

Constricted Urban Planning: Investigating the Site and Suitability of Low-Income  
Housing in Fairfax County, Virginia

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## ABSTRACT

Increasing suburban poverty and the extremely high housing costs of growing metropolitan areas amplify the importance of suburban low-income housing programs. Aside from traditional hurdles to social and economic mobility, suburban low-income households are confronted by impediments that are inherent to sprawling, fragmented suburban landscapes with poor access. This research investigates the site suitability of a booming suburban region, Fairfax County, Virginia, for low-income housing. To do so, this research identifies and explains location amenities and neighborhood characteristics that maximize the success of low-income housing programs for low-income households, and explores how suburban landscapes constrict the ability of policymakers and planners to incorporate such location considerations into low-income housing planning. Using a Geographic Information Systems (GIS) model, the site suitability of Fairfax County, Virginia for low-income housing is examined. Results highlight numerous location amenities in a heavily developed suburban environment, yielding overall decent low-income housing site suitability scores across Fairfax County. However, the sprawling nature of Fairfax County also provides few optimal locations for low-income housing development. The incorporation of key location amenities in strategic locations as well as modern planning techniques hinging on new urbanism and smart growth concepts are emphasized to improve low-income housing suitability in many American suburbs. This research links GIS methodology with social policy,

providing policymakers and planners with a tool to analyze the spatial distribution of critical location amenities and low-income housing development.

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## **Table of Contents**

Introduction	<b>1</b>
Background Framework	<b>3</b>
Terminology	<b>10</b>
Low-Income Housing Assistance Programs	<b>12</b>
Optimal Location Criteria	<b>20</b>
Study Area	<b>33</b>
Methodology	<b>43</b>
Results	<b>47</b>
Discussion	<b>77</b>
Conclusion	<b>82</b>
Limitations, Assumptions, and Future Work	<b>84</b>
References	<b>88</b>
Appendix A: Methodology Appendix	<b>95</b>
Appendix B: Methodology Appendix References	<b>103</b>
Appendix C: IRB Documentation	<b>103</b>

## **List of Figures**

- Figure 1: Fairfax County, Virginia **34**
- Figure 2: Fairfax County Business Clusters **34**
- Figure 3: Planning Districts with Selected Inner and Outer Suburbs **38**
- Figure 4: Population Growth by Planning District **39**
- Figure 5: Market Value of Owned Housing Units by Planning District **39**
- Figure 6: Housing Units by Planning District **40**
- Figure 7: Low-Income Housing Site Suitability in Fairfax County, Virginia **49**
- Figure 8: Poverty Level by Census Tract **52**
- Figure 9: Ethnic Diversity by Census Tract **53**
- Figure 10: Access to Amenities **54**
- Figure 11: Selected Neighborhoods and Low-Income Housing Suitability **55**
- Figure 12: Suitability of Land Parcels **57**
- Figure 13: Histogram of Land Parcel Suitability Distribution with Natural Breaks **57**
- Figure 14: Low-Income Housing Site Suitability with Extremely High Suitability Parcels Highlighted **58**
- Figure 15: Suitability of Existing Low-Income Housing Developments **61**
- Figure 16: Suitability of Fairfax County Rental Program Developments **61**
- Figure 17: Suitability of Public Housing Developments **61**
- Figure 18: Suitability of Vouchers **61**
- Figure 19: Zoning Designation of Extremely High Suitability Parcels **64**
- Figure 20: Zoning Designation of Extremely High Suitability Parcels (Table) **65**
- Figure 21: Supervisor Districts **68**
- Figure 22: Low-Income Housing Suitability of Supervisor Districts **69**
- Figure 23: Suitability of Parcels and Low-Income Housing Developments by Supervisor District Political Party **70**
- Figure 24: Suitability of Parcels and Low-Income Housing Developments by Supervisor Districts **70**
- Figure 25: Case Study Developments with 1 Mile Radius **74**
- Figure 26: Stonegate Village **75**
- Figure 27: Castellani Meadows **75**
- Figure 28: Location Attributes within 1 Mile of Low-Income Housing Case Study Developments **76**
- Figure 29: PCA Analysis of Input Factors **100**
- Figure 30: Survey Question Example **101**
- Figure 31: Final Weights **101**
- Figure 32: Ten Percent Sample Size of Low-Income Housing Site Suitability **102**
- Figure 33: Input Factor Z Scores **102**

## List of Acronyms

**AMI:** Area Median Income  
**AHP:** Analytic Hierarchy Process  
**CDC:** Community Development Corporation  
**CDBG:** Community Development Block Grant  
**CNU:** The Congress for the New Urbanism  
**FCPS:** Fairfax County Public Schools  
**FCRP:** Fairfax County Rental Program  
**FHA:** Federal Housing Administration  
**GIS:** Geographic Information Systems  
**HUD:** Department of Housing and Urban Development  
**LIHTC:** Low-Income Housing Tax Credit  
**MCE:** Multi Criteria Evaluation  
**NIMBY:** Not-In-My-Backyard  
**PCA:** Principal Component Analysis  
**PDH:** Planned Development Housing  
**PUD:** Planned-unit Development  
**TOD:** Transit-oriented Development

## **Introduction**

Low-income housing and social equity experts have traditionally focused their efforts on inner city poverty and related disparities. However, the recent rise of suburban poverty has increased concern for urban processes manifesting in suburban neighborhoods. In addition, the extremely high housing costs of growing metropolitan areas, particularly in wealthy suburbs, places intense financial barriers on low-income households to make a decent living. The inability of policymakers and planners to situate low-income rental housing in neighborhoods with beneficial location amenities is especially detrimental to suburban low-income households, who already face a number of engrained obstacles to improving their economic and social wellbeing. These obstacles include a lack of access to employment and other amenities, a suburban realm that typically favors more affluent homeowners, and a nuanced historical context of low-income housing policy in the United States. Implementing optimal location amenities and neighborhood characteristics into low-income housing site location remains challenging for planners for a variety of reasons, including legacies of urban form (morphology), market forces (that alter the production of new homes and increase rental prices), shifting government priorities and policies, and social influences. Planning for suburban low-income rental housing is especially troublesome in sprawling, fragmented neighborhoods shaped by real-estate interests, zoning laws, and varying degrees of homeownership.

Much of the existing body of low-income housing research concentrates on declining city and suburban neighborhoods. This research instead investigates low-income housing within a booming suburban region, Fairfax County, Virginia. As one of the most affluent counties in the United States, Fairfax County, Virginia exemplifies affluent suburban expansion with little regard for the needs of low-income households. Using Fairfax County, Virginia as a case study,



this research addresses the following basic research questions: what location amenities and neighborhood characteristics maximize the success of low-income housing programs for low-income households, and how does the suburban landscape constrict the ability of policymakers and planners to incorporate such location considerations into low-income housing planning?

This research underscores the vital importance of location considerations and decisions to the success of low-income housing programs. The three main objectives to this research are: (1) to establish and explain a list of location amenities and neighborhood characteristics that maximize the success of low-income housing programs, (2) to incorporate these optimal location factors into a Geographic Information Systems (GIS) model, and (3) to use the GIS model's results to examine the site suitability for low-income housing across Fairfax County, Virginia. This study provides a basis for low-income housing policymakers and planners to utilize optimal location criteria for the craft and implementation of low-income housing policies and developments. The most effective existing planning techniques and land use patterns in Fairfax County are emphasized for future application. This study also displays the power of GIS technology in low-income housing planning, bridging the gap between geospatial innovation and the study of social processes and issues. Finally, this study exposes the forces and barriers imposed on suburban low-income households, illuminating the challenges of marginalized populations in what might otherwise be defined as successful suburban areas. The primary goal of this research is to stress location considerations in rethinking how low-income households are integrated within suburban landscapes.

The study commences with a background on suburbanization and housing trends to outline the metropolitan processes confronting suburban low-income rental housing. Next, a brief terminology section and a summary of low-income housing assistance programs provide

context and clarity. Optimal location factors for low-income housing planning are then identified and explained, followed by a description of the study area. The subsequent section outlines the study's methodology before presenting the GIS model's results, while the final section discusses the ramifications of the study's results and pinpoints emerging planning practices that are auspicious for low-income housing.

### **Background Framework**

As evident from the 2008 housing crisis and associated recession, housing has a major impact on the lives of Americans. Housing affordability is consistently a high priority issue in the United States (Fairbanks 2000; Schwartz 2006). While American housing policy tends to focus on homeownership, the distribution of low-income rental housing greatly impacts urban populations. This section outlines suburbanization and urban form processes, housing affordability and supply issues, and government involvement in low-income rental housing policy to provide a backdrop for investigating suburban low-income housing location. Planning for low-income housing has traditionally been an uphill battle (Halpern 1995; Turner et al. 2009), and the geography of suburban America further disfavors low-income households. For example, the processes of decentralization and expansion have fragmented the urban landscape (Knox 1991; Lee 2007; Short et al. 2007; Lang and Knox 2009), hindering suburban low-income housing planning.

The process of suburbanization represents more than the demographic shift of people beyond the urban core. Facilitated by post World War II federal policies, which supported the construction of highways and the Federal Housing Administration's (FHA) mortgage insurance program (Bauman et al. 2000), a class-based 'flight' from central cities was accommodated and

financed (Lang and Knox 2009). Unlike their wealthier counterparts, low-income households could not take advantage of such policies because of insufficient funds for automobiles or mortgage down payments (Hanchett 2000). In addition, new suburban communities and the mortgage industry discriminated by class and race (Hirsch 2000; Radford 2000; Ranney and Wright 2003), depriving low-income households of the suburban experience. The creation of dispersed and fragmented suburban landscapes continues to create hardship for low-income households. For example, the flight of jobs, amenities and other opportunities has followed people to the suburbs. This decentralization from the city center to more peripheral suburban communities disrupts the classic city-suburb notion of a central business district with concentric rings of increasingly wealthy populations (Short et al. 2007). While transportation and communication innovations form new suburban office parks and business clusters, the newly created polynucleated metropolitan area is less receptive to low-income housing, with exclusionary land use regulations often denying access and opportunity (Lee 2007).

High demand for large housing units (single detached homes) and the real estate industry's emphasis on new construction can not only propagate urban fringe development (or sprawl), but it can also perpetuate disenfranchisement (Morgan 1999; Short et al. 2007). Large, single detached fringe homes are typically too expensive and spatially removed for low-income households to consider. In addition, local governments can render their suburban neighborhoods less suitable for low-income housing by reducing allowed density and building heights, restricting available land for residential development, and increasing sub-division requirements. Land use zoning disproportionately affects low-income households because it especially constrains affordable housing supplies (Ihlanfeldt 2004; Chakraborty et al. 2009). As Chakraborty et al. (2009, p.440) note, "low-density zoning lowers housing production, causes a

shift towards single-family housing, lowers the percentage of rental units and rental affordability, and results in the exclusion of racial minorities.” This is described as exclusionary land zoning, as it excludes lower-income groups from living in certain locations (Harney 2009).

Decentralizing metropolitan areas facilitate further suburban expansion, leading to larger, disjointed suburbs. Sprawling suburbs, transportation corridors, and communication innovations produce “networks of metropolitan areas, principle cities, and micropolitan areas” (Lang and Knox 2009, p.795) that rely on each other through commuting, business, economic activity, and other factors. As development stretches further from the city center and urban areas become increasingly blurred and connected, the needs of marginalized populations continue to be undervalued. Policymakers and planners focus more on transportation, infrastructure, and development issues, not low-income housing (Pendall et al. 2006; Turner et al. 2009). Market forces place low-income populations at a disadvantage, because less money is to be made off them (Pattillo 2009). In addition, issues relative to lower incomes, not having a car, and a lack of social services are amplified by sprawling geographies (Allard and Roth 2010). For example, Allard and Roth (2010) discuss a sole emergency shelter provider in suburban Virginia that is forced to turn away three hundred people per month because of limited funding stretched thin across a large suburban region.

Fringe development, exclusionary zoning, and expansion render wealthy suburbs inaccessible to low-income households, keeping poorer populations concentrated within older, decaying suburbs. According to Short et al. (2007, p.648), aging, ethnic, and low-income suburbs “are currently losing the battle for investment resources.” Public services such as schools, police, fire, and recreation are influenced by property taxes, generating spatial disparities between communities (Weisbrod et al. 1978). For example, disparities in public school funding “result in

fewer educational resources, less qualified teachers and higher teacher turnover and, ultimately, lower educational achievement in low-income and minority communities” (Squires and Kubrin 2005, p.3). In addition, many employment opportunities are located in affluent suburbs, creating a mismatch of affordable housing location and employment access. Sard and Waller (2002, p.4) elaborate,

[t]here is no question that the demand for affordable housing far exceeds the supply and that much of the current stock of affordable housing is concentrated in areas at a distance from the centers of job growth. As a result, many families may face a Catch-22 situation. If they live in housing they can better afford, they may not be able to get or keep a job; but if they move close to work, their housing costs may rise to the point where they have difficulties affording necessities, including work-related expenses.

Suburban disparities coupled with large geographies comprised of separate political municipalities create fragmented metropolitan areas (Short et al. 2007). Fragmentation fosters localities that are inconsistent with planning and land use, making it difficult to achieve region-wide results. Localities act independently with little regard for a regional public good, enabling “particular suburbs to exclude public infrastructure, subsidized housing, or any other socially exclusionary measure” (Short et al. 2007, p. 646). Competition between localities to attract a higher tax base, commercial development, and political leverage “ignores the rightful and equal claims of poor people to decent city services, strong schools, accessible public transportation, welcoming public spaces, and supports for a viable commercial infrastructure” (Pattillo 2009, p.35). Locality fragmentation solidifies suburban disparities.

Expanding suburban fringes (Allard and Roth 2010; Raphael and Stoll 2010) coupled with inner city gentrification (Lees et al. 2007) has led to an increase in suburban poverty, particularly in inner suburbs. Short et al. (2007, p.646) states, “It is impossible to decouple the phenomenon of suburban edge sprawl from the demise of older suburbs,” as newer, outer

suburbs are instead the main site of development and investment. In 2008, the suburban poor outnumbered the central city poor by 1.5 million people (Allard and Roth 2010). For example, within the Washington, D.C. metropolitan area (home to some of the most affluent suburbs in the country, as well as some of the lowest unemployment rates), neighborhoods in Montgomery County (MD), Prince Georges County (MD), Fairfax County (VA), Loudoun County (VA), and Prince William County (VA) witnessed more than 40 percent increases in the number of poor from 2000 to 2008 (Allard and Roth 2010). Suburban decline is characterized by little population growth, a lack of local resources, and suffering local economies. There is decaying infrastructure, aging and increasing minority populations, and an aging housing stock (Short et al. 2007). The suburban poor are unique in that they rely on inadequate public transportation and a lack of social services (Raphael and Stoll 2010). Housing is a prime representative of suburban disparities, and low-income housing is especially useful to investigate because it focuses on those marginalized by suburban processes.

Adequate housing is fundamental for day-to-day procedures, including employment, schooling, childcare, and health (Crowley 2003). Unaffordable, overcrowded, or unhealthy housing can lead to a decrease in the financial, educational, and emotional wellbeing of populations (Tighe 2010). Housing affordability is the primary housing problem in most areas (Bogdon and Can 1997). Most families and individuals spend more on housing than anything else, with average households “devot[ing] roughly one-quarter of income to housing expenditures, while poor and near-poor households commonly devote half of their incomes to housing” (Quigley and Raphael 2004, p.191). A shortage of affordable housing can leave families little money for food, utilities, medical care, or child care. Worst-case scenarios include

poor credit, an inability to pay mortgages, forced relocation, eviction, and homelessness (Crowley 2003). The lowest-income groups tend to have the greatest burdens of affordability problems, due to poverty concentration, deteriorating low-income neighborhoods, and racial discrimination and segregation (Bogdon and Can 1997). Affordable housing is a complex and heavily debated issue that suffers from a lack of government attention and funding (Schwartz 2006).

Housing policy has the potential to remove societal obstacles that hinder housing opportunities for low-income households (Schwartz 2006). Providing affordable housing is imperative because it preserves housing for long-time residents, encourages income and racial integration, and protects the environment by decreasing suburban sprawl (Lerman 2006). Grigsby and Bourassa (2003) narrow the motivations behind low-income housing into five groups: (1) to improve public health, (2) to reduce societal injustice, (3) to preserve the social order, (4) to increase the equality of opportunity, and (5) to accommodate population growth.

Unfortunately, there is not enough affordable housing available to low-income households (Crowley 2003; Powel and Stringham 2004; Quigley and Raphael 2004). A primary reason for a lack of affordable units is faster increases in rents than incomes (Schwartz 2006). To atone for quality improvements, rents for units increase, making many units unaffordable to low-income households (Quigley and Raphael 2004). In addition, low-income populations have disproportionately increased in urban areas due to international immigration and urbanization (not to mention urban natural increase, especially in Black and Hispanic populations). As low-income populations increase, low-income housing units cannot be built or maintained fast enough to keep up with the growing demand (Quigley and Raphael 2004). Adding to affordable housing supply pressures is the removal from the market of deteriorating units (Mulherin 2000),

the decisions of affluent renters who opt to pay far less than 30 percent of their incomes (Schwartz 2006), as well as Not-In-My-Backyard (NIMBY) opposition (Tighe 2010). Regardless of how the supply of low-income housing is restricted, the consequence is increased competition for limited housing options (Crowley 2003). Crowley (2003, p.26) explains, “[t]he lowest income households are forced to compete with one another for increasingly scarce housing they can afford. The supply problem of affordable rental housing is like a game of musical chairs in which players scramble for too few seats and someone is always left out.”

An increased low-income rental housing stock is not likely to come from the federal government. This is especially true in light of the recent recession and government sequestration. The federal government was the primary actor in low-income housing policy until the 1980s, when federal spending cuts left localities searching for new ways to address housing issues. Since then, housing policy has been increasingly reserved for local governments (Schwartz 2006). Local housing policy allows localities to tailor programs to unique demographic and housing characteristics. Land use regulation is also reserved for local governments (Pendall et al. 2006), allowing localities to further influence the geography of low-income housing.

The withdrawal of the federal government from low-income housing assistance means planning for low-income housing is increasingly influenced by the market and public opinion. Local governments must compete in complex international financial markets for housing finance, skewing the “distribution of housing resources from the poor to the rich” (Ranney and Wright 2003, p.132). Private interests prevail, furthering an already lop-sided housing paradigm focused on homeownership. It is unrealistic to expect local governments to establish practices geared towards low-income housing that bring about local opposition. In this aspect, state governments



are better suited for housing policy. However, there has been minimal interest from state governments to pursue low-income housing reforms (Quigley and Raphael 2004).

Crowley (2003) argues that the federal government is the most equipped to mitigate low-income housing issues. If the Department of Housing and Urban Development (HUD) and Congress take actions to rehabilitate, preserve, and facilitate low-income housing, there is the potential for success to trickle down to local authorities. However, unique locality needs, private interests, and the federal government's potential for inefficiency and stagnancy decrease the chances for federally dominated housing policy. Consequently, Hyra (2008) stresses cooperation between federal policies and local political conditions for the ultimate success of low-income housing programs.

### **Terminology**

It is crucial to distinguish between the terms 'affordable housing' and 'low-income housing' because the meanings of these terms are contentious and often lack precision. This section offers a brief summary of both terms before providing a working definition for the present research.

Affordable housing is difficult to measure because of imprecise and changing definitions (Bogdon and Can 1997). As Quigley and Raphael (2004, p.191) note, the rhetoric of the term 'affordable' is troublesome because it

jumbles together in a single term a number of disparate issues: the distribution of housing prices, the distribution of housing quality, the distribution of income, the ability of households to borrow, public policies affecting housing markets, conditions affecting the supply of new or refurbished housing, and the choices that people make about how much housing to consume relative to other goods.

Determining housing affordability involves the amount of housing stock and the demand of constituents (income sufficiency). Upper-income groups may view affordable housing as the

terms associated with buying homes, as well as paying off loans. Conversely, lower-income groups, minority households, and younger households may develop an understanding of affordable housing as the terms associated with renting contracts and the relationship between incomes and rent (Quigley and Raphael 2004). Issues of supply and demand are locally contingent and undermine the value of developing a universal definition. In this research, ‘affordable housing’ means the extent to which housing is affordable for a given population.

Employing the term ‘low-income housing’ is also problematic. ‘Low-income housing’ is a specific type of ‘subsidized’ housing that relies on direct or indirect government or nonprofit organization support in the provision of housing (Johnson 2007). Here, the degree of housing assistance – not the measure of affordability – is of critical importance. Many relevant sources embrace the term ‘low-income housing’ as a specific tool to make rental housing more affordable for low-income households (Bogdon and Can 1997; Biles 2000; Orlebeke 2000; Schwartz 2006), and this research aims to do the same. Although there is low-income subsidized housing geared towards homeownership, this study focuses on low-income rental housing. Most low-income housing programs provide assistance for rental units, which are at odds with suburbanization. As noted earlier, U.S. housing policy is geared towards homeownership (Bauman et al. 2000), privileges suburban land use regulations that favor single family units (Chakraborty et al. 2009), and has facilitated the construction of sprawling suburban communities populated by more affluent residents (Short et al. 2007). This study places emphasis on low-income housing (as opposed to affordable housing) to discuss the struggles of subsidized rental housing for poor populations in one portion of suburban America (Fairfax County, Virginia).

Programs receiving federal assistance rely on HUD's guidelines. HUD's definition of affordable housing is

in general, housing for which the occupant(s) is/are paying no more than 30 percent of his or her income for gross housing costs, including utilities. Please note that some jurisdictions may define affordable housing based on other, locally determined criteria, and that this definition is intended solely as an approximate guideline or general rule of thumb (HUD).

Households that pay over 30 percent of their income for housing are shackled with a cost burden and therefore have even less money available for food, health care, child care, and other necessities. In general, the United States traditionally focuses on affordable housing for low-income families (incomes less than 80% of the area median income or AMI). Expanding on HUD's rules, housing policy often targets extremely low-income families who might spend over half of their incomes on housing, or live in severely inadequate housing (Johnson 2007).

This research is not designed to determine what populations are considered low-income, or what housing is considered affordable. No single income threshold is defined when discussing low-income location amenities. Instead, this research refers to definitions and measurements presented by HUD and Fairfax County (as discussed in the Study Area section) as guidelines. As the next section shows, low-income housing programs vary in scope and methodology. In addition, developments and households receiving assistance often use a combination of programs.

### **Low-Income Housing Assistance Programs**

The National Housing Act of 1934 created the Federal Housing Administration to rejuvenate the housing market after the Great Depression. Policies put forth by the FHA helped solidify a two-tier housing policy in the United States: a private housing market geared towards homeowners, and a federally assisted housing market which is dwarfed by the first tier in terms

of funding, attention, and success (Bauman et al. 2000). Today, the three main federal government subsidies for low-income rental housing include (1) directly supporting specific housing developments; (2) aiding renters in privately owned housing; and (3), funding state and local housing programs (Schwartz 2006). There are a number of programs designed to help low-income renters, but these efforts generally fall into two broad approaches –a production approach and a voucher approach. While a full analysis of these programs is beyond the scope of this research, a brief summation of some important efforts provides an understanding of the complex delivery environment for low-income rental housing in the United States.

### Public Housing

The most familiar type of assisted housing in the United States is public housing (Schwartz 2006). Public housing encompasses project-based units funded by federal public housing funds. Residents pay 30 percent of their income for rent, with the rest covered by direct federal assistance.

A host of negative images are often associated with public housing, including poverty, dismal design, poor management, and high crime rates. The provision of public housing in the United States was motivated more by the desire to eliminate slums than by the goal of actually housing low-income populations (Biles 2000; Turner et al. 2009). During the 1950s, the construction of mammoth public housing projects in poor inner city neighborhoods resulted in concentrated poverty and the stark isolation of poor and ethnic households (Biles 2000). In addition, Turner et al. (2009, p.3) argue that the “reliance on huge, high-rise developments, cost-cutting design, shoddy construction, inadequate funding, and chronic mismanagement all contributed to the severe distress of public housing projects.” The result was the negative stigma attached to public housing projects and vocal criticism of the various federal government

housing programs that helped sponsor and foster a greater degree of social and spatial segregation of certain residents. In particular, the siting of public housing projects were criticized for failing to improve the lives of tenants (Jacobs 1961; Newman 1972; von Hoffman 1996; Radford 2000). Poor locations perpetuated gang violence, drug use, and other forms of deviant behavior (Hyra 2008). Public housing became a permanent concern, as isolation and extreme poverty concentration resulted in mobility issues. Intergenerational reliance on public housing grew more troublesome, with very few households transcending beyond federally assisted housing (Biles 2000).

#### *Low-Income Housing Tax Credit (LIHTC)*

The Low-Income Housing Tax Credit (LIHTC) program was established in conjunction with the Tax Reform Act of 1986 to alleviate funding concerns absorbed by public housing and other programs. This program provides incentives for the private sector to produce low-income housing, and was designed to replace the federal government's construction of new public housing. Through this program, state and local LIHTC agencies acquire, rehabilitate, or develop new rental housing for low-income households. As the largest low-income rental housing subsidy, the LIHTC provides tax credits to individuals and companies who invest in low-income housing (Orlebeke 2000).

The strength of the LIHTC program is its flexibility to changing market conditions and housing needs. Tax-credit housing might be more effective than even rental housing vouchers or mobility programs in dispersing low-income households to more affluent suburbs (Schwartz 2006). Currently, approximately one quarter of tax-credit developments are in suburban areas. Compared to market-rate rental housing, tax-credit housing is more likely to be situated within low-income and minority areas (partially because of an emphasis on difficult development areas

or qualified census tracts with higher concentrations of poverty). At the same time, LIHTC housing has extended into middle- and higher income neighborhoods.

The biggest concern with the LIHTC is a 15-year expiration date on the affordability of developments, unless additional restrictions are implemented (Schwartz 2006). Another issue is the potential for rent burdens on lower income tax-credit residents. While most federal programs subsidize rents exceeding the renter's 30 percent income threshold, the LIHTC's "maximum allowable rent is set at 30% of 50 or 60% of median family income" (Schwartz 2006, p.85). The LIHTC produces more low-income housing than any other program, and is becoming increasingly flexible and efficient. However, the market-based method raises concerns for sustainability, and for providing deep subsidies to extremely low-income households.

### HOPE VI

In the early 1990s, HUD implemented project HOPE VI to help alleviate the spatial concentration and distressed conditions of public housing. A critical goal of the program was to disperse public housing poverty by encouraging and supporting mixed-income developments. Through the demolition of distressed public housing units, a mixed income approach, privatized management, and design features promoting new urbanism and defensible space, HOPE VI drastically enhanced the public housing program (Schwartz 2006)

Although the HOPE VI program was initially launched to facilitate integration, deconcentrate poverty, and revitalize inner-city neighborhoods, it has not improved upon public housing location. The smaller, mixed-income approach of HOPE VI has been successful, but the program also demolishes many existing, deteriorating developments. It has resulted in a diminished total unit stock, forcing the relocation of many former residents. Unfortunately, relocation efforts have lacked proper dispersion, with many HOPE VI minorities tending to

cluster, and HOPE VI Whites tending to move to primarily White areas (Kleit and Galvez 2011). Whether their housing choice is influenced by presumed discrimination or due to barriers preventing full information or resources, many minorities continue to have spatially constrained housing options. Ultimately, the HOPE VI's relocation program has proven itself to be less successful when compared to rental vouchers in terms of the poverty, quality, and safety of the new neighborhood (Kleit and Galvez 2011).

### Housing Choice Vouchers

Housing Choice Vouchers (formerly known as Section 8 of the Housing Act of 1937) provide federal assistance for low-income households to seek rental housing in the private market. Recipients often use vouchers in combination with other low-income housing programs. Voucher programs tend to produce less concentrated results when compared to project-based developments such as public housing (Kleit and Galvez 2011). In a report to Congress, Goering et al. (1995) reveal that one-third of families in the voucher program and two-thirds of families in public housing were living in high poverty areas in Washington D.C. Not only are vouchers less expensive than project-based subsidies, but they also render more neighborhoods and housing accessible to low-income populations (Schwartz 2006). With public housing tending to be located in unfavorable areas, the benefit of vouchers is that they offer more flexibility in terms of neighborhood choice. For example, voucher holders have been shown to live closer to employment versus public housing residents (Sard and Waller 2002).

Nevertheless, the decisions of voucher holders are influenced by race and ethnicity, with many minority voucher holders continuing to concentrate spatially in segregated neighborhoods. Kleit and Galvez (2011) explain that voucher holders might not want to move away from friends, family, or familiar neighborhoods. This is magnified for those who face language or educational

barriers. In addition, minority households can fear discrimination in unfamiliar communities (Tighe 2010). These concerns, coupled with the absence of basic amenities such as public transportation and rising rental prices in more affluent neighborhoods restrict spatial mobility (Pendall et al. 2006; Short et al. 2007). Many voucher recipients choose to remain in their current locations or shift to neighborhoods with only marginal improvements (Goetz 2000). While it can be argued that vouchers have been successful in moving low-income and minority households to safer neighborhoods with better schools, services, and employment opportunities, much of the evidence suggests that this requires considerable mobility counseling and assistance in finding suitable housing (Schwartz 2006).

### Mobility Programs

Residential mobility programs are akin to the housing voucher program, but they offer added assistance to low-income households (typically inner-city households) to move to less segregated, wealthier neighborhoods. Mobility programs hinge on the concept of ‘geography of opportunity’ (Rosenbaum and DeLuca 2010), with low-income families experiencing the benefits (particularly education for children) of residential integration. The aim is to change the social context of particular low-income households, helping them transition to stable, amenity and opportunity rich environments, and ultimately, self-sufficiency. In their investigation of Chicago’s famous Gautreaux Program, Rosenbaum and DeLuca (2000, p.6) find that the “interconnection between poverty and place” matters. They also note that recent welfare reform efforts continue to demonstrate that “many officials are not giving much thought to where families are moving” (p.6).

While mobility programs show higher levels of satisfaction with neighborhoods and safety in comparison to vouchers and public housing, there are mixed results in terms of health,



employment, and criminal activity improvements (Schwartz 2006). Perhaps the greatest challenge for effective residential mobility programs is labor investment required for counseling and careful administration to ensure that families are not being displaced into equally disadvantaged neighborhoods. The costs of residential mobility programs remain cumbersome for widespread adoption. In addition, there is concern over whether candidate screening should be employed, or whether limits should be applied to the number of families that can be moved into neighborhoods with successful track records.

#### Community Development Block Grant Program

The Community Development Block Grant program (CDBG) is another way the federal government subsidizes low-income housing for localities. It provides federal funds for states and localities to create stable urban communities. CDBG gives recipients wide discretion in deciding how to implement funds, allowing localities to use funds for infrastructure and other bricks and mortar projects (as opposed to housing) (Orlebeke 2000). The HOME Investment Partnership Program is the largest federal block grant program that specifically focuses on low- and middle-income housing. Localities still have great autonomy in utilizing HOME funds. CDBG and HOME's largest flaw is the inability to provide funds for extremely low-income households (Schwartz 2006).

#### Nonprofit Organizations

Nonprofit organizations are another popular resource for localities to fund low-income housing. Nonprofit organizations are crucial for local housing strategies, with devoted missions and greater flexibility than localities alone. Government agencies and nonprofits often have very strong, intertwined relationships (Schwartz 2006). Community development corporations (CDCs) are specific non-profit organizations that "sit somewhere in between the public and

private sectors” (Ranney and Wright 2003, p.129), and play a pivotal role in securing low-income housing in many communities. While CDCs are often invaluable to the economic development of an area, Halpern (1995) notes that housing markets and metropolitan trends greatly influence CDC success.

Much of the work regarding federal housing policy over the last few decades has focused on rethinking how various policies or subsidies might contribute to a spatial bias, or more optimistically, alleviate poverty concentration. Stimulated by William Julius Wilson’s influential book, *The Truly Disadvantaged* (1987), researchers have been keen to examine the adverse effects that out-migration from central city neighborhoods have had on the left-behind concentrations of impoverished minority families. Concerned that ongoing economic restructuring, shifting demographics, continuing racism, and other processes / conditions have increased the social and spatial isolation of low-income households, researchers have sought to scrutinize how low-income housing programs alleviate or perpetuate metropolitan disparities.

Numerous studies reveal how past motivations, decisions, and processes have tainted low-income housing programs (Biles 2000; Radford 2000; de Souza Briggs 2005). Turner et al. (2009, p.1) state it bluntly: “federal and local housing policies were complicit in creating projects that were racially segregated, economically isolated, under-funded, poorly managed, and inadequately maintained.” Although intentions have become more benevolent, most contemporary programs such as Housing Choice Vouchers (Hartung and Heing 1997), mixed use developments (Pattillo 2009), and the Low-Income Housing Tax Credit (Sard and Waller 2002) still have noticeable shortcomings. The low-income housing policy dilemma comes down to improving low-income neighborhoods, or providing more assisted units. Low-income housing

policy in the United States has traditionally focused on increasing production, but many recent neighborhood initiatives suggest the focus is shifting (Halpern 1995; Orlebeke 2000). Increased funding for low-income housing remains politically unpopular, and consequently the affordable housing community continues to seek creative solutions or compromise. This research is not designed to praise nor condemn particular low-income housing initiatives. Instead it stresses the importance of effective and efficient use of location amenities to improve low-income housing programs.

Whether through the provision of a voucher or the site of a new dwelling, it is clear that location matters when siting low-income households. Unfortunately, nearly all recent research attention has been directed at explaining why the spatial mobility of low-income households must be pursued. Considerably less attention has been directed at the basic (and older) planning and policy dilemma of determining what site characteristics are crucially important when considering where to build (or relocate) households, or what to consider improving in existing neighborhoods. As Thomson and Hardin (2000, p.98) correctly identify, “[p]lanners must take into account both the socioeconomic characteristics of sites as well as the constraints of physical layout, available area, and land suitability in performing their tasks.” The following section shifts to a discussion of optimal location criteria, which identifies and explains critical location amenities and neighborhood characteristics that bolster the potential for more effective low-income housing programs.

### **Optimal Location Criteria**

The significance of location in low-income housing policy has not always been realized. Housing policy at the turn of the twentieth century instead focused on improving dwellings to restore immigrant-occupied slums. Proper homes were seen as the key to the Americanization of

immigrants, fostering ideals of health and morality. Improving tenement dwellings could therefore revitalize inner city slums riddled by disease, crime, and poverty. Improving the surrounding built-environment was not a relevant goal in low-income housing policy until 1915 (Fairbanks 2000). At that point, ideas of sanitation, open space, and land use zoning led reformers to shift “from a preoccupation with dwellings to a definition of housing that emphasized the inextricable connections between dwellings and other neighborhood amenities” (Fairbanks 2000, p.37).

In recent decades, the federal government has become increasingly interested with the location and neighborhood quality of low-income housing (Kleit and Galvez 2011). The significance of the location of low-income housing planning was revealed in part because of the prevalence of poorly planned cookie-cutter suburbs with no access to location amenities (Orlebeke 2000). In addition, the difficulties exposed by isolated public housing projects (as noted above), and the recognition of the extreme consequences of poverty concentration (Turner et al. 2009) bolstered calls for social and economic inclusion across urban landscapes (Halpern 1995). For example, the Washington D.C riots of 1968 provided an opportunity to rebuild the city in a fashion that was more inclusive for black and low-income residents (Gillette 1995). Neighborhood initiatives of the 1960s became “a vehicle for assimilating socially and economically marginalized people into the larger society” (Halpern 1995). Afterwards, the 1971 *President’s Third Annual Report on National Housing Goals* emphasized the need to craft low-income housing policy related to the environment and community growth (Orlebeke 2000). Mixed-income approaches, community development programs, and relocation programs all stem from this era, and serve to highlight the significance of location to low-income housing.

It is clear that location remains critical, because as Squires and Kubrin (2005) highlight, privilege is not detached from place. The potential for quality education, safety, access to employment, and the distance to daily necessities are affected by a home's geography (Weisbrod et al. 1980; Chapman and Ritzdorf 1986; Kleit and Galvez 2011). Poor housing location can exacerbate poverty, unemployment, a lack of education, crime, and poor health. Location amenities are especially vital to low-income households, as they strongly influence potential for economic and social mobility. According to Squires and Kubrin (2005, p.47), "access to decent housing, safe neighborhoods, good schools, useful contacts and other benefits is largely influenced by the community in which one is born, raised, and currently resides." Low-income housing planned around optimal location amenities can offset many disparities confronting low-income households. Developments situated in optimal locations have the potential to increase the chances for low-income households to establish successful life trajectories.

Unfortunately, existing research is inconclusive in deciding which location amenities and neighborhood characteristics are critical in the effort to maximize low-income housing success. It is evident that the uniqueness of localities will continue to matter in housing provision. However, it is possible to identify a list of important variables that emerge across multiple studies. For example, access to employment (Hartung and Heing 1997; Biles 2000; Sard and Waller 2002), education (Crowley 2003; Frankenberg et al. 2003; Squires and Kubrin 2005), and low neighborhood poverty rates (Massey and Denton 1993; Turner et al. 2009; Tighe 2010) are three variables that are consistently deemed important to welfare and housing reform. Other important variables include low crime rates (Hartung and Heing 1997; Goetz 2000; Sard and Waller 2002), health-related amenities (Sard and Waller 2002; Quigley and Raphael 2004; Squires and Kubrin 2005), and access to public transportation (Weisbrod et al. 1980; Chapman

and Ritzdorf 1986; Coulton et al. 1999). Finally, access to child care (Goetz 2000; Fuller et al. 2002; Shlay et al. 2004) and population density (Saegert et al. 2002; Schwartz 2006; Kleit and Galvez 2011) are important considerations, especially in conjunction with some of the previously mentioned variables. Many other factors, such as diversity, access to parks, distance to welfare offices, and neighborhood familiarity have been cited as important, but with less consistency.

The ability of planners and policymakers to situate low-income housing around optimal location amenities is limited by a wide range of factors, including public opposition, zoning constraints, and competing real estate interests. For the purpose of this study, these limiting factors are temporarily ignored. Identifying the low-income housing site suitability for Fairfax County land parcels requires a blank slate. A limitations and assumptions appendix further identifies and explains the confines and suppositions to this research. This section discusses how low-income housing location is linked to poverty concentration, employment, education, crime, health, public transportation, child care, and population density.

### Poverty Rates

Perhaps the most consequential outcome of low-income housing distribution is poverty concentration. Schwartz (2006, p.108) states, “more than half of all public housing units are in census tracts with poverty rates of 30% or higher,” and “half of all public housing is located in tracts where minorities comprise at least 50% of the population.” Although voucher holders are more likely to locate in the suburbs when compared to project-based residents (Hartung and Heing 1997), poverty and racial concentrations are not necessarily alleviated (Massey and Denton 1993). An overwhelming majority of voucher recipients move within the same neighborhood (Turner et al. 2009), or to suburban ghettos (Hartung and Heing 1997). LIHTC

units are also concentrated because of a focus on implementing development within qualified census tracts with higher concentrations of poverty.

Low-income housing is concentrated in high poverty areas due to legacies of government policies, social influences, and urban market forces. Historically, federal policy targeted supposed blighted urban areas for the initial location of public housing projects (Biles 2000). A combination of federal, state, and local policy intentionally concentrate LIHTC housing in difficult to develop areas (Sard and Waller 2002). Voucher holders remain in high poverty areas because of a preference towards existing networks of family, friends, and ethnicity. In addition, low-income households often lack the ability to find out about or move to housing options in more auspicious neighborhoods (Kleti and Galvez 2011). Discrimination and steering within the housing market based upon race and class also contribute to existing poverty concentration trends (Turner et al. 2009; Tighe 2010). All other factors aside, market forces disproportionately locate low-income housing within higher poverty neighborhoods (Hartung and Heing 1997) due to (1) exclusionary zoning that limits the affordable housing supply in wealthy neighborhoods (Ihlanfeldt 2004), (2) locality competition to attract higher tax bases (Patillo 2009), and (3) a secondary mortgage market that emphasizes developer funding as opposed to holistic low-income housing planning (Ranney and Wright 2003).

Poverty concentration leads to many issues, such as crime, unemployment, and a misguided youth. Inadequate access to goods and services, most notably employment and education, characterize areas of poverty concentration (Tighe 2010). Generational poverty and related effects of high crime, poor health, unemployment, and a lack of education perpetuate reliance on low-income housing (Turner et al. 2009). If low-income housing is concentrated in segregated, high-poverty neighborhoods, then low-income households will continue to live in

such neighborhoods (Hartung and Heing 1997; Kleit and Galvez 2011). This concentration undermines many underlying motivations for low-income housing, especially improving public health, reducing societal injustice, preserving social order, and increasing equality of opportunity (Grigsby and Bourassa 2003).

Low-income housing that stresses income integration is a potential remedy for poverty concentration. Mixed-income approaches allow low-income households to take advantage of greater social services, better infrastructure, and increased political clout (Turner et al. 2009). Mixed-income neighborhoods also increase the potential for exposure to role models and employment connections (Schwartz 2006). Undoubtedly, some of these supposed improvements might not benefit low-income households. Also, discrimination, language barriers, and cultural differences that inhibit class interaction diminish the benefits of role models and employment networks (Goetz 2000).

Income integration can sever existing social and family ties that low-income households rely on. Kleit and Galvez (2011, p.379) explain, “people look for neighborhoods that offer a balance of social and employment accessibility, but social accessibility outweighs employment.” A valued sense of community can keep households within blighted neighborhoods. However, these location choices take place within the existing urban context. Since low-income and minority populations have been concentrated, the familiar networks are concentrated as well (Hartung and Heing 1997). Income integration does have the potential to soften poverty concentration’s crippling effects if the needs and wants of low-income households can be balanced with those of more affluent community members (Turner et al. 2009). Despite the massive impact poverty concentration has on low-income neighborhoods, it is crucial to



recognize that employment is the most critical location amenity for low-income households to transition out of assisted housing.

### Employment Opportunity

Low-income housing is almost worthless if it is situated away from low-income job opportunities. Low-income housing absent of employment opportunities risks devastating failure, as exemplified by traditional public housing projects (Biles 2000). If low-income housing is meant to serve as a springboard to upward social mobility, then low-income housing must be implemented with employment opportunities in mind.

Sard and Waller (2002) stress the importance of low-income housing in job-growth areas. If there is a spatial mismatch between employment opportunities and low-income housing locations, then a massive impediment for economic and social mobility is created. While public transportation might alleviate some of the concern, it cannot address the full magnitude of the problem. As Hartung and Heing (1997) note, it is advantageous to recognize that low-income households who live closer to employment opportunities are more likely to be employed.

### Education

While employment remains paramount in helping individuals transition out of assisted housing, education has also been shown to be essential to improving generational poverty (Squires and Kubrin 2005). There is a direct relationship between decent housing, quality neighborhoods, and good education (Crowley 2003). High poverty and minority areas suffer from education disparities, solidifying an ongoing culture of poverty (Turner et al. 2009).

American suburbs tend to have better schools than inner cities, mostly due to greater financial support (Squires and Kubrin 2005). In the 2007 report *School Facility Investments in the Washington Metropolitan Area*, Woolley and Winkler (2007) found that school investments

in suburbs like Fairfax County dwarfed those of the District of Columbia. Even after accounting for suburban growth capacity pressures, inner city “schools with higher concentrations of minority and low-income students received less construction investment, despite evidence that these schools are the most likely to need facility improvement” (Woolley and Winkler 2007, p.18). Low-income neighborhoods have fewer resources, less qualified teachers, higher teacher turnover rates, and much lower educational achievements (Frankenberg et al. 2003). On the other hand, children of voucher recipients that move to the suburbs generally witness educational improvements. There are fewer dropouts, more college-bound students, more helpful teachers, and better school attitudes towards children (Goetz 2000). A quality education drastically decreases the chances for generational reliance on subsidized housing.

### Crime

Neighborhood character is directly linked to crime. Dangerous and distressed neighborhoods are more likely to have higher rates of robbery, assault, and worse offenses (Schwartz 2006). Crime is also distressing because it reflects other quality of life disparities. High crime neighborhoods signal areas with low education, poor health, unemployment, defective family living, and a lack of access to amenities. Crime afflicted neighborhoods do not have greater proportions of immoral people. Instead, they have greater proportions of desperate, deprived, hungry, and uneducated people. These neighborhoods are concentrated within inner cities and increasingly within some inner ring suburbs (Squires and Kubrin 2005).

Low-income housing initiatives that move households to low-poverty neighborhoods reduce involvement in violent crime (Sard and Waller 2002). Better neighborhoods also diminish exposure to drugs, street crime, and gang activity (Hartung and Heing 1997). Suburban voucher holders report a greater sense of safety, allowing low-income parents more freedom to work

without fearing dangerous commutes or abandoning their families. Children are also able to travel safely to school and avoid gang involvement (Goetz 2000). Low-income housing situated in neighborhoods with low crime rates facilitates an overall higher quality of life for tenants.

### Health

Neighborhood quality also has a drastic impact on health. Buildings in high poverty neighborhoods tend to be dilapidated, increasing the potential for physical hazards, lead poisoning, and other unsafe living conditions (Quigley and Raphael 2004). High poverty neighborhoods also increase the risk for violence, a lack of exercise, respiratory diseases, and malnutrition (Sard and Waller 2002). Poverty concentrated neighborhoods often sit in food deserts, with a lack of healthy food options (Turner et al. 2009). In addition, Crowley (2003) argues that a lack of safe and decent low-income housing is a principal explanation for infant mortality within poor populations.

Aside from physical consequences, poor living conditions hamper mental and social health. Sustained poverty and a low quality of life increase the risk for depression, mental issues, substance abuse, and an abusive family life. The physical and emotional toll of poverty positions extremely low-income households at a unique and sustained disadvantage. As Squires and Kubrin (2005, p.52) summarize, “access to clean air and water, exposure to lead paint, stress, obesity, smoking habits, diet, social isolation, proximity to hospitals and other medical treatment facilities, and availability of health insurance all vary by neighborhood and contribute to long-established disparities in health and wellness.” Health difficulties, as with crime and poverty barriers, impede the abilities of low-income households to secure employment, gain an education, and move out of subsidized housing. Low-income housing developments should at least be located near hospitals or other medical facilities, and have access to grocery stores.

### Public Transportation

Public transportation is important for the lifestyles of low-income households (Weisbrod et al. 1980; Chapman and Ritzdorf 1986; Kleit and Galvez 2011). Lower income populations rely more heavily on public transportation than other income groups. Cars can be too expensive for low-income households, and those who can afford a car are confronted with high gas prices and long commutes to distant jobs (Coulton et al. 1999). A lack of transportation accessibility is one of the largest barriers to employment for low-income households (Goetz 2000). Not only has employment decentralized away from low-income neighborhoods, but health facilities, grocery stores, and other location amenities have decentralized as well (Bostock 2000). While public transportation is traditionally inadequate at reaching suburban destinations (Coulton et al. 1999), improvements are underway in many metropolitan areas (see the study area section for discussions on the Washington, D.C. Metro expansion and the discussion section for transit-oriented development).

Transportation connects housing to jobs and other location necessities. Accessible public transportation increases access to employment, education, grocery stores, and other urban amenities. In addition, public transportation increases the potential for what Voith (1992, p.24) calls agglomeration economies, or “the benefits from having many businesses in close proximity.” High concentrations of businesses clustered around public transportation nodes make such locations beneficial to low-income households as an end, and not just as a means to getting other places (Voith 1992). Low-income housing near major public transportation nodes, like subway stations, allows low-income households to take advantage of surrounding development. Transit-oriented low-income housing also prevents access issues that accompany relocating low-income households to affluent, sprawling neighborhoods (Rosenbaum and Harris 2001).

Low-income housing planned near public transportation is effective because it is easier than attempting to mold entire metropolitan areas to cater to low-income needs (Coulton et al. 1999). Public transportation access serves as a suitable short term remedy to urban disparities, allowing low-income households to travel to places where there are at least some favorable amenities. It is important to reiterate that public transportation improvement alone is not the solution for low-income disparities. Many dilapidated, poverty concentrated neighborhoods are already situated near public transportation networks (Glaeser et al. 2008). Low-income households cannot truly utilize public transportation to their advantage until it is combined with other favorable neighborhood characteristics.

### *Child Care Opportunities*

Child care options and child-oriented facilities (schools and daycare centers) are highly valued by low-income families (Chapman and Ritzdorf 1986; Crowley 2003; Shlay et al. 2004). Low-income households tend to have more children than affluent households, and are often headed by single parents (Bostock 2000). A lack of child care options impedes the abilities of parents to work (Goetz 2000; Shlay et al. 2004), which is extremely troublesome for low-income parents who do not have the leisure of working from home. Quality care is also important for the development of young children (Crowley 2003). Similar to education, quality child care for low-income households decreases generational poverty and dependence on subsidized housing. Low-income children stand to benefit the most from quality childcare, but children from affluent families are much more likely to be enrolled in such programs (Fuller et al. 2002). As with many other location amenities, there is often a spatial mismatch between child care options and those most in need.

Child care-related expenditures often account for over a quarter of low-income households' total income (Shlay et al. 2004). Programs for low-income families do exist, and have gained momentum in recent years. For example, federal and state funding for low-income child care tripled from 1995 to 2000 (Fuller et al. 2002). Even so, only about 30 percent of low-income families utilize such programs (Shlay et al. 2004).

Incorporating child care into low-income housing planning (or vice-versa) can improve this statistic. The placement of child care facilities near low-income housing developments (or vice versa) can relieve family constraints for employment-seeking parents, support early childhood development, and decrease generational poverty.

### Population Density

The final optimal location factor considered in this study is population density. While seemingly having a less direct impact than other neighborhood characteristics, densely populated areas are beneficial for low-income households (Saegert et al. 2002; Schwartz 2006; Kleit and Galvez 2011). The most obvious benefits for low-income households are related to the clustering of development and infrastructure. Areas with high population density increase the potential for agglomeration economies (Voith 1992), public transportation (Glaeser et al. 2008), and subsequent favorable location amenities. An emphasis on dense neighborhoods also steers low-income housing away from suburbs that are too isolated and expansive for low-income households to find prosperity (Rosenbaum et al. 2001).

Population density accounts for many location factors that are more difficult to measure. For example, dense neighborhoods increase diversity, which may help deconcentrate poverty by mixing incomes and breaking up poor racial enclaves (Squires

et al. 2005). In addition, dense neighborhoods increase the chance for mixed income interaction. Such contact potentially assists low-income households in infiltrating employment and social networks (Kleit and Galvez 2011). Population density can even help prevent criminal activity due to the presence of social capital. Higher density increases the familiarity of community residents, fostering trust, social organization, and community information (Saegert et al. 2002). While dense neighborhoods do not guarantee positive social cohesion, diversity can lead to increased tolerance and trust.

To summarize, various research shows that low poverty rates, employment opportunities, quality education, low crime rates, access to health-related amenities, access to public transportation, access to child care, and high population density are important factors to consider when investigating the success of low-income housing programs. Many other location factors contribute to the success of low-income households, but this list captures the most prominent necessities. It should be emphasized that none of these factors alone can alleviate low-income housing disparities. Siting low-income housing in locations that optimize these amenities has the power to increase low-income housing success.

Finding locations that include all of these factors could be difficult. Such locations are likely already occupied in a heavily developed urban landscape. In addition, low-income housing must compete with other interests that find these amenities favorable. Instead, scrutinizing locations that already have decent low-income housing suitability can reveal which location amenities are necessary to improve suburban neighborhoods and therefore maximize low-income housing success. This research will

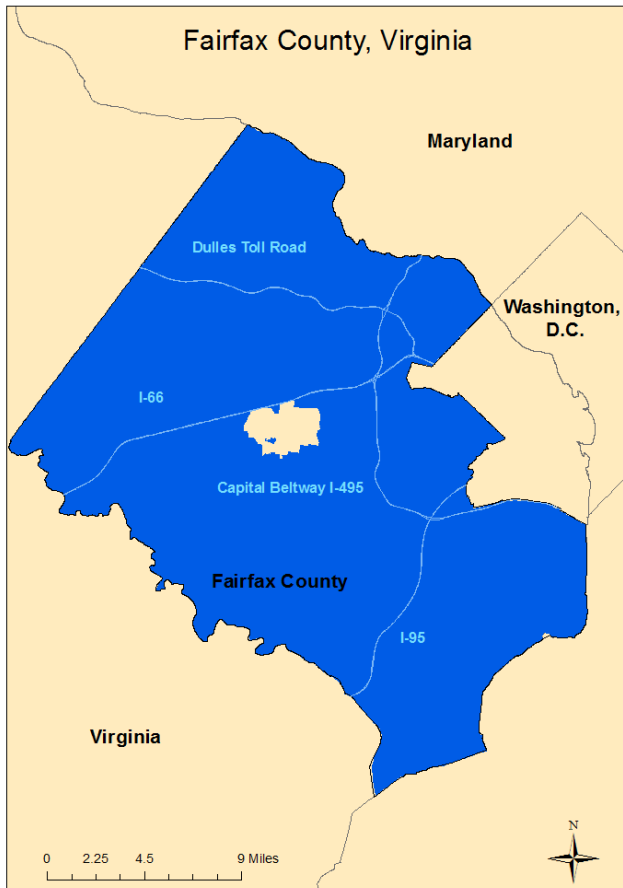
incorporate these factors into a GIS model, revealing the low-income housing site suitability for all locations in Fairfax County. First, a background of the study area is necessary to contextualize low-income housing and location factors within Fairfax County.

### **Study Area**

Fairfax County, Virginia lies across the Potomac River from Washington, D.C., to the south and west of Maryland (Figure 1). Its 395 square miles span from bordering the District of Columbia to well beyond the Capital Beltway. In 2010, the county's population was 1,081,726 people (US Census Bureau 2010 Demographic Profile), making it the most populous county in the Washington, D.C. metropolitan area. The county continues to grow, with a projected 2025 population of 1,189,133 people. There are over 396,000 housing units, with a projected 2025 number of over 450,000 housing units (fairfaxcounty.gov). Parts of the Washington D.C Metro system extend into Fairfax County, with new construction extending past Tysons Corner to Dulles International Airport. However, less than nine percent of residents commute via public transportation (fairfaxcounty.gov). The main highway corridors are I-95, I-66, the Dulles Toll Road, and the Capital Beltway (I-495).



**Figure 1: Fairfax County, Virginia**



Fairfax is a youthful, diverse county. The median age is just over 37 years old, and over 30 percent of the population is foreign born. About 37 percent of residents are non-White, consisting mostly of Asian and Hispanic populations. More than 38 percent of residents speak a language other than English at home ([fairfaxcounty.gov](http://fairfaxcounty.gov)).

Fairfax is also highly educated. For those over 25 years of age, 92 percent have a high school degree, and 58 percent have a Bachelor's degree or higher (US Census Bureau American Communities Survey, 2007-2011). The Fairfax County Public Schools (FCPS) system is perennially regarded as one of the best school systems in the country. In 2008, it had the second highest graduation rate (85.1 percent) in the nation. In a Washington Post list of the top high schools in the country, all FCPS high schools were included (only county in the country to have

all of its high schools on the list), ([washingtonpost.com](http://washingtonpost.com)). Thirteen of the top sixteen high schools in Virginia are in Fairfax County ([usnews.com](http://usnews.com)).

Fairfax's most notable characteristic is its thriving economy. The county's close proximity to the federal government helped it survive the recent recession. In addition, suburbanization and decentralization has sent many downtown D.C. jobs to employment clusters within Fairfax (Figure 2). In November, 2012, there were over 592,000 jobs in the county, with a 3.6 percent unemployment rate (Fairfax County Economic Development Authority). The 2012 AMI for a family of four was \$107,500 (Sherfinski 2012), making Fairfax one of the most affluent counties in the nation. Fairfax's popularity for living and conducting business has made it one of the most expensive places to live in the United States. An average annual income for a two-bedroom apartment is about \$53,000 (Kravits 2010).

Fairfax's extremely high housing prices are daunting for low-income households. While over 44 percent of all renters pay 30 percent or more of their income on rent ([fairfaxcounty.gov](http://fairfaxcounty.gov)), households earning less than \$50,000 a year are the ones with extreme housing expenditures (Pelletiere 2007). Kravitz (2010) explains that "Fairfax County, one of the wealthiest localities in the nation based on household income, has long faced challenges in providing enough affordable housing." Pelletiere (2007, p.2) further observes,

in general, the lowest income people have the greatest difficulty finding housing they can afford, and in an expensive market such as Fairfax, this problem is compounded. Federal housing assistance is not an entitlement like food stamps, and even households that receive assistance, such as housing vouchers, may find themselves shut out of Fairfax County's market as local rents often exceed regional Fair Market Rents and landlords are not compelled to accept a voucher as payment.

Those with earnings under 50 percent AMI, and especially those under 30 percent AMI, are the households that struggle the most to secure affordable housing. Although Fairfax County stands out as one of the most expensive places to live in the nation, most households making upwards of

\$75,000 have little issue finding housing options (Pelletiere 2007). The high priced environment caters to more affluent populations, disproportionately affecting low-income households.

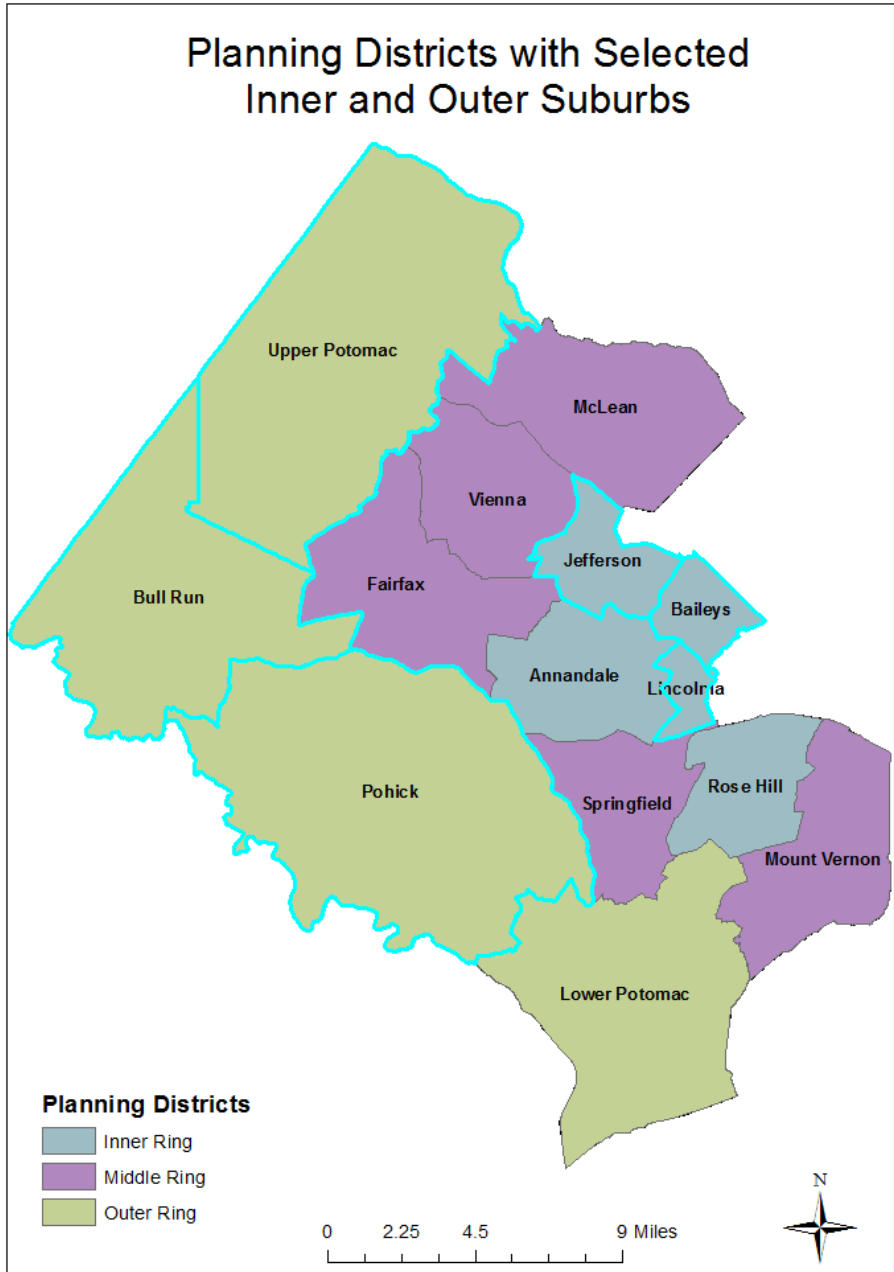
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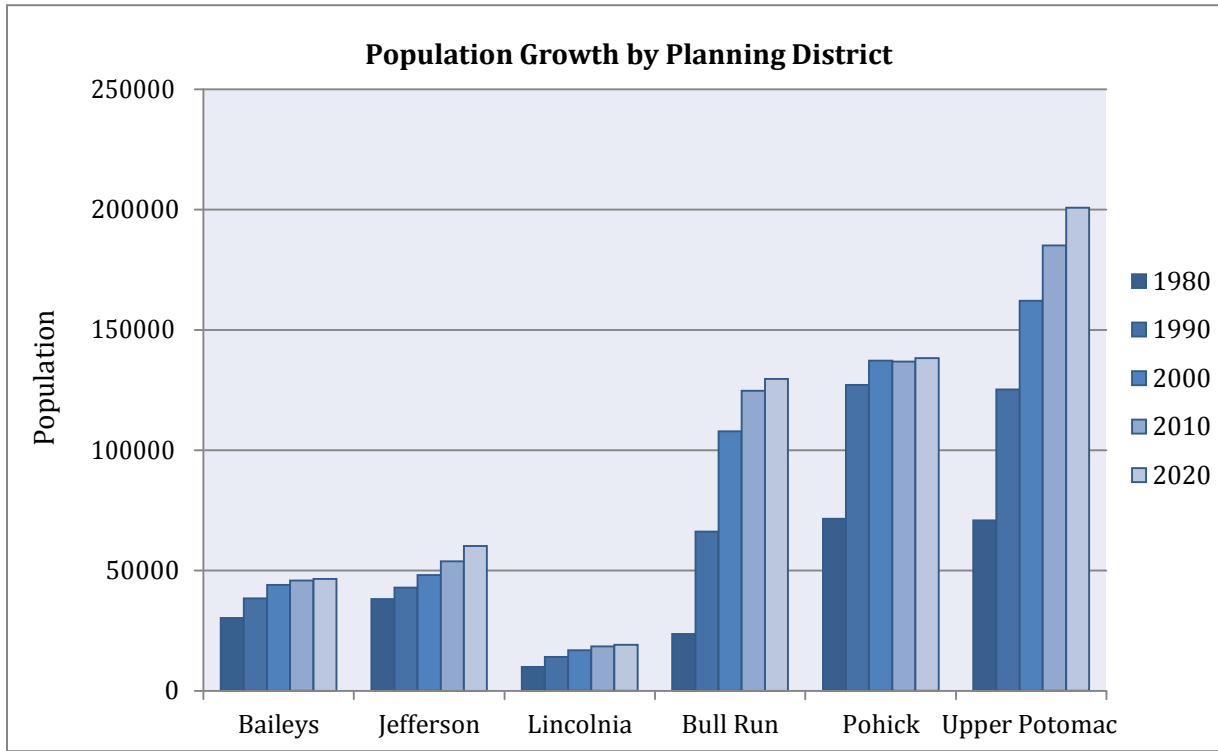
Disparities are worsened by Northern Virginia's continued spatial expansion. New housing developments accommodate Fairfax County's increasing population. Although developers and builders are encouraged to provide affordable and workforce housing if possible, it is not required. Affordable housing plans are involved in the massive development project designed to bring Metrorail to Fairfax's (and Virginia's) largest office market, Tysons Corner. Hosh (2010) states, "[t]he county's ambitious 40-year plan to remake the work-oriented area into an urban, transit-focused downtown includes sweeping guidelines to boost the affordable housing stock." However, developers are not convinced, claiming that density bonuses are not worth the cost of providing affordable housing. High construction costs and intense competition for development forces developers to increase rents. Higher incomes are therefore necessary for developers to profit.

Contrasting three inner suburban planning districts (Jefferson, Baileys and Lincolnia), and three outer suburban planning districts (Upper Potomac, Bull Run, and Pohick) helps demonstrate Fairfax's suburban disparities (Figure 3). Continued suburban growth has pushed development further outwards, leading to disproportionate population explosions in Fairfax's outer suburbs (Figure 4). The outer suburbs have more expensive houses, and fewer proportions of multifamily housing than the inner suburbs. Baileys, Jefferson, and Lincolnia each have less than five hundred houses with a market value of over \$700,000, while Upper Potomac alone has over ten thousand houses above that value (Figure 5). The inner suburbs have slightly more multifamily units than single family units, whereas single family housing in the outer suburbs drastically outweighs multifamily housing (Figure 6). Although Fairfax has sharp housing disparities, it does have some successful low-income housing programs.

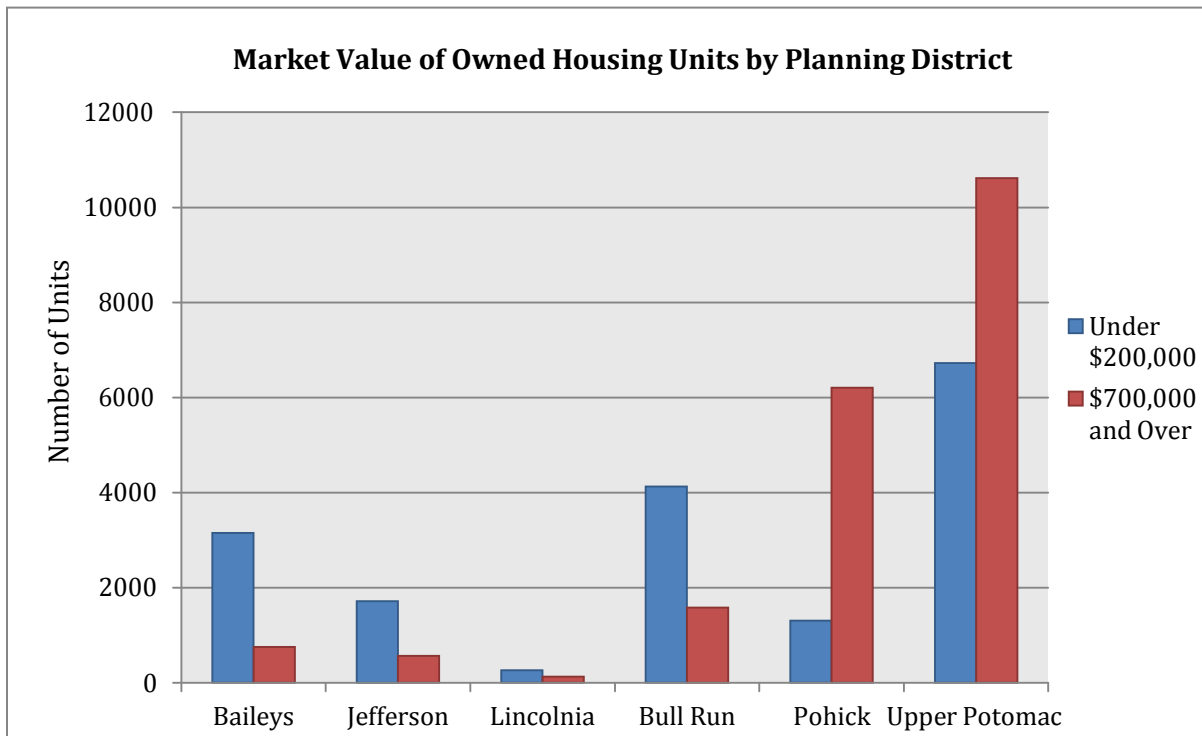
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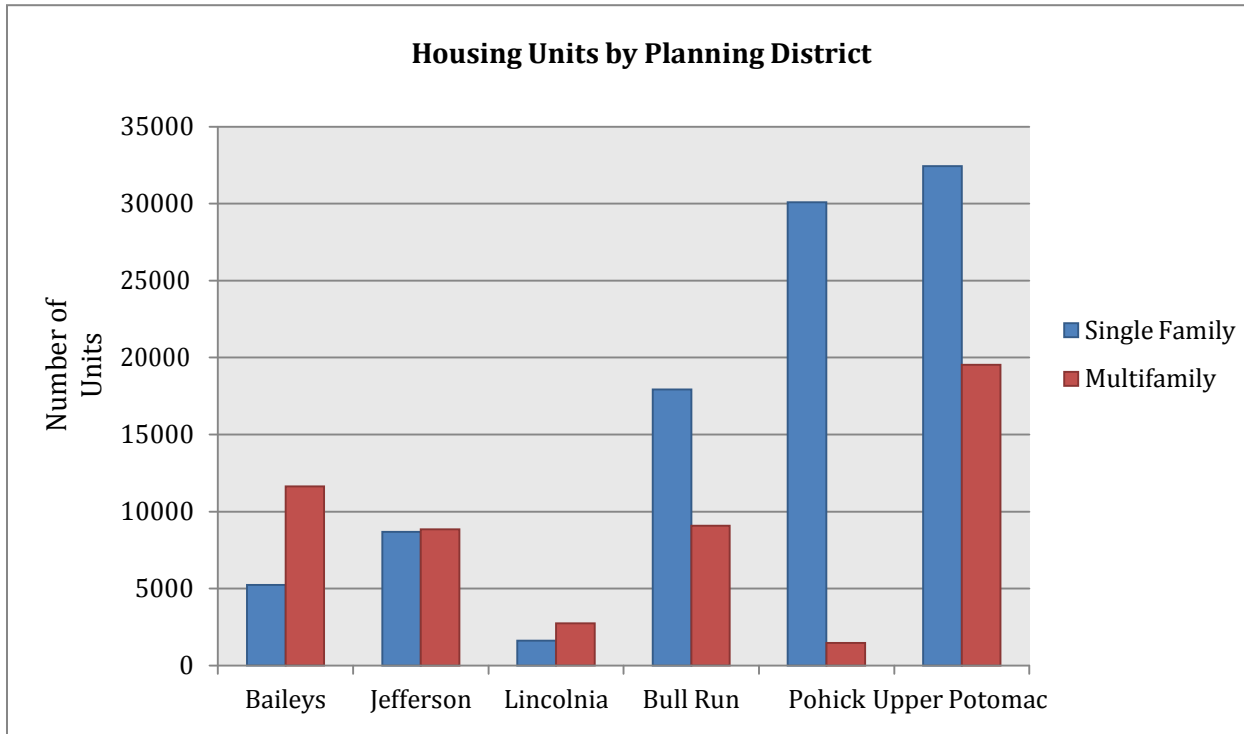
**Figure 4:**



**Figure 5:**



**Figure 6:**



The main low-income housing programs in Fairfax County are the Public Housing Rental Program, the Fairfax County Rental Program (FCRP), and the Housing Choice Voucher Program (formerly known as Section 8). The Public Housing program sponsors units through federal public housing funds. Residents pay 30 percent of their income for rent, with the rest covered by federal assistance. Households served generally have incomes up to 50 percent AMI. The average annual income for Public Housing tenants in 2010 was \$21,694 (fairfaxcounty.gov). The FCRP includes properties that are developed with funds other than public housing funds. FCRP units are funded through a variety of ways, including tax credit financing (like the LIHTC), HOME community block grant funds, vouchers, and federally sponsored private funds such as Section 236. While incomes served range from low to moderate incomes, most FCRP units serve households with higher incomes than in the Public Housing and Housing Choice Voucher Programs.

In 2010, the FCRP and Public Housing Rental Program had occupancy rates of 97 percent and 99 percent respectively, and the Housing Choice Voucher Program housed over 8,000 individuals. Fairfax County has been designated a high performer by HUD on multiple occasions for its successful voucher program (fairfaxcounty.gov). HUD has also named Fairfax a Moving to Work agency, which provides federal support for locally-designed affordable housing strategies. The prestigious award gives Fairfax more leverage in developing cost-effective strategies to aid families in achieving self-sufficiency. In addition, Fairfax's recent Bridging Affordability plan seeks to end homelessness in 10 years, reduce affordable housing waiting lists, and meet affordable-housing demands for people who are members of Fairfax's workforce. This program highlights Fairfax's increasing reliance on public-private partnerships and nonprofits for affordable housing funding (Kravitz 2010; Kunckle 2012).

Evidence suggests that Fairfax's affordable housing policy is headed in the right direction. Including federal and state funds, Fairfax County spent \$113.4 million on housing programs in fiscal year 2012 (Kunckle 2012). One of Fairfax's top affordable housing goals is to cut program waiting lists in half by the end of the decade (Kravitz 2010). This targets some of the lowest income groups in Fairfax County, as the majority of households on waiting lists for FCRP, Public Housing, and Housing Choice Vouchers are below 30 percent AMI (Pelletiere 2007). In addition, Fairfax has pledged to "commit at least \$11.7 million to affordable housing for the neediest families in fiscal 2013" (Kunckle 2012). Since policy objectives are shifting towards focusing on those who are in most need of assistance, optimal location characteristics for developments need to be considered for effective and efficient programs.

Policymakers do seem to recognize how Fairfax's shift to an urban community requires a new paradigm of affordable housing assistance. Fairfax has dedicated large funds to



rehabilitating the existing low-income housing stock, acknowledging negative effects of inner suburban decline (Kravitz 2010). In addition, the significance of affordable housing to education, health, and safety is prevalent in Fairfax. Officials seek “to expand the county’s affordable housing for its growing number of middle-income public-sector workers, such as teachers, entry-level nurses, firefighters, and police officers” (Kravitz 2010). Housing’s relationship to employment is especially noticeable in Fairfax’s housing policy. The Bridging Affordability program gives preference to working families, aiming to assist them in obtaining employment and increasing their income. Policymakers have also stressed the importance of locating affordable housing near employment to reduce transportation costs for low-income households (Kunckle 2012).

Workforce housing is a heavily debated issue in the county, as it subsidizes households making up to \$120,000 annually (Sherfinski 2012). For example, the Tysons Corner redevelopment plan “calls for developers to set aside 20 percent of new residences in the area for households that make between 50 percent and 120 percent of the area median income” (Sherfinski 2012). The bulk of this workforce housing in Tysons will likely be dedicated to the \$70,000 - \$120,000 income range. Fairfax needs to differentiate between subsidizing housing for workers in Fairfax, and supporting subsidized housing that emphasizes employment for low-income households.

Overall, Fairfax is a wealthy, highly educated, and diverse county. Massive economic and population growth has been disproportionately channeled to the outer suburbs. Fast growing outer suburbs and a sprawling landscape leave intense disparities for low-income households in an already high-priced housing environment. On top of Fairfax’s already noteworthy low-income

housing programs, new policies reflect Fairfax's increasing urban character. While recent housing policy narrows the scope to lower incomes with the greatest need for assistance, funding and developer profit issues threaten these aspirations. More holistic planning situated around optimal location amenities and neighborhood characteristics will help Fairfax mitigate housing disparities in an expanding and increasingly urbanized landscape.

### **Methodology**

GIS-based site suitability methods have become increasingly significant to urban and regional planning over the last few decades (Collins et al. 2001; Malczewski 2004; Brail 2008). The application of GIS to site selection processes allows decision makers to factor in physical, social, or environmental characteristics, as opposed to working exclusively with economical or technical criteria (Al-Shalabi et al. 2006). Although less practiced, Thomson and Hardin's research (2000) shows the effectiveness of using GIS to model low-income housing site suitability. This study deploys a multi criteria evaluation (MCE) model, which incorporates multiple factors into a linear combination with full tradeoff. The determined input factors are weighted and combined, producing a site suitability map. This approach is similar to a regression equation, and is common in GIS site suitability modeling (Clevenger et al. 2002; Kar and Hodgson 2008).

This section outlines the methodology for producing low-income housing site suitability scores for Fairfax County land parcels. Most of this section explains the GIS processes for constructing the model and analyzing its results. The GIS model also relies on other techniques, such as a principal component analysis and the analytic hierarchy process. Clevenger et al. (2002, p.510) explain, "[m]odel building is a deductive-inductive process, with model formulation and validation occurring iteratively." GIS processes depend on the data that is either

available or collectable, the study area, and processing capabilities. The methods listed in this section provide a framework for analyzing low-income housing site suitability, but it should be noted that there are multiple approaches to accomplishing this study’s objectives. A methodology appendix explains the methodology process in more detail.

The preliminary step in analyzing low-income housing site suitability is determining the location factors and neighborhood characteristics that optimize the success of low-income housing programs. For this section, the optimal location criteria outlined in the previous section will be referred to as input factors. The following table summarizes the low-income housing site suitability model’s input factors:

<b>Poverty</b>	highlights concentrations of low-income populations and related metropolitan disparities. Poverty is a basis for numerous disparities, such as poor health, low education, and high crime.
<b>Employment</b>	helps low-income households build a monetary base to eventually relinquish reliance on assisted housing.
<b>Schools</b>	provide extra-curricular activities, after-school help and care, and decrease the likelihood of generational poverty. While education is a crucial factor for low-income households, education rates are not incorporated into this study because of the uniformly high education rates in Fairfax County. School proximity is used instead.
<b>Crime</b>	is an indicator for many urban disparities. High crime rates inhibit the success of low-income housing developments, thrusting neighborhoods further into decline.
<b>Medical Care</b>	access is important because low-income households are more vulnerable to diseases, malnutrition, and violence.
<b>Shopping Centers / Grocery Stores</b>	help prevent malnutrition. Low-income populations tend to live in food deserts without a car.
<b>Public Transportation</b>	provides access to employment and other necessities for low-income households who cannot afford a car. Public transportation nodes also have associated development for low-income households to take advantage of.
<b>Child Care</b>	affects parental decisions on employment, as well as fosters positive trends for the youngest residents in low-income housing.
<b>Population Density</b>	allows for closer proximity to employment and other favorable amenities. Dense neighborhoods increase the chance for diversity and positive economic and social interaction.

The methodology appendix outlines how each input factor is measured and lists additional input variables necessary for GIS processes to run.

The input factors must first be tested for interdependence (Malczewski 2000). A principal component analysis (PCA) ensures the variables are not redundant and are in fact good indicators of optimal location planning. Abdi et al. (2010, p.433) argue that the principal component analysis “is probably the most popular multivariate statistical technique,” in that it is useful for simplification, data reduction, modeling, outlier detection, and variable selection (Wold et al. 1987). In this case, all of the input factors passed the PCA test, with no variable correlations stronger than .42.

After the input factors are added into ArcGIS ModelBuilder (the GIS software used to build the model), every input factor is converted to a raster surface to produce a continuous grid of data. Although vector-based modeling of site suitability is possible, raster-based models are more efficient for large amounts of data (Kar and Hodgson 2008). Next, the rasterized input factors are standardized to render them comparable. Reclassifying the data enables the input factors to be indexed in the same manner, regardless of measurement units (Clevenger et al. 2002). The input factors can then be weighted and combined.

Weighting the input factors is the most pressing step in MCE analysis (Al-Shalabi 2006). Saaty’s analytic hierarchy process is one of the most effective and widely used techniques to prioritize multiple variables (Clevenger et al. 2002). Farkas (2007, p.1) explains, “the analytic hierarchy process (AHP) is a multicriteria decision making method that employs a procedure of multiple comparisons to rank order alternative solutions to a multiobjective decision problem.”

Although the literature review determined the input factors, expert-based opinion determines the factor weights. Northern Virginia affordable housing developers were surveyed to

rank the input factors. A Saaty pairwise comparison method (Saaty 2008) was used, requiring participants to rank the importance of each of the input factors in pairs. The results were entered into a Saaty pairwise comparison matrix, and weights were derived based on the analytic hierarchy process calculation (Goepel 2012). With assigned weights, the reclassified input factor raster surfaces are combined using a Weighted Overlay. Finally, a suitability value for each land parcel in Fairfax County is extracted from the weighted raster surface (Skeppstrom and Olofsson 2006). The final output ranks every land parcel for low-income housing site suitability.

Results are derived both qualitatively and quantitatively using the final low-income housing site suitability map. Aside from depicting the data's spatial patterns, GIS processes allow for a more in-depth analysis of the results. Overlaying Fairfax County's low-income housing developments displays the spatial relationship between low-income housing suitability and existing development. Statistical procedures group parcels and developments by suitability level, quantifying spatial patterns. Incorporating zoning classifications, supervisor districts, and a case study of two existing developments through GIS processes allows further analysis of the model's results. These maps and figures are discussed in the results section. In addition, a significance test reveals the influence each input factor has on low-income housing suitability in Fairfax County, and confirms the validity of the model.

The multi criteria evaluation model utilizes a principal component analysis to establish variable interdependency, a Saaty pairwise comparison method to weight the input factors, and ArcGIS ModelBuilder to produce a low-income housing site suitability map. Within the model, input factors are rasterized, reclassified, and weighted according to survey responses. After the input factors are combined, the resulting low-income housing suitability grid's information is extracted to land parcels. The final map shows low-income housing site suitability in Fairfax

County based off of the nine weighted input factors. By adopting a GIS approach, there is an opportunity for planners and policy makers not only to model low-income housing site suitability, but also to measure low-income household distribution and to reflect on the geographic availability of low-income housing across various spatial scales.

## **Results**

This section presents the low-income housing site suitability model's results for Fairfax County, Virginia, along with further analysis. Initial speculations are presented for resulting patterns, and best practices in low-income housing location planning are identified. Trends and processes beyond the scope of Fairfax County are referred to in this section, but are dealt with in greater detail in the discussion section.

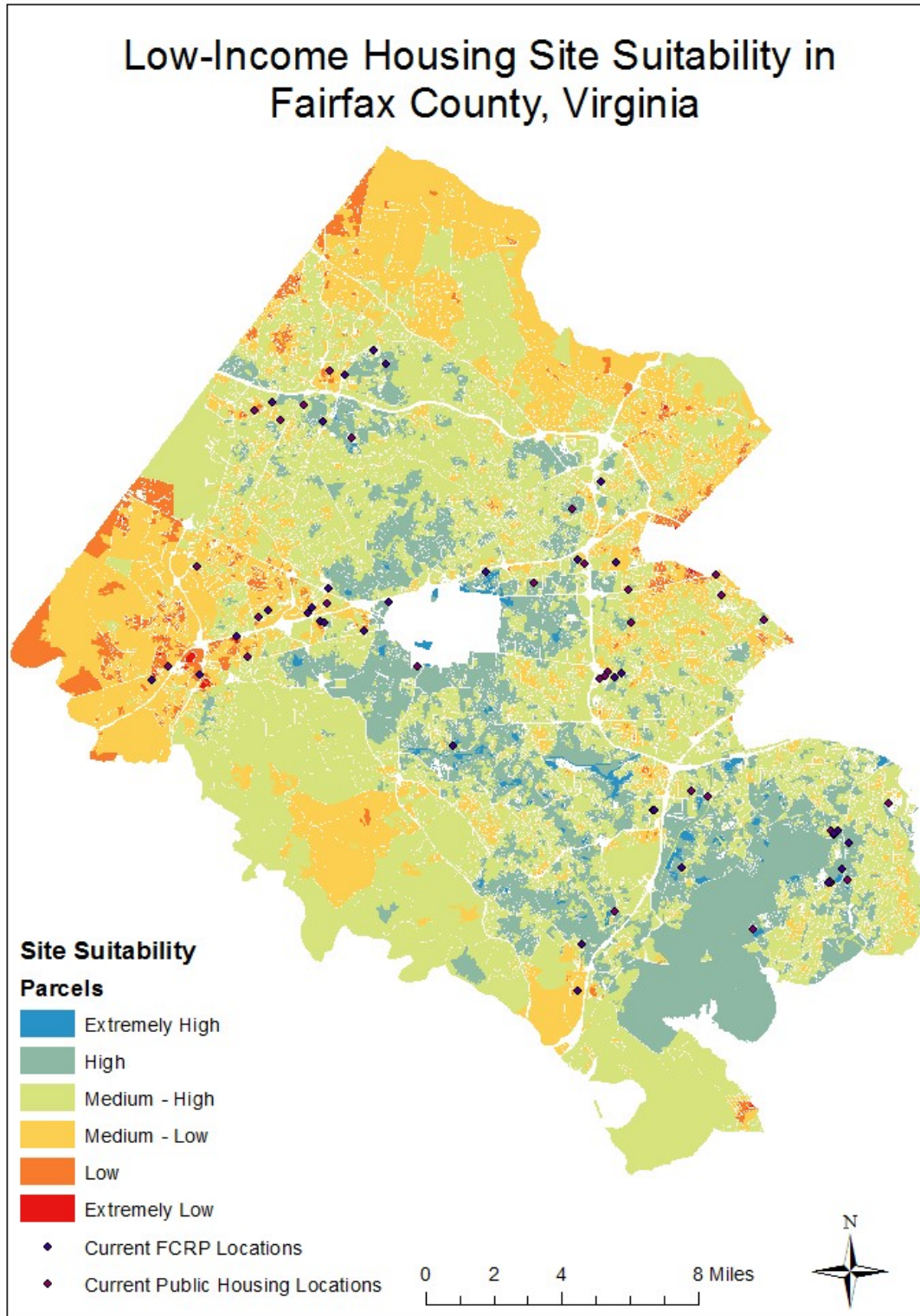
Fairfax's suburban landscape yields mostly medium to high low-income housing site suitability, but reveals *few* optimal locations for low-income housing development. The overall low-income housing suitability of Fairfax County and its low-income housing developments is better than expected; however, the results suggest a constricted ability of low-income housing planners to site low-income housing developments in the most optimal locations. The results can be summarized in these six findings:

1. *The highest scoring parcels for low-income housing development in Fairfax County are in the mid-county neighborhoods, while the lowest scoring parcels are clustered mostly within outer ring neighborhoods and some inner ring neighborhoods.*
2. *Fairfax County yields very few extremely suitable land parcels for low-income housing development, but has overall higher than expected suitability scores.*
3. *The suitability of existing low-income housing developments in Fairfax County is very similar to the distribution of land parcel suitability for low-income housing.*
4. *The domination of single family residential land zoning in Fairfax County decreases suitability scores, but does not diminish the chances for low-income housing development.*

5. *Fairfax County supervisor districts with a Democratic supervisor are more suitable for low-income housing development, and have better sited low-income housing developments than supervisor districts with a Republican supervisor.*
6. *The suitability and siting of specific low-income housing developments is complicated, and individual location amenities have the potential to drastically increase a neighborhood's low-income housing suitability scores.*

Suitability in this study takes a low-income household perspective. The higher the parcel suitability, the more likely location amenities will maximize the success of low-income housing programs for low-income households. This perspective may deviate from what developers might consider suitable locations for low-income housing (unless the developers are low-income housing advocates). Also, it is important to note that suitability in this case is specific to Fairfax County. This is important to recognize, because even extremely low scoring land parcels in Fairfax County may still be better sites for low-income housing than neighboring places in the Washington D.C. metropolitan area. The low-income housing site suitability model's resulting map (Figure 7) scores Fairfax County land parcels for low-income housing site suitability. Moving from red colored parcels to blue colored parcels represents increasing parcel suitability for low-income housing development, based on the derived input factors.

Figure 7:





1. *The highest scoring parcels for low-income housing development in Fairfax County are in the mid-county neighborhoods, while the lowest scoring parcels are clustered mostly within outer ring neighborhoods and some inner ring neighborhoods.*

The older, inner suburbs within the Beltway have lower suitability scores mostly due to higher poverty rates (Figure 8). These neighborhoods are some of the most ethnically diverse in the county (Figure 9), and suffer from outdated infrastructure (relative to the rest of the county) due to decentralized development patterns (Short et al. 2007). The outer, fringe areas of the county have low suitability scores because of sprawling landscapes with poor access (Short et al. 2007). An exception is the east side of the county, which is bound by water and still close to the District. The mid-county ring of suburbs has many high scoring parcels because of increased access relative to the county's fringes (Figure 10), and lower poverty compared to the inner-Beltway communities. Also evident are high scoring parcels near transportation corridors, especially along the Dulles Toll Road to the northwest, I-66 in central-Fairfax, and I-95 to the southeast (Figure 11).

Specific high scoring neighborhoods include Tysons Corner and Reston along the Dulles Toll Road. These neighborhoods are comprised of office parks with jobs that are often beyond the reach of low-income households. However, accompanying hotels and restaurants provide many low-income job opportunities. The current construction of the Metro's Silver Line extends the Metro along the Dulles Corridor, making Tysons and Reston great communities for low-income households to access public transportation. It remains to be seen if low-income housing will be incorporated into Fairfax's plans to transform Tysons into "a 24-hour urban center where people live, work and play – instead of a sprawling suburban office park" (Fairfax County 2011). Other high scoring neighborhoods include redeveloping Merrifield, college-flavored George Mason, and downtown Fairfax along I-66. Also, high scoring parcels in Burke Centre, Newington

Forrest, and Franconia / Springfield at the intersection of I-95 and the Beltway are clustered in safe neighborhoods with access to shopping centers and transportation corridors. The large high scoring area in the east part of the county is a military base, Fort Belvoir.

The lowest scoring neighborhoods inside the Beltway are near West Falls Church, Seven Corners, and Bailey's Crossroads. These neighborhoods are representative of the growing diversity and increasing foreign-born populations in many American suburbs (Allard and Roth 2010). These neighborhoods also have some of the highest poverty levels in the county. A couple of Metro stations and bus stops are located near these neighborhoods, but the layout caters to the automobile, placing large distances and dangerous roads in between low-income households and public transportation. A proposed streetcar project connecting the Bailey's Crossroads / Skyline area to Pentagon City in Arlington seeks to increase accessibility (Jackman 2012) and may serve to adjust suitability scores in the near future.

As might be expected, the majority of the worst scoring parcels are situated within extremely wealthy areas in the north, such as Mclean and Great Falls, and along the southwestern fringes of Chantilly and Centreville. CNN Money's 2011 list of top-earning towns ranked Great Falls as the most affluent town in the nation, with a median family income of over \$367,000. In addition, most houses sit on over two acre lots, and there are no condos, apartments, or townhomes (CNN Money 2011). Chantilly and Centreville depict the quintessence of suburbanization, with sprawling communities made up of large "McMansions" and scattered strip malls. These areas are well beyond the reach of the D.C. Metro and bus system. Figure 11 displays each of the aforementioned neighborhoods on top of the suitability map.

Figure 8:

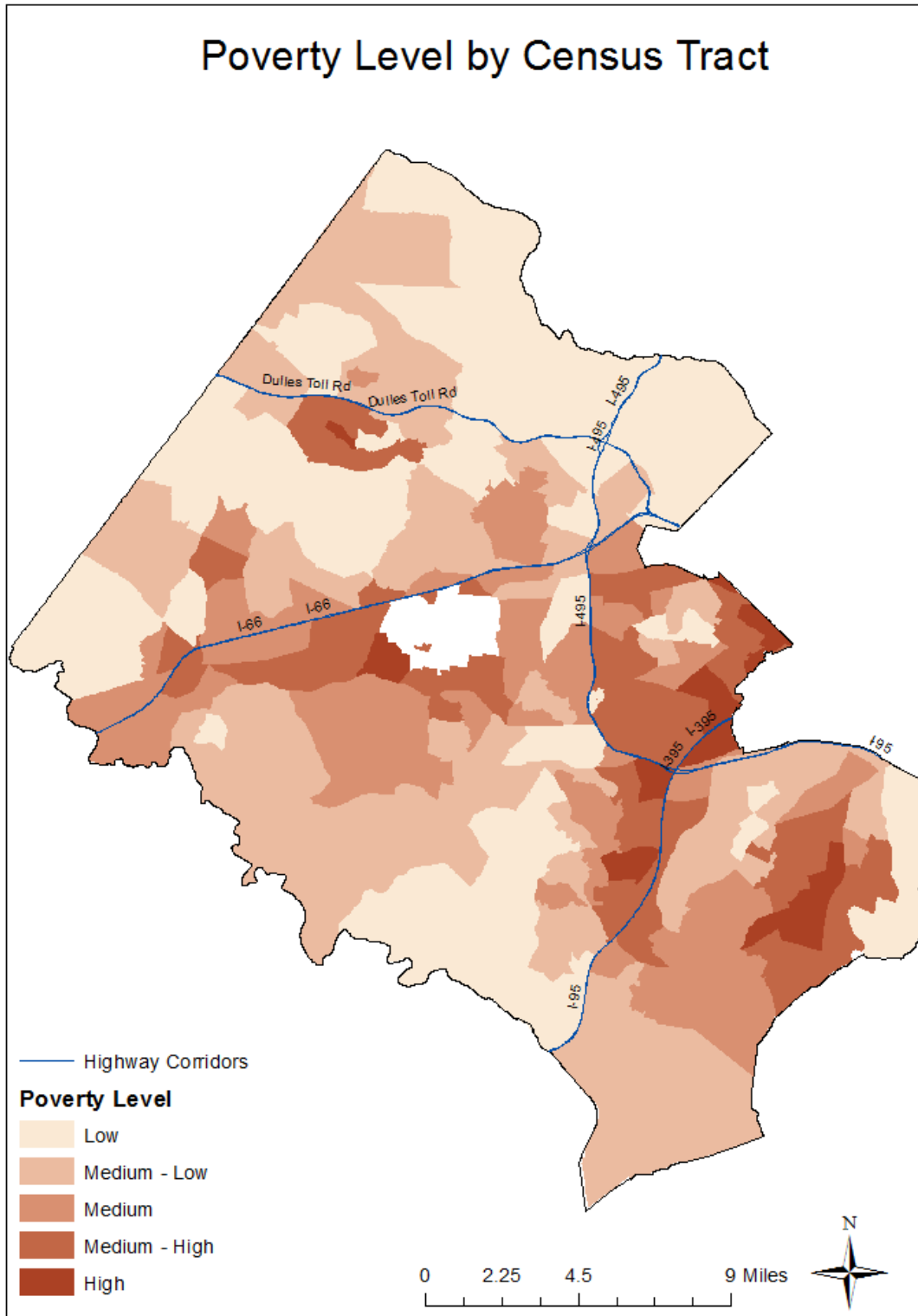


Figure 9:

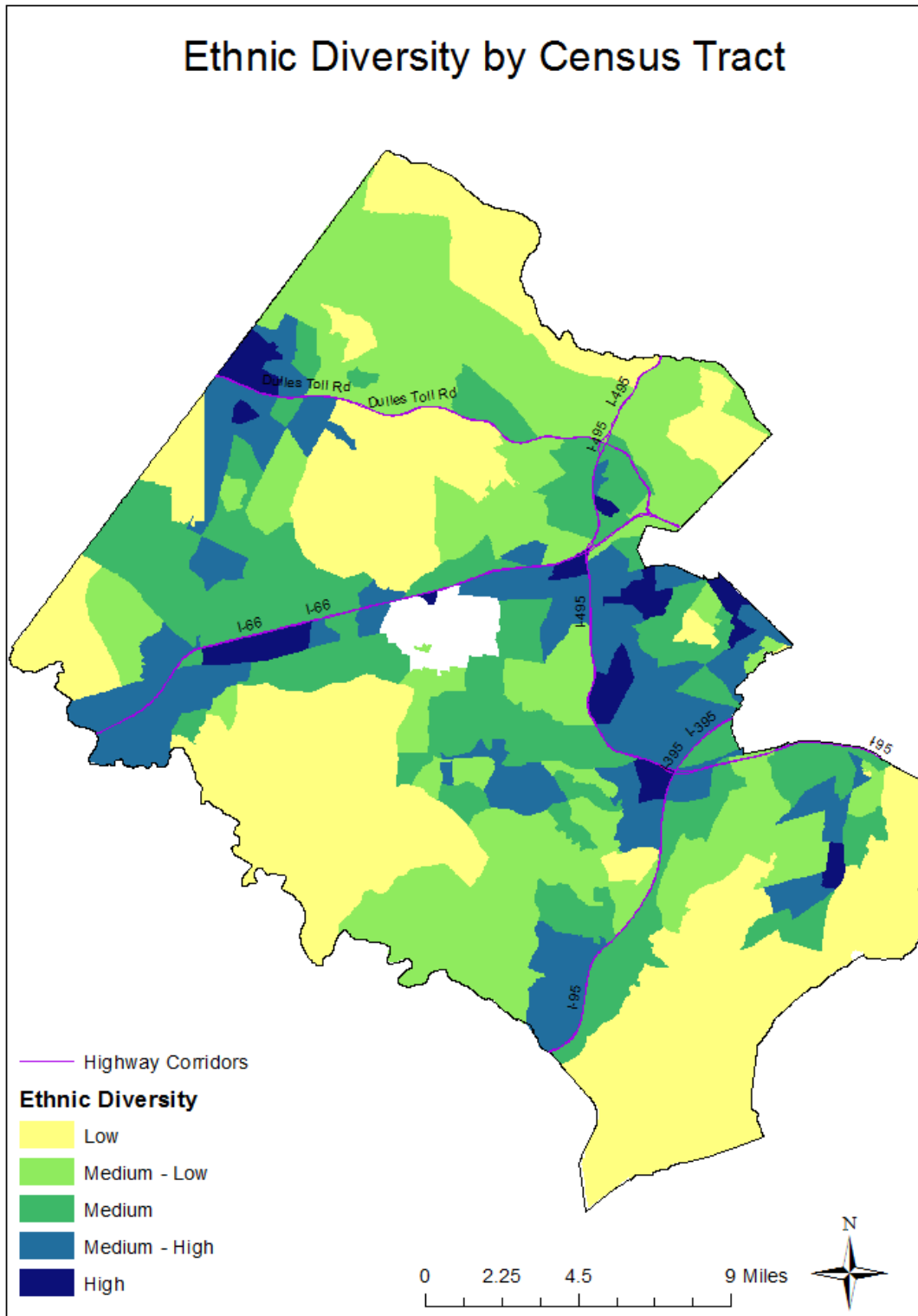


Figure 10:

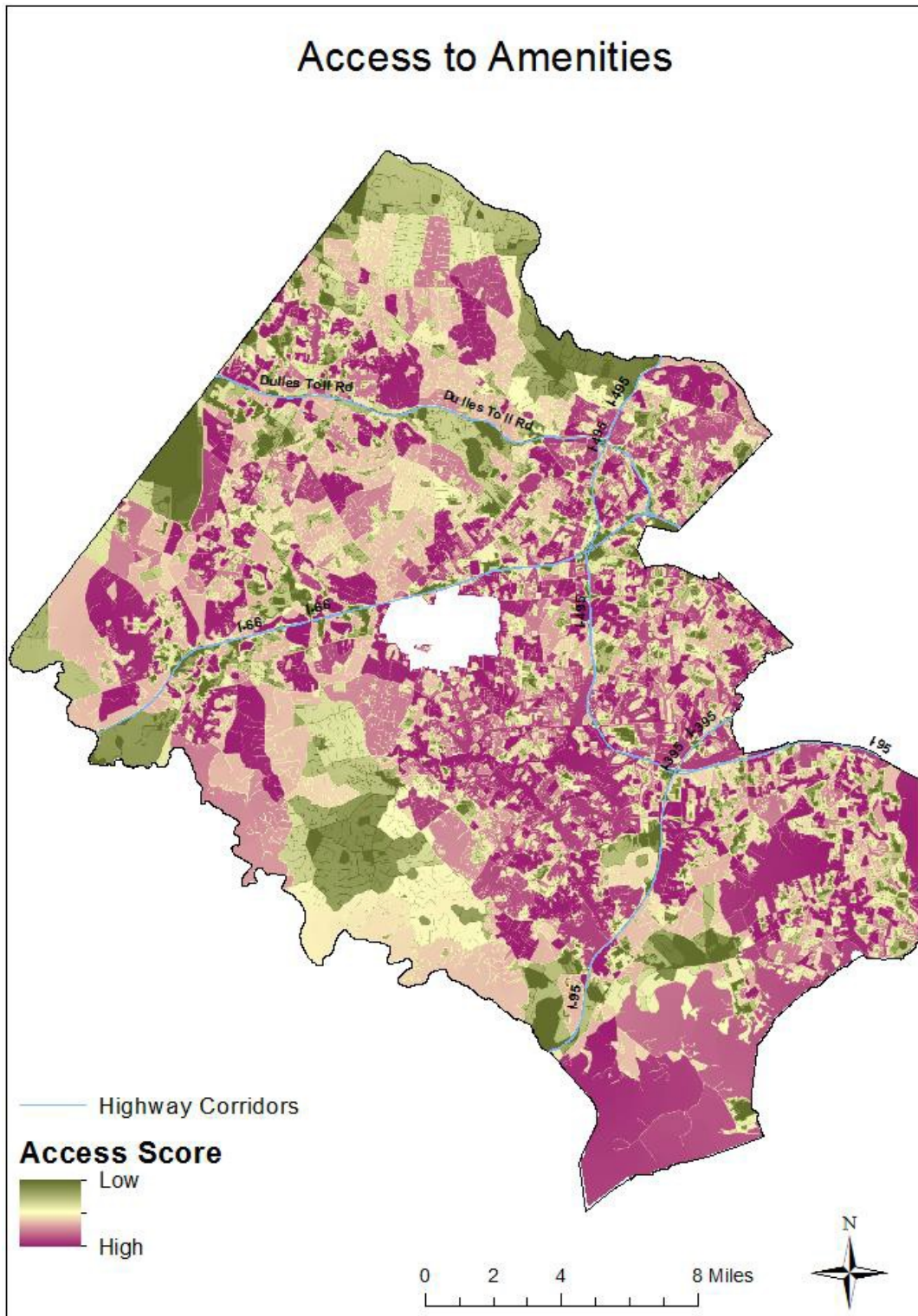
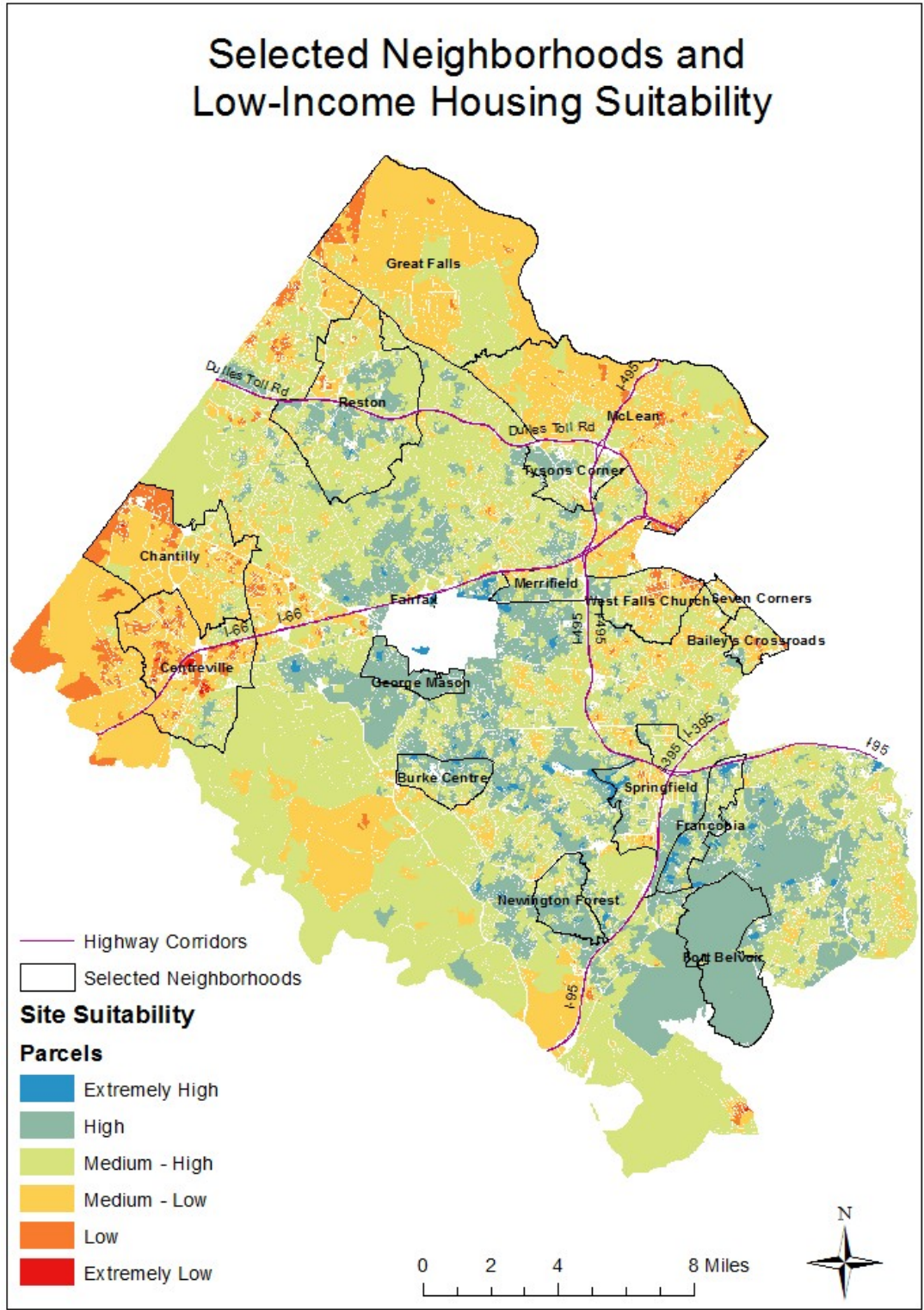


Figure 11:



2. *Fairfax County yields very few extremely suitable land parcels for low-income housing development, but has overall higher than expected suitability scores.*

Figures 12 - 14 depict the distribution of Fairfax County land parcels broken down by suitability level. Very few parcels in the highest suitability level (suitability score of 2) highlight the limited abilities of planners to incorporate optimal location criteria into low-income housing development siting. Optimal locations are rare even when ignoring existing development, zoning constraints, or the difficulties in securing funding sources. On a more positive note, there are very few extremely low scoring parcels (suitability score of 7). Fairfax's wealthy and developed suburban environment yields at least some location amenities near most land parcels. Over 68 percent of the parcels fall within the medium – high (suitability score of 4) to high (suitability score of 3) suitability range. Figure 13 also reveals only marginal 'tails' to the data distribution, as the linear weighted combination deploys full tradeoff with moderate risk between variables.

The geography of suburbs helps explain Fairfax's low-income housing suitability scores. An era defined by the automobile leaves most of Fairfax with medium – high to high suitability scores for low-income housing. It also leaves behind few complete communities that would be the most auspicious for affordable developments. The decentralized and expanding mass of suburbs provides pockets of optimal locations across a sea of sprawling development (Knox 1991; Short et al. 2007; Lang and Knox 2009; Allard and Roth 2010).

However, as a new paradigm that stresses mixed-use development, smart growth, transit-oriented development, and environmental measures takes hold, more complete communities are becoming the norm (Knox 1991; Richardson 2003). This suggests more suburban communities will follow the lead of Tysons and Merrifield with redevelopment measures. These supposedly holistic planning practices could be a superficial way of catering to middle and upper income classes (Knox 1991; Pendall et al. 2006). Well-designed communities (or the appearance of well-

designed communities) present no benefit for low-income households if affordable housing is not available. The discussion section will elaborate on this dilemma in more detail.

**Figure 12: Suitability of Land Parcels**

Suitability Level	Number of Parcels	Percentage of Parcels
Extremely High	3091	0.9%
High	72140	20.1%
Medium – High	173556	48.5%
Medium – Low	90968	25.4%
Low	17488	4.9%
Extremely Low	938	0.3%

**Figure 23: Histogram of Land Parcel Suitability Distribution with Natural Breaks** (Calculated using 255 natural break categories for every input factor before the weighted overlay, see methodology appendix to distinguish this calculation from the model’s methodology. Due to extremely large amount of land parcels, ArcGIS calculates this histogram with a sample size of parcels.)

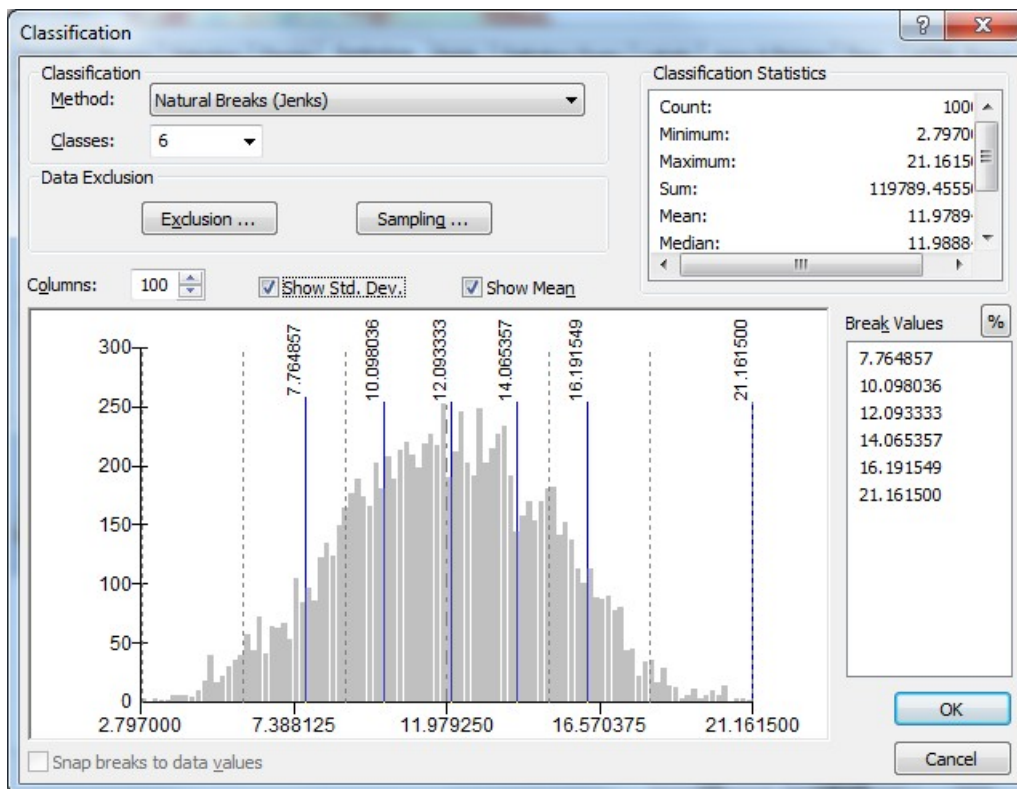
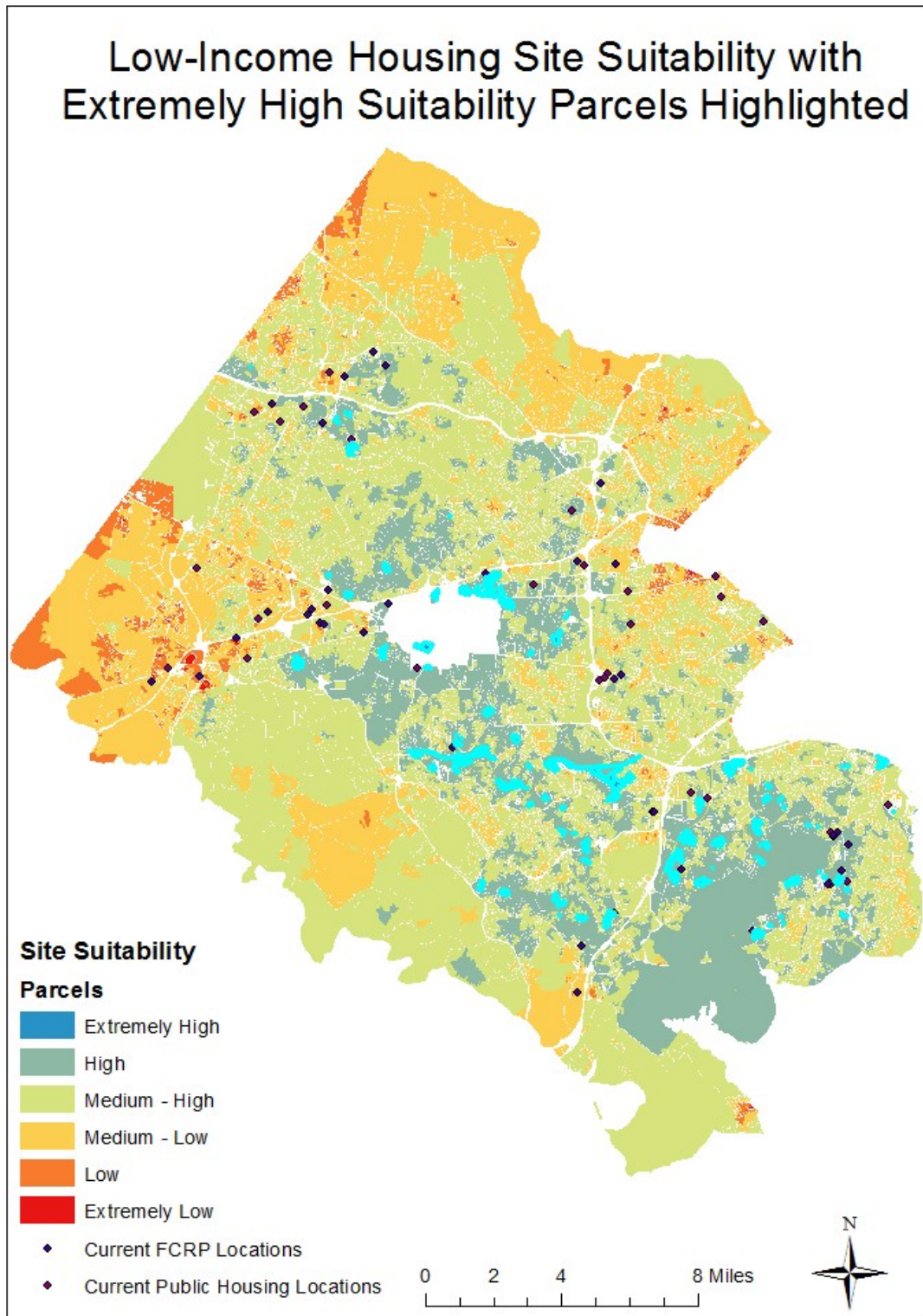




Figure 14:



3. *The suitability of existing low-income housing developments in Fairfax County is very similar to the distribution of land parcel suitability for low-income housing.*

Figure 7 also displays Fairfax County's existing low-income housing developments.

There is a lack of low-income housing development in the high scoring mid-county neighborhoods, a spatial mismatch within the Beltway, and an obvious spatial mismatch in the southwest corner of the county. Figures 15 – 18 quantify the suitability of Fairfax's low-income housing developments. The distribution of developments by suitability level aligns with Figure 12's distribution of land parcel suitability. Over 70 percent of the existing developments fall within the medium – high to high suitability range. This is almost identical to the 68 percent of parcels that fall within that same range.

In splitting Fairfax's developments by low-income housing program, 66 percent of public housing locations and 76 percent of FCRP locations have a medium – high to high suitability score. The FCRP is implemented at a more local scale compared to public housing's federal backing ([fairfaxcounty.gov](http://fairfaxcounty.gov)). FCRP also targets higher incomes ([fairfaxcounty.gov](http://fairfaxcounty.gov)). It could therefore be easier to implement FCRP developments in more suitable areas due to stronger economic and political backing. The dates for which each program's developments were sited could also influence suitability, with more recent dates facing limited opportunities due to Fairfax's rapid urbanization. Although it is shown that 67 percent of voucher households reside in medium - high to high scoring parcels, it is important to note that this calculation is arbitrary because voucher households are aggregated by block group to protect the identity of voucher holders.

While the relatively high suitability scores of existing developments could verify the success of low-income housing planning in Fairfax County, *no* existing developments have extremely high suitability scores. Optimal locations may have been seized by other types of

development with stronger support. In addition, a lack of extremely high scoring parcels lowers the chances for developments to be located in optimal locations. These results imply a constricted ability of planners to implement low-income housing in optimal locations. However, the overall medium – high to high suitability scores in Fairfax suggest planning has been successful in executing the next best options.

Planners should seek to site low-income housing developments in optimal locations, but as noted earlier, any low-income housing is better than none at all given the historic concerns of housing stock supply. Given the abundance of medium to medium – high scoring parcels in Fairfax County, low-income housing developments are most likely to be located in parcels with decent suitability. Although it remains unclear what suitability level is necessary for low-income households to benefit from assisted housing, it is reasonable to assume that the higher the suitability level, the better the chances are for low-income households to maximize success in utilizing assisted housing programs.

**Figure 15: Suitability of Existing Low-Income Housing Development**

<b>Suitability Level</b>	<b>Number of Developments</b>	<b>Percentage of Developments</b>
Extremely High	0	0%
High	20	30.8%
Medium – High	26	40.0%
Medium – Low	14	21.5%
Low	4	6.2%
Extremely Low	1	1.5%

**Figure 16: Suitability of Fairfax County Rental Program Developments**

<b>Suitability Level</b>	<b>Number of Developments</b>	<b>Percentage of Developments</b>
Extremely High	0	0%
High	11	34.4%
Medium – High	10	31.3%
Medium – Low	7	21.9%
Low	3	9.4%
Extremely Low	1	3.1%

**Figure 17: Suitability of Public Housing Developments**

<b>Suitability Level</b>	<b>Number of Developments</b>	<b>Percentage of Developments</b>
Extremely High	0	0%
High	9	27.3%
Medium – High	16	48.5%
Medium – Low	7	21.2%
Low	1	3.0%
Extremely Low	0	0%

**Figure 18: Suitability of Vouchers**

<b>Suitability Level</b>	<b>Total Number of Voucher Households</b>	<b>Percentage of Vouchers</b>
Extremely High	2505	1.05%
High	50787	21.35%
Medium - High	107144	45.04%
Medium - Low	61295	25.77%
Low	15298	6.43%
Extremely Low	856	0.36%

4. *The domination of single family residential land zoning in Fairfax County decreases suitability scores, but does not diminish the chances for low-income housing development.*

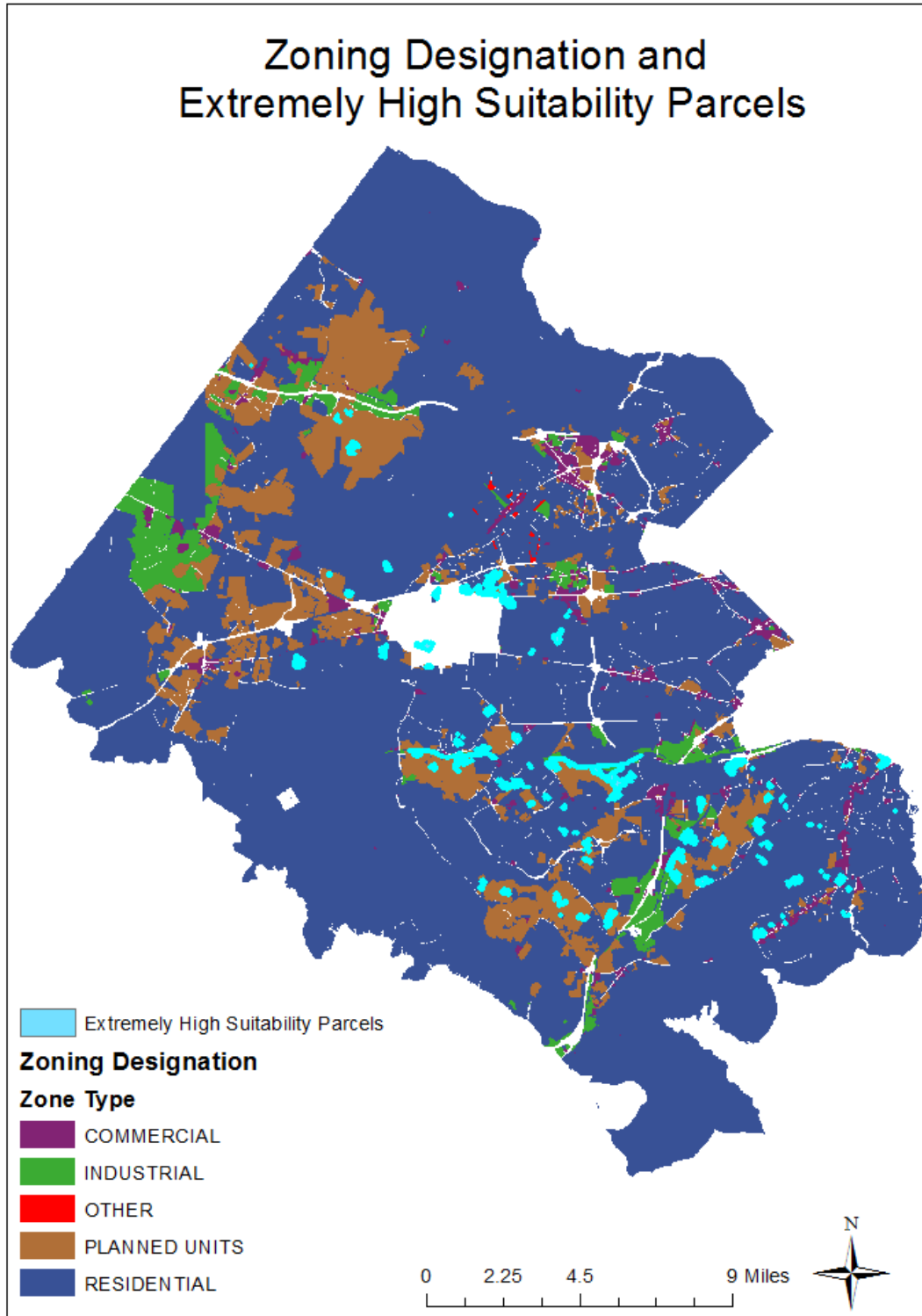
A major factor not incorporated into the model is Fairfax County's land zoning. Figures 19 and 20 illustrate the zoning designations of the most suitable parcels. The majority of the extremely high scoring parcels are already residential, which is not surprising given that much of Fairfax is a massive blend of suburbs. The domination of residential zoning could be the reason for so few extremely high scoring parcels in the first place. A tighter ratio of residential to commercial zoning would permit more optimal location amenities, forming a more suitable environment for low-income housing.

On the other hand, much of Fairfax County is already zoned appropriately for low-income housing. Many parcels are zoned for multifamily units, and those that are not are most likely single family residential. This is favorable for low-income housing development, as zoning up is often easier than downzoning. Downzoning from a more intense land use (e.g. commercial), to a less intense land use (e.g. residential) is difficult because "downzoning usually experiences a decrease in value due to the loss of potential development" (Richardson 2003, p.60). Residential zoning may diminish optimal locations, but it should not have a detrimental effect on the implementation of low-income housing. Indirect effects of land zoning, however, can severely affect the chances for affordable housing development. Harsh neighborhood opposition to low-income housing (and multi-family housing in general) is more likely to manifest in neighborhoods zoned as single-family residential (Swanstrom et al. 2004; Raphael and Stoll 2010).

Over a third of the extremely high scoring parcels are zoned as Planned Development Housing (PDH). This type of residential zoning encourages creative and efficient design methods

that are favorable for low-income households (Fairfax County Zoning Ordinance 2012). It is not coincidental that many of the highest scoring parcels in Fairfax County are located in PDH designations with high access to location amenities. PDH locations are more walkable, have more open space, and include more desired features, but also tend to attract middle and upper income groups (Knox 1991). However, part of the intent of PDH is “to encourage the provision of dwellings within the means of families of low and moderate income” (Fairfax County Department of Planning and Zoning). More PDH development could be the key to successful low-income housing planning in Fairfax County. It is vital to ensure that low-income dwellings remain incorporated into PDH zoning.

Figure 19:



**Figure 20: Zoning Designation of Extremely High Suitability Parcels (Table)**

<b>Zone Code</b>	<b>Zoning Designation</b>	<b>Zoning Type</b>	<b>Number of Parcels</b>
PRC	Residential Development	Residential - Planned Development Housing	632
R-20	Residential - 20 Dwelling Unit Per Acre	Residential - Multi-Family	606
R-8	Residential - 8 Dwelling Unit Per Acre	Residential - Attached and Detached	400
R-3	Residential - 3 Dwelling Unit Per Acre	Residential - Attached and Detached	339
R-5	Residential - 5 Dwelling Unit Per Acre	Residential - Attached and Detached	291
PDH-3	Residential - 3 Dwelling Units Per Acre	Residential - Planned Development Housing	190
R-1	Residential - 1 Dwelling Unit Per Acre	Residential - Attached and Detached	142
R-12	Residential - 12 Dwelling Unit Per Acre	Residential - Multi-Family	99
PDH-4	Residential - 4 Dwelling Units Per Acre	Residential - Planned Development Housing	89
PDH-2	Residential - 2 Dwelling Units Per Acre	Residential - Planned Development Housing	55
PDH-5	Residential - 5 Dwelling Units Per Acre	Residential - Planned Development Housing	44
C-6	Community Retail	Commercial - Office - Retail	37
R-2	Residential - 2 Dwelling Unit Per Acre	Residential - Attached and Detached	36
PDH-20	Residential - 20 Dwelling Units Per Acre	Residential - Planned Development Housing	26
PDH-12	Residential - 12 Dwelling Units Per Acre	Residential - Planned Development Housing	22
PDH-8	Residential - 8 Dwelling Units Per Acre	Residential - Planned Development Housing	19
R-4	Residential - 4 Dwelling Unit Per Acre	Residential - Attached and Detached	15
I-5	Industrial General	Industrial	12
C-8	Highway Commercial	Commercial - Office - Retail	11
PDH-16	Residential - 16 Dwelling Units Per Acre	Residential - Planned Development Housing	7
R-C	Residential Conservation	Agricultural - Conservation	6
PDC	Planned Development Commercial	Commercial - Office - Retail	4
I-3	Industrial Light Intensity	Industrial	3
I-4	Industrial Medium Intensity	Industrial	2
PD-R	Residential	Residential - Planned Development Housing	2
C-5	Neighborhood Retail	Commercial - Office - Retail	1
R-30	Residential - 30 Dwelling Unit Per Acre	Residential - Multi-Family	1



5. *Fairfax County supervisor districts with a Democratic supervisor are more suitable for low-income housing development, and have better sited low-income housing developments than supervisor districts with a Republican supervisor.*

Incorporating Fairfax's supervisor districts helps simplify spatial patterns, as well as relate Fairfax's low-income housing suitability scores to the county's political environment. All supervisor districts have an approximately equal population, with one elected supervisor to serve on Fairfax County's Board of Supervisors. The Board's responsibilities include establishing county government policy, passing resolutions and ordinances, approving budgets, setting local tax rates, approving land use plans, and making appointments to various positions (Fairfax County, VA 2013). Out of the nine supervisor districts, six have a Democratic supervisor, and three have a Republican supervisor. The three Republican districts are clustered in the southwest corner of the county (Figure 21). Because the majority of districts have Democratic supervisors, most land parcels in Fairfax fall within Democratic districts. In addition, the three Republican districts (particularly Sully and Springfield) tend to have larger land parcels, contributing to the smaller total number of parcels in Republican districts. As outlined earlier, the highest scoring parcels for low-income housing development are located in the middle ring suburbs, while the inner and outer suburbs have lower suitability scores (Figure 22).

Compared to Republican districts, Democratic districts have more existing low-income housing developments in total, and more developments that sit within high scoring land parcels for low-income housing development (Figure 23). Although the Republican districts have fewer land parcels, the Democratic districts have a larger percentage of high to extremely high scoring parcels for low-income housing development (22 percent of Democratic parcels, 12 percent of Republican parcels). What is most striking is the disparity between the percentages of low-income housing developments that sit within high scoring parcels. 39 percent of developments in

Democratic districts (18 developments) sit within high scoring parcels, compared to only 11 percent of Republican districts (2 developments). Lee (Democratic) is the highest ranking district for the percentage of high to extremely high scoring parcels, and has seven developments within that suitability range (Figure 24). On the other hand, Braddock (Republican) is the second ranked district for the percentage of high to extremely high scoring parcels, but only has 2 developments within that suitability range.

These results show that supervisor districts with a Democratic supervisor are more likely to have higher scoring land parcels for low-income housing development compared to districts with a Republican supervisor. This highlights more location amenities and favorable neighborhood characteristics in Democratic districts, in part reflecting more urban neighborhoods. In addition, it reflects the more Democratic political affiliations of urban areas. More low-income housing developments in Democratic districts show stronger support and implementation of low-income housing by the Democratic Party in Fairfax County. In addition, a higher percentage of low-income housing developments in high scoring parcels displays low-income housing's emphasized political agenda versus other land use interests in Democratic districts. It appears that Republican districts are less invested in low-income housing, but further research is necessary to solidify this claim.

Figure 21:

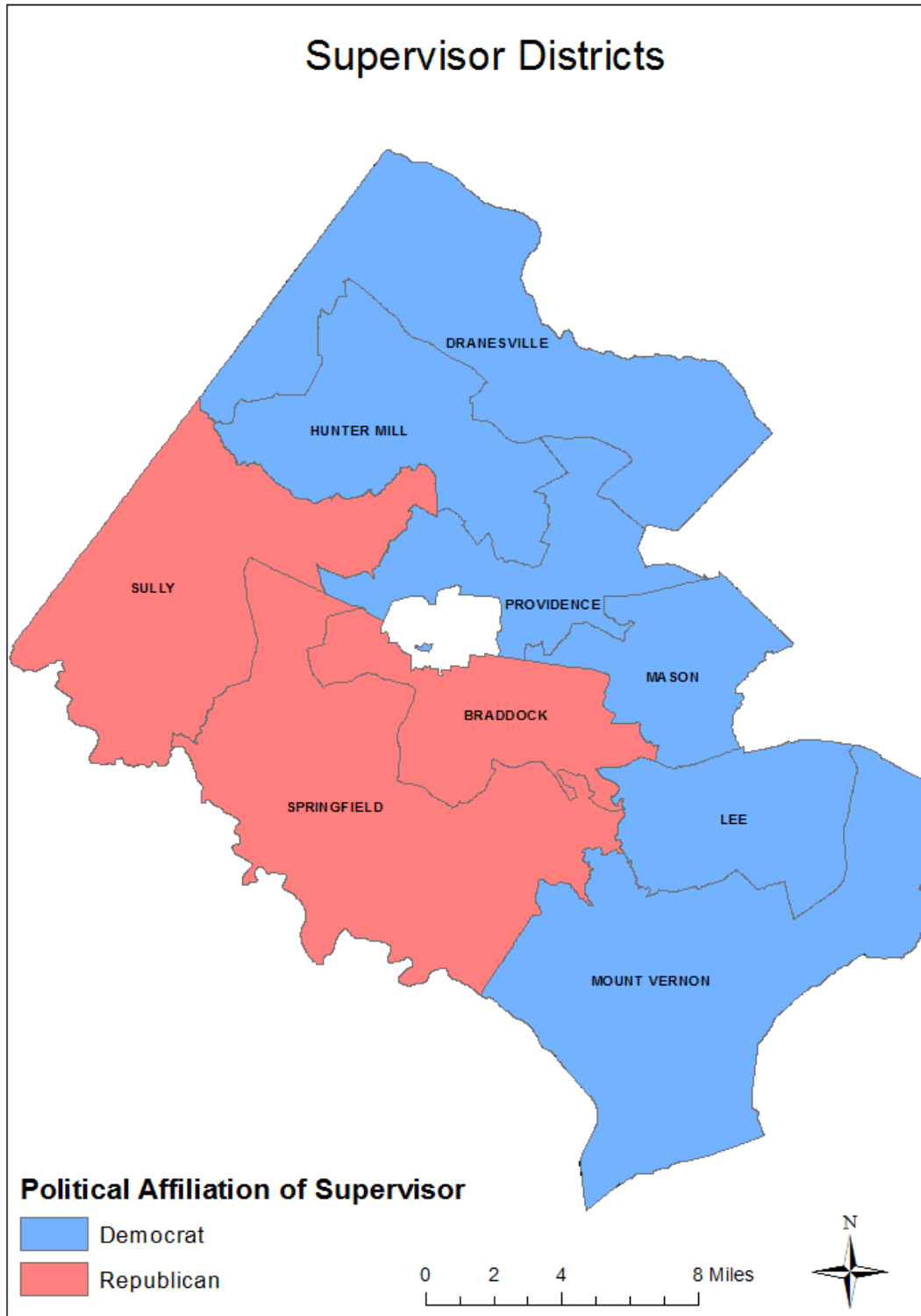
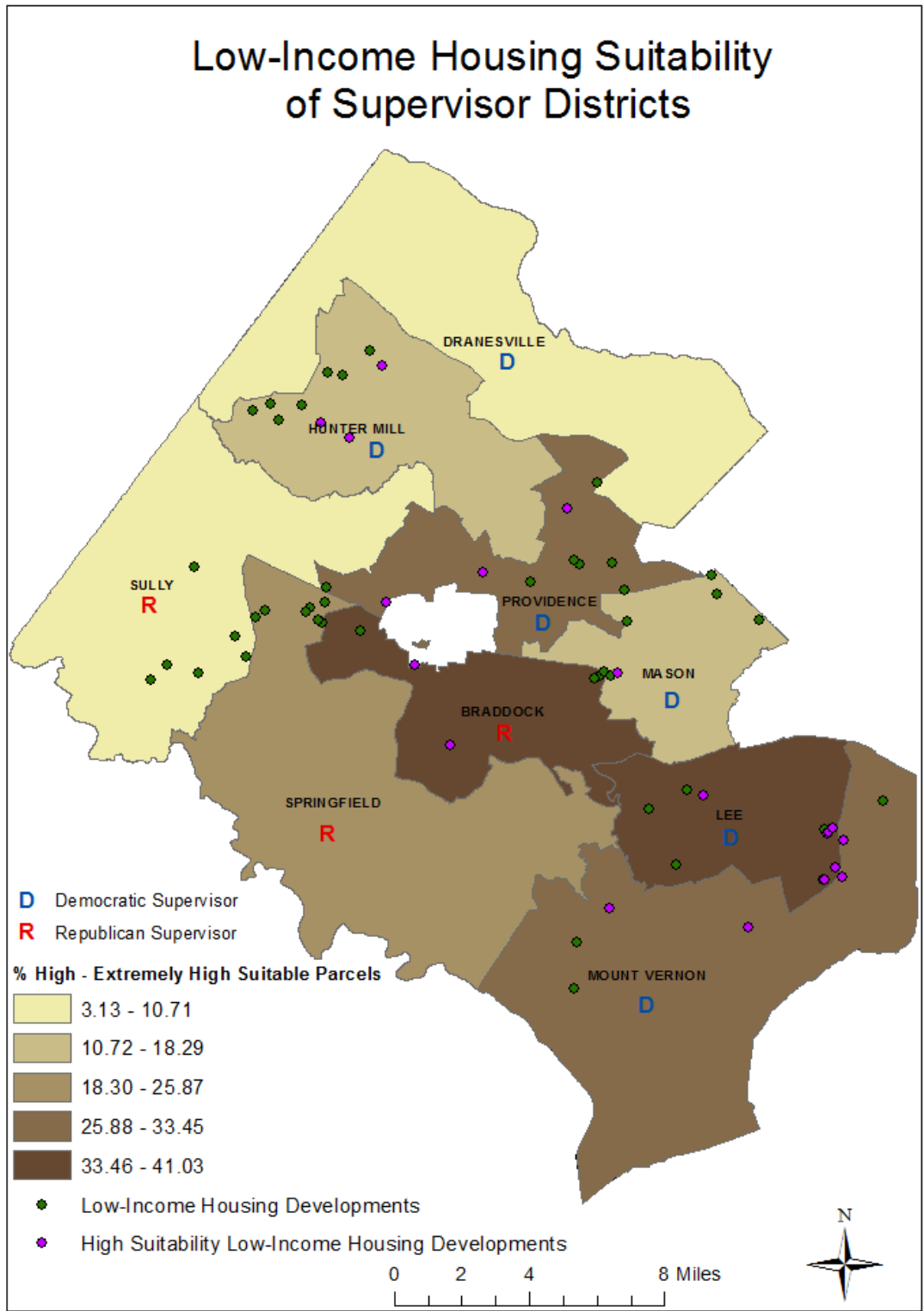


Figure 22:



**Figure 23: Suitability of Parcels and Low-Income Housing Developments by Supervisor District Political Party**

	<b>Democratic Supervisor Districts</b>	<b>Republican Supervisor Districts</b>
Total Number of Land Parcels	238751	120118
Number of High - Extremely High Suitable Parcels	51349	14356
Percent of High - Extremely High Suitable Parcels	21.51	11.95
Total Number of Developments	46	19
Number of High - Extremely High Suitable Developments	18	2
Percent of High - Extremely High Suitable Developments	39.13	11.11

**Figure 24: Suitability of Parcels and Low-Income Housing Developments by Supervisor Districts**

<b>Supervisor District</b>	<b>Political Party of Supervisor</b>	<b>Percentage High - Extremely High Suitable Parcels</b>	<b>Total Number of Developments</b>	<b>Number of High - Extremely High Suitable Developments</b>
Lee	Democrat	41.03	13	7
Providence	Democrat	30.02	11	3
Hunter Mill	Democrat	17.7	10	3
Mount Vernon	Democrat	25.98	7	4
Springfield	Republican	20.91	7	0
Braddock	Republican	38.18	6	2
Sully	Republican	3.13	6	0
Mason	Democrat	10.72	5	1
Dranesville	Democrat	3.89	0	0

6. *The suitability and siting of specific low-income housing developments is complicated, and individual location amenities have the potential to drastically increase a neighborhood's low-income housing suitability scores.*

A case study of two low-income housing developments exposes the power of specific location amenities. As seen in Figure 25, the chosen developments are Stonegate Village in Reston (Figure 26), and Castellani Meadows in Centreville (Figure 27). Both developments are situated along transportation corridors in the slightly newer and more affluent suburbs of western Fairfax. Stonegate Village lies within a highly suitable neighborhood for low-income housing, while Castellani Meadows's neighborhood is much less suitable. Both developments are a part of the Fairfax County Rental Program.

Stonegate Village is financed through a combination of Section 236, the LIHTC, and Section 8 Subsidies. Castellani Meadows is financed exclusively through the LIHTC. More direct government subsidies could have required Stonegate Village to be located near optimal location amenities. Since Castellani Meadows relies solely on the LIHTC, site location may have been more contingent upon developer preferences (Baum-Snow and Marion 2009). Because a "LIHTC developer's choice of building location is likely to be influenced by expectations about future rents in the neighborhood" (Baum-Snow and Marion 2009), the siting of Castellani Meadows may have been more motivated by profit than Stonegate Village. Cheaper land further to the southwestern fringe of Fairfax may have been more desirable for the siting of Castellani Meadows.

Revealing the targeted income levels provides greater clarity for the geography of these developments. Stonegate Village targets the income range of \$15,912 - \$37,650 for one bedroom households, or under 50 percent AMI, while Castellani Meadows's target income level is \$27,699 - \$45,180 for one bedroom households, or about 50 – 60 percent AMI. Stonegate Village's lower

targeted income range requires multiple funding sources, with more direct federal funding.

Compared to lower income households, the more moderate income households of Castellani Meadows are better suited for the surrounding built environment. A tenant making over \$40,000 annually can likely afford a car and is less reliant on optimal location criteria.

Figure 25 displays a one-mile radius around each of the developments. Walking distance is often considered to be half a mile, but many people are willing to walk further distances for certain amenities such as public transportation (O'Sullivan and Morrall 1996; Leslie et al. 2007). Figure 28 shows the number of location amenities and neighborhood characteristics within a one-mile radius for each development. Surprisingly, Castellani Meadows fares better in almost every category than Stonegate Village. The only category where Stonegate Village is better suited for low-income housing development is in the number of Metrorail stations. Stonegate Village's one Metrorail station compared to none for Castellani Meadows reveals how a specific location amenity can significantly change a neighborhood's suitability scores. This Metrorail station at Reston Town Center is not yet constructed, as the Silver Line is still being constructed out to Dulles Airport. Not factoring in the Silver Line's future development could have drastically decreased suitability levels along the Dulles Toll Road.

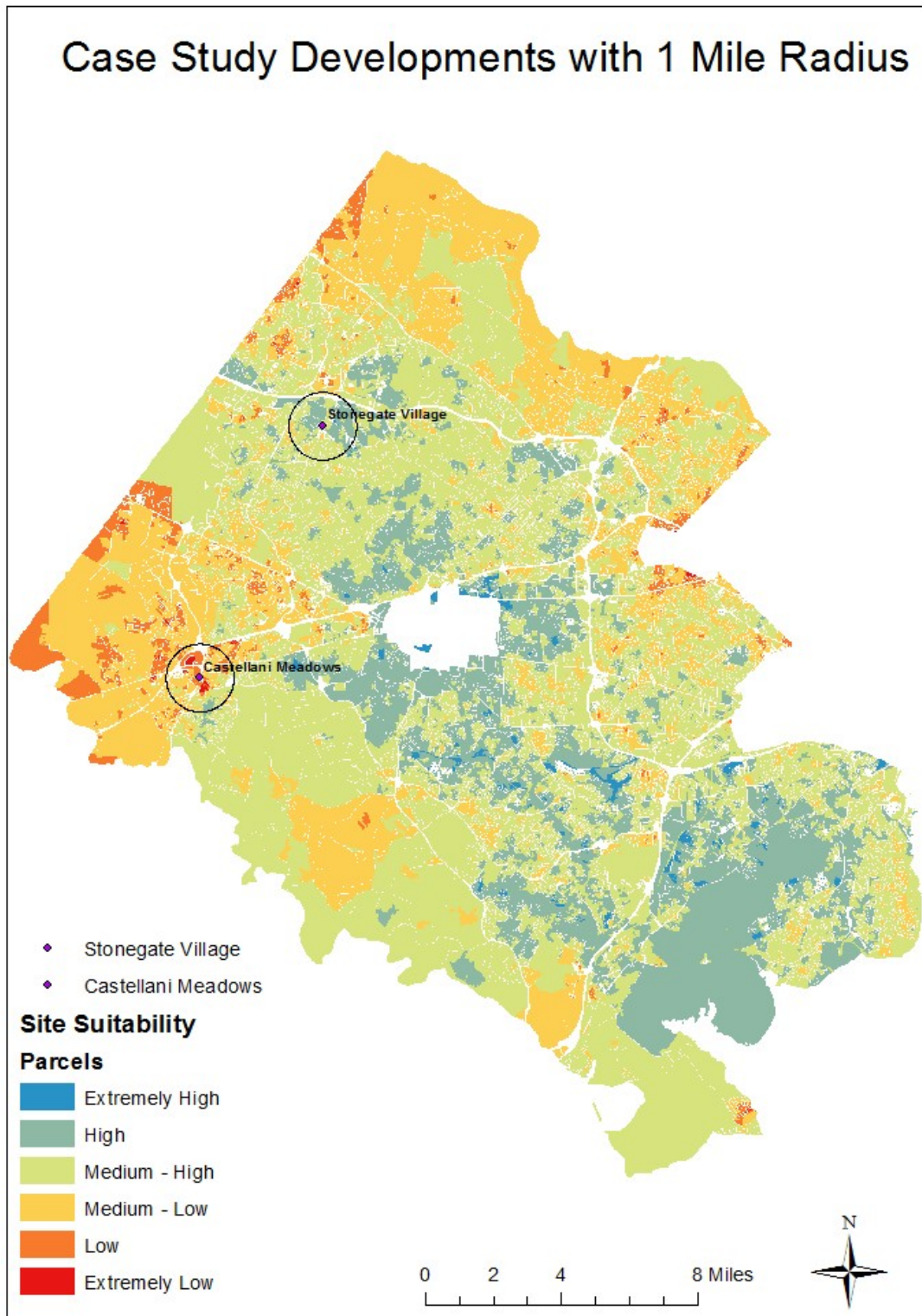
This case study exposes the dilemma of weighting input factors. Adjusting the weights can significantly alter suitability scores across the county. Had Metrorail stations not been weighted as high, Castellani Meadows would have a higher suitability score than Stonegate Village. This example also reveals the power of high-valued location amenities, as one Metrorail station significantly improves the opportunities for low-income households. Transit-oriented development (TOD) is a hot topic in modern urban planning, and incorporating low-income

housing into TOD is a great way to ensure low-income housing is implemented in optimal locations (Tumlin and Millard-Ball 2003).

The aggregate landscape outside of the one-mile radius plays a huge role in the suitability of these areas. The model's cost distances are not based off of one mile distances from each feature, but off of continuous surfaces across the county. Being a mile and half from a feature is still highly valued relative to further distances. If these two one-mile radiuses were incorporated into the model in isolation, Castellani Meadows would have a higher suitability score than Stonegate Village. Just over a mile from Stonegate Village is the mixed-use and walkable Reston Town Center, and nearby development associated with Dulles Airport. Outside Castellani Meadows's mile radius there is little development favorable for low-income housing (relative to Reston). It is also important to emphasize that a low suitability score does not necessarily mean that a location is terrible for low-income households to live. It simply means that the location is not ideal according to the determined criteria.



Figure 25:



**Figure 26: Stonegate Village**



**Figure 27: Castellani Meadows**



**Figure 28: Location Attributes within 1 Mile of Low-Income Housing Case Study Developments**

<b>Development</b>	<b>Number of Child Care Locations</b>	<b>Number of Medical Care Facilities</b>	<b>Number of Schools</b>	<b>Number of Shopping Centers / Grocery Stores</b>	<b>Number of Metrorail Stations</b>	<b>Number of Bus stops</b>	<b>Total Crime Incidents</b>	<b>Total Jobs</b>	<b>Average Poverty Score (Block Groups)</b>	<b>Average Population per Square Mile (Block Groups)</b>
Stonegate Village	3	0	2	1	1	0	1499	983	163	6543
Castellani Meadows	6	2	2	8	0	0	1535	1766	92	7225

Fairfax’s heavily developed suburban landscape is characterized by a majority of medium – high to high scoring parcels for low-income housing development. From this perspective, low-income housing planning can be considered much less constricted than originally thought. Future research that employs sensitivity modeling could analyze how the incorporation of specific location amenities in strategic locations affect parcel suitability scores (further discussed in the methodology appendix). The model also reveals a shortcoming of planners to implement low-income housing in optimal locations. As noted, no existing developments fall within the extremely high suitability category. The model’s results also highlight urban planning’s inability to produce a sufficient number of complete communities. A small number of extremely high scoring parcels generates concern for suburban development patterns. While planners should strive to improve site selection processes, infusing more accessible location amenities into the suburban landscape is a more realistic goal in light of competing real estate interests and other forces constricting low-income housing planning. The outlook is optimistic, as creative and holistic planning methods like planned development housing and transit-oriented development seek to craft complete communities while implementing low-income housing.

## Discussion

It first needs to be reiterated that Fairfax County's overall low-income housing suitability scores were better than originally anticipated. The heavily developed suburban landscape yields numerous location amenities, and the existing low-income housing developments for the most part reflect Fairfax's successful affordable housing initiatives. That being said, Fairfax County's complete absence of existing low-income housing developments in extremely suitable locations for low-income housing is troublesome. Low-income housing planning that emphasizes optimal location amenities and neighborhood characteristics can aid in the siting of low-income housing developments in more suitable locations. However, optimal locations for low-income housing are likely to be desired by other development types. Whether for more upscale housing units, retail, or office parks, location characteristics such as low crime and access to public transportation are highly desirable. Low-income housing interests must compete with other interests that have stronger economic and political backings. Coordinated efforts of housing, transportation, and other initiatives are necessary to improve suburban low-income housing location. Unfortunately, the fragmented nature of suburban planning and policy groups presents difficulties for adequate coordination (Weisbrod et al. 1980; Allard and Roth 2010).

Of greater concern is Fairfax County's lack of complete communities ripe for low-income housing development. If Fairfax County is representative of suburban America, then suburban low-income housing initiatives seem fruitless. The mass production of sprawling, single-family houses and strip malls connected by large freeways fragments the suburban landscape (Short et al. 2007; Allard and Roth 2010). Rambling development yields numerous location amenities, but in a poorly integrated fashion for low-income housing. In addition, the tainted history of low-income housing programs (Bauman et al. 2000; Fairbanks 2000; Radford

2000), institutional racism (Bogdon and Can 1997, Squires and Kubrin 2005; Turner et al. 2009), public opposition (Nguyen 2005; Tighe 2010), and real estate interests catering to the private market (Pendall et al. 2006; Chakraborty et al. 2010) continuously counteract suburban low-income housing initiatives. Instead of attempting to navigate the siting of low-income housing developments around these immense barriers, policymakers and planners should strive to improve the suburban landscape through the use of innovative planning methods that can produce more equitable suburban regions, while simultaneously appeasing real estate motives.

A shifting planning paradigm emphasizing new urbanism ideals reflects the American public's dismay towards the cookie-cutter, suburban experience. Demographics, economic circumstances, and social trends have contributed to evolving neighborhood preferences. Modern planning practices reflect these preferences, and can improve low-income housing location planning. However, initiatives to combat soaring rents, exclusionary land use regulations, and gentrification are necessary for low-income households to benefit from such practices.

Demographics strongly influence urban development and design preferences (Nelson et al. 2007). The aging Baby Boomers desire luxury condos and senior living communities with higher amenity access. At the same time, the rapid growth of single-person households and childless families calls for more urban and rental housing (Nelson et al. 2007; Kannan 2010). The coming to age of the 80 million Echo Boomers, also known as Generation Y, has had a substantial impact on real estate practices. Born between 1979 and 2000, and representing more than 25 percent of the population (Kirk 2011), Echo Boomers are moving mostly to urban and semi-urban communities. Only 12 percent of Echo Boomers are moving into traditional suburbs (Kannan 2010). Echo Boomers prefer mixed use development, high walkability to work and

shops, public transportation, and diverse communities (Kannan 2010). Providing affordable units is a must for developers to tap into this large market, as the Echo Boomers have been financially burdened by poor economic conditions (Kirk 2011).

Modern planning practices have also surfaced in light of economic and social circumstances. The economic recession, weak employment, and student loan debt have led young professionals to delay marriage, purchasing a home, and having children (Kirk 2011). Urban living is becoming increasingly desired over the traditional suburban lifestyle, as younger generations prefer more diverse and sociable neighborhoods (Kannan 2010). Low-income households benefit from this trend with a heightened focus on rental housing, and increased location amenities incorporated into residential planning.

Contemporary planning practices including new urbanism, smart growth, transit-oriented development, and planned-unit development are better suited for low-income housing, and reflect a changing planning paradigm. Song and Knaap (2003, p.220) summarize this transition: “there is a demand for denser, more walkable residential environments in the United States as a whole, and the growing demand is a result of changing demographics, changing tastes, and the closing of the suburban frontier.” New urbanism, which has been coined as “the most significant movement in urban planning and architecture in this century” (Song and Knaap 2003, p.218), epitomizes the modern planning perspective. It promotes high density, mixed use development, public transportation, walkability, and social interaction facilitated by design (Song and Knaap 2003). The Congress for the New Urbanism (CNU) also stresses a range of housing choices including low-income housing, and accessible schools, shops, and other location amenities (CNU). Another popular and related planning movement is the smart growth movement, which directs development towards already urbanized areas or to where growth is desired (Richardson

2003; Downs 2005). The most common smart growth principles are limiting sprawl, increasing density, mixed use development, public transportation, and revitalizing older existing neighborhoods. According to Downs (2005), creating more affordable housing is also a smart growth principle, but less universally advocated.

Transit-oriented development (TOD) is a specific planning method employed by new urbanism and smart growth advocates. TOD incorporates mixed use development with more housing and jobs near public transportation, aiming to establish communities with higher densities, less automobile dependence, and an improved quality of life. Adequate affordable housing is an essential initiative for successful TOD. Tumlin and Millard-Ball (2003, p.2) explain, “since low-income households tend to own fewer cars and are more likely to use transit, an affordable housing component of a transit-oriented development can add more riders, as well as furthering other public policy objectives.” Another land use measure at planners’ disposal is planned-unit development, or PUD (similar to PDH mentioned in the results section). PUDs design communities with optimal location amenities and neighborhood characteristics by applying land use regulations to entire land parcels, as opposed to lot by lot. This allows for more holistic planning of entire neighborhoods, thereby increasing density, creating more open and park space, and facilitating mixed use development (Knox 1991).

Skeptics of modern planning practices worry that these methods are merely a façade of flashy redevelopment, catering to middle and upper income groups (Knox 1991; Shibley 1998; Pendall et al. 2006). Land use regulations can raise amenity levels, but in turn increase housing prices. Complete communities are potentially only accessible to more affluent residents, furthering metropolitan fragmentation (Pendall et al. 2006). In addition, PUDs tend to employ only one developer, giving one entity the ability to cater to specific income or social groups

through neighborhood design. While low-income households could benefit from this specialization, middle and upper income groups are usually targeted for developers to increase profit. The result is that PUDs often become isolated fortresses from surrounding suburbs, as opposed to complete communities offsetting suburban disparities (Knox 1991). No matter how suitable for low-income housing these communities may be, they are irrelevant for low-income households if affordable units are neither included, nor emphasized.

Gentrification is also a major concern for low-income housing advocates. The cheapest places to redevelop are blighted urban areas, where low-income households are already concentrated. The high demand for urban rental units increases rents, pricing low-income residents out to neglected inner suburbs (Lees et al. 2008). Redeveloping urban areas around public transportation and with adequate location amenities is a costly endeavor, leading developers to build luxury urban lofts with swanky neighborhood features to attract wealthier consumers (Lees et al. 2008; Pattillo 2009). Incorporating low-income housing and crafting policies to combat gentrification is necessary for low-income households to benefit from the shifting planning paradigm.

Modern planning practices emphasizing new urbanism ideals have become more marketable (Shibley 1998; Song and Knaap 2003; Nelson et al. 2007), as reflected by the concern that these practices are increasingly utilized for upper income initiatives. Developers realize that consumers favor approaches that promote environmental standards, cater to healthy living habits, and provide diverse housing options. Affordable housing options may be a necessity for developers to compete for consumers. Whether motivated by profit or social equity, modern planning practices are advantageous for low-income households if adequate affordable housing is incorporated.



Another facet of the evolution of urban development is the increased reliance on comprehensive planning (Feiock 2004). Most localities (including Fairfax County) use comprehensive plans to “mitigate conflicts between different land uses,” and function “to coordinate such related issues as transportation, economic development, housing, parks, and recreation” (Pendall et al. 2006, p.3). Comprehensive plans have great authority in deciding local development patterns, increasing the chances for more equitable and holistic development (Feiock 2004). Comprehensive planning allows localities to set guidelines or rules for development, such as establishing minimum quantities for low-income housing. The shifting planning paradigm has great potential to benefit low-income households, but policymakers and planners must actively seek to ensure that affordable housing is implemented within these practices.

While many of the auspicious planning mechanisms for low-income housing are gaining momentum, they are ambitious. However, marginal location improvements can make huge impacts on the suitability of neighborhoods for low-income housing. Instead of revitalizing entire suburban regions, it might be more prudent to simply incorporate single location amenities. For example, an adequate bus system in particular is an easy way to serve low-income households, and can serve as a temporary remedy while more ambitious plans are proposed and vetted. It is possible to increase low-income housing suitability in suburban neighborhoods if policymakers and planners work to incorporate specific location amenities in strategic locations.

### **Conclusion**

Planning for low-income rental housing in the United States has traditionally been constricted by legacies of government policies, institutional racism, an emphasis on

homeownership, and real estate interests. These factors need to be reexamined within the suburban context as low-income populations in American suburbs increase. While some inner city disparities such as crime and unemployment are not as rampant in the suburbs, suburban poverty is heavily concentrated with related disparities. The suburban landscape is especially troublesome for the success of low-income households because many of the processes that traditionally hindered marginalized populations also helped form the suburban realm. Additional obstacles such as a lack of social services, political fragmentation, and massive distances impair low-income household success in suburban neighborhoods. The geography of suburbs is a product of planning for homeownership, freeways, office parks, and sociopolitical instruments that place marginalized populations at a disadvantage. Even in Fairfax County, whose affordable housing efforts have been highly commended (and supported by this study), the success of low-income rental housing programs is limited by the suburban realm's lack of optimal locations for low-income housing developments.

Using a low-income housing site suitability model, this study reveals a mildly constricted ability of planners to implement low-income housing in locations with favorable amenities and neighborhood characteristics. Besides specific geographic mismatches, most existing low-income housing developments in Fairfax County are located within medium to high scoring land parcels for low-income housing suitability. However, in order to improve low-income housing programs, planners must stress more holistic planning methods. The limited availability of extremely suitable parcels for low-income housing development in Fairfax County calls for a rethinking of suburban land use patterns and design methods, not necessarily better site selection methods.

This research is not meant to tarnish planning practices that cater to the market or noteworthy constituents, but it does call for a more flexible planning paradigm open to all population groups. Planning low-income housing around optimal location amenities is challenging, but emerging practices can help implement more holistic planning methods. New urbanism, smart growth, transit-oriented development, and planned-unit development are increasing in popularity, and most importantly, becoming marketable. As long as these movements incorporate affordable housing into their methodology and refrain from becoming a façade of flashy redevelopment, the future will be optimistic for suburban low-income housing. Non-traditional suburban interests such as affordable housing, environmental conservation, and walkable / healthy communities coming together can produce more holistic suburbs. Coalitions of non-dominant interests can produce a strong alternative force, influencing policies and planning methods to rectify suburban development patterns that hamper the success of low-income households. For more immediate results, planners should strive to incorporate more location amenities across suburban regions, and in particular, near low-income housing developments.

This research demonstrates that the spatial mismatch of suburban low-income housing can be revealed by blending GIS methodology with critical social housing policy questions. While this research does not eliminate the constrictions of many planning decisions, it does equip policymakers and planners with a tool to reevaluate the low-income housing suitability of land parcels, and to rethink the spatial distribution of vital location amenities.

### **Limitations, Assumptions, and Future Work**

Acknowledging this research's limitations and assumptions is a prerequisite to outlining its methodology. Given the complexity of urban areas, no single model or body of research can

encompass all of the processes affecting low-income housing. A narrowed scope of the GIS model provides a snapshot of low-income housing suitability across Fairfax County.

Simplification is what bolsters the GIS model's power, in that it is unbound from many potential low-income housing planning constraints. However, limitations and assumptions are an outcome of such simplification.

The degree to which to certain income ranges are affected by specific location amenities and neighborhood characteristics is not clear. This research assumes that the lower the household income, the more it will be affected by and rely on optimal location amenities. The relationship of income level to location amenities is much more complicated in reality. As outlined in the study area section, households in Fairfax County with earnings under 50 percent AMI have the greatest need for housing assistance. Therefore, low-income housing suitability in this research applies to this income threshold. However, this is merely a general guideline, as there can be many exceptions.

The physical and logistical attributes of housing developments are ignored in this study. This includes overlooking building design, size, age, management, and overall quality. In reality, the type of development matters for the logistics of location siting. However, physical and logistical variations of low-income housing developments should not alter the suitability of a location based off of optimal location criteria. For example, a nearby school is likely to be considered favorable regardless of the development. Many exceptions to this generalization exist. Building designs can cater to specific income levels that are not affected by some location amenities. This research assumes that developments will be of appropriate quality, management, and design for its tenants.

This research is a precondition to factoring in household composition or where households previously resided. Household race, ethnicity, employment status, religion, or where friends and relatives reside are therefore excluded from the analysis. Realistically, these excluded factors could alter the suitability of locations for specific households. However, specific tenants are not known prior to low-income housing site selection. Therefore, the model does not factor in what households will ultimately reside in developments when computing low-income housing site suitability.

This research does not take stances on the crafting and implementation of low-income housing programs. It does not discuss how low-income housing should be defined, measured, or calculated, or comment on the qualifications for low-income housing. Levels of federal, state, and local government involvement, public versus private implementation, and funding sources are left out of the model. These specifics are reserved for the discussion section. The only exception is the emphasis on incorporating optimal location amenities and neighborhood characteristics into low-income housing site selection.

Perhaps the largest limitation to this research is perspective. The author is not of a low-income population group, and has never lived in low-income housing. This research instead relies on existing research for low-income housing criteria, which is also not likely to be from a low-income household perspective. Any perspective other than those affected has some level of misinterpretation. Even low-income household perspectives can be tainted, due to a lack of education, preferences towards family and familiarity, and a number of other factors.

A distilled framework is necessary to produce meaningful results. Optimal location criteria for siting low-income housing are generalized based off existing literature. The GIS model's resulting site suitability scores are limited to the established list of location amenities

and neighborhood characteristics. The model ignores constricting factors that limit low-income housing location planning. This provides a hypothetical, blank slate required to determine low-income housing site suitability.

Finally, the following list presents suggestions for future work relative to this research.

- Sensitivity modeling to simulate how each location factor affects low-income housing suitability in Fairfax County.
- Deploying low and high risk linear weighted combinations to compare to this study's moderate risk approach.
- Interviewing low-income housing residents to adjust factor weights, and to add other secondary preference variables, such as distance to family, or ethnic composition of neighborhoods.
- Including limiting factors into the model (perhaps as constraints), such as land use zoning, existing development, and property values.
- Applying the model to other geographies, especially within the Washington, D.C. metropolitan region or other major suburbs in the United States.

## References

- (2008). Planning Support Systems for Cities and Regions. R. K. Brail. Cambridge, Massachusetts, Lincoln Institute of Land Policy.
- (2010). 2010 Demographic Profile. U. S. C. Bureau.
- (2010). "Tysons Comprehensive Plan." Retrieved December 13, 2012, 2012, from <http://www.fairfaxcounty.gov/tysons/comprehensiveplan/>.
- (2011). "CNU Congress for the New Urbanism." Retrieved February 24, 2013, 2013, from <http://www.cnu.org/>.
- (2012). 2007-2011 American Community Survey 5 year estimates. U. S. C. Bureau.
- (2012). "Child Care Search." 2012, from <http://www.fairfaxcounty.gov/childcare/search/>.
- (2012). "Fairfax County Rental Program." Retrieved December 13, 2012.
- (2012). "Fairfax County Economic Development Authority." Retrieved February 5, 2013, from <http://www.fairfaxcountyed.org/>.
- (2012). "GIS Data Layer Information." 2012, from <http://www.fairfaxcounty.gov/maps/metadata.htm>.
- (2012). "Glossary of HUD Terms." Retrieved December 13, 2012.
- (2012). "Longitudinal Employer-Household Dynamics." 2012, from <http://lehd.did.census.gov/>.
- (2012). "Ranking America's High Schools." Retrieved November 17, 2012, 2012, from <http://www.washingtonpost.com>.
- (2012). "TIGER Products." 2012, from <http://www.census.gov/geo/maps-data/data/tiger.html>.
- (2012). "Virginia High Schools." Retrieved November 17, 2012, 2012, from <http://www.usnews.com>.
- (2012). Zoning Ordinance. D. o. P. a. Zoning, Fairfax County.
- (2013). "Fairfax County, Virginia." Retrieved March 27, 2013, 2013, from <http://www.fairfaxcounty.gov/>.
- Abbot, A. (2012). 2011 Police Incident Reports by Block. F. C. P. Department.
- Abdi, H. and L. J. Williams (2010). "Principal Component Analysis." Wiley Interdisciplinary Reviews: Computational Statistics 2(4).
- Allard, S. W. and B. Roth (2010). Strained Suburbs: The Social Service Challenges of Rising Suburban Poverty, Brookings Institute.
- Al-Shalabi, M. A., S. B. Mansor, et al. (2006). GIS Based Multicriteria Approaches to Housing Site Suitability Assessment. Shaping the Change. Munich, Germany.
- Bauman, J. F., R. Biles, et al. (2000). From Tenements to the Taylor Homes. University Park, Pennsylvania, The Pennsylvania State University Press.
- Baum-Snow, N. and J. Marion (2009). "The Effects of Low-Income Housing Tax Credit Developments on Neighborhoods." Journal of Public Economics 93(5-6): 654-666.

- Biles, R. (2000). Public Housing and the Postwar Urban Renaissance, 1949 - 1973. From Tenements to the Taylor Homes: In Search of an Urban Housing Policy in Twentieth-Century America. R. B. John F. Bauman, Kristin M. Szylyan. University Park, Pennsylvania, The Pennsylvania State University Press.
- Bogdon, A. S. and A. Can (1997). "Indicators of Local Housing Affordability: Comparative and Spatial Approaches." Real Estate Economics **25**(1): 43-80.
- Bostock, L. (2000). "Pathways of Disadvantage? Walking as a Mode of Transport Among Low-Income Mothers." Health and Social Care in the Community **9**(1): 11-18.
- Briggs, X. d. S. (2005). The Geography of Opportunity: Race and Housing Choice in Metropolitan America. Washington, D.C., The Brookings Institution.
- Brooks, E. (2012). GIS Data Requests. V. T. Libraries, Virginia Tech Univeristy Libraries, Maps and GIS.
- Chakraborty, A., G.-J. Knaap, et al. (2010). "The Effects of High-density Zoning on Multifamily Housing Construction in the Suburbs of Six US Metropolitan Areas." Urban Studies **47**(2): 437-451.
- Chapman, N. J. and M. Ritzdorf (1986). "A Tradeoff Method to Assess Housing Location Preferences." Journal of Environmental Psychology **6**: 345-358.
- Clevenger, A. P., J. Wierzchowski, et al. (2002). "GIS-Generated, Expert-Based Models for Identifying Wildlife Habitat Linkages and Planning Mitigation Passages." Conservation Biology **16**(2).
- Clingermayer, J. C. (2004). "Heresthetics and Happenstance: Intentional and Unintentional Exclusionary Impacts of the Zoning Decision-making Process." Urban Studies **41**(2): 377-388.
- Collins, M. G., F. R. Steiner, et al. (2001). "Land-Use Suitability Analysis in the United States: Historical Development and Promising Technological Achievements." Environmental Management **28**(5): 611-621.
- Coulton, C., L. Leete, et al. (1999). Housing, Transportation, and Access to Suburban Jobs by Welfare Recipients in the Cleveland Area. The Home Front: Implications of Welfare Reform for Housing Policy. S. J. Newman. Washington, D.C., The Urban Institute Press.
- Crowley, S. (2003). "The Affordable Housing Crisis: Residential Mobility of Poor Families and School Mobility of Poor Children." Journal of Negro Education **72**(1).
- Downs, A. (2005). "Smart Growth: Why We Discuss It More than We Do It." Journal of the American Planning Association **71**(4): 367-378.
- Fairbanks, R. B. (2000). From Better Dwellings to Better Neighborhoods: The Rise and Fall of the First National Housing Movement. From Tenements to the Taylor Homes: In Search of an Urban Housing Policy in Twentieth-Century America. J. F. Bauman, R. Biles and K. M. Szylyan. University Park, Pennsylvania, The Pennsylvania State University Press.
- Fairfax (2012). Zoning Ordinance. F. C. D. o. P. a. Zoning, Fairfax County.
- Farkas, A. (2007). The Analysis of the Principal Eigenvector of Pairwise Comparison Matrices.
- Feiock, R. C. (2004). "Politics, Institutions, and Land-use Regulation." Urban Studies **41**(2): 363-375.
- Frankenberg, E., C. Lee, et al. (2003). A Multiracial Society with Segregated Schools: Are We Losing the Dream? The Civil Rights Project. Cambridge, Massachussets, Harvard University.
- Fuller, B., S. L. Kagan, et al. (2002). "Welfare Reform and Child Care Options for Low-Income Families." The Future of Children **12**(1): 96-119.



- Galster, G. C., P. Tatian, et al. (1999). "The Impact of Neighbors Who Use Section 8 Certificates on Property Values." Fannie Mae Foundation **10**(4).
- Garreau, J. (1991). Edge City: Life on the New Frontier. New York, New York, Doubleday.
- Gillette, H. (1995). Between Justice and Beauty: Race, Planning, and the Failure of Urban Policy in Washington, D.C. Philadelphia, University of Pennsylvania Press.
- Glaeser, E. L., M. E. Kahn, et al. (2008). "Why Do the Poor Live in Cities? The Role of Public Transportation." Journal of Urban Economics **63**(1): 1-24.
- Goepel, K. (2012). AHP Analytic Hierarchy Process (Multiple Inputs).
- Goering, J. M., H. Stebbins, et al. (1995). Promoting Housing Choice in HUD's Rental Assistance Programs: A Report to Congress, United States Department of Housing and Urban Development, Office of Policy Development and Research.
- Goetz, E. G. (2000). "The Effects of Subsidized Housing on Communities." University of Minnesota Extension.
- Goetzmann, W. N., M. Spiegel, et al. (1998). "Do Suburbs and Cities Cluster?" Cityscape: A Journal of Policy Development and Research **3**(3).
- Grigsby, W. G. and S. C. Bourassa (2003). "Trying to Understand Low-income Housing Subsidies: Lessons from the United States." Urban Studies **40**(5-6): 973-992.
- Halpern, R. (1995). Rebuilding the Inner City. New York, Columbia University Press.
- Hanchett, T. W. (2000). The Other "Subsidized Housing": Federal Aid to Suburbanization, 1940s - 1960s. From Tenements to the Taylor Homes: In Search of an Urban Housing Policy in Twentieth-Century America. R. B. John F. Bauman, Kristin M. Szylyvian. University Park, Pennsylvania, The Pennsylvania State University Press.
- Harney, B. (2009). "The Economics of Exclusionary Zoning and Affordable Housing." Stetson Law Review **38**(2).
- Hartung, J. M. and J. R. Heing (1997). "Housing Vouchers and Certificates as a Vehicle for Deconcentrating the Poor: Evidence from the Washington, D.C., Metropolitan Area." Urban Affairs Review **32**(3): 403-419.
- Hirsch, A. R. (1998). Making the Second Ghetto: Race & Housing in Chicago 1940 - 1960. Chicago & London, The University of Chicago Press.
- Hirsch, A. R. (2000). Choosing Segregation: Federal Housing Policy Between *Shelley* and *Brown*. From Tenements to the Taylor Homes: In Search of an Urban Housing Policy in Twentieth-Century America. R. B. John F. Bauman, Kristin M. Szylyvian. University Park, Pennsylvania, The Pennsylvania State University Press.
- Hoffman, A. v. (1996). "High Ambitions: The Past and Future of American Low-Income Housing Policy." Housing Policy Debate **7**(3): 423-446.
- Hosh, K. A. (2010). Fairfax's Affordable Housing Plan Might Not Change Tysons. The Washington Post. Washington, DC.
- Hyra, D. S. (2008). The New Urban Renewal. Chicago and London, The University of Chicago Press.
- Ihlanfeldt, K. R. (2004). "Exclusionary Land-use Regulations within Suburban Communities: A Review of the Evidence and Policy Prescriptions." Urban Studies **41**(2): 261-283.

- Jackman, T. (2012). Fairfax Joins Arlington, Approves Streetcar in Baileys Crossroads. The Washington Post, The Washington Post.
- Jacobs, J. (1961). The Death and Life of Great American Cities. New York, Random House, Inc.
- Jenkins, D. (2012). HCV\_OCT2012  
FCRP  
PH. T. P. C. F. County.
- Johnson, M. P. (2007). "Planning Models for the Provision of Affordable Housing." Environmental and Planning B: Planning and Design **34**: 501-523.
- Kannan, S. (2010). The Growing Market for Smart Growth Consumer Demand and Demographic Drivers, Robert Charles Lesser & Co.
- Kar, B. and M. E. Hodgson (2008). "A GIS-Based Model to Determine Site Suitability of Emergency Evacuation Shelters." Transactions in GIS **12**(2): 227-248.
- Kirk, P. (2011). Developers Give Gen Y What They Want. Urban Land Magazine, Urban Land Institute.
- Kleit, R. G. and M. Galvez (2011). "The Location Choices of Public Housing Resident Displaced by Redevelopment: Market Constraints, Personal Preferences, or Social Information?" Journal of Urban Affairs **33**(4): 375-407.
- Knox, P. (1991). "The Restless Urban Landscape: Economic and Sociocultural Change and the Transformation of Metropolitan Washington DC." Annals of the Association of American Geographers **81**(2): 181-209.
- Kravitz, D. (2010). Fairfax County Supervisors Approve Affordable Housing Plan. The Washington Post. Washington, DC.
- Kunckle, F. (2012). Fairfax County Debate Over Affordable Housing Reignited by Supervisor's \$500 million price tag. The Washington Post.
- Kunckle, F. (2012). Fairfax County Focusing on Neediest in More Modest Affordable Housing Program. Washington Post. Washington DC.
- Lang, R. and P. Knox (2009). "The New Metropolis: Rethinking Megalopolis." Regional Studies **43**(6): 789-802.
- Lee, B. (2007). "'Edge' or 'Edgeless' Cities? Urban Spatial Structure in U.S. Metropolitan Areas, 1980 - 2000." Journal of Regional Science **47**(3): 479-515.
- Leslie, E., N. Coffee, et al. (2007). "Walkability of Local Communities: Using Geographic Information Systems to Objectively Assess relevant Environmental Attributes." Health & Place **13**(1): 111-122.
- Loretta Lees, T. S., Elvin Wyly (2008). Gentrification. New York, NY, Routledge.
- Malczewski, J. (2000). "On the Use of Weighted Linear Combination Method in GIS: Common and Best Practice Approaches." Transactions in GIS **4**(1): 5-22.
- Malczewski, J. (2004). "GIS-Based Land Use Suitability Analysis: A Critical Overview." Progress in Planning **62**(1): 3-65.
- Massey, D. S. and N. A. Denton (1993). American Apartheid: Segregation and the Making of the Underclass. Cambridge, MA, Harvard University Press.

- Morgan, D. R. and P. Mareshcal (1999). "Central-City / Suburban Inequality and Metropolitan Political Fragmentation." Urban Affairs Review **34**(4): 578-595.
- Mulherin, S. (2000). "Affordable Housing and White Poverty Concentration." Journal of Urban Affairs **22**(2): 139-156.
- Nelson, A. C., FAICP, et al. (2007). "The Next 100 Million: Reshaping America's Built Environment." Planning January: 3-6.
- Newman, O. (1973). Defensible Space: Crime Prevention Through Urban Design, MacMillian Publishing Company.
- Newman, S. J. (1999). The Home Front: Implications of Welfare Reform for Housing Policy. Washington, D.C., The Urban Institute Press.
- Nguyen, M. T. (2005). "Does Affordable Housing Detrimentially Affect Property Values? A Review of the Literature." Journal of Planning Literature **20**(1): 15-26.
- Orlebeke, C. J. (2000). "The Evolution of Low-Income Housing Policy, 1949 to 1999." Housing Policy Debate **11**(2): 489-520.
- O'Sullivan, S. and J. Morrall (1996). "Walking Distances to and from Light-Rail Transit Stations." Transportation Research Record(1538).
- Pattillo, M. (2009). Investigating in Poor Black Neighborhoods "As Is". Public Housing and the Legacy of Segregation. M. A. Turner, S. J. Popkin and L. Rawlings. Washington, DC, The Urban Institute Press.
- Pelletiere, D. (2007). Ensuring Housing Opportunities in Fairfax: Making the Most of the One Penny Fund by Serving Working Families with the Greatest Need, Coalition for Smarter Growth.
- Pendall, R., R. Puentes, et al. (2006). From Traditional to Reformed: A Review of the Land Use Regulations in the Nation's 50 largest Metropolitan Areas, Brookings Institution.
- Powell, B. and E. Stringham (2004). Housing Supply and Affordability: Do Affordable Housing Mandates Work?, Los Angeles: Reason Public Policy Institute.
- Quigley, J. M. and S. Raphael (2004). "Is Housing Unaffordable? Why Isn't It More Affordable?" Journal of Economic Perspectives **18**(1): 191-214.
- Radford, G. (2000). The Federal Government and Housing During the Great Depression. From Tenements to the Taylor Homes, In Search of an Urban Housing Policy in Twentieth-Century America. J. F. Bauman, R. Biles and K. M. Szylvian. University Park, Pennsylvania, The Pennsylvania State University Press.
- Ranney, D. C. and P. A. Wright (2003). Global Decisions/Local Collisions. Philadelphia, Temple University Press.
- Raphael, S. and M. A. Stoll (2010). Job Sprawl and the Suburbanization of Poverty, Brookings Institute.
- Richardson, J. J. (2003). "Downzoning, Fairness and Farmland Protection" Journal of Land Use & Environmental Law **19**(1): 59-90.
- Rosenbaum, E. and L. E. Harris (2001). "Low-Income Families in Their New Neighborhoods: The Short-Term Effects of Moving From Chicago's Public Housing." Journal of Family Issues **22**(2): 183-210.
- Rosenbaum, J. E. and S. DeLuca (2000). Is Housing Mobility the Key to Welfare Reform? Lessons from Chicago's Gautreaux Program. Survey Series, The Brookings Institution. **September 2000**.

- Rosenbaum, J. E. and A. Zuberi (2010). "Comparing Residential Mobility Programs: Design Elements, Neighborhood Placements, and Outcomes in MTO and *Gautreaux*." Housing Policy Debate **20**(1): 27-41.
- Saaty, T. L. (2008). "Decision Making with the Analytic Hierarchy Process." Int. J. Services Sciences **1**(1).
- Saegert, S., G. Winkel, et al. (2002). "Social Capital and Crime in New York City's Low-Income Housing." Housing Policy Debate **13**(1): 189-226.
- Sard, B. and M. Waller (2002). *Housing Strategies to Strengthen Welfare Policy and Support for Working Families*, Brookings Institution.
- Schwartz, A. F. (2006). Housing Policy in the United States. New York City, Routledge.
- Sherfinski, D. (2012). Six-figure Income Qualifies for Housing Aid in Tysons. The Washington Times.
- Shibley, R. G. (1998). "The Complete New Urbanism and the Partial Practices of Placemaking." Utopian Studies **9**(1): 80-102.
- Shlay, A. B., M. Weinraub, et al. (2004). "Barriers to Subsidies: Why Low-Income Families Do Not Use Child Care Subsidies." Social Science Research **33**: 134-157.
- Short, J. R., B. Hanlon, et al. (2007). "The Decline of Inner Suburbs: The New Suburban Gothic in the United States." Geography Compass **3**(1): 641-656.
- Skeppstrom, K. and B. Olofsson (2006). "A Prediction Method for Radon in Groundwater Using GIS and Multivariate Statistics." Science of the Total Environment **367**(2-3): 666-680.
- Smart, M. P. (2011). "Top-earning towns." 2013, from [http://money.cnn.com/galleries/2011/moneymag/1108/gallery.best\\_places\\_top\\_earning\\_towns.moneymag/index.htm](http://money.cnn.com/galleries/2011/moneymag/1108/gallery.best_places_top_earning_towns.moneymag/index.htm).
- Song, Y. and G.-J. Knaap (2003). "New Urbanism and Housing Values: A Dissaggregate Assessment." Journal of Urban Economics **54**(2): 218-238.
- Squires, G. D. and C. E. Kubrin (2005). "Privileged Places: Race, Uneven Development and the Geography of Opportunity in Urban America." Urban Studies **42**(1): 47-68.
- Swanstrom, T., C. Casey, et al. (2004). *Pulling Apart: Economic Segregation among Suburbs and Central Cities in Major Metropolitan Areas*. The Living Cities Census Series, The Brookings Institution.
- Thomson, C. N. and P. Hardin (2000). "Remote Sensing/GIS Integration to Identify Potential Low-Income Housing Sites." Cities **17**(2): 97-109.
- Tighe, J. R. (2010). "Public Opinion and Affordable Housing: A Review of the Literature." Journal of Planning Literature **25**(1).
- Tumlin, J. and A. Millard-Ball (2003). *How to Make Transit-Oriented Development Work*. Planning Magazine, American Planning Association.
- Turner, M. A., S. J. Popkin, et al. (2009). Public Housing and the Legacy of Segregation. Washington, DC, The Urban Institute Press.
- Voith, R. (1992). "City and Suburban Growth: Substitutes or Compliments?" Business Review.
- Wampler, T. (2012). *Transportation Data*. F. C. D. o. Transportation.

Weisbrod, G., M. Ben-Akiva, et al. (1980). "Tradeoffs in Residential Location Decisions: Transportation versus Other Factors." Transportation Policy and Decision-Making **1**(1).

Wilson, W. J. (1987). The Truly Disadvantaged: The Inner City, the Underclass, and Public Policy. Chicago, The University of Chicago Press.

Woiak, S. (2012). Hospitals / Urgent Care Centers and Shopping Centers. G. M. S. B. Fairfax County Department of Information Technology.

Wold, S., K. Esbensen, et al. (1987). "Principal Component Analysis." Chemometrics and Intelligent Laboratory Systems **2**(1-3): 37-52.

Woolley, M. and M. K. Winkler (2007). School Facility Investments in the Washington Metropolitan Area. Washington, DC, The Urban Institute.

## Appendix A: Methodology Appendix

The first step in building the low-income housing site suitability GIS model is downloading the data. The following table explains how the data was derived for each input factor:

<b>Input Factor</b>	<b>Data Source</b>	<b>Factor Type</b>
<b>Poverty</b>	Data downloaded from the U.S Census Bureau shows the percentage of people whose income in the past 12 months is below the poverty level, aggregated by block group.	-
<b>Employment</b>	Job locations based off of where workers live (for individuals making \$1,250 per month or less) were downloaded using the Census Bureau's Longitudinal Employer-Household Dynamics.	+
<b>Schools</b>	School locations were downloaded from the Fairfax County GIS and Mapping website.	+
<b>Crime</b>	2011 crime incidents aggregated by block were provided by the Fairfax County police department.	-
<b>Medical Care</b>	The Fairfax County Department of Information Technology provided locations for hospitals and urgent care centers.	+
<b>Shopping Centers / Grocery Stores</b>	Locations were provided by the Fairfax County Department of Information Technology.	+
<b>Public Transportation</b>	Data provided from the Fairfax Department of Transportation was split into two variables: Metrorail station locations and Metrobus stop locations.	+
<b>Child Care</b>	Child care locations were geocoded using addresses obtained through a query on Fairfax County's child care website.	+
<b>Population Density</b>	Using population data downloaded from the Census Bureau, ArcMap calculated the population per square mile, aggregated by block group.	+

A Principal Component Analysis uses JMP statistical software to analyze the correlations for all variables, confirming no variable redundancy (Figure 29). The degree of correlation between two variables approximates how much they overlap (Abdi et al. 2010). In the top Correlation box of Figure 29, no correlation is stronger than .42. Whether positive or negative, a correlation of 1 is a

perfect correlation, and correlations of .8 or .9 are strong correlations. A correlation of .4 suggests that there is some relationship between the variables, but a weak one. Therefore, the PCA reveals no redundancy in the input factors.

Other inputs necessary for the GIS model are Block Groups and All Edges TIGER files downloaded from the Census Bureau, as well as Land Parcels provided by the Fairfax County Department of Information Technology. After all of the layers are imported into ArcMap and organized into a geodatabase, every layer is projected to NAD 1983 State Plane Virginia North FIPS 4501 Feet for geographic consistency. Every variable is then clipped to the Block Groups to maintain a consistent study area. For future use, the Block Groups need to be rasterized using the Polygon to Raster tool in the conversion toolset. The following steps involve modifying the input factors so they can be weighted and combined. Every input factor must be converted to a raster surface in order to be standardized, weighted, and overlaid. Unless otherwise specified, all raster environments call for a cell size of 50, and an extent set to the Block Groups. A cell size of 50 feet is used because it is the smallest cell size allowing all processes to run.

First, Poverty and Population Density are converted to raster surfaces in the same manner as the Block Groups. For Job Locations (Employment) and Crime Incidents (Crime), the point data must be interpolated to produce a raster surface. An Inverse Distance Weighting (IDW) interpolation is utilized, with the numeric data assigned to each point set as the Z value for the respective layers (number of job locations by home for Job Locations, and number of crime incidents by block for Crime Incidents). The IDW method was chosen over other interpolation techniques because of its reliability and usefulness for dense networks (Naoum and Tsanis 2004, Skeppstrom and Olofsson 2006). After the interpolation is complete, the outputs are multiplied

by the rasterized Block Groups using the Raster Calculator to clip the interpolated surfaces to the study area.

The rest of the input factors (all point location data) use cost distance methodology to obtain a meaningful raster surface. The Cost Distance tool assigns a friction value to every raster cell, calculating the difficulty in traveling from one point to another (Richard and Armstrong 2010). To do this, a cost surface must first be created. First, only roads from the All\_Edges layer must be selected. This selection is then buffered (100 feet), converted to a raster, and reclassified to produce a cost surface. The reclassification sets values of 1 = 1000, and values of 0 = 1, giving extreme priority to road networks for the cost distance calculation. This cost surface is used in the Cost Distance tool for every point location layer (Metrostations, Metrobus stops, Medical Care Facilities, Child Care Locations, Shopping Centers / Grocery Stores, and Schools). As with the interpolated layers, the cost distance raster surfaces need to be multiplied by Block Groups using the Raster Calculator.

The next step is to standardize the rasterized input factors. Each raster surface is reclassified using the Reclassify tool, creating nine categories. Each input factor is analyzed to determine whether high or low values are more suitable for low-income housing development. When this step is completed, each raster surface is reclassified so that the lower the number, the more suitable for low-income housing.

Now that the variables are standardized, they are weighted and combined. The weights are derived from surveying six affordable housing developers in Northern Virginia. The respondents compared each factor against all others and rated their relative importance (see Figure 30 for questionnaire example). A Saaty pairwise comparison matrix organizes the survey results. Numeric values are assigned to the survey question entries, and normalized weights are



derived for the input factors (Figure 31) using a linear proportion equation (Kamenetzky 1982; Wold et al. 1987; Pereira and Duckstein 1993). These weights are justified using Goepel's (2012) Analytic Hierarchy Process calculation spreadsheet in Microsoft Excel. The Weighted Overlay tool dialog box sets each input factor to its assigned weight, and then combines the reclassified raster surfaces with full tradeoff.

Lastly, the overlaid raster suitability information is extracted to the land parcels. Because of the huge number of land parcels in Fairfax County, the parcels need to be split up into at least four groups to allow processes to successfully run in ArcMap. Zonal Statistics is run for each parcel group using the weighted overlay raster surface in order to extract raster information to each parcel (Skeppstrom and Olofsson 2006). Each zonal statistic raster is processed through the Int tool in the Spatial Analyst toolset before it can be converted to vector data. This tool converts each cell value of a raster to an integer through truncation. The integer outputs are converted back to polygons, and merged to create one layer. Finally, spatial joining the merged parcels to the original land parcels provides an average value of low-income housing site suitability for every land parcel.

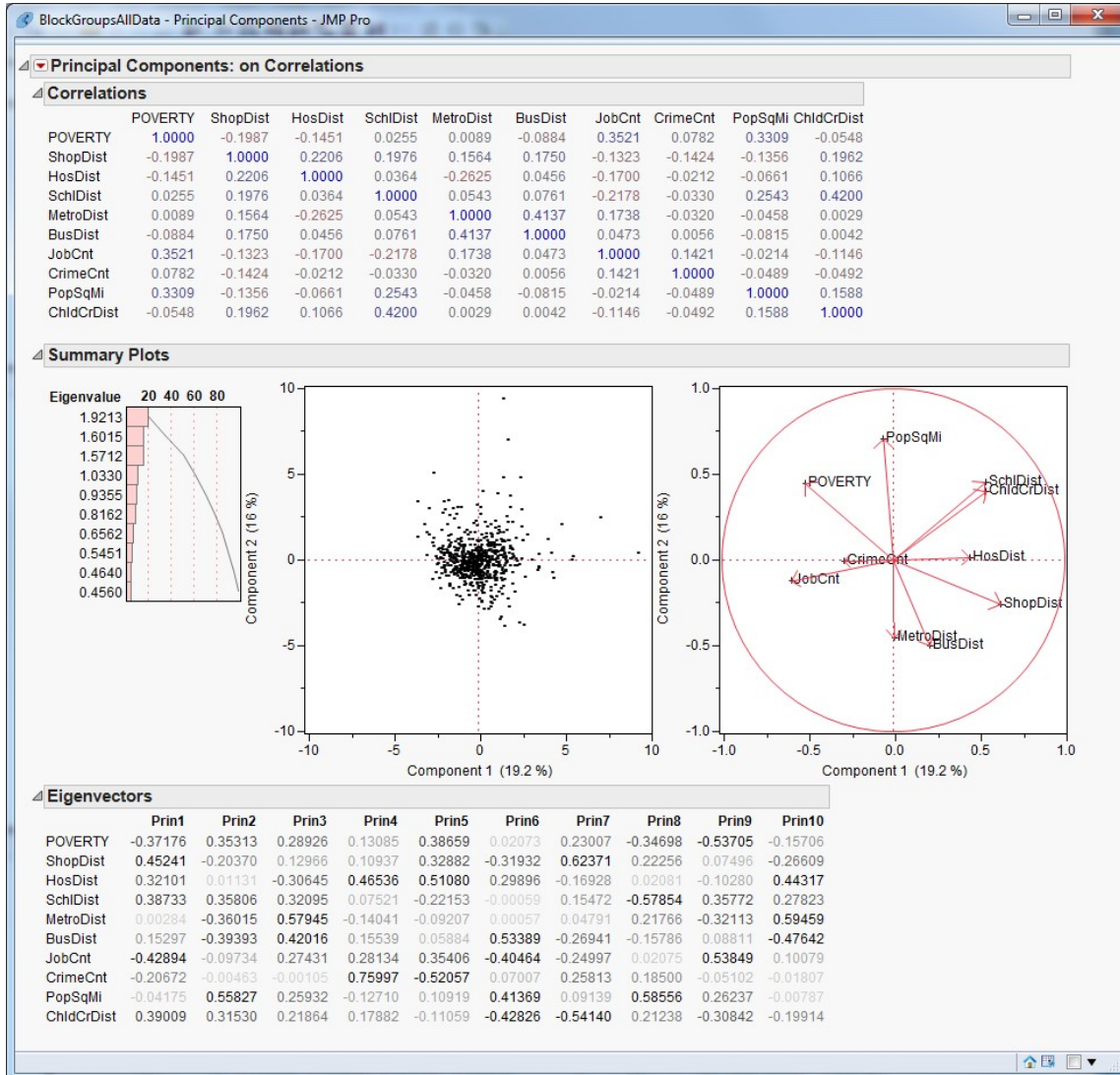
After the model's results are derived, the land parcels relative to each individual input factor are tested for significance. By scrutinizing each input factor across all land parcels versus only the extremely high scoring parcels, the effect each input factor has in raising low-income housing site suitability in Fairfax County can be observed. If none of the input factors are deemed significant between the population (all parcels) and the sample (only extremely high scoring parcels), then all of the input factors are required to increase suitability scores. If certain variables are deemed significant, then these variables alone can increase suitability scores, rendering the remaining variables unnecessary. Because GIS procedures are cumbersome in

processing the extremely large number of land parcels in Fairfax County, a ten percent subset of parcels selected at random serves as the population group (Figure 32). Out of these parcels, the extremely high scoring parcels are selected to represent the sample group. For each individual input factor, the Z-score (the number of standard deviations away from the mean) is calculated for the sample group in comparison to the population group:  $Z = (\text{sample mean} - \text{population mean}) / \text{population standard deviation}$ . Because lower scores represent higher suitability, when moving from the population group to the sample group it is expected that all input factors will have negative Z scores.

Figure 33 shows the Z scores for each input factor. A 95 percent confidence interval would require an input factor's Z score to be greater than 1.96 (or -1.96). In this case, no input factor has a Z score exceeding -.90. Therefore, none of the input factors are significant, confirming the influence of all input factors in increasing low-income housing suitability in Fairfax. This is expected in a heavily developed region where no single factor can dictate the landscape. In addition, all input factors had negative Z scores, excluding crime. This means that crime slightly increases in the most suitable locations, representing a tradeoff for greater low-income housing suitability. The Z score of all of the input factors combined is -1.42. While this is not statistically significant at a 95 percent confidence interval, it does reveal that combining the input factors is more likely to increase suitability in Fairfax County than any input factor alone. Within the model, the probability of the extremely high scoring parcels not being more suitable than the total number of parcels is 7.78 percent (p-value of .077804). Future analysis could investigate how changes in each input factor can affect suitability. By holding all input factors constant and adjusting an individual input factor, simulations can be run to examine the resulting suitability scores. Planners can use this information to determine how many of which

location amenities produce maximum suitability within an area. This process is beyond the scope of this research, as it requires many simulations on each input factor and deals with hypothetical situations, not the existing landscape.

**Figure 29: PCA Analysis of Input Factors**



**Figure 30: Survey Question Example**

**1. Which variable is more important for the location of low-income housing?**

- Low crime rate
- Low poverty rate
- Equal importance

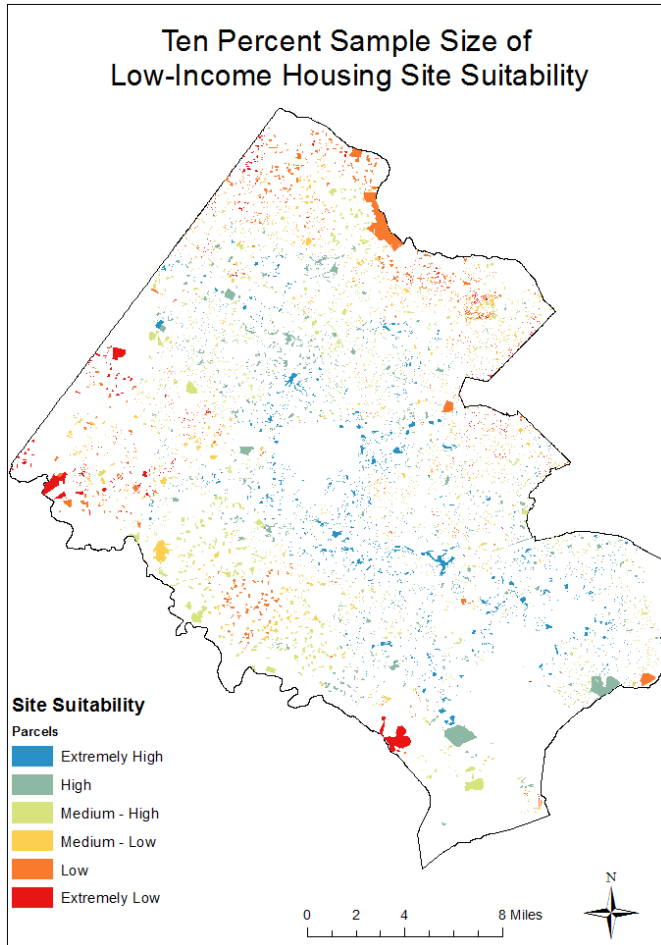
**2. How much more important?**

- Equal
- Moderately more important
- Highly more important
- Very highly more important
- Extremely more important

**Figure 31: Final Weights**

<b>Variable</b>	<b>Weight</b>
Employment	19
Metrorail Stations	16
Bus Stops	12
Schools	9
Grocery Stores / Shopping Centers	9
Low Crime Rates	8
Child Care	8
Low Poverty Rates	7
Medical Care	7
Population Density	5
Sum	100

**Figure 32:**



**Figure 33: Input factor Z Scores**

	<b>Sample Mean</b>	<b>Pop Mean</b>	<b>Pop Standard Deviation</b>	<b>Z Score</b>
Grocery Stores / Shopping Centers	67.5	124.42	62.98	-0.90
Schools	65.11	117.23	66.26	-0.79
Employment	78.23	128.18	65	-0.77
Metrorail	77.68	125.49	63.12	-0.76
Child Care	84.62	131.97	63.25	-0.75
Medical Care	87.05	126.18	57.69	-0.68
Bus stops	46.99	87.76	75.31	-0.54
Population Density	114.97	134.16	68.45	-0.28
Low Poverty	60.78	70.06	79.47	-0.12
Low Crime	100.49	88.41	65.01	0.19
All Variables Combined	75.32	115.08	28.07	-1.42

**Population Number of Parcels: 31,901**

**Sample Number of Parcels: 6089**

## Appendix B: Methodology Appendix References

Kamenetzky, R. D. (1982). "The Relationship Between the Analytic Hierarchy Process and the Additive Value Function." *Decision Sciences* **13**(4): 702-713.

Naoum, S. and I. K. Tsanis (2004). "Ranking Spatial Interpolation Techniques Using a GIS-Based DSS" *Global Nest* **6**(1): 1-20.

Richard, Y. and D. P. Armstrong (2010). "Cost Distance Modeling of Landscape Connectivity and Gap-Crossing Ability Using Radio-Tracking Data." *Journal of Applied Ecology* **47**(3): 603-610.

Pereira, J. C. and L. Duckstein (1993). "A Multiple Criteria Decision-Making approach to GIS-based land suitability evaluation." *International Journal of Geographic Information Systems* **7**(5).

## Appendix C: IRB Documentation

VT IRB-12-836 Approval Letter.pdf - Adobe Reader

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Tools Sign Comment Extended

**VirginiaTech**

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website <http://www.irb.vt.edu>

**MEMORANDUM**

**DATE:** September 28, 2012

**TO:** Robert Douglas Oliver, Mike Van Atta

**FROM:** Virginia Tech Institutional Review Board (FWA00000572, expires May 31, 2014)

**PROTOCOL TITLE:** Situating Suburban Low-Income Housing: An Uneven Urban Landscape

**IRB NUMBER:** 12-836

Effective September 27, 2012, the Virginia Tech Institutional Review Board (IRB) Chair, David M Moore, approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

<http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

**PROTOCOL INFORMATION:**

Approved As: **Exempt, under 45 CFR 46.110 category(ies) 2**

Protocol Approval Date: **September 27, 2012**

Protocol Expiration Date: **N/A**

Continuing Review Due Date\*: **N/A**

\*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

**FEDERALLY FUNDED RESEARCH REQUIREMENTS:**

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

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