

Figure 7: Sprawl commercial area parking (red) and buildings (black)

393

Figure 8: Sprawl commercial area per acre tax revenue in 3D

394

393 Ibid.

394 McCarty, "Mapping the Effects of Parking Minimums."

The shopping centers can be determined by their large parcel size, but most do not stand out vertically from the surrounding single-family pods. As with the other 3D models, in the most productive places "almost all available space is used for buildings."[395] These maps taken together show that parcels that have a lower percentage of land used for parking produce more tax revenue per acre than those that have a higher percentage of parking. The maps show that the "big box store[s] or shopping mall[s are] only marginally more productive than […] modestly sized detached housing."[396] It is visually very striking to see where the most property tax revenue per acre comes from and the relationship between revenue and land allotted to parking.

2.5.1 Literature Review Conclusion

Looking at property tax revenue per acre rather than gross revenue allows localities to judge how productive each square foot of land is and to see how their urban development policies affect their potential revenues. Sections 2.1 and 2.2 covered how these land use policies were made and how those policies were not created organically or created to meet the free market, but instead were a series of policies to enable auto-centric transportation. These policies greatly influence how the majority of Americans live their daily lives, but the resulting sprawl has considerable negative externalities including increased infrastructure expenditures for local governments. As they face increased fiscal pressure, local governments need to build in a way that will ensure their fiscal health. By evaluating their property tax revenue on a per acre basis, they can make

[395] Ibid.
[396] Ibid.

sure that their hard infrastructure has a healthy return on investment, that they are making the most out of the limited land that they have, and that they can stay fiscally viable in the short and long term. A locality in fiscal stress because of high expenditures and inefficient land use practices is only handcuffed by its own development policies. Parking minimum requirements and sprawl zoning codes that do not bring cost savings or higher revenues are policies that may need to be reexamined.

3. METHODOLOGY

Four datasets were used in this project. 2019 property assessment data was provided by the City of Fairfax Real Estate Assessment Office as an Excel file. Building polygon, parking lot polygon, and parcel polygon shapefiles were provided by the City's GIS office. Other City documents were used as reference: the 2035 Comprehensive Plan, the City Zoning Ordinance, and the FY 2019-2020 Adopted Budget.

In order to do the per acre calculations, the "Property Tax" data (propertytaxdata_2019) had to be joined to the geographic "Parcels" data (Property_Poly).[397] This was done by joining the "Property Tax" *ParcelID* field to the "Parcels" *PIN* number. In order to ensure that all property parcels in the "Parcels" data were matched to Property Tax data, some adjustments to both databases had to be made.

In "Parcels", 130 parcels were labeled as *'CONDOS'* in the *PIN* field and instead had an identifier in the *CPIN* field. In the "Property Tax" data the *CPIN* number would match to multiple rows, each a different property tax payment for the same parcel. A one-to-many join was not possible, so the rows containing the assessment values were summed in Excel with the new row given the *CPIN* identifier for that property (Table 2). In ArcMap, the *CPIN* identifier was then copied into the *PIN* field replacing the *'CONDOS'* identifier so that the join could be done while including the properties previously labelled as *'CONDOS'*.

[397] In this section tables are denoted with double quotation marks " ", column headings are shown in italics *heading*, and table values are signified by single quotations and italics *'value'*

Table 2: the CONDOS assessed values are summed into one row

Property ID	Parcel ID	Composite Land Use	Primary Neighborhood	Zoning	Building Assessed Value	Land Assessed Value	Total Assessed Value	Primary NBC Modifier	Start Number	Street Name & Way
68191	58 3 96 69 00A	300 - Comm - Condo	CC28 - WOODSON SQ	PD-C - PD Comm.	163200	67900	231100	4.0 - Commerical	9669	MAIN ST
68204	58 3 96 69 00B	300 - Comm - Condo	CC28 - WOODSON SQ	PD-C - PD Comm.	161000	67900	228900	4.0 - Commerical	9669	MAIN ST
68215	58 3 96 69 00C	300 - Comm - Condo	CC28 - WOODSON SQ	PD-C - PD Comm.	172200	67900	240100	4.0 - Commerical	9669	MAIN ST
68226	58 3 96 69 00D	300 - Comm - Condo	CC28 - WOODSON SQ	PD-C - PD Comm.	163200	67900	231100	4.0 - Commerical	9669	MAIN ST
	58 3 96 69	300 - Comm - Condo	CC28 - WOODSON SQ	PD-C - PD Comm.	659600	271600	931200	4.0 - Commerical	9669	MAIN ST

The Mayfair on Main property, located on the corner of Main St. and East St., was not labeled as *'CONDOS'* in the "Parcels" data, however there were 26 rows for it in the "Property Tax" table with *Primary Neighborhood = 'RC12 - Mayfair on Main'*. In "Parcels" the *PIN = '57 4 02 131'*, so once summed the *PIN* was changed to *'57 4 39'* in order to match the summed "Property Tax" data, all of which were labeled as *'57 4 39'* with a suffix number.

Figure 9: This property separated its parking from its building parcels

Other properties in "Parcels" did not include parking lots as part of their parcels; many of these were townhouse developments. As seen in Figure 9, an office condo property on Armstrong St., the parcels only cover the building extent (in orange) and not the parking lot (in blue). The parking lot is private and can only be used by people who are using those buildings. Therefore, when examining the land used by those buildings, it is necessary to include their private parking lot. For properties like this, the parking lot area was distributed proportionally to the area of each building's parcel. The *Acreage* (*SHAPE_STAr*) of a single building was divided by the sum of all the buildings in order to find the proportion of the building to the entire property, then the proportion was multiplied by the area of the parking and open space on the property to distribute the

correct amount parking area to the building. That proportional parking area was then added to the building's area which distributed the parking to each building. The formula for that calculation is below:

$$Parking\ Proportion = SHAPE\_STAr + \left(\frac{SHAPE\_STAr}{sum\ of\ building\ area} \times sum\ of\ parking\ area\right)$$

The property tax calculations were done in ArcMap because of user familiarity and ease. The *Acreage* field was converted into acres using the Calculate Geometry function. A *gross tax* and *per acre tax* field were added to the "Parcels" table. The "Parcels" table and the "Property Tax" table were joined by matching the *PIN* field to the *ParcelID* field. 57 parcels were not joined, most of which were the parking lots and open space that had been proportioned out. A few properties on and around Virginia St. and Sager Ave. were divided into two parcels but were taxed as one parcel, so the parcel had to be merged to cover the entire property. Likewise, the properties at 10389 Main St. and 10381 Main St. are taxed together but were split into three separate parcels which had to be combined into one parcel.

Gross tax was calculated by multiplying the *Total Assessed Value* by the 2019 tax rate of 1.075 (Total Assessed Value * 0.01075). Parcels with a *Primary NBC Modifier* equal to *'4.0 – Commerical'* [sic] were selected and given the additional commercial tax rate of 0.125 (*Total Assessed Value* * (0.01075 + 0.00125)). The per acre tax was calculated by dividing the *gross tax* by the acreage (*gross tax / Acreage*).

The data was then loaded into ArcGIS Pro. One map and five local scenes were created. The Buildings & Parking map used the Buildings polygon shapefile and the Impervious Surface shapefile, with a definition query on the Impervious Surface layer to only include paved or unpaved parking. This was created in a map layout and a local scene layout. All the 3D maps were created the same way, just with different display fields. Each local scene was given a "Parcel" layer. In the Appearance tab, the Extrusion Type was set to 'Absolute Height' and the field was set to whichever display field was necessary. The resulting extrusion was not viewable so in the Extrusion Expression pop-out, the feature was divided by 100 to make the 3D map viewable. For example, in the per acre map, the field was set to *peracre_tax* and the Extrusion Expression read *$feature.peracre_tax / 100*. A graduated color scheme was added with natural (Jenks) breaks and 30 classes. All parcels equal to zero were excluded from display. The 3D Zoning and Existing Land Use maps were given a color scheme based on the zoning designations in the "Parcels" *Zone1* and *ELU* fields respectively.

Both the Zoning and Existing Land Use maps contain an Old Town designated area that did not exist in the original data. This area was drawn based on the 2035 Comprehensive Plan's Future Land Use Map designation of Activity Center #3: Old Town (Figure 10). All properties within those boundaries were given a *Zone1* code of *'OT'* and an *ELU* code of *'OT – Old Town.'* The Activity Center boundary was chosen over the Old Town Historic District boundary because the Historic District was too small and did not include important downtown properties. It was also chosen over the Old

Town Transition Overlay District because the Transition District was too large and included too many non-downtown properties.

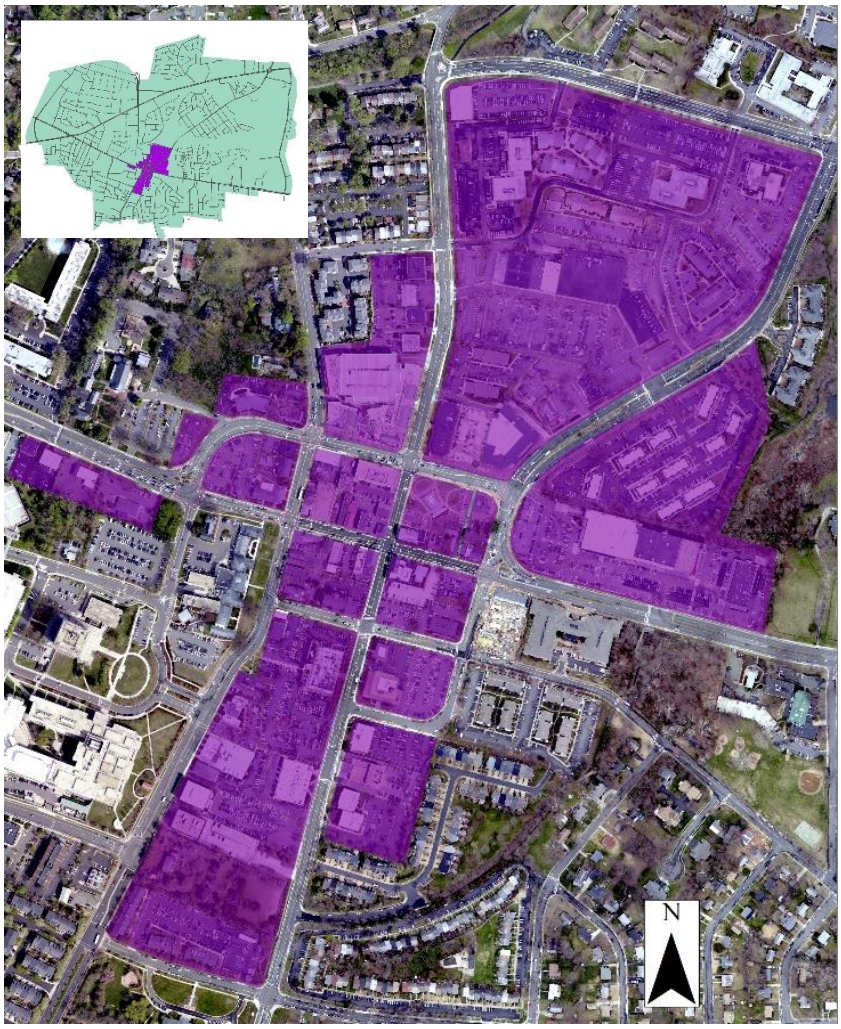

Figure 10: Boundary of Activity Center #3 – Old Town

This research uses property tax as a lens to view land use efficiency. In order to do that, all properties were mapped according to their taxable value regardless of

exemption status. This allows for land use productivity to be viewed and inefficiencies to be diagnosed due to land use type rather than actual revenue.

The statistical analysis was done with the help of Dr. Matthew Rice. First, all the per acre parcel values were extracted and split into ten categories based on their existing land use: Old Town, All Commercial, All Residential, Commercial – Lodging, Commercial – Office, Commercial – Retail, Residential – Multifamily, Residential – Attached, Residential – Detached, and Auto Dealer. All calculations were done in Excel using the Data Analysis Tools. Means and variances were then found for each category Table 10. An analysis of variance test was conducted at alpha = 0.05 level, resulting in a rejection of the null hypothesis that the means are all equal. At least one of the ten means is not equal to the others (Table 3). In order to determine the correct t-test to test for equality of means testing, an F-test was run. The two-tailed Snidecor/Cocharn F-test for equality of variances was tested at an alpha level of 0.05 with the null hypothesis that the population variances for the two samples are equal. Table 4 shows the results of the F-test where the acceptance of the null hypothesis is colored green and the rejection of the null hypothesis is in red. A comprehensive, pairwise, t-test for equality of means was conducted between every possible pair consistent with the specific results of the F-test for equality of variances. The Student's t-test was one-tailed at alpha = 0.05 with the null hypothesis that the sample means are equal and the alternative hypothesis that the mean of the first variable is greater than the mean of the second variable.

Table 3: Analysis of Variance

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Old Town	105	6420236.27	61145.1073	1624043295		
All Commercial	311	12159074.1	39096.7012	474872700		
All Residential	6711	255048669	38004.5699	1464669561		
Commercial - Lodging	15	502537.548	33502.5032	761671207		
Commercial - Office	139	6231279.33	44829.3477	409678127		
Commercial - Retail	157	5425257.19	34555.7783	459851321		
Residential - Multifamily	189	10172959.8	53825.1842	1785281673		
Residential - Attached	1593	120297496	75516.3191	3061378373		
Residential - Detached	4929	124578213	25274.541	310665118		
Auto Dealer	36	951276.052	26424.3348	83241061.4		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3.1572E+12	9	3.508E+11	292.054013	0	1.88054421
Within Groups	1.7026E+13	14175	1201142719			
Total	2.0183E+13	14184				

Table 4: F-Test for Equality of Variances – p-values

	Old Town	All Commercial	All Residential	Commercial - Lodging	Commercial - Office	Commercial - Retail	Residential - Multifamily	Residential - Attached	Residential - Detached	Auto Dealer
Old Town		0.000000000	0.212899765	0.055311468	0.000000000	0.000000000	0.298896846	0.000031258	0.000000000	0.000000000
All Commercial			0.000000000	0.076690874	0.160908537	0.414663896	0.000000000	0.000000000	0.000000021	0.000000022
All Residential				0.076747744	0.000000000	0.000000000	0.023523908	0.000000000	0.000000000	0.000000000
Commercial - Lodging					0.036006440	0.070122884	0.035197255	0.002175323	0.001897682	0.000000060
Commercial - Office						0.244004516	0.000000000	0.000000000	0.008047428	0.000000340
Commercial - Retail							0.000000000	0.000000000	0.000123344	0.000000061
Residential - Multifamily								0.000002345	0.000000000	0.000000000
Residential - Attached									0.000000000	0.000000000
Residential - Detached										0.000004678
Auto Dealer										

4. RESULTS

A map of surface parking lots, in red, and building footprints, in black, (Figure 11) shows the extent of land used by both surface parking and building structures. In commercial corridors, parking lots are often larger than the buildings themselves because the most common parking requirement for commercial uses is one space per 200 sq. ft. of floor space. As noted in Section 2.2.3, that parking requirement results in surface parking lots 1.65 times the building footprint (Figure 12). Single-family residential does not require parking lots; however multifamily and townhouse properties do have a parking requirement per unit and therefore also have significant land portioned for parking (Figure 13).

Figure 11: Fairfax City buildings and parking lots

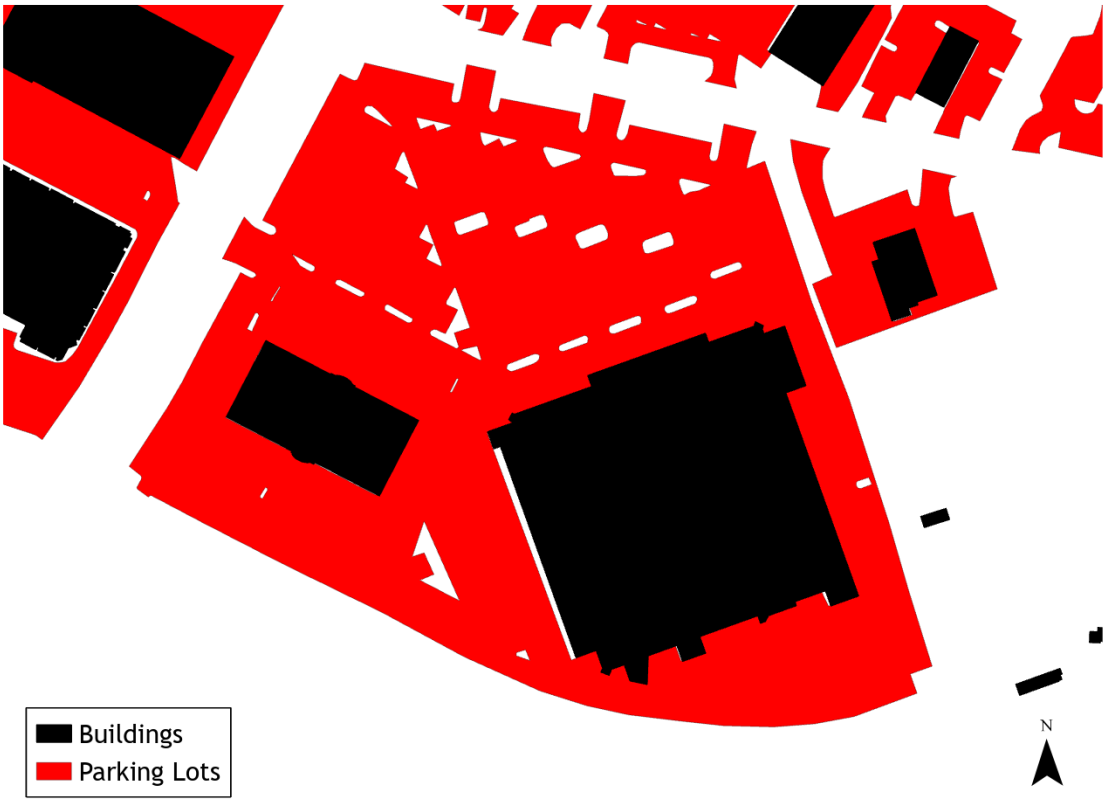

Figure 12: Home Depot on Old Lee Hwy.

Figure 13: Cavalier Court apartment complex on Jermantown Rd.

The Old Town Historic District also has a significant parking footprint. However, there is also a large building footprint, especially for historic buildings, with most off-street parking occurring on University Dr. and Chain Bridge Rd. south of Main St., and the Courthouse Plaza shopping center north of Main St. A 3D view of the Historic District, Figure 14, will be useful in comparing to the 3D tax revenue maps.

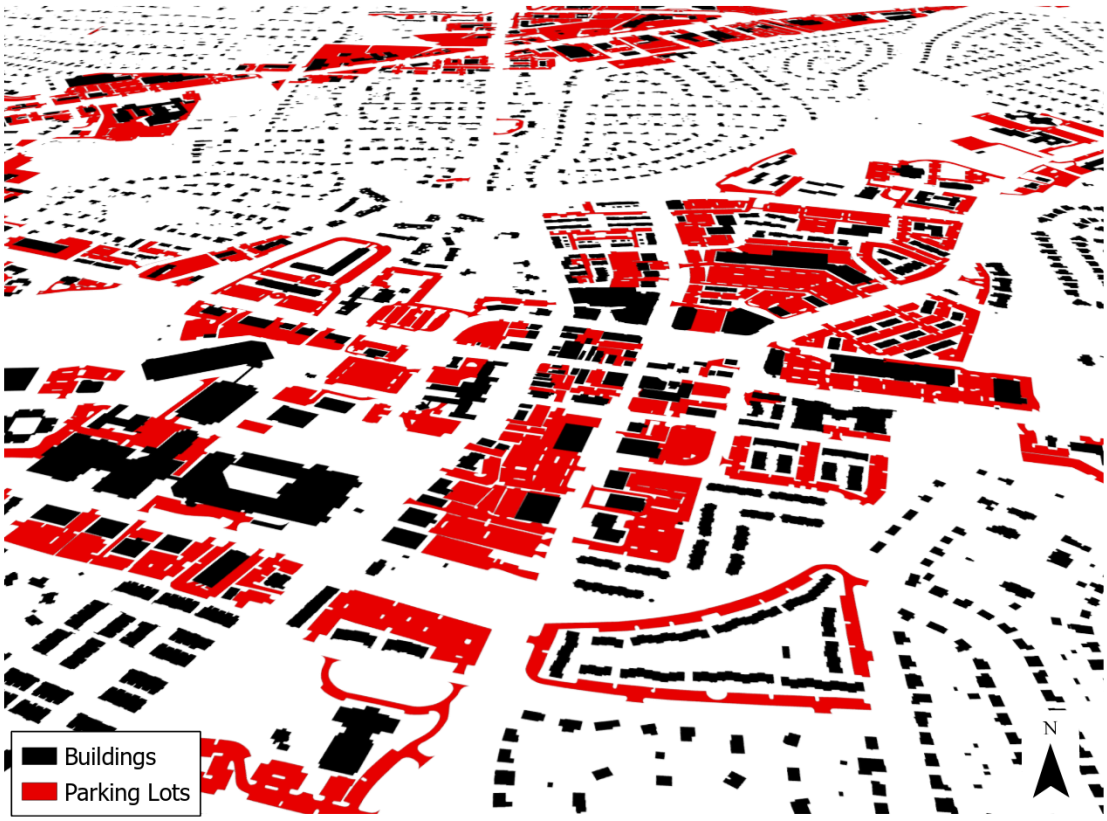

Figure 14: Birds-eye-view of Old Town Fairfax City

To give a more tangible view of the tax revenue results, eight example properties will be singled out (Table 5, Figure 15).

Table 5: 8 Example Properties

Property Name or Address	Property Type	Development Style	Acreage
Fair City Mall	Shopping center	Sprawl	33.31
EastWind Vietnamese Restaurant	Downtown commercial retail	Urban	0.07
Mayfair on Main	Single family residential attached	Urban	1.01
Single-Family Home	Single family residential detached	Sprawl	0.37
Providence Square	Apartment building	Urban	2.34
Fairfax Square	Apartment complex	Sprawl	26.10
Rosenthal Honda & Volkswagen	Auto Dealer	Sprawl	4.15
3554 Chain Bridge Rd.	Office building	Sprawl	1.71

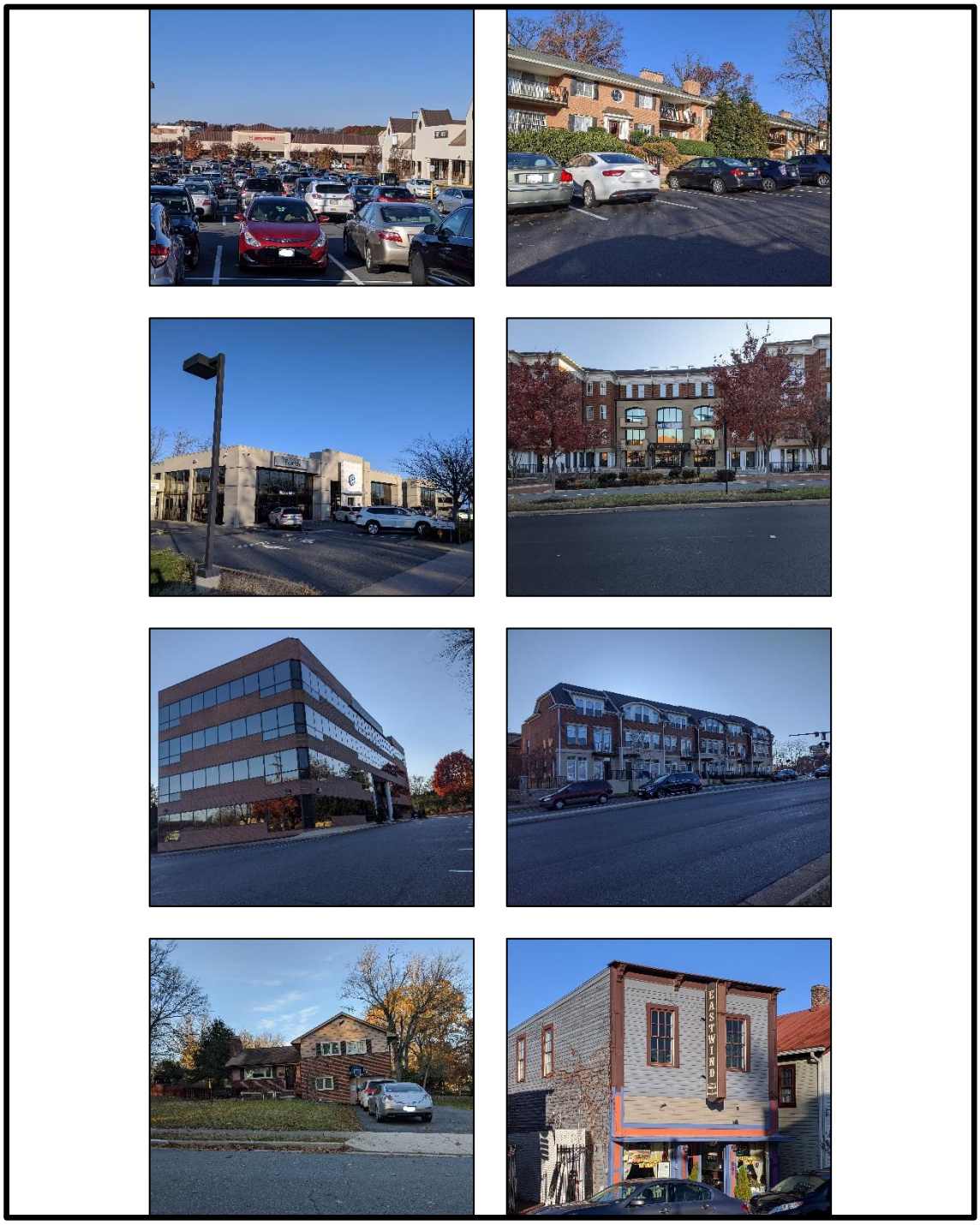

Figure 15: 8 example properties. Clockwise from top left − Fair City Mall, Fairfax Square, Providence Square, Mayfair on Main, EastWind, Single-Family Home, 3554 Chain Bridge Rd., and Rosenthal Auto

These eight properties consist of both urban development patterns in or adjacent to the central downtown, and sprawl style development outside of Old Town. Each one is an example of a common land use in the City. There is both a commercial sprawl property, Fair City Mall, and a downtown commercial, EastWind Vietnamese Restaurant Noodle House at 10414 Main St. in Old Town. Two other commercial properties are included, one an auto dealer, a common land use along Fairfax Blvd., and the other, an office building that includes a surface parking lot for employees. Four residential examples are included, two urban and two sprawl. The urban styles sit next to each other on Main St. Mayfair on Main is a single-family attached property and Providence Square is a multifamily apartment building. The sprawl style residential properties are a single-family detached home and Fairfax Square, a multifamily apartment complex.

The gross property tax revenue map (Figure 16) shows a visualization of large gross revenue returns in the commercial corridors. Single-family neighborhoods are low-lying in light green and larger revenue returns show up in the tallest 3D graphics and are colored dark green. Fair City Mall is the highest grossing property in the entire city followed by Fairfax Square apartment complex, Army Navy Country Club, and Fairfax High School. These properties have the highest overall assessed land plus assessed building value.

Table 6 and Figure 17 show the gross revenues of the eight example parcels. Fair

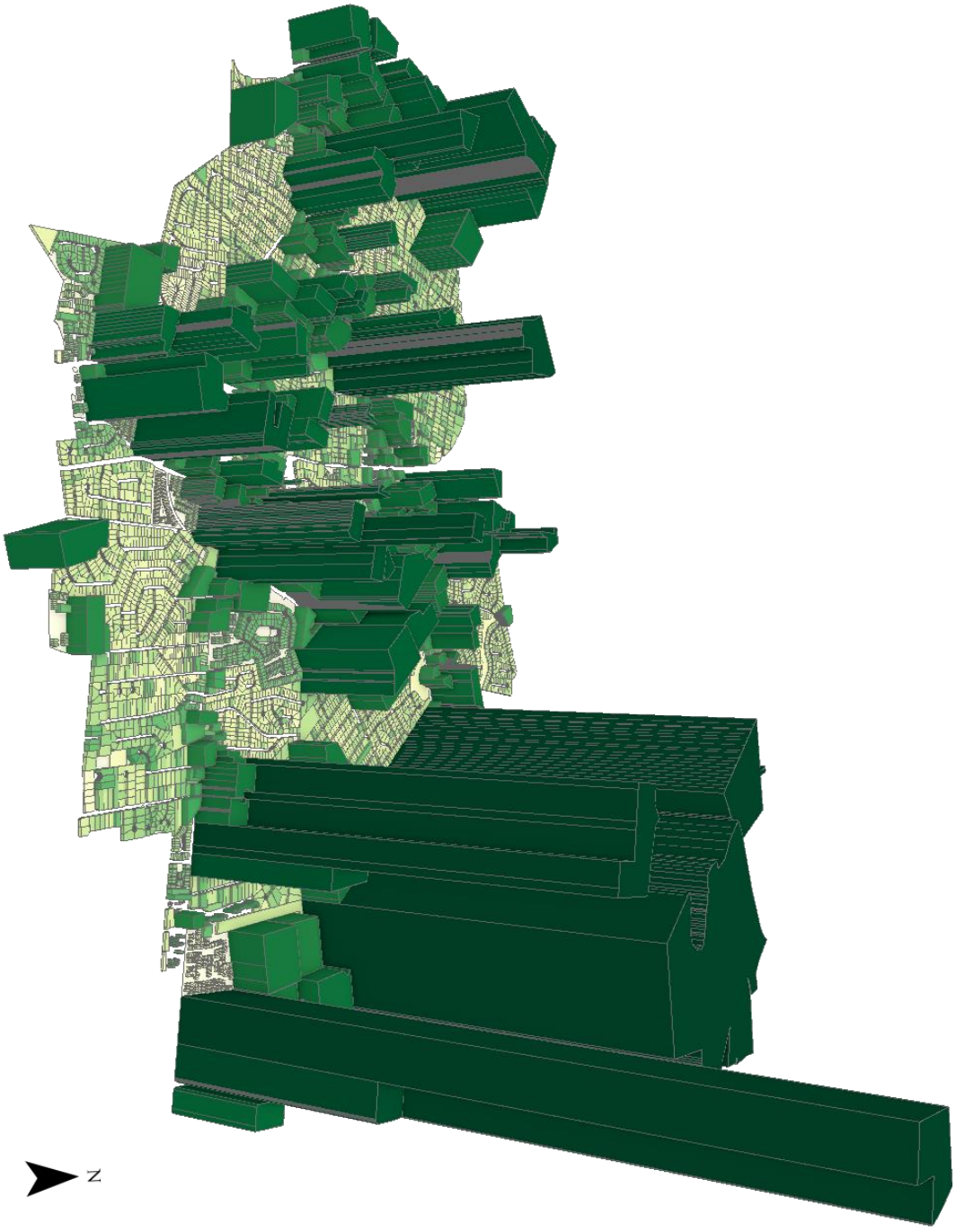

Figure 16: Gross property tax revenue map of Fairfax City in 3D

City Mall yields over $1 million for the city, while Fairfax Square and Providence Square

are the only other non-exempt properties in the entire City that yield over half a million dollars in gross property tax. The 3D visualization of the gross tax revenue (Figure 16) shows the impact of these three properties. On the lower end of the list, the office building yields a respectable $61,138 and EastWind pays the second lowest property tax of the group at a little less than $9,000. The single-family home yields the least, and while the example property is below both the mean and median gross property tax of detached single-family homes, the mean and median would both rank last on this list of gross property tax revenue.

Table 6: Gross Property Tax Revenue of 8 Example Properties

Property Name or Address	Gross Revenue
Fair City Mall	$1,194,665
Fairfax Square	$773,349
Providence Square	$518,958
Rosenthal Honda & Volkswagen	$196,713
Mayfair on Main	$181,125
3554 Chain Bridge Rd.	$61,138
EastWind Vietnamese Restaurant	$8,955
Single-Family Home	$4,818

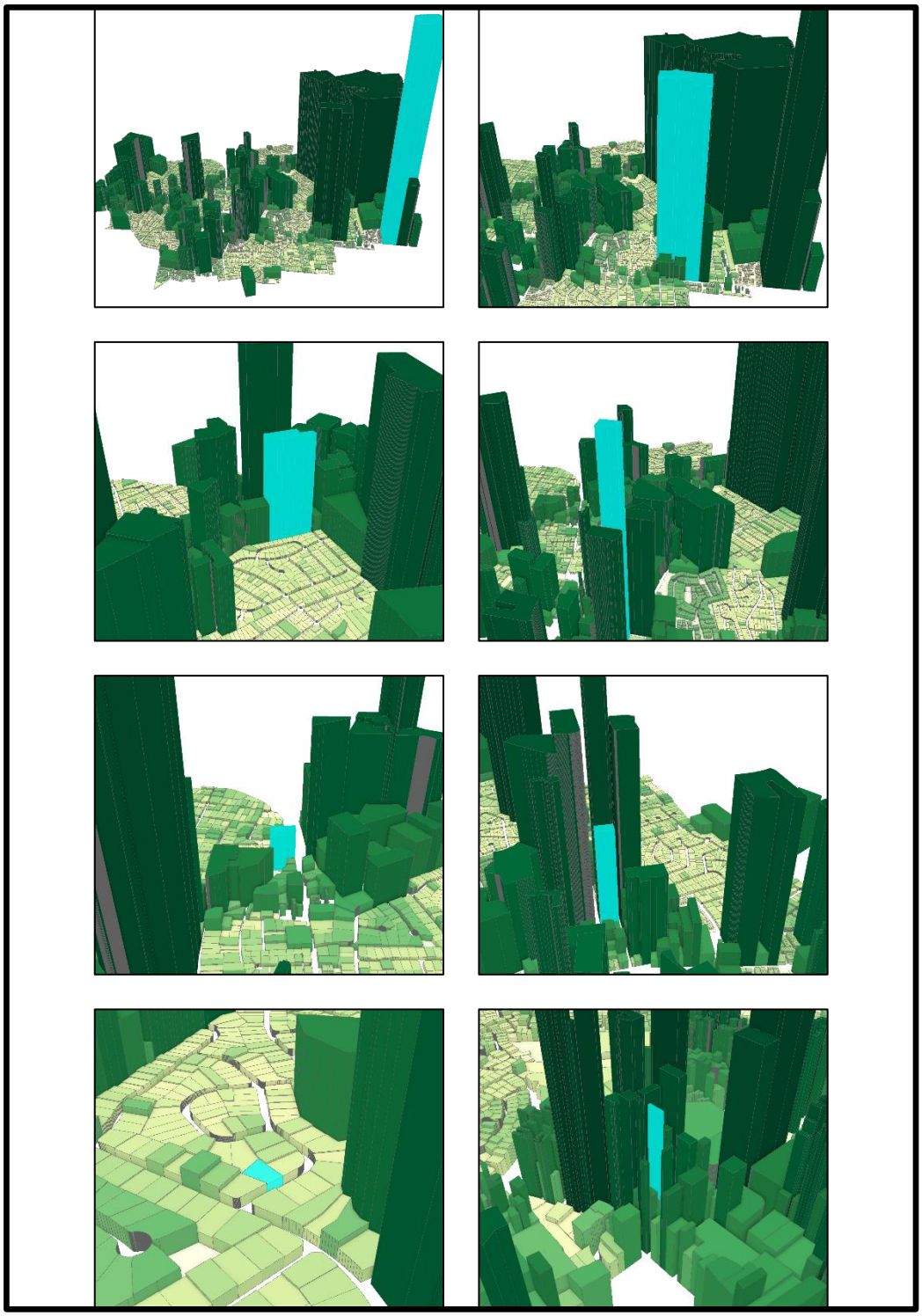

Figure 17: Gross revenue from 8 example properties highlighted in blue. Clockwise from top left – Fair City Mall, Fairfax Square, Providence Square, Mayfair on Main, EastWind, Single-Family Home, 3554 Chain Bridge Rd., and Rosenthal Auto

The per acre map (Figure 18) is extremely different from the gross revenue map. As with Figure 16, the height and colors are coordinated with the tax revenue. Detached single-family neighborhoods are low-lying in light green, while certain small lot, attached single-family neighborhoods have high per acre returns. The significant peak in the map comes in the Old Town core. The commercial corridor on Route 29 and the west side of the city are mostly mid-range or low per acre tax revenues compared to the high gross revenue in Figure 16.

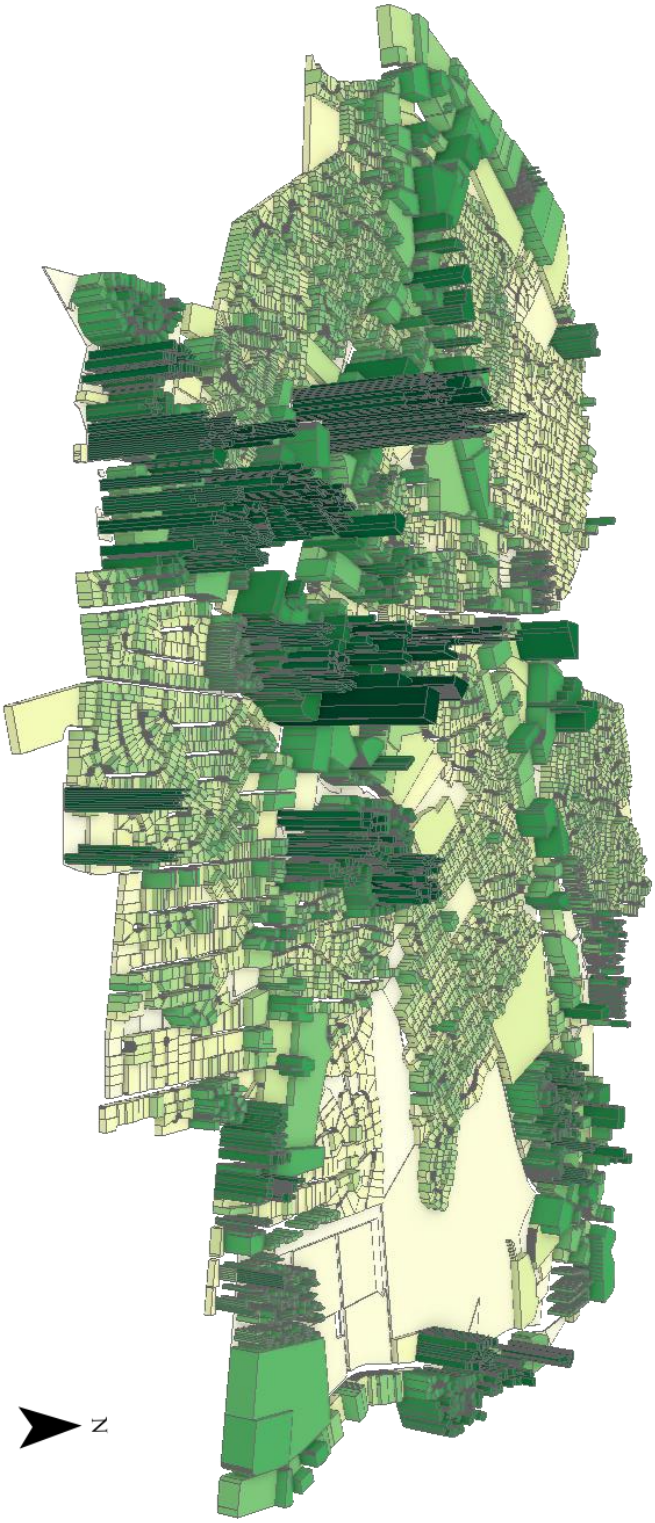

Figure 18: Per-acre property tax revenue in Fairfax City

The eight example parcels also see a change from gross revenue to per acre revenue (Table 7, Figure 19). Fair City Mall and Fairfax Square were the top two grossing properties in this group, but their per acre revenues fall into the bottom half. EastWind goes from being the second lowest grossing property to being in the top half. In fact, EastWind's per acre tax revenue is more than twice as high as Rosenthal Auto, more than three times as high as Fair City Mall, and nearly five times that of Fairfax Square. Fairfax Square grosses about $250,000 more than Providence Square, but Providence Square yields about seven-and-a-half times the revenue for each acre of land.

Table 7: Per acre Property Tax Revenue of 8 Example Properties

Property Name or Address	Per acre Revenue
Providence Square	$221,581.40
Mayfair on Main	$180,096.50
EastWind Vietnamese Restaurant	$139,336.50
Rosenthal Honda & Volkswagen	$52,899.18
Fair City Mall	$40,030.77
3554 Chain Bridge Rd.	$39,849.40
Fairfax Square	$29,624.64
Single-Family Home	$12,854.46

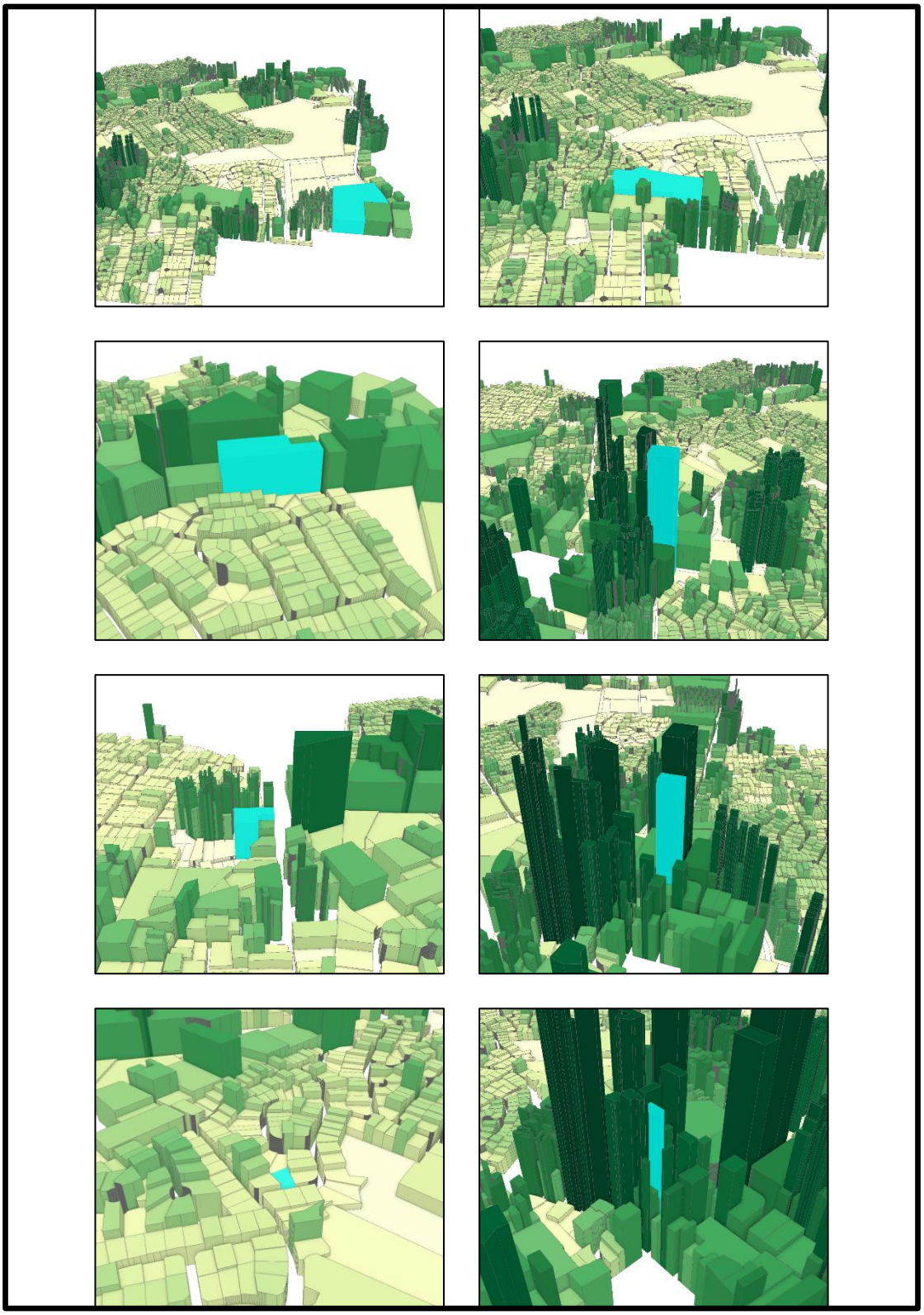

Figure 19: Per-acre tax revenue of 8 example properties highlighted in blue. Clockwise from top left − Fair City Mall, Fairfax Square, Providence Square, Mayfair on Main, EastWind, Single-Family Home, 3554 Chain Bridge Rd., and Rosenthal Auto

The difference between sprawl commercial and Old Town commercial developments is the presence of ample free parking. Table 8 contains four prominent shopping centers that must satisfy a parking requirement of five spaces per every 1,000 sq. ft. of floor space, whereas the Old Town properties in Table 9 do not have to satisfy that same requirement. Although they do not make much in gross tax revenue, the four properties in Table 9 are on average over three times as productive per acre as Fair City Mall. Even within Old Town, properties with surface parking lots have difficulty matching the per acre output of those without. The value of each acre of land on a property satisfying the minimum parking requirement is likely less than twice that of a single-family home.

Table 8: Shopping Centers with parking

Property	Gross Tax	Per acre Tax
Old Town Marketplace	$318,939	$49,613.39
Fair City Mall	$1,194,665	$40,030.77
Fairfax Commons	$334,208	$63,284.34
The Shops at Fairfax	$211,272	$36,224.30

Table 9: Old Town properties with little to no parking

Property	Gross Tax	Per acre Tax
Firestation #3	$7,500	$113,073.10
Auld Shebeen	$33,070	$147,977.80
EastWind Vietnamese Restaurant	$8,955	$139,336.50
10403 Main St.	$24,581	$117,010

Figure 20 shows the per acre results with each property colored by corresponding existing land use (ELU). The mean and variance of the ten designated ELU categories are listed in Table 10 and shown in the graphs in Figure 21 and Figure 22. Residential Attached is the highest mean per acre property tax revenue, followed by Old Town, while Residential Detached has the lowest mean. However, the variance in mean value is highest for Residential Attached. It should be noted that the highest point on the box-and-whisker plot (Figure 22) for Commercial – Retail is actually Mayfair on Main, a single-family attached development that is designated incorrectly by the City.

Table 10: Mean and Variances for ELU Per acre Revenue

Zoning Category	Mean	Variance	N
Residential - Attached	75057	54881	1593
Old Town	61145	40299	105
Residential - Multifamily	53572	41893	189
Commercial - Office	44986	20229	139
All Commercial	39097	21792	311
All Residential	38005	38271	6711
Commercial - Retail	34556	21444	157
Commercial - Lodging	33503	27598	15
Auto Dealer	26579	9209	36
Residential - Detached	25275	17626	4929

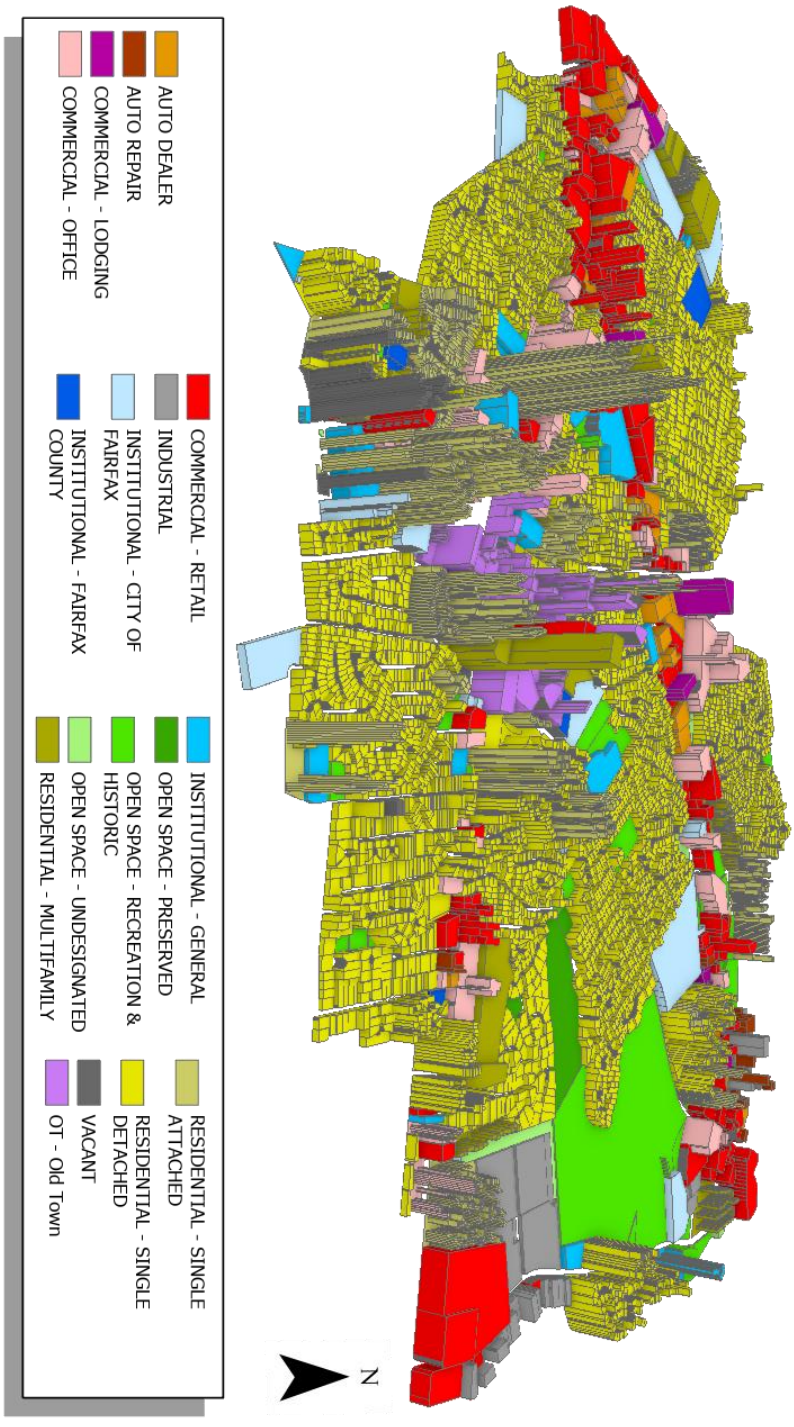

Figure 20: Per acre revenue map colored by existing land use

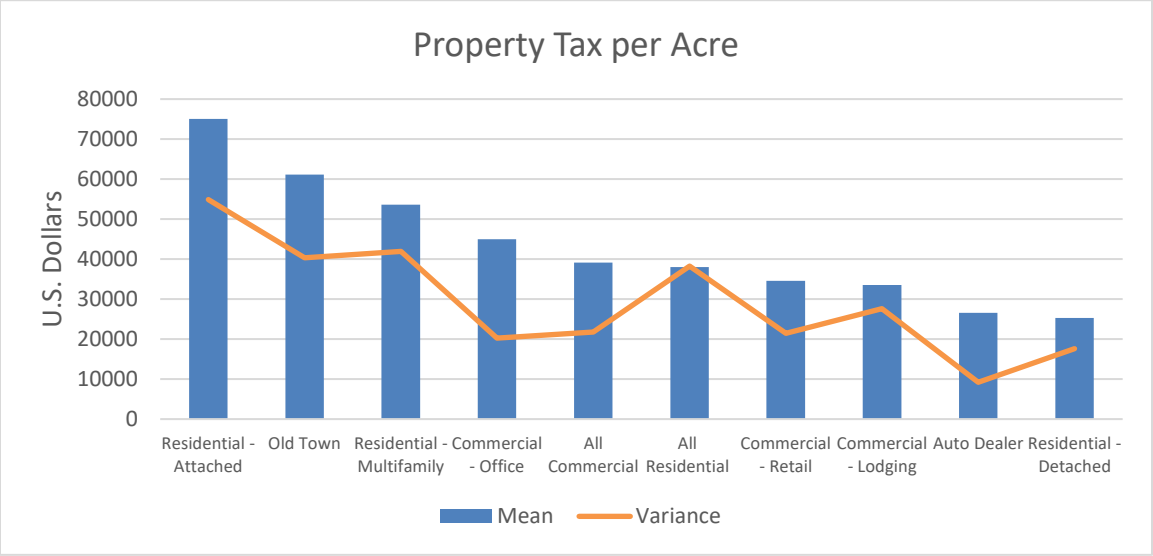

Figure 21: Property tax per acre sample means and variances for 10 land use categories

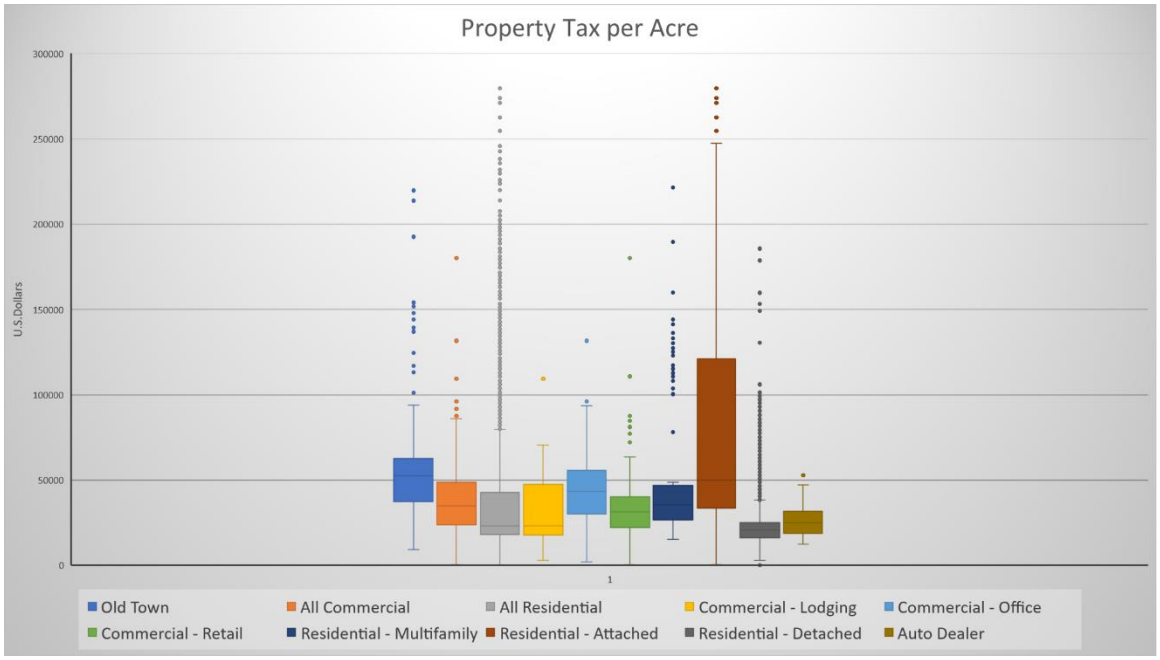

Figure 22: Box-and-whisker plot of property tax per acre sample means for 10 land use categories

Table 11 shows the results of the t-test of the equality of means. Green signifies that the sample mean in Column A is less than the sample mean in Row A. Red signifies that the sample mean in Column A is greater than the Sample Mean in Row A. Gray designates two sample means that are not significantly different from one another. The results show that Residential – Attached per acre property tax yield is significantly greater than all other existing land use categories examined. Old Town's per acre tax yield is significantly greater than all other land use categories except for Residential – Attached and Residential – Multifamily. Auto Dealer and Residential – Detached had significantly lower sample means than all other categories, other than Commercial – Lodging's small sample size, making them the least productive land uses.

Table 11: Pairwise Student's T-Tests for Equality of Means

	Row A →	Old Town	All Commercial	All Residential	Commercial - Lodging	Commercial - Office	Commercial - Retail	Residential - Multifamily	Residential - Attached	Residential - Detached	Auto Dealer
Column A ↓	N →	61145	39097	38005	33503	44829	34556	53825	75516	25275	26424
Old Town	test statistic		5.3484677498	6.1428054224	2.5672023341	3.8021431876	6.1993316538	1.4467878268	-3.4463388870	9.1022971447	8.2343946099
61145	p-value		0.0000002037	0.0000000004	0.0057509832	0.0001058833	0.0000000028	0.0745144863	0.0003820843	0.0000000000	0.0000000000
All Commercial	test statistic			0.8267150923	0.9586766408	-2.6346979610	2.1398057024	-4.4462938864	-19.6113837211	10.9618588244	6.4675359079
39097	p-value			0.2044426767	0.1692182465	0.0043565000	0.0164445984	0.0000065737	0.0000000000	0.0000000000	0.0000000024
All Residential	test statistic				0.4553234580	-3.8358560405	1.9440262833	-5.0890972556	-25.6423941793	24.0028163732	7.2797110168
38005	p-value				0.3244456270	0.0000900343	0.0267256299	0.0000004184	0.0000000000	0.0000000000	0.0000000029
Commercial - Lodging	test statistic					-1.9821753250	-0.1770244939	-1.8297601886	-5.7874524956	1.1539441355	0.9714337167
33503	p-value					0.0246312561	0.4298499413	0.0343798855	0.0000179115	0.1339212469	0.1733687701
Commercial - Office	test statistic						4.2231820770	-2.5553405242	-13.9068879075	11.2705429611	8.0252901792
44829	p-value						0.0000160779	0.0055629927	0.0000000000	0.0000000000	0.0000000000
Commercial - Retail	test statistic							-5.4776849865	-18.5977691943	5.3656683484	3.5518170291
34556	p-value							0.0000000469	0.0000000000	0.0000001365	0.0002655441
Multifamily	test statistic								-6.4334791299	9.2586852922	7.9908661121
53825	p-value								0.0000000003	0.0000000000	0.0000000000
Residential - Attached	test statistic									35.6621010814	23.8580028611
75516	p-value									0.0000000000	0.0000000000
Residential - Detached	test statistic										-0.7460407935
25275	p-value										0.2301783452
Auto Dealer	test statistic										
26426	p-value										

5. CONCLUSION

This paper began with the question “is sprawl an efficient land use pattern?” In order to examine that, this research focused on local property tax revenue and developed three hypotheses:

1. Gross tax revenue will be highest in shopping centers
2. Per acre tax revenue will be highest in Old Town Fairfax
3. The difference between the Old Town per acre tax revenues and that of traditional sprawl land uses will be statistically significant

Outside of public uses such as schools; shopping centers and strip malls are often the highest grossing properties. Apartment complexes also are often high grossing. The two highest grossing properties are Fair City Mall, a shopping center, and Fairfax Square Apartments, a garden-style apartment complex. From the point of view of gross tax revenue, these sprawl-style development patterns are highly valuable.

However, when measuring the value of each acre of land, most of the highest grossing properties nearly disappear. Instead, attached single-family developments and Old Town Fairfax, a denser traditional main street neighborhood, and both stand out in the middle of town as the highest revenue sources. Each acre of land in Old Town is worth much more than the same acre in Fair City Mall or Fairfax Square Apartments.

A statistical analysis comparing means of different land uses confirms that more compact development patterns are more productive per acre than sprawl. Although Old Town does not have the highest per acre tax yield, it is significantly higher than sprawl

mainstays such as detached single-family housing and retail. Denser housing developments, such as multifamily and attached housing are productive residential land uses while detached single-family neighborhoods are significantly less productive than all other uses except auto dealers. In fact, some of the most recognized sprawl land uses, detached single-family housing, auto dealers, and shopping center retail are the least productive land uses in the entire City. Not only are they three of the four least productive land uses, but they have three of the four lowest variances, meaning they will consistently produce low per acre tax revenues.

These results point to an inefficiency of land use in the sprawl development pattern used by the City of Fairfax. Each acre of land devoted to detached single-family homes, shopping centers, strip malls, auto dealers, and offices with ample commuter parking is worth much less to the City than an acre of traditional development. All of these sprawl style developments are auto-oriented, whereas the traditional development is not because it was built before the invention of the car. Auto-oriented sprawl is less productive per acre than compact traditional development. Euclidean zoning policies that encourage detached single-family neighborhoods are a poor land use choice by local governments. They are the least productive land use for a city, both in gross revenue and per acre revenue, and consume large quantities of land. These neighborhoods are also expensive to service and are likely being subsidized by more productive areas of a locality.

The inefficiency of land use is correlated to the existence of minimum parking requirements. Across the City, parking lots devalue properties. They take what could be

productive acreage and make it less productive than it potentially could be. When each acre of land is measured for its returnable tax value to the City, properties with significant land devoted to parking return considerably less than those without. The value of each acre of land on a property satisfying the minimum parking requirement is likely less than twice that of a single-family home. The theoretically most valuable property type, a retail center, is in reality not much more valuable than the least valuable land use, single-family detached homes. Meanwhile the most valuable land use type in the City, dense traditional development, is illegal to build under the current zoning code requirements.

Building more compactly and reducing inefficient land uses such as parking and large-lot detached single-family homes would raise per acre property tax revenues for a locality. In theory, the higher revenues per acre would allow the locality to raise total property tax revenues while at the same time reducing the property tax rate.

By measuring each acre of land by the tax value it produces, a locality can see which land uses make that acre the most valuable, and therefore what types of land use are the most productive. In the City of Fairfax, like other research covered in Section 2.5, compact development is a more productive land use than sprawl. However, the City is primarily made up of sprawl. As covered in Sections 2.1 and 2.2, this is not a natural occurrence, but a contrived one made by the City itself through its zoning ordinance. The City has abandoned efficient lower-cost high-revenue development for high-cost low-revenue sprawl on its own accord. They are risking their fiscal viability by not leveraging their very limited land for the revenue necessary to maintain their expenditures. Because parking lots devalue property, it would be financially beneficial to the City to eliminate

their minimum parking requirements in the zoning code, especially in a walkable area such as Old Town, and encourage more compact traditional development.

5.1 Criticisms and Future Research

This project misses an important component of citywide tax analysis, sales tax, which was not provided for research. Future research would incorporate sales tax revenue into a per acre tax revenue analysis. The absence of sales tax does not discredit the land use findings because the per acre analysis based solely on property tax is an effective way to see how using land that is used for parking devalues properties. A counter argument would suggest that available parking raises sales and therefore sales tax; however, that is less impactful on total revenue than property devaluation because sales tax revenue is 14.95% of citywide revenue and can be inconsistent, whereas real estate tax is 49% of revenue and is extremely consistent.[398]

The Old Town district that was studied was an incomplete look at the Old Town. It was the best available City-provided downtown designation, but it does not include any residential properties. Three residential properties should be included in a downtown definition: Providence Square, Mayfair on Main, and Madison Mews. The absence of these urban style residential likely skewed the results of the statistical analysis. The exclusion of these three properties and the absence of any residential in the Activity Center exemplifies the City's sprawl-oriented approach to land use. Old Town is an urbanized area, and any urbanized area must include residential in order to be successful.

[398] "City of Fairfax, Virginia Adopted Budget Fiscal Year 2019-2020" (City of Fairfax, n.d.), https://www.fairfaxva.gov/government/finance/budget.

The City views itself through the lens of sprawl which necessitates a separation of uses, so they believe that they cannot include residential where activities are happening.

Statistical analysis may also have been skewed by designating certain property's existing land use incorrectly. Mayfair on Main is designated as commercial retail and the office building at 3554 Chain Bridge Rd. is designated as a detached single-family home. Because this research is not an official decisionmaker on land use designations, it was improper to adjust property's existing land use outside of the Old Town district. The City could do a more accurate analysis by labelling land uses more accurately.

The results of attached single-family housing and multifamily housing deserve a closer inspection. Some attached housing conclaves had shared private parking spaces, however, not enough to deserve a proportional distribution of common area as discussed in Section 2.4. A follow-up examination of per acre revenues may make a different decision, although attached housing is still likely a very high per acre revenue land use. Multifamily housing was found to not be significantly less productive than Old Town. This result hides the inefficiency of some multifamily properties. The 43 highest per acre multifamily properties are Providence Square and the properties in the Mount Vineyard development, all with per acre values over $100,000. Only one other multifamily property has a per acre value over $50,000. As previously mentioned, Providence Square should be included in Old Town. In addition, some of the Mount Vineyard parcels should be designated as Residential – Single Attached. Examining the remaining 154 properties would result in a better understanding of the inefficient land use of garden-style apartment complexes.

This research concludes that parking lots devalue property and that the City's revenues would benefit from the elimination of parking minimums. This is possible by either not having parking requirements in the zoning code or setting a maximum parking requirement rather than a minimum. Because the City's transportation system is auto-oriented, researching alternative transportation options would be necessary when eliminating minimum parking requirements. Any city or town is a complex system, changing transportation methods changes development patterns and new developments create new transportation challenges, as seen in Sections 2.1 and 2.2. There are no easy answers in correcting for sprawl since any change to the current built environment will have both short and long-term consequences. Building more residential in Old Town and mandating that all commercial buildings be mixed use with residential or office upstairs would negate some of the transportation concerns. When destinations are within walking distance, short local trips no longer require a car and Old Town would have a built-in clientele. Although this paper encourages more compact development patterns, it does not support density for density's sake. The correlation between parking lots and the devaluation of property could be expanded further. Future research could examine how much each parking requirement devalues per acre revenue.

This paper discusses local government expenditures in Section 2.4; however, directly studying expenditures was out of scope for this research. Further research would combine the tax revenue analysis here to expenditure data in order to determine the City's return on investment for each property. This research is an assessment on the productivity

of specific land uses, but a return on investment study would be a more thorough review of the sustainability of the City's development patterns.

APPENDIX

Table 12: Fairfax City Minimum Parking Requirements (square footage requirements only)

USE TYPES/ USE GROUPS	GENERAL REQUIREMENTS	Spaces per 1000 sqft. floor space	Parking lot:Building ratio
Adult day care	5 spaces per 1,000 sq. ft. of floor area	5	1.65
Day care centers	5 spaces per 1,000 sq. ft. of floor area	5	1.65
Community services	1 space per 300 sq. ft. of floor area	3.3	1.089
Hospitals	1 space per 2 beds, but not less than 1 space per 200 sq. ft. of floor area	5	1.65
Medical care facilities	1 space per 2 beds, but not less than 1 space per 200 sq. ft. of floor area	5	1.65
Nursery schools	5 spaces per 1,000 sq. ft. of floor area	5	1.65
Utilities, major	1 space per 1,000 sq. ft. of floor area	1	0.33
Adult uses	1 space per 100 sq. ft. of floor area	10	3.3
Amusement centers	1 space per 250 sq. ft. of floor area	4	1.32
Animal care facilities	1 space per 250 sq. ft. of floor area	4	1.32
Art gallery or studio	1 space per 400 sq. ft. of floor area	2.5	0.825
Auction houses	5 spaces per 100 sq. ft. of floor area	50	16.5
Brew pubs	1 space per 300 sq. ft. of floor area	3.3	1.089
Building supplies and lumber sales	1 space per 300 sq. ft. of floor area	3.3	1.089
Catering or delivery services	1 space per 200 sq. ft. of floor area	5	1.65
Convenience stores	1 space per 200 sq. ft. of floor area	5	1.65
Fuel stations	1 space per 200 sq. ft. of floor area	5	1.65
Funeral homes	1 space per 50 square feet of floor space in funeral service rooms	20	6.6
Furniture, appliance or carpet/flooring stores	1 space per 400 sq. ft. of floor area	2.5	0.825
Grocery stores	1 space per 200 sq. ft. of floor area	5	1.65

Hotels; hotels, extended-stay; motels	1 space per guest room, plus 1 space per 200 sq. ft. of conference, banquet, restaurants or food services floor area	5	1.65
Manufacturing, limited	1 space per 1,000 sq. ft. of floor area	1	0.33
Office, general	1 space per 300 sq. ft. of floor area	3.3	1.089
Office, medical	1 space per 200 sq. ft. of floor area	5	1.65
Plant nurseries and greenhouses	1 space per 200 sq. ft. of floor area	5	1.65
Private clubs	1 space per 200 sq. ft. of floor area	5	1.65
Recreation, indoor	1 space per 250 sq. ft. of floor area	4	1.32
Restaurants or food service	1 space per 200 sq. ft. of floor area; none for outdoor dining and service areas	5	1.65
Restaurants w/ dancing and entertainment	1 space per 100 sq. ft. of floor area	10	3.3
Retail, general	1 space per 200 sq. ft. of floor area	5	1.65
Retail, large format	1 space per 200 sq. ft. of floor area	5	1.65
Schools, technical, trade, business	6 per classroom, plus 1 per 300 sq. ft. of office floor area	3.3	1.089
Service, general	1 space per 200 sq. ft. of floor area	5	1.65
Services, personal	1 space per 200 sq. ft. of floor area	5	1.65
Shopping centers	1 space per 200 sq. ft. of floor area	5	1.65
Tobacco and smoke shops	1 space per 200 sq. ft. of floor area	5	1.65
Vehicle sales and leasing	1 per 500 sq. ft. of floor area	2	0.66
Fuel sales, residential	1 space per 1,000 sq. ft. of floor area	1	0.33
Manufacturing, general	1 space per 1,000 sq. ft. of floor area	1	0.33
Manufacturing, heavy	1 space per 1,000 sq. ft. of floor area	1	0.33
Manufacturing, limited	1 space per 1,000 sq. ft. of floor area	1	0.33
Research and development	1 space per 1,000 sq. ft. of floor area	1	0.33
Vehicle storage and towing	One space per 300 sq. ft. of floor area	3.3	1.089
Warehouse/freight movement	1 space per 1000 sq. ft. of floor area	1	0.33

	Additional space required		
	Minimum space, possible additional requirements		

[399]

[399] Zoning Ordinance: City of Fairfax.

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