Access to Active Play Parks for Youth Segments in Alexandria, Virginia

by

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To my wife Erin, for putting up with me while I did this study

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Abstract

Park accessibility is important for city planners because the accessibility of parks can impact people throughout the community. Youth park accessibility is especially important, as parks positively impact physical, emotional, and social development. This study uses dasymetric mapping of census block group population data to estimate segments of youth population at each residential parcel, and then associates those segments with age-appropriate active play features at each park. Network analysis connects parcels to parks and their amenities, providing a more precise accessibility rating at the city-level than studies based solely on geodesic buffers from park centroids.

This study shows that while Alexandria, Virginia has many parks throughout the city, the distribution of age-appropriate active play features is not uniform. Most children in Alexandria have access to at least one active-play park. Only 132 parcels have zero access to age-appropriate, active-play parks, a rate of less than one-hundredth of a percent. There are areas for improvement, but the City of Alexandria has done an excellent job ensuring children have access to active play parks. For other cities, this sort of accessibility analysis could help planners to target areas to increase funding for fitness amenities and programs within parks, establish new parks, or add pedestrian paths to improve walkability to existing park resources.

Chapter 1 Introduction

This study analyzes the active play park features in Alexandria, Virginia and their accessibility to youth ages zero to seventeen. The study uses residential parcels as a more accurate estimation of population distribution than the customarily used census tract of census block group. The higher level of detail enables a more accurate assessment of park accessibility for youths walking along the road network.

1.1. Definitions

Accessibility is generally defined as how well people can travel to a type of location. Paez et al. (2012) define accessibility as, “the potential for reaching spatially distributed opportunities.” Paez et al. divides accessibility into two components, travel cost and quality of opportunities. There are two ways to analyze accessibility, from the origin and to the destination. Examples of accessibility from the origin include the number of supermarkets within one mile of the population. Accessibility to the destination includes the population within five miles serviced by a hospital.

Well-being is used in many ways, depending on the field of study. The Centers for Disease Control and Prevention defines well-being in its simplest terms as, “judging life positively and feeling good” (Centers for Disease Control and Prevention 2016). They further recognize the primary aspects of well-being researched as physical, economic, social, emotional, psychological, life satisfaction, development and activity, and engaging activities and work. Much of the previous study centering around parks and children assess the physical, social, and developmental aspects of well-being.

Pauleit et al. (2003) define greenspace to include woodlands, farmlands, parks, playing fields, open spaces, playgrounds, and gardens. For the purpose of this study, greenspace is defined as publicly maintained parks, playgrounds, and playing fields with no admission criteria beyond hours of operation.

1.2. Motivation

Parks provide many positive impacts to society in general and specifically children. Parks provide opportunities for play, exercise, and social development. Play is vital in children's physical, cognitive, social and emotional development (Little and Wyver 2008). Social interaction between children increases with use of sports and outdoor environments. The opportunities to meet and interact with other children promotes social development, face-to-face communication skills, and making friends. (Seeland, Dübendorfer and Hansmann 2009). Formal park activities combined with the presence of other active children results in an increased level of physical activity (Floyd, et al. 2011).

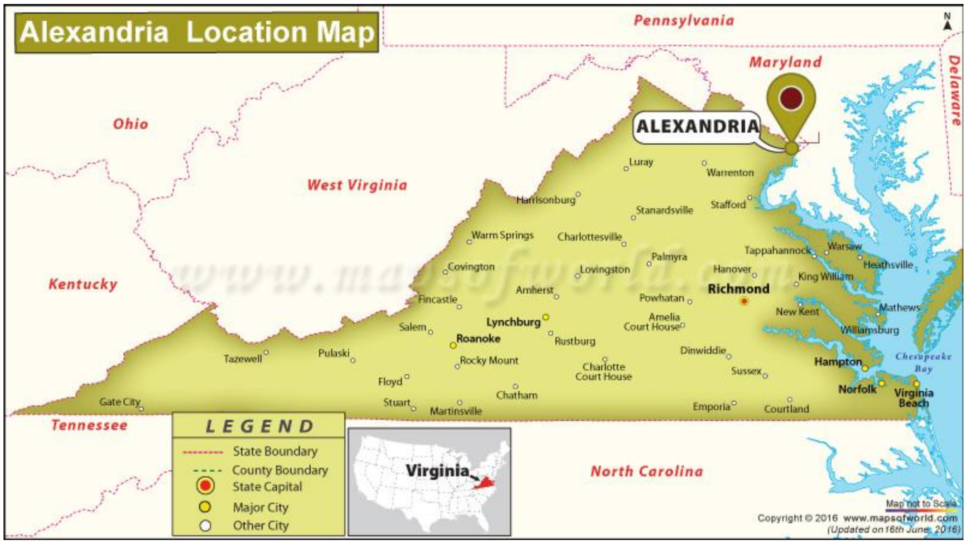
Public parks and green space provide locations for physical activity through play or exercise. This study focuses on youth access to parks. Youth accessibility is different from adult accessibility. Adults in this metropolitan area may have access to automobile transportation. When traveling alone, children are limited to walking or biking distances. As such, youth accessibility is less than that of adults. Also, adults may have the option of moving to another area if they wish to increase their accessibility, while children are limited in that their parents decide where the family should live.

Identifying areas that have low accessibility to parks for youth can help city planners either develop new parks or encourage other well-being programs for those areas between parks. Parks are an excellent location for the development of physical and social skills as well as improve emotional well-being. If a park is not available to the youth of an area, other programs or efforts should be developed to target that area to make up for the lost opportunity represented by the lack of an active play park.

1.3. Study Area

The city of Alexandria, Virginia is directly south of the United States' capital and is home to an estimated 150,000 residents. The city has over 900 acres of protected open space and over 560 acres of city-owned parks out of 9,920 acres, a rate of 9%. Figure 1 below shows the location of Alexandria in relation to the state of Virginia and its capital, Richmond. Alexandria is bounded to the east by the Potomac River, to the south by Interstate 495, to the west by the city of Annandale, and the north by the city of Arlington.

Figure 1 Alexandria, Virginia Location



(Maps of World n.d.)

Alexandria has 103 parks listed on their website. The parks range in size from 0.05-acres to 65-acres. Typical features include basketball, tennis, and volleyball courts, seating areas, dog areas, picnic tables, playgrounds, athletic fields, skateboard parks, and swimming pools. The city boasts of 49 multi-use athletic fields, 36 playgrounds, 36 tennis courts, and four pools. (City of

Alexandria, Virginia 2017). Only one park is not included in the GIS Department's data. Figure 2 below shows that 81% of parks are less than 9.75 acres. In fact, 49% of parks are less than 2.25-acres. These many small parks give the opportunity to have equitable distribution throughout the city. There are still a significant number of parks with over 40-acres. These large parks are more difficult to distribute throughout the city

Figure 2 Alexandria Park Size Histogram

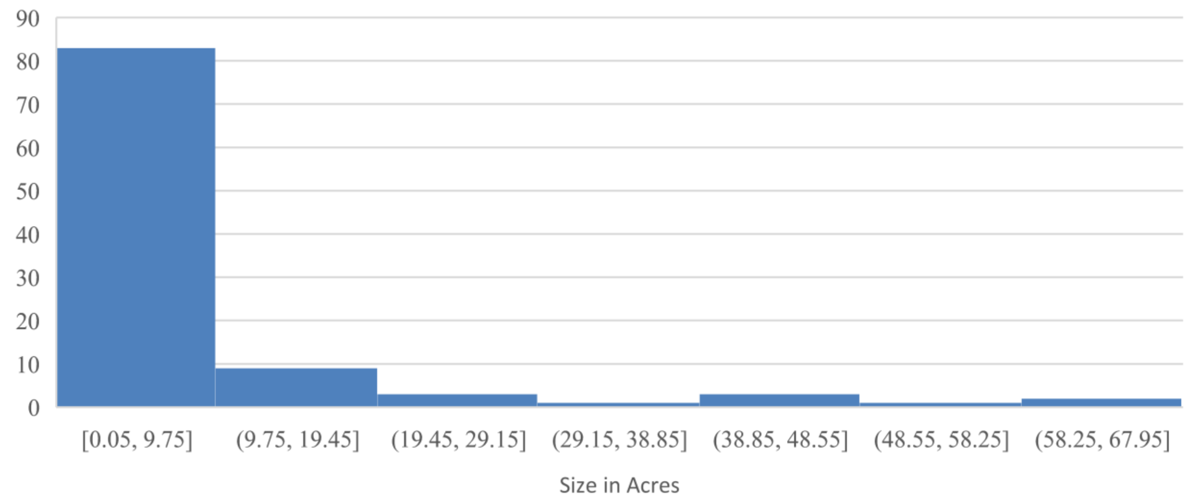
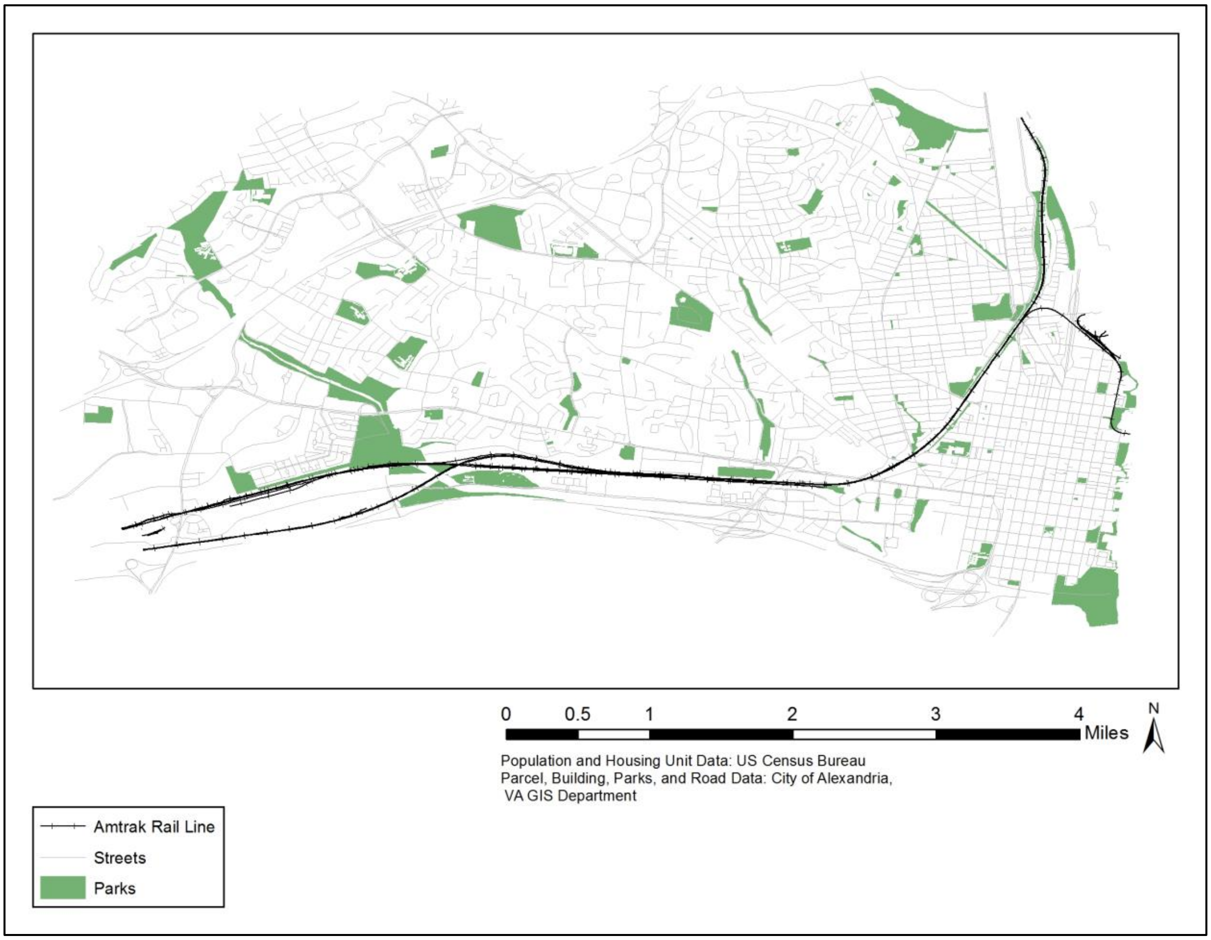


Figure 3 below shows that although there is a multitude of parks and other green spaces in the city, the parks are not uniformly distributed. This can lead to unequal access for the residents. Analyzing the access to green space helps planners determine the need for new parks or expansion of public transportation to make the current parks more accessible to residents. Adding further unequal access is the difference in active play features. Also, Figure 3 might appear to have an adequate distribution of parks, but it does not take active play features into account.

Figure 3 Alexandria, Virginia Parks



Parks with different sizes are not evenly distributed across the city. The more extensive parks are located mainly in the western part of the city with a couple of exceptions along the waterfront to the east. The western half of the city also has a different structure to its road network than in the east. In the east, a road grid is standard. The road network in the western portion of the city has a higher percentage of cul-de-sacs and has fewer road intersections. This can affect accessibility by limiting the available road branches within a specified distance.

1.4. Uses for this Study

Current academic green space studies focus on many areas throughout the world, but no published study focuses on Alexandria, Virginia. Building an accessibility model can help provide planners with the data and information necessary to support new public works projects to expand, improve, or provide easier public transportation to the park system.

It is unrealistic to expect the city of Alexandria to purchase large amounts of existing property to change the use of the parcels to a new park, as it is prohibitively expensive. Instead, by focusing on opportunities for physical activity within parks, this study might serve as evidence to provide a targeted audience for fitness marketing campaigns. Knowing which areas have more park access allows the city to focus on efforts in the areas with reduced access to parks. These efforts could be the NFL's Play60, Alexandria's My Gym, or the Presidential Youth Fitness Program. Such efforts encourage kids to become active and keep moving. Focusing these programs on areas with less access to parks could provide more equitable access to fitness and contribute to youth well-being.

Another alternative to purchasing new, large parks is micro-parks. The city has several "tot lots" that are less than 0.5-acres and simply have a playground. Plots of land like alleys, small empty spaces between larger parcels, and parking lots can provide access to active play parks for new areas, especially for physical play for the youngest age groups, with less investment requirements than developing bigger, more traditional parks (Nordh et al. 2009).

Finally, even without developing new park spaces, adding age-appropriate, active-play features are something that the city can control at a reasonable cost. By installing age-appropriate features in areas with no access to those features, the city can provide the opportunity for parents to take their children to a park where the children can be encouraged to play actively. Playing fields, skateboard parks, and playgrounds are appropriate for children and youth at different stages of development and should be analyzed as appropriate for specific age and play/physical activity segments. Breaking the population and parks into different age bands and their associated active play parks allows for the use of different approaches to more accurately analyze the distribution of age-appropriate active play features. This study also identifies those parks with active play features that have a significantly higher number of expected users within their service area. This potential overcrowding of active play features may reduce the positive effect of accessible active play parks. If the parks are always crowded, it can discourage youth and their parents from using the park.

Several studies have shown that distances between one-third and one-quarter of a mile are “walkable.” Dunton et al. and Wolch et al. use 500-meters (0.31-mile) as a travel distance to define what parks are within a child’s proximity (Dunton et al. 2014; Wolch et al. 2011). These studies view travel distances as sensitive to a child’s age, looking at three travel distances, 0.25-, 0.5-, and 1-mile to determine the variable’s sensitivity. The study breaks down the population by appropriate age groups for those travel distances with parents of older children being expected to be willing allow or assist their children in traveling long distances to a park. This study looks at how much accessibility is improved by increasing travel distance as youths age.

Obesity is a growing problem for youth in the United States. While there are many factors, one factor that municipalities can affect is access to parks for active play. Dr. Heidi Blanck shows that parks and playgrounds provide many benefits for youths. The social aspect is helpful to development as well as the physical. Multiple research studies show that access to parks is directly related to activity and inversely related to rates of obesity and overweight population. (Blanck et al. 2012; Cohen et al. 2007; Jennings et al. 2016).

1.5. Organizational Framework

This study is organized into five chapters. Chapter 2 reviews available studies and peer-reviewed articles to discuss standard techniques for analyzing accessibility. This study’s methodology was based on the benefits and disadvantages of these methods. Chapter 3 describes the methodology of assigning appropriate population and housing data to parcels, creating active play park features, building park service areas, and calculating park accessibility and park congestion. Chapter 4 discusses the results of the study and presents the outcomes and identify strengths and weaknesses of this methodology. Chapter 5 examines the implications of this method and identifies possible directions for future research.

Chapter 2 Related Work

Measurement of physical accessibility of populations to facilities, and particularly park accessibility, has been studied extensively throughout the world. Using GIS allows for a more detailed analysis by quickly developing service areas and providing more detailed population distributions. Conventional approaches include applying a standard service area distance, either through Euclidean or network approaches, and treating all parks as equally desirable.

This chapter discusses accessibility in general, park accessibility, the connection between parks and well-being, and limitations of previous works. This study's differentiation is discussed in each of the sections. Unlike many other studies, it uses dasymetric mapping at the residential parcel level and separates age groups by different distances and park amenities.

2.1. Accessibility

Many accessibility studies focus on large, rural areas. This was done to analyze access to limited resources. A frequent topic is the access to healthcare facilities which affect the well-being of distributed populations. Multiple studies focus on access to health services in extremely rural areas. These areas include New Zealand, the Philippines, and Bhutan. (Bagheri, Holt and Benwell 2009; Delgado and Canters 2011; Jamtsho, Corner and Dewan 2015). Most of these studies rely on vehicles for transportation. Not many studies use walking as the primary mode of transportation. While such general observations are intuitive, evidence based on carefully analyzed spatial data provides a stronger argument and details areas with the most extreme accessibility challenges.

Euclidean or geodesic distance is often used for accessibility. However, Pedigo and Odoi (2010) found that network analysis is more accurate and better suited for determining accessibility. This is especially true for rural areas where road networks are the only way of moving. In a dense urban environment, network analysis can also be a useful means of estimating travel distances, but may not always be the most accurate method, especially where walking is being assessed. The GIS road network may not include shortcuts that residents use when walking. These shortcuts include alleys, parking lots, and cutting through other's property. In a dense urban environment, network analysis is also stronger when roads are assigned different speed limits or have data that considers traffic congestion.

2.2. Park Accessibility

Socio-economic factors directly affect park accessibility. Wang et al. (2015) show that low-income groups have lower access to parks than more affluent residents in both Brisbane, Australia and Zhongshan, China. According to research literature, this is broadly true in the United States as well (Rigolon and Flohr 2014; Jennings and Gaither, 2015). Part of this is due to property valuations and taxes. Wolch et al. (2005) shows that high-income areas have larger park systems compared to low-income areas. There are some studies with detailed and to some degree contradictory findings, including Boone et al. (2009) who studied Baltimore, Maryland. This study showed that African Americans had better walking access to parks than white residents, but fewer acres compared to whites due to the spatial pattern and timing of suburbanization. They also studied needs-based assessment, which focused on children, the elderly, the carless, and low-income neighborhoods. They found that areas with more high-need people in the population had a lower mean distance of 239-meters (0.15-miles) to the nearest park than areas with fewer high-needs residents, where residents had a mean distance of 864-meters (0.54-miles). These areas have high park congestion, but good accessibility (Boone et al. 2009).

Comber et al. (2008) built a GIS database to analyze greenspace accessibility based on ethnicity and religion in Leicester, England. One of the key exclusions highlighted by Comber et al. is that of school playing fields and golf courses. Since these are not open to the public, it makes sense to separate out these green spaces. Another idea to consider is the insertion of access points in the network analysis to determine travel times. Rather than just walking into the park at any point along the perimeter, this would normalize where the entrances are located (Comber et al. 2008). Alessandro Rigolon and Travis Flohr research the effect of economic divisions and access to parks in youth. They focus their attention on the Denver area, where there are different income and racial backgrounds. Their study concludes that the low-income neighborhoods have the lowest access to parks. When amenities are included as variables, the difference in access between low- and high-income areas is even more pronounced (Rigolon and Flohr 2014). Gary Higgs developed a GIS framework to analyze access to public sporting locations in Wales (Higgs et al. 2015).

Tijs Neutens writes two papers that focus on how traffic congestion affects accessibility. The time penalty for travel by vehicle is different at different times of day, thus affecting accessibility (Neutens et al. 2014). Hours of operation might affect accessibility (Neutens et al. 2010). While these studies focus on government offices in Ghent, Belgium, they could also affect the parks of Alexandria, Virginia. Since most of the parks in Alexandria are open sunrise to sunset, this could influence accessibility for residents.

Many studies focus on regions, large cities, or even nationally. Using Euclidean distances between census tracts and park centroids, Zhang et al. (2011) analyzed the entire United States using a container approach. They also used a weighted average of the nearest seven parks to account for resident choice. Residents may not always choose the closest park; their choice often revolves around amenities. Zhang et al. (2011) selected the most frequently chosen technique of using census tracts and park centroids. This approach is efficient for work at a nationwide scale, but for a city such as Alexandria, this method would not have sufficient detail to provide useful information to city officials.

2.3. Connections between Parks and Well-being

Access to parks increases the likelihood of physical activity. Kaczynski et al. (2009) showed that increased park size corresponded positively with odds of adults conducting 150-minutes of moderate-to-strenuous physical activity (MSPA) for one week in a mid-sized Canadian city. An increase in available park size led to an increase of 2% in the odds of conducting 150-minutes of MSPA. However, additional parks within one-kilometer (0.6-mile) increase the odds of MSPA by 17%. They analyzed proximity to the nearest park, number of parks within 1-kilometer, and total park area to determine if there was a significant predictor of MSPA. The study states that only the number of parks within one-kilometer was a significant predictor of MSPA among residents. They identified other variables that were predictors of high MSPA including children in the household and residents above 55-years of age. Park accessibility was not a significant predictor for the age group of 35-54, as a higher percentage of the age group worked and traveled outside of their immediate neighborhood. Their study collected data through surveys and did not attempt to determine causality, only correlation. Other socio-economic factors beyond age were not analyzed (Kaczynski et al. 2009)

Andrew Oftedal and Ingrid Schneider state that while many studies have been conducted, there is not always a strong positive relationship between outdoor recreation and physical health. In their study in Minnesota, they found that the number of recreation opportunities was more consistently related to health than per capita opportunities (Oftedal and Schneider 2013). This means that the opportunity to exercise at a park is more important than the congestion of the parks.

Larson et al. (2016) show that the percentage of parkland within in a community is a strong predictor of overall and physical well-being. They studied the physical, social, community, financial, and purpose components of well-being to develop an overall Gallup-Healthways well-being index. While they used the percent of the population within 0.5-miles of a park, they did not conduct a GIS analysis to determine this population ratio. The study drew from the Trust for Public Land's Park Score Index (Larson et al. 2016). The Trust for Public Land's website provides the rationale for their 0.5-mile delineation, but does not discuss their methodology for calculating the population percentage living within 0.5-miles of a park (The Trust for Public Land n.d.)

Oftedal and Scheider highlight the study by Cohen et al. (2007) that shows that approximately two-thirds of park users were sedentary, or of too low an intensity to provide significant health benefits. Cohen et al. (2007) limited their description of park users' effort to sedentary, walking, and vigorous exercise. The authors' observations and resident surveys showed that people within 1-mile of a park were four times more likely to visit the park at least weekly than those that lived further than one-mile from a park (Cohen et al. 2007).

This study also segregates parks based on their features. Each age group has an associated group of parks that have age-appropriate active play features. This has not occurred in previous literature. By breaking the parks apart based on age-appropriateness, the study does not assign the accessibility of a teenager to a playground the same weight as the accessibility of a teenager to a sports field.

Floyd et al. (2011) shows through direct observation higher levels of physical activity are linked to courts and formal activities. Active play features like basketball and tennis courts are associated with higher levels of activity than picnic tables. They also found that the type of active play feature matters. Baseball and softball fields resulted in lower energy expenditures compared to basketball and tennis courts. The authors did find some differences in age groups, with preschool-age children preferring more spontaneous play than older children.

Little and Wyver (2008) identify that in a world of decreasing outdoor play driven by concern for children's safety, parks provide a good area for children to engage in risk-taking in a relatively controlled environment which allows children to gain confidence, refine locomotive skills, and understand themselves and others. They also suggest that parks can promote life-long physical activity in pursuit of an active, healthy lifestyle. This contributes to obesity prevention. Low movement skills can lead to lower self-esteem and fewer friends. Seeland et al. (2009) concludes that parks promote social inclusion through communication and recreation in parks. Seeing and interacting with other children promotes friendships and is a way to help promote multicultural environments.

2.4. Limitations of Walking Distances Selected in Previous Studies

Identifying appropriate distances for children to walk to parks is little studied, but many studies look at travel to and from school (Bejleri et al. 2011; Lopez and Wong 2017; Schlossberg et al. 2006). These studies can give a general perspective on children's travel distances.

Several studies specify the lack of supporting evidence on selecting distances. Common distances selected for children walking are 0.5- and one-mile. Schlossberg et al. (2006) studied various transportation methods for taking children to and from school. They utilize 0.5-mile intervals from one- to 3.5-mile. Their rationale for beginning at one-mile is that the 1.5-mile break is used by many school districts to delineate where bus service begins. (Schlossberg et al. 2006). Alexandria City Public Schools defines students who live within one-mile of their elementary schools and those living within 1.5-mile from their secondary schools as walkers (Alexandria City Public Schools n.d.).

School is a mandatory activity, but children are less likely to travel that far for day-to-day entertainment or play. Schoeppe et al. (2016) surveyed adults in Queensland, Australia on their perception of safe distances for eight to twelve-year-old children's unsupervised travel and play. The survey results showed that a majority, or 74%, of adults wanted to restrict eight to twelve-year-old children independent play to less than five hundred meters, or approximately 0.3-mile. An additional 14% were comfortable with the children playing within 0.3- to 0.6-mile and the remaining 12% would allow distances of over 0.6-mile. (Schoeppe et al. 2016). This is significantly less than the distances studied for children walking to school. A central difference is that schools do not provide school buses for those children living within one- to 1.5-mile of their school.

Several factors affect how adults perceive the safety of their children when traveling to school. M. C. Lopez and Y. D. Wong determined that while distance was the primary factor, perceptions of neighborhood accessibility, connectivity, traffic safety, and personal safety can have a significant effect on children walking to school. A neighborhood that is perceived as accessible, with quality connectivity (pathways), and in low traffic and low crime area would normally have more children whose parents allow them to walk to school. (Lopez and Wong 2017). Schlossberg et al. (2006) found that traffic danger, distance, and personal safety were not the top reasons for driving children to school. The top three reasons for driving were that school was on the way to work, the child's backpack was too heavy, and bad weather. (Schlossberg et al. 2006). The literature suggests that the decision of whether and how far to walk is complex, and so it is not easy to give determine walking distances by relying on previous studies.

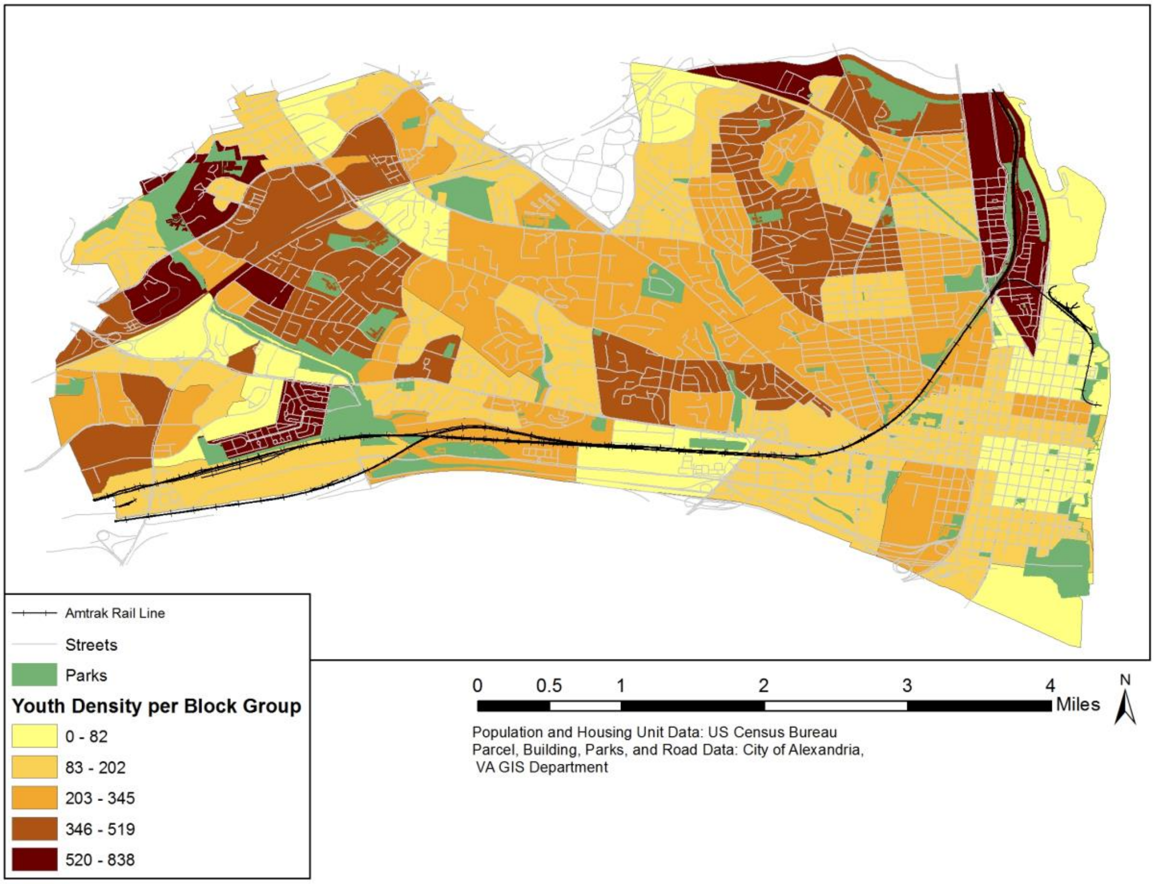
This study builds on previous work by segregating park accessibility by both age group and distance. It is unreasonable to judge toddlers and teenagers by the same travel distance. For this study, age groups have been assigned park transportation distances based on their age in the age bands defined by the census. For newborns to children four years old, 0.25-mile is a reasonable distance for parents to take their children to a park. For ages five to nine, 0.5-mile is used. For youth from ten to seventeen, one-mile is used due to the increased likelihood of access to bicycles and automobiles. Ten- to seventeen-year-olds also are more apt to engage in team sports and would be willing to travel further to participate.

Chapter 3 Methods

This study analyzes the green space in Alexandria, Virginia and its accessibility to various socio-economic segments, focused primarily on children up to age 17. The study provides a detailed coverage-based method by computing the distance to the nearest park from all residential parcels in the city. This provides a more accurate analysis of park accessibility based on residential parcels than is typical in the literature, which is often based on census tracts as noted in Chapter 2 above.

Figure 4 below underscores this point by showing the population density of children aged five to seventeen in Alexandria, Virginia at the census block level. The census blocks cover many neighborhoods and do not provide an effective representation of where the children live. It would be difficult to determine the accessibility of the park system when painting the city with such a broad brush. Many census block groups have at least one park adjacent to or within its boundaries. Other census block groups, often with small populations, are larger than the majority of the parks in the city. Without estimating where people actually live within the census block groups, it is impossible to accurately assess park access. By breaking down the population into expected population per residential parcel, the study observes the different accessibilities as population density increases or decreases near parks.

Figure 4 Youth Population Density in 2015 by Census Block Group in Alexandria, VA



Census block groups include many types of parcels including industrial and commercial that do not have residents. These parcels can also provide a false sense of distance to parks. Figure 4 above does not have sufficient detail to determine if the area around a park is home to any children. Several parks in Alexandria have commercial or industrial lots adjacent to the park. To overcome this issue, this study employs dasymetric mapping to estimate locations of youth by distributing the city's youth population across residential parcels. The study used ArcMap 10.5.1 as the GIS software.

The data and methods used to dasymetrically map the youth population and to calculate access to parks based on walking networks are discussed in this chapter. The chapter is organized into the following main sections: Data Selection and Preparation, Calculations and Processes and Conclusion.

3.1. Data Selection and Preparation

Data for this study comes from the US Census Bureau and the City of Alexandria GIS Department. This data is free for download through the internet. Population data and census block group data was from 2015; parcel, building, and road data were from 2017; and housing data was from 2015. This section describes the data; the following section discusses how the data was processed to produce results. Table 1 below shows the feature classes used for this study, their source, and the variable fulfilled by the feature class.

Table 1 Source Data and Variable Fulfilled

Feature Class	Source	Variable Fulfilled
2015 Census Block Group Polygons	US Census Bureau (US Census Bureau 2017)	Census Block Groups
2015 Population Data – American Community Survey 5-year estimates by census block group	US Census Bureau (US Census Bureau 2017)	Total Population, Population by Age, Population by Sex
2017 Parcel Data	City of Alexandria GIS (City of Alexandria GIS Department 2017)	Residential Parcels
Building Polygons	City of Alexandria GIS (City of Alexandria GIS Department 2017)	Housing Units on Residential Parcels
2015 Housing Data – American Community Survey 5-year estimates	US Census Bureau (US Census Bureau 2017)	Number of Housing Units per Census Block Group
Park Polygons	City of Alexandria GIS (City of Alexandria GIS Department 2015)	Park Location and Size
Road Line Segments	City of Alexandria GIS (City of Alexandria GIS Department 2017)	Road Network
Railroad Line Segments	City of Alexandria GIS (City of Alexandria GIS Department 2017)	Railroad Network

3.1.1. Census Block Shapefile

Data from the Census Bureau are commonly available at the census block group level. This is the most precise geography at which the government breaks down population by age. This served as the table to which all other data was related. Population data broken down by age was linked to the census block shapefile. The study performed a simple selection by attribute of the census block group shapefile based on the county number 510, which indicates the city of Alexandria and clips the statewide block group shapefile to the study area.

3.1.2. Population Table

This study focused on park accessibility for youths. Based on the population breakdown by age provided by the US Census Bureau, the age groups are divided for this study into Male 0-4, Male 5-9, Male 10-14, Male 15-17, Female 0-4, Female 5-9, Female 10-14, Female 15-17, and total population ages 0-17 years. Age groups 18 and over do not fall within the scope of this study and were ignored.

The Census Bureau provided the age breakdown in its census block groups. The study initially utilized census tracts but recalculated with census block groups as the data was more precise for estimating the distribution of people to residential parcels. The data downloaded from the Census Bureau was not formatted for importing into ArcMap. The data was reformatted with field titles in the first row and block groups in the first column. Field titles were simplified and combined in Microsoft Excel as per the following example: “Male 5 to 9 years” and “Female 5 to 9 years” became “T0_4.” The Excel file also had two rows of titles that were reduced to one row for use in ArcMap.

3.1.3. Parcel Shapefile

The parcel shapefiles from the City of Alexandria GIS Department include information about the location and owner of the parcel. It is the primary shapefile used for this study. All other shapefiles and tables eventually relate to the parcel shapefile. The parcel data is from 2017. It was the only available timeframe for the data. This mismatch in years between the Census data and parcel data is not a significant source of error in the study, as very few parcels changed uses in the two years since the census estimate. Unlike many cadastral datasets for other cities, the parcel shapefile for Alexandria does not include an attribute for how many housing units are in each parcel. Therefore, an alternate method of determining the number of housing units present was developed. Spatially joining the parcel shapefile with a building shapefile from the GIS Department brings the housing unit field to the parcel shapefile.

3.1.4. Building Shapefile

As mentioned above, this study makes use of spatial data provided by the City of Alexandria GIS Department that is a polygon shapefile showing all buildings over one hundred square feet in size and providing the number of housing units in each building. It also indicates the building use. People live in residential and multi-use buildings, which were the relevant types of building selected to estimate housing units per parcel for this study. The building data is from 2017. Ideally, the building shapefile would match the population data, but the GIS Department only has the most recent data on their website. According to the United States Census Bureau’s American Community Survey 5-year estimates in 2015 and 2016, the total number of housing units in Alexandria Virginia only increased by 770-units or one percent of the city’s total. Extrapolating this rate to 2017, a two percent difference in the number of housing units likely does not introduce a significant level of error into the study.

3.1.5. Housing Unit Table

The Census Bureau website provided the estimated number of housing units within each census block group using the American Community Survey (ACS) 5-year estimates. This detailed housing report included the total number of housing units, owner versus rental quantities, size of structures by housing unit, age, rooms, type of heating fuel, and value of the housing unit. The only relevant field for this study was the total number of housing units. Data from 2015 was selected in order match the year of the census block group population data and shapefile.

Preparation of the housing data consisted of removing the second header row and replacing periods with underscores for use in ArcMap. The relevant field code for the number of housing units was “HD01_VC01.” This data was used to calculate expected youth population in residential parcels.

Both the housing unit table and building shapefiles are necessary for this study because either one alone does not provide the required information. The housing unit table does not show how the housing units are distributed. The building shapefile allows the study to identify how many housing units are on each parcel when spatially joined with the parcels. The housing unit table only provides the total housing units in the census block.

3.1.6. Park and Road Shapefiles

The park and road shapefiles were also downloaded from the Alexandria GIS Department. The park shapefile was manually updated with the park size from the Alexandria Parks Department website. Each park was identified if it had active play features for further comparison later. The park size was not adjusted for the size of the active play feature. This would have required identifying the actual size of just the active play features and was beyond the scope of this study. This does introduce some error into the calculations and will be further discussed in Section 5.2. Table 2 below shows which active play features this study considers age-appropriate. Active-play features for newborns to four-year-olds are playgrounds. Ages five through nine add playing fields and swimming pools. Ages ten through seventeen have the most active play feature types including basketball courts, playing fields, skateboard parks, swimming pools, tennis courts, and volleyball courts.

Table 2 Age-Appropriate Active Play Features by Age Group

Age Group	Basketball Court	Playground	Playing Field	Skateboard Park	Swimming Pool	Tennis Court	Volleyball Court
0-4		X					
5-9		X	X		X		
10-17	X		X	X	X	X	X

A series of Select by Attribute tools created shapefiles that included only active play parks for each age group, from zero- to four-, five- to nine-, and ten- to eighteen-years-old.

The roads shapefile from the city GIS department did not include a field for sidewalks. Pedestrians prefer to walk on sidewalks. A Selection by Attribute was run to select all roads with a speed limit of thirty-five miles per hour or less. This new shapefile serves as a proxy for pedestrian routes. Those roads with a speed limit of less than twenty-five miles per hour might not have a sidewalk but are still considered part of the pedestrian transportation network.

3.2. Calculations and Processes

There are four main steps in the workflow for this study. Further preparation of the data included assigning housing unit data to parcels, assigning census population data to parcels, creation of active play features, and creation of park access points. These steps ensure that the data is correctly formatted for analysis. Conducting network analysis creates service areas and begins the analytical section of the study. Calculating park load and calculating available park acreage per parcel complete the analytics to compare parks and parcels to determine accessibility of age-appropriate active play park feature for youths in Alexandria, Virginia.

3.2.1. Selecting Age-Appropriate Travel Distances

Many studies use common, round numbers for travel distances. Some studies acknowledge that these values were selected for ease of use without any reference to supporting evidence. This study shares this weakness, as no definitive reference was found for the distance bands that are standard in the walkability literature. The author's life experience and logical process resulted in using round numbers for travel distance. This may not be the most accurate representation of how far a child can be expected to travel to access a park. It does seem reasonable to assume that older children would walk or perhaps bike up to the 0.5-mile and one-mile distances. The actual distances may vary from year to year, from region to region, and within the age groups used for this study. For example, a seventeen-year-old typically has an increased travel area due to the freedom given by parents as a result of their maturity and access to automobiles than a ten-year-old. However, not every seventeen-year-old child has these mobility enhancers. The distances used in this study should be suitable representations of how far an average youth in the age group is likely to travel.

3.2.2. Assigning Housing Unit Data to Parcels

Since the parcel data provided by the City of Alexandria did not include the number of housing units, steps were taken to calculate this data. The building shapefile from the City of Alexandria did include the number of housing units in the building. The buildings were spatially joined to the residential parcels to pass along the housing unit attribute. The parcels collected the sum of the attributes of all buildings that intersected the parcel. This meant that if a parcel had two five-unit buildings on it, the parcel would have the attribute of ten units. A small potential error occurred if a building straddled two parcels. In this case, the units were counted twice. This occurred infrequently and would not affect the results significantly. The result of this step is that every residential parcel had an attribute with the number of housing units in the parcel.

3.2.3. Assigning Census Population Data to Parcels

There were five inputs required to calculate expected population per parcel; housing units per census block group, census block groups, population data by census block group, housing units per building, and parcels. It was unreasonable to expect exact knowledge of how many people reside in each parcel in the city using only census data. While the ACS 5-year estimates provide total housing units per census block, data from the city of Alexandria is more accurate. The 5-year estimate is exactly that, an estimate. The GIS Department likely cooperates with the permitting and building inspection processes to update their files more frequently than the Census Bureau. The city will also have the distribution of housing units within the census block. The 5-year estimate only provides a total number of housing units whereas this study requires the number of housing units per parcel. To best simulate this, the total population in each census block group was divided by the number of housing units in that block group and then multiplied by the number of housing units on the parcel to predict the number of residents living on the parcel as shown in Equation 1 below:

$$Pop_p = \frac{Pop_{BG}}{HU_{BG}} * HU_p$$

Equation 1 Calculating Expected Population per Parcel

Pop_p is shown to be equal to Pop_{BG}, the total population in the block group, multiplied by HU_P, the total number of housing units in the parcel, divided by the number of housing units in the block group, HU_{BG}. The next step is calculating the expected youth population per parcel using Equation 2:

$$Pop_{Yr} = \frac{(Pop_{M0-4}+Pop_{M5-9}+Pop_{M10-14}+Pop_{M15-17}+Pop_{F0-4}+Pop_{F5-9}+Pop_{F10-14}+Pop_{F15-17})}{HU_{BG}}$$

Equation 2 Calculating Expected Youth Population Rate per Housing Unit

The rate of youth population in the parcel, Pop_{Yr}, is equal to the sum of the male and female populations of youths ages 0-4, 5-9, 10-14, and 15-17 in the census block divided by the number of housing units in the block group, HU_{BG}. The census block group shapefile was joined to the population data by the block group identifier. The census block group shapefile was then spatially joined to the parcel shapefile to transfer the rates to the parcels. If a parcel was in multiple block groups, such as a large apartment complex, the average of the rates was stored in the attribute.

A similar process used a portion of Equation 2 to calculate the expected youth in each age group on the parcel. For example, adding the male and female total population for children ages zero to four and dividing that sum by the number of housing units in the block group and multiplied by the number of housing units in the parcel resulted in the expected youth population ages zero to four in that parcel.

$$Pop_{YP} = Pop_{Yr} * HU_p$$

Equation 3 Calculating the Expected Youth Population per Parcel

To determine the final expected youth population in the parcel, Equation 3 was used. The expected rate of youth population, Pop_{Yr}, was multiplied by the number of housing units on the parcel as calculated in Section 3.2.2 above, HU_p. This process was followed for each age group as well as all youths.

The process for calculating expected youth population per parcel in ArcMap is shown in Figure 5 below. Housing data and population data were joined to the census block group shapefile. Buildings were spatially joined to parcels to assign each building a parcel. Only residential and multi-use buildings were selected for inclusion in the next steps. The population data was then joined to the parcel data. The expected population was calculated as shown in Equation 1 and Equation 2 above.

Figure 5 Model Showing Workflow for Calculating Population per Parcel

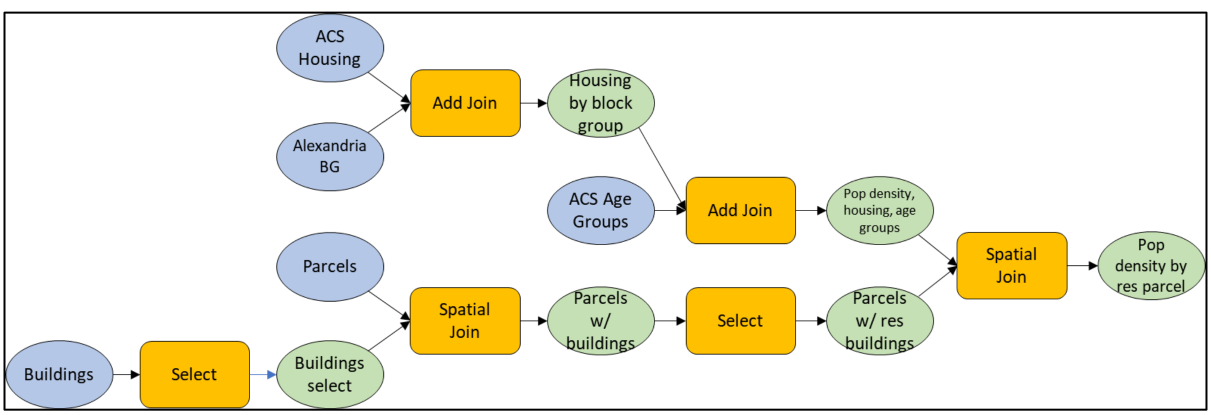
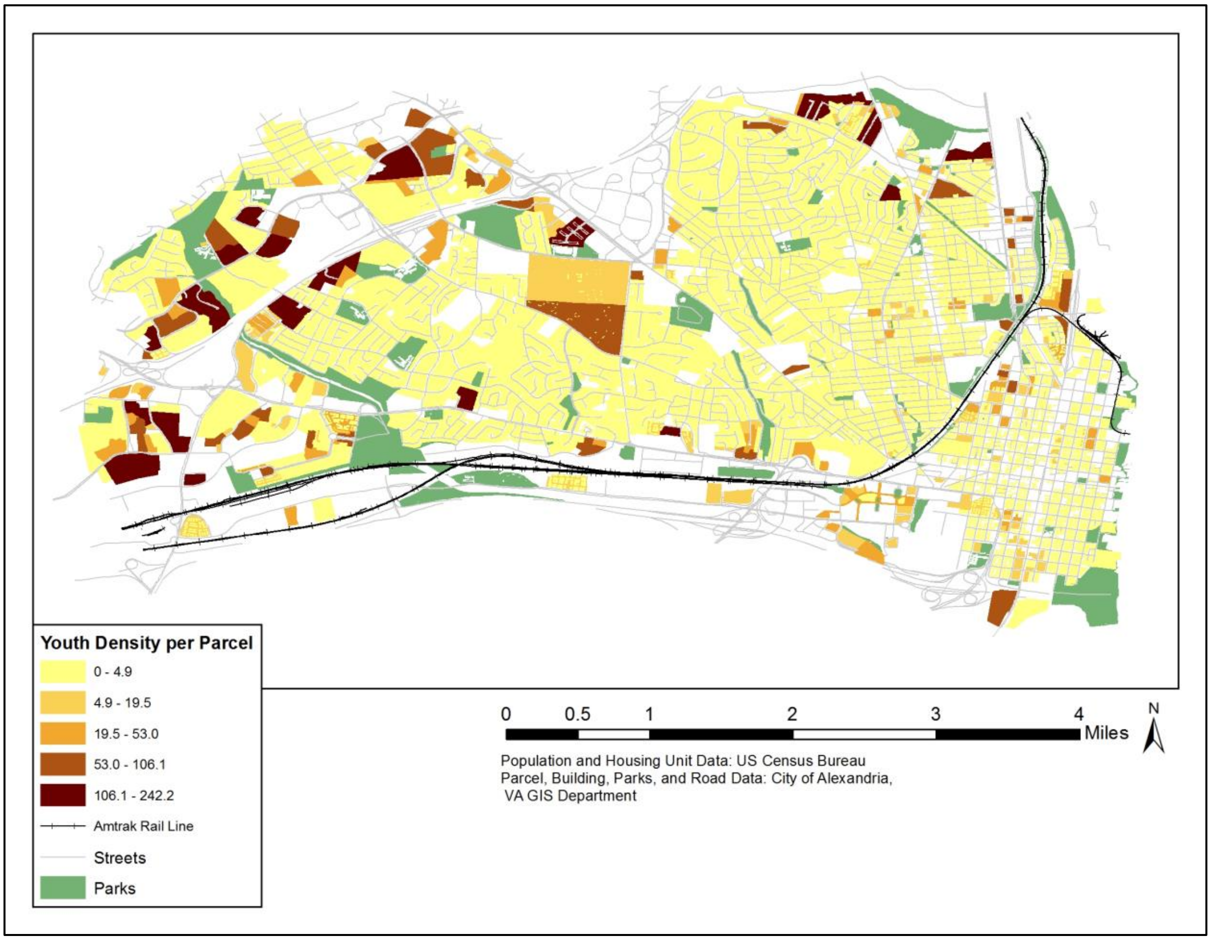


Figure 6 shows the population density of all youths under seventeen years old. Several parcels stand out. These are large apartment complexes, primarily in the west part of the city with four complexes in the northeast section.

Figure 6 Total Youth Population Density in Alexandria Virginia based on Residential Parcels



3.2.4. Creation of Active Play Features

To analyze how accessible parks are based on their age-appropriate, active-play features, they must be classified according to active play. Floyd et al. (2011) show that children from zero- to twelve- years-old are significantly more likely to use playgrounds and older adolescents use amenities dedicated to sports. Table 2 above shows age-appropriate active play features for this study. The presence or absence of these active play features in given parks was determined through the City of Alexandria's park information website. A field was created in the parks shapefile to indicate the presence of an active play feature. Separate shapefiles were created for each age group with active features for that age group using the Select by Attribute tool.

3.2.5. Creation of Park Access Points

To calculate accessibility to parks, access points are required for network analysis. It was not realistic to use the centroid of the park for calculations, as some parks are vast, and the centroid is not an accurate representation of where users enter the park.

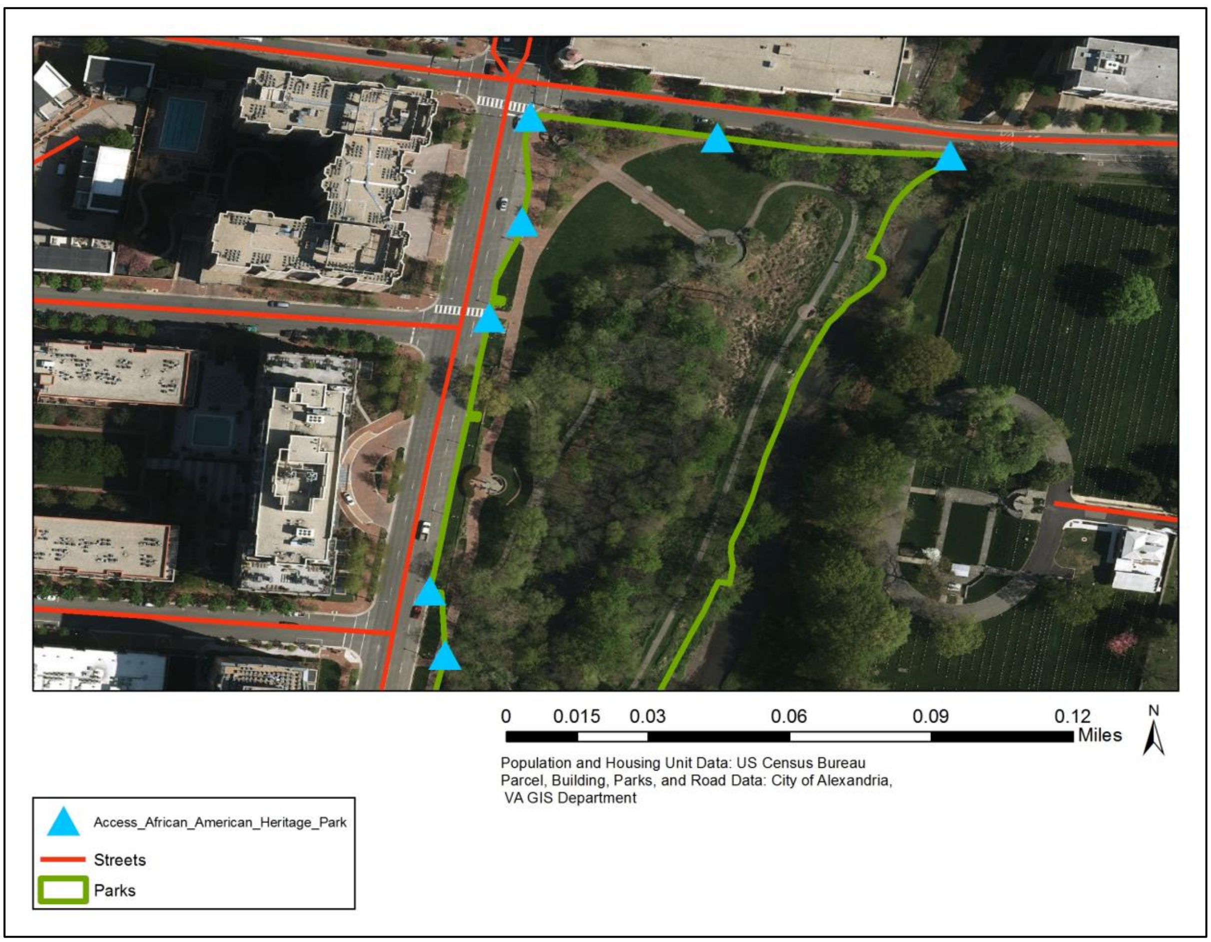
Conversely, the corner points of the park were not always good substitutes for access points, as there are sometimes surrounding parcels that block pedestrian traffic. An example of this is a park that abuts a residential property. Pedestrians cannot traverse private property to access the park. As such, overhead imagery was used to determine common-sense access points as shown in the example in Figure 7 below. These are the points that provide pedestrians the closest possible access from the road network in approaching the park from every direction.

Figure 7 Map of Access Points at Beach Park

Since the centroid of a park would not suffice for the detailed level of analysis required, access points for each park were created. The first step was to use the ArcMap tool Feature Vertices to Point, creating points at each vertex of the 103 parks in Alexandria. As a next step, for each of the parks in Alexandria, the study used basemap world imagery to look for distinct access points to parks. In cases where points at vertices did not make for appropriate park access (as noted above), these extra vertices were deleted manually. New points were created for obvious access points not located on vertices. Obvious access points included sidewalk entry and access points near a road intersecting with the park.

As a general rule, the corner and road intersection access points were used to identify the easiest way to get into the park from an adjoining or intersecting road. For example, Figure 8 below shows eight access points for the African American Heritage Park. The top right corner access point allows for pedestrians arriving along Jamieson Avenue from the east. The top middle access point is easily defined by the sidewalk entering the park. The top left access point is both a corner point and an easily identified sidewalk entry. Along the west side of the park, several access points are either sidewalk entries or access points near a T-intersection to allow access from the west along Ballenger Avenue or Emerson Avenue, the two east-west streets in the western portion of the map.

Figure 8 Access Point Types at the African American Heritage Park



After adding access points, the park shapefiles were then segmented based on active play features. This created three sets of park polygons with access points: all parks, parks with active play features, and parks with no active play features. Each park had its access points broken out through the United States Geological Survey tool Split by Attribute (United States Geological Survey n.d.). The USGS built a customization of ArcMap 10 to help divide a shapefile into multiple shapefiles based on unique values of an attribute. Using this tool, the all-parks access points shapefile was split into 103 shapefiles, each associated with the name of the park. This split is used for creating service areas for each park.

3.2.6. Creating Park Service Areas

Using the ArcGIS Network Analyst toolbox allows for the creation of walksheds that show the distance traveled from a starting location along the network. Although the travel distance will vary significantly from family to family based on a wide variety of factors, this study simplifies the travel distances to three bands based on age of the youth. The following steps were repeated for all parks, active parks, and active parks for ages zero to four, five to nine, and ten to seventeen. Distances used were one-quarter, one-half, and one-mile for all parks and all active parks. Age-appropriate active parks used distances considered proper for the age group. Newborns to four-years-old utilized 0.25-mile, children aged five- to nine-years-old used 0.5-mile, and youth ten- to seventeen-years-old used one-mile.

Importing the street dataset from the City of Alexandria into the tool builds the transportation network. The study then selected a new service area and loaded the appropriate access point shapefiles as the facilities. The appropriate distance was selected with a matching break to ensure only a single ring. Key option selections included U-turns allowed, as pedestrians do not have to follow vehicle turning restrictions. To avoid multiple overlapping service areas for the same park based on multiple access points to that park, merge by break value was selected. This shapefile confirms if a residential parcel is within the park's service area. Overlapping service areas were used later in the process when calculating available park acreage.

The resulting service areas show what area is covered within a certain walking distance of the park following the road network. This is used to estimate which parcels are in within given walking distances of specific parks and then to calculate the number of expected children that can be serviced by that park, including expected youth users per acre.

3.2.7. Calculating Park Load

Park load is a useful calculation showing the total number of people within the park's service area divided by the park's area. It indicates the degree to which a park may potentially be congested with users. This method normalizes the number of park users for comparison across parks. Park load is defined in Equation 4 below:

Equation 4 Calculating Youth per Park Acre

$$L_P = \frac{Pop_{Yp}}{A_p}$$

Here park load (L_P) is shown to be equal to youth ($Pop_{Yp)}$ divided by the area of the park in acres (A_P). Two parks with the same number of people in their service area but with differing park sizes will have different park loads, indicating park congestion.

To determine whether a residential parcel falls within a park service area, parcel centroids were created. These centroids take on all the attributes of the parcel (except its geometry), which simplifies the determination if the parcel is within the service area. Either the centroid is in or out of the service area whereas a parcel polygon could be partially inside the service area. Each of the park service areas were spatially joined with the parcel centroids while summing the attributes. This ensured that the park service area now had the sum of all expected youth in the residential parcels within the service area. All park service areas with the same distance (0.25-, 0.5-, and one-mile) were then merged to create one shapefile for the 103 parks. The service area was manually edited with the park's FeatureID to prepare for the next step.

To show each park's load, the park shapefile was joined to the merged service areas based on the park's FeatureID. New fields were created for the density of the various age groups at differing distances, for example, "Hd0_17" for the density of all youth within 0.5-mile of the park. These fields were calculated using Equation 4 above. This allows for the geographical representation of the park's density within its boundaries.

3.2.8. Calculating Accessible Active Park Acreage per Parcel

The final step was calculating active park acreage per youth. This calculation shows which residential parcels have the highest and lowest accessibility to active parks. The calculation uses Equation 5 below.

$$A_{AP} = \frac{A_P}{Pop_{Yp}}$$

Equation 5 Calculating Accessible Active Park Acres per Expected Youth

The accessible active park area in acres, A_{AP}, is shown to be equal to the active park area in acres, A_P, divided by the expected youth population in the parcel, Pop_{Yp}. Dividing by the expected youth population normalizes the accessible active park acres to enable comparison of different parcels. Since different parcels can have a significantly different number of expected youths, ranging from less than one to over one hundred, normalization is necessary. This process highlights those parcels and neighborhoods with good access to active parks and those with inferior access to active parks.

To determine the active park area for each parcel, a spatial join was conducted using the sum criteria. By joining the merged service area shapefile (as described in Section 3.2.7 Calculating Park Load above) with the residential parcels, it brings the total park acreage accessible within the specified distance from each parcel. Then all parcels with a non-zero expected youth population and a non-zero active park area were selected by attribute. A field calculation was conducted using Equation 5 to determine the number of park acres available per expected youth living at that parcel. The expected youth population used for each distance corresponded with the earlier stated reasonable walking distance; youth aged zero to four were paired with active parks within 0.25-mile, youth aged five to nine with 0.5-mile, and youths aged ten to seventeen paired with one-mile.

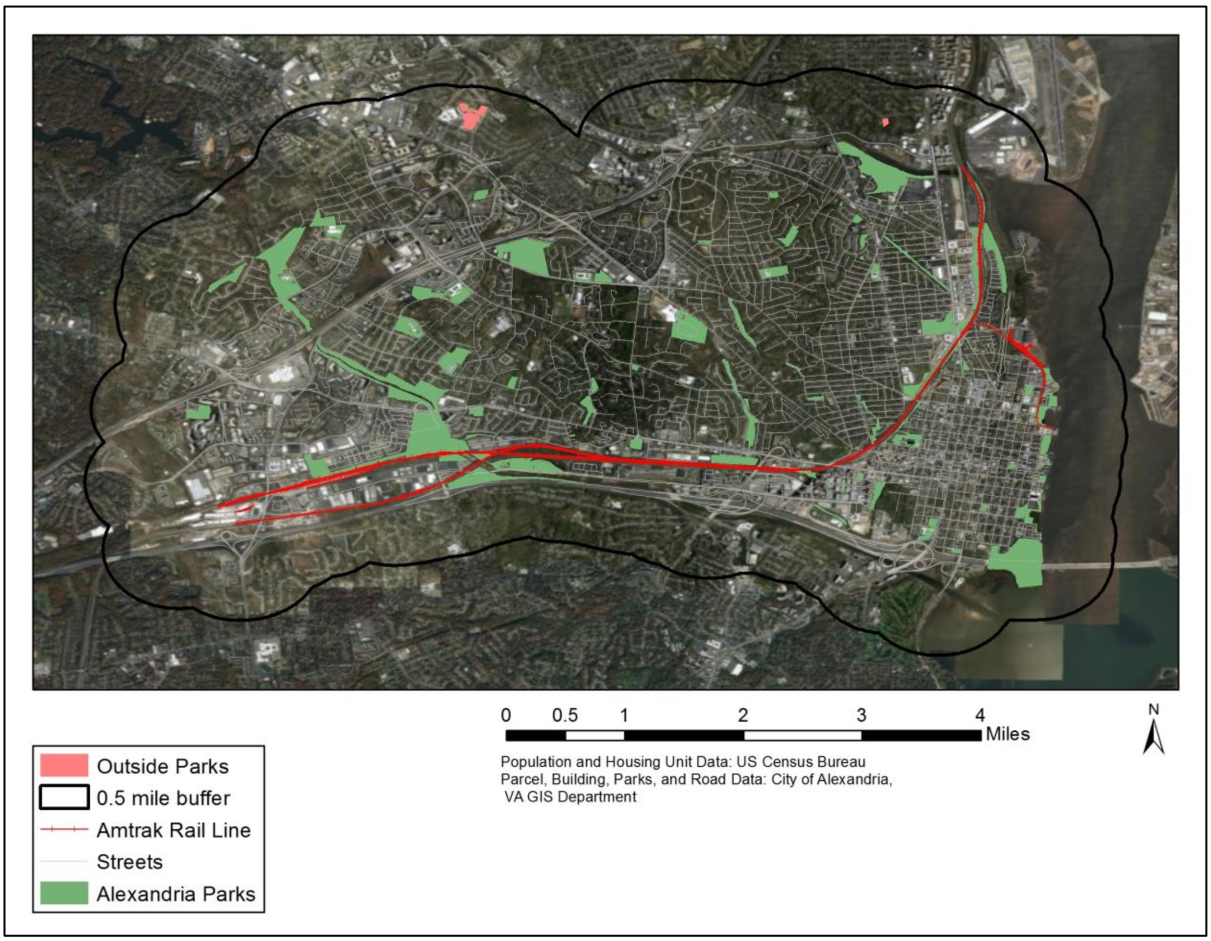
3.2.9. Mapping Techniques

Displaying accessible park acres per expected youth on a map was a two-step process. A Jenks natural break classification minimizes the variance within a class while maximizing the variance from other classes. Five classifications were selected for this study. Because the study wanted to highlight those parcels with zero active park access, a sixth classification was necessary. To keep the variance between classes high and not have an extra-large classification at the lower end of the spectrum, a five classification Jenks natural break was conducted on each park acreage per parcel attribute. The breakpoints were noted and then transferred to a manual break with six classifications. This resulted in a classification for no access and five classifications for the remaining data.

3.3. Conclusion

One concern when conducting an accessibility analysis is handling borders. In some cases, an amenity is located outside the official boundaries of the study area but can affect accessibility. In line with this study, a park might lie just over the city boundary. The city boundary would not prevent residents from crossing to use the park. There are two options for handling this problem; treating the boundary as a "hard" boundary in which people are assumed to not travel across it and including the road network and amenities just beyond the study area in the study. Figure 9 shows an analysis of overhead imagery surrounding the boundaries of Alexandria, Virginia. It shows only two small parks with active features within 0.5- mile. These parks do not affect the analysis due to their distance from Alexandria residential parcels. The school in the north central part of the map is over 0.5-mile along roads from the closest parcel.

Figure 9 Active Parks within 0.5-mile of Alexandria



Further boundaries such as highways and railroads with few crossing points also restricted the southern and northern borders of the city. To the east, the Potomac River bounds the city. Parks in adjacent cities do not affect the analysis in this study because the small handful within 0.5-mile of the city boundaries is blocked by highways or rivers.

Chapter 4 Results

The goal of this study is to analyze the distribution of age-appropriate active play features in Alexandria, Virginia parks. This study used techniques that have not been publicized widely and represent a step forward in correctly analyzing actual accessibility.

This chapter reviews the study's process and describes lessons learned, presents the results of the study, and analyzes how well distributed the active parks are in the City of Alexandria. It looks at each age group and their related service areas to show what parts of the city have better access to active parks. Finally, the chapter identifies the residential parcels with no age-appropriate access to active play features at parks. This analysis can then be included in further studies to serve the youth of Alexandria better.

4.1. Analyzing Service Areas

The three age groups show different levels of accessibility, but there are some common themes. There are common areas with poor access to the west, north central, and south central. These areas are bounded by highways and or railroads that impede pedestrian accessibility. These provide effective boundaries to travel, thus squeezing the service area into long, skinny areas unlikely to intersect parks. While some of the higher values are skewed due to easy access to large parks, several areas stand out with no access to active parks. In the west, an intersection of highways reduces the available road network. A visual inspection of overhead imagery shows that there are no parks nearby outside the city limits, making this an accurate representation of available parks. A similar situation occurs along the northern border of the city, as highways block access and smaller parks reduce available acres. Parcels around the larger parks show higher access as expected. However, this does not directly address the size of the active play features. A park may have over sixty acres, but if fifty-nine acres are woods with only one-acre available for open area and a playground, this gives a false indication of higher level of access. This is addressed in Chapter 5.3 Suggestions for Future Work.

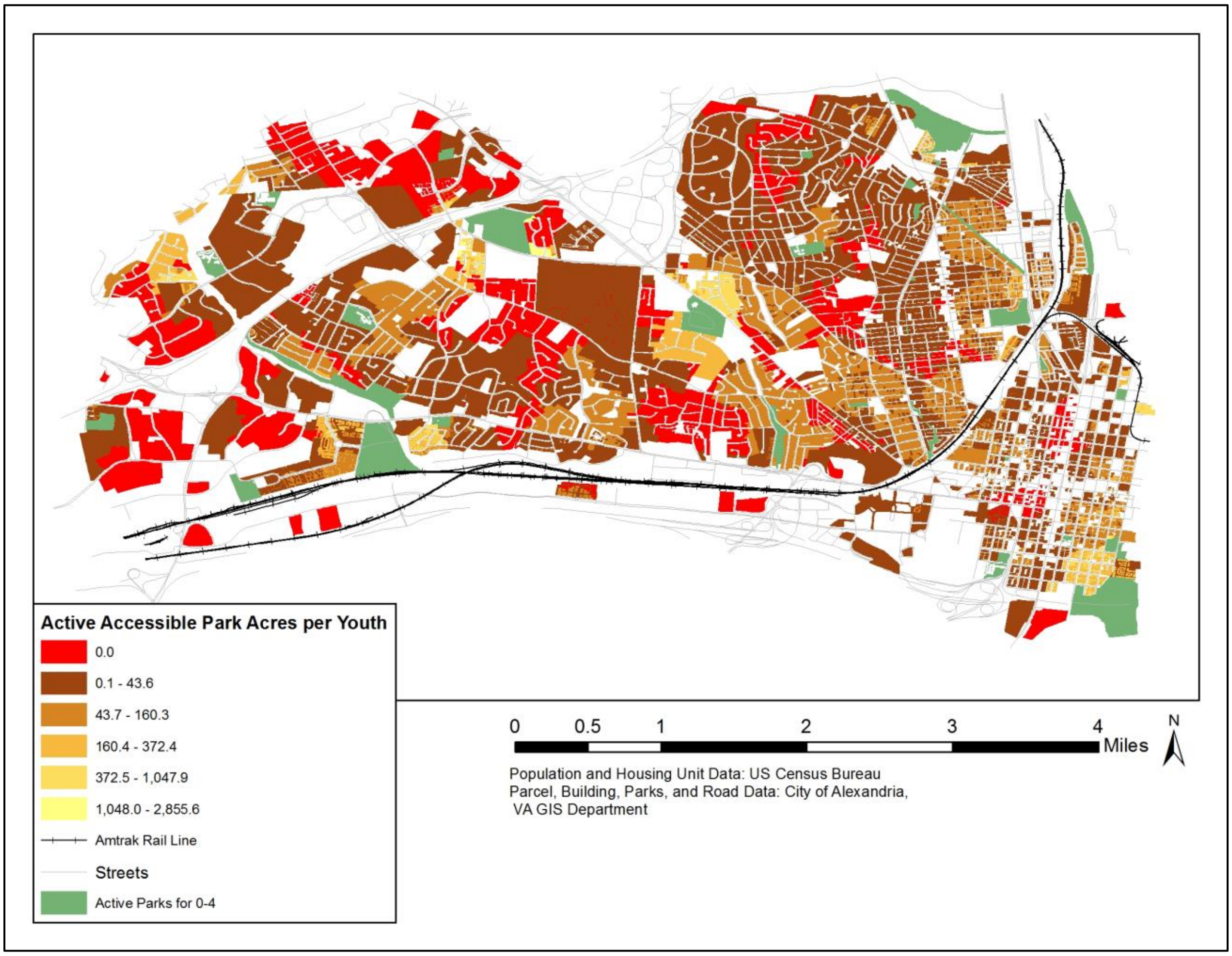
Areas with a dense road network appear to be more accessible, as the route options multiply with each intersection. Homes around schools have excellent access to parks. Many schools have multiple types of active play features, primarily playgrounds and playing fields.

The maps showing accessible active-play acres per expected youth were classified using Jenks classifications with an added classification for parcels with no accessible active play parks. The maps for the older age groups have significantly different breaks than the youngest group due to the higher maximum acres.

4.1.1. Youth Ages 0 to 4 and the 0.25-Mile Service Area

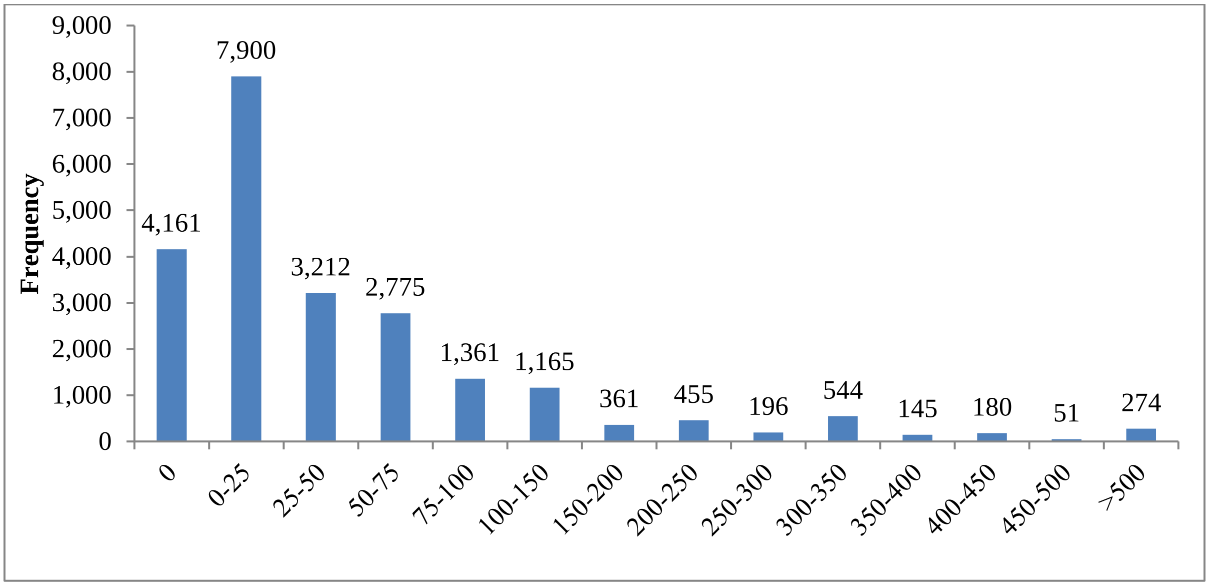
As expected, youth ages zero to four had the least access to active parks. This is primarily a consideration of the shortened distance in the service area. Figure 10 below shows the accessible park acres per youth in each residential parcel. The common areas of poor access in the west, north central, and south central are joined by neighborhoods in the center of the city. Some of these areas are residential cul-de-sacs. This design, while sought after for quieter traffic patterns, significantly decrease walking networks along roads. Since there is only one way in or out of the neighborhood, homes at the end of the cul-de-sac have inadequate access to parks. The primary driver behind lack of accessibility for youth ages zero to four appears to be the shortened travel distance. Many of the poor accessibility areas would have better access if the distance were increased. There are also several poor accessibility areas that are within 0.25-mile of a park. These parks in the north-central and southwestern sections of the map are prime candidates for installation of a playground. This would only affect a small number of parcels, as most of the zero-access parcels are over 0.25-miles from a park.

Figure 10 Accessible Active Park Acres per Youth Aged Zero to Four within 0.25-Mile



The distribution of accessibility is skewed towards fewer available acres per youth as shown in Figure 11 below. The large number of small parks throughout the city means that a parcel is more likely to be within 0.25-mile of the small park. The larger parks do not have as many parcels within their combined service areas because there are fewer large parks than small parks.

Figure 11 Histogram of Accessible Active Park Acres for Youth Ages Zero to Four



4.1.2. Youth Ages 5 to 9 and 0.5-Mile Service Area

Overall, youth aged five to nine have better accessibility than the younger age group. The middle age group has higher maximum available acres and fewer poor access areas. Figure 12 below shows the accessibility of the middle age group. Surprisingly, there are more parcels in the downtown area to the southeast portion of the map between the railroad tracks and the eastern side of the city with poor accessibility when compared to the zero to four age group. This is due to the specialization of the parks in that area. Several “tot lots” in the downtown area have small areas that are just playgrounds. As the age group progresses, the space required for an active play feature increases, thus moving most active play areas out of the downtown area. The exceptions to this are the parks along the river to Alexandria’s east. These large parks service much of downtown.

Figure 12 Accessible Active Park Acres per Youth Aged Five to Nine within 0.5-Mile

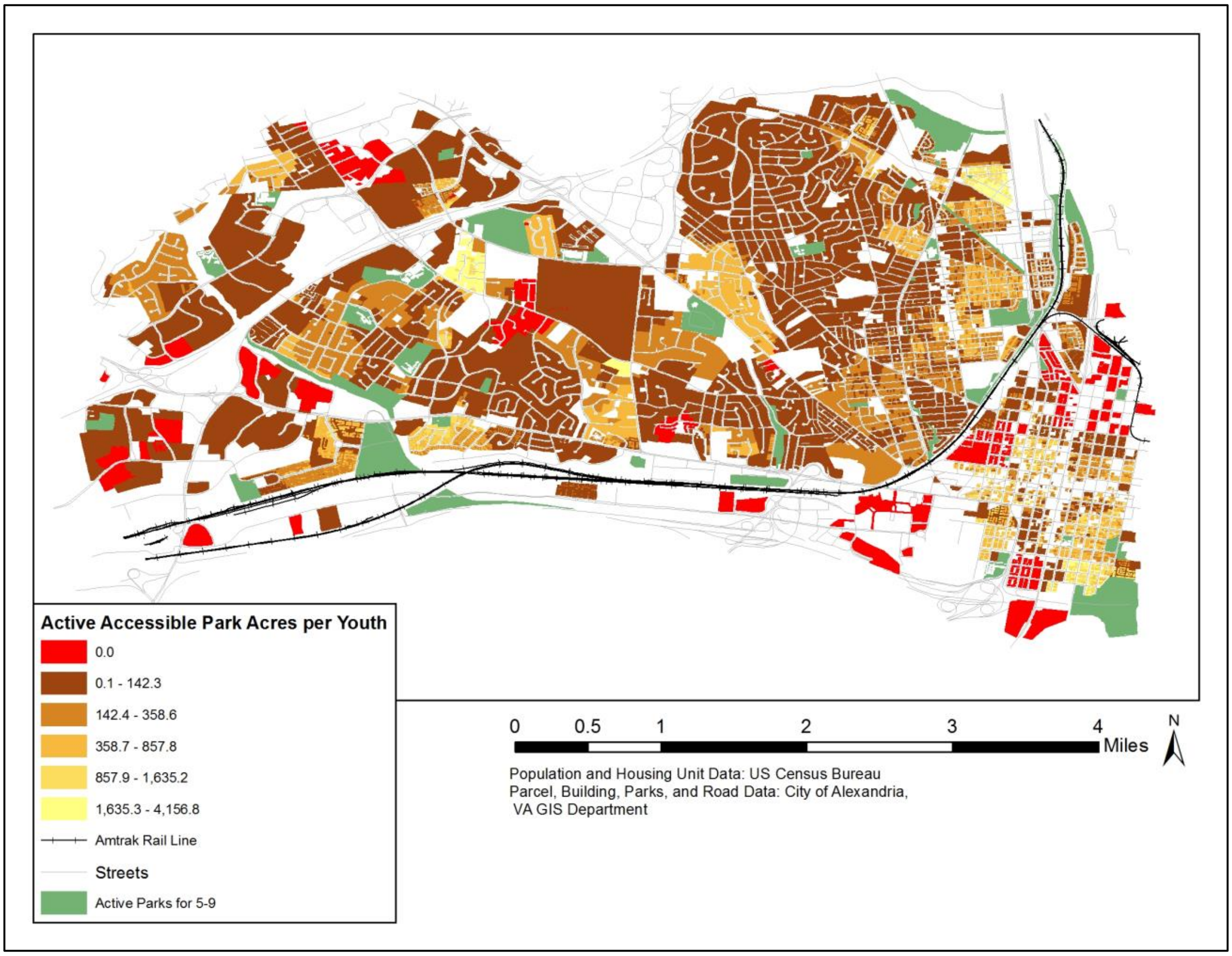
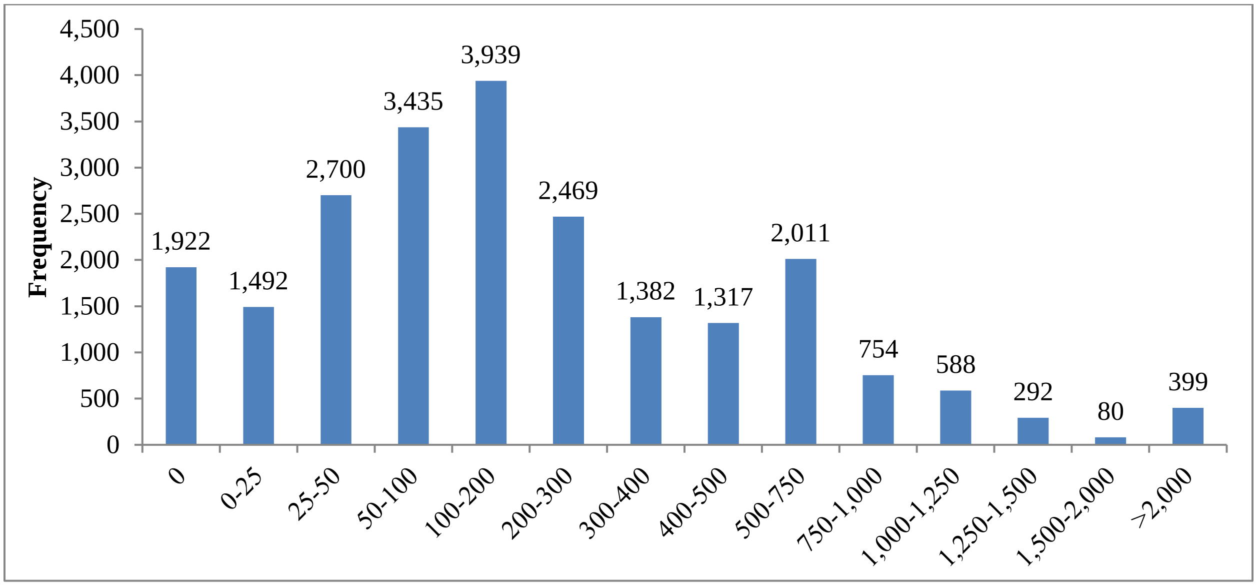


Figure 13 below shows the distribution of accessible active park acres for children ages five to nine based on residential parcels. The high number of parcels with less than 200-acres available shows that accessibility is not equitable throughout the city. While the skewing is not as bad as that of newborns to four-year-old shown in Figure 11 above, it is still distorted towards less access. 200-acres of access per youth is remarkable. This histogram does not show that there is a significant amount of poor access in the city, it just highlights the inequity of access.

Figure 13 Histogram of Accessible Active Park Acres for Youth Ages Five to Nine

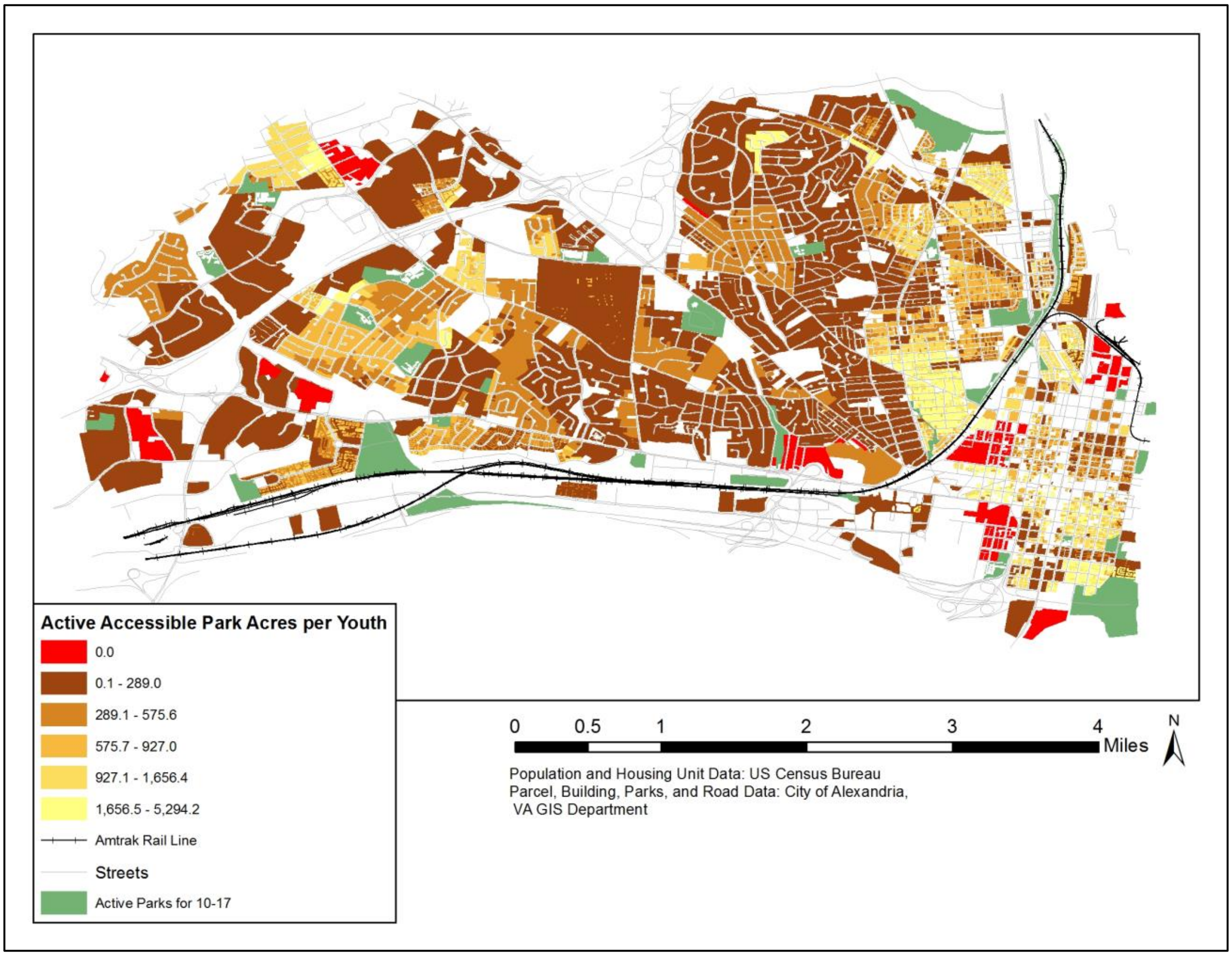


4.1.3. Youth Ages 10 to 17 and One-Mile Service Area

The oldest age group has the best access to active play features. This is primarily due to the increased travel distance. Figure 14 below shows the accessible active park acreage for youth ten to seventeen. The age group also has the most type of active play features. The lowest Jenks break for youth aged ten to seventeen includes up to 370 acres per expected youth. This is still a significant level of accessibility.

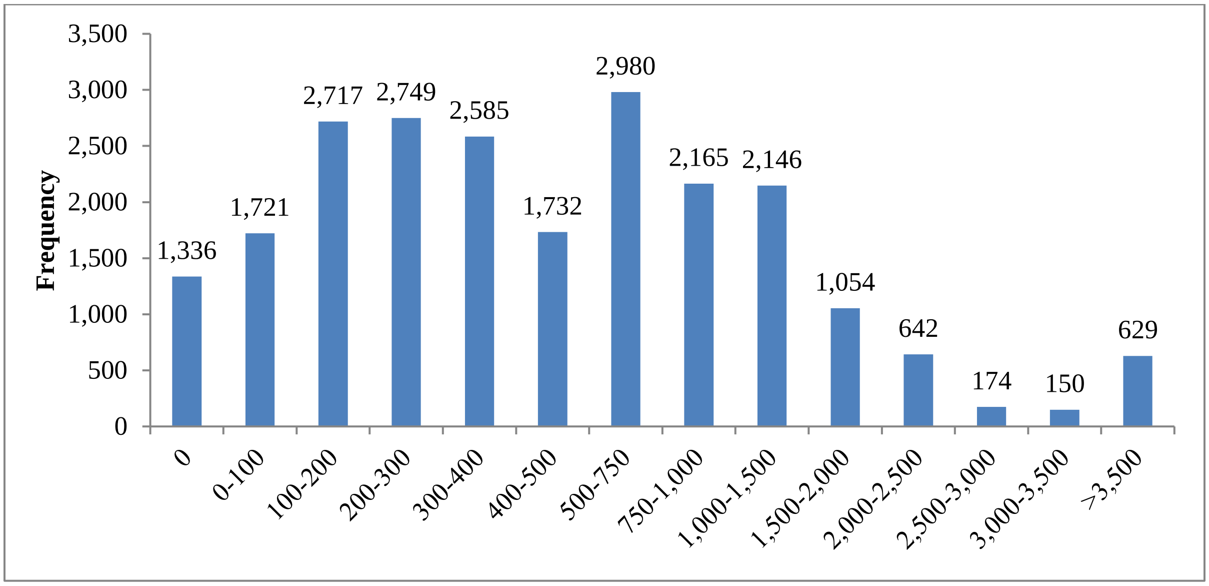
When compared to the youngest age group, this value would be above average. Even at the one-mile distance, some of the same poor access areas as other age groups can be seen. Again, the lack of a road network is the primary cause. As with the other age groups, railroads and highways provide effective linear barriers to pedestrian travel.

Figure 14 Accessible Active Park Acres per Youth Aged Ten to Seventeen within One-Mile



The distribution of park accessibility for youth ages 10-17 in Figure 15 below is much more even than the younger age groups. There is no skewing to the low end of the range. This is due to the increased service area provided by the longer travel distance. It does not highlight a significant need for changes, as even the lowest non-zero grouping still has sufficient park access.

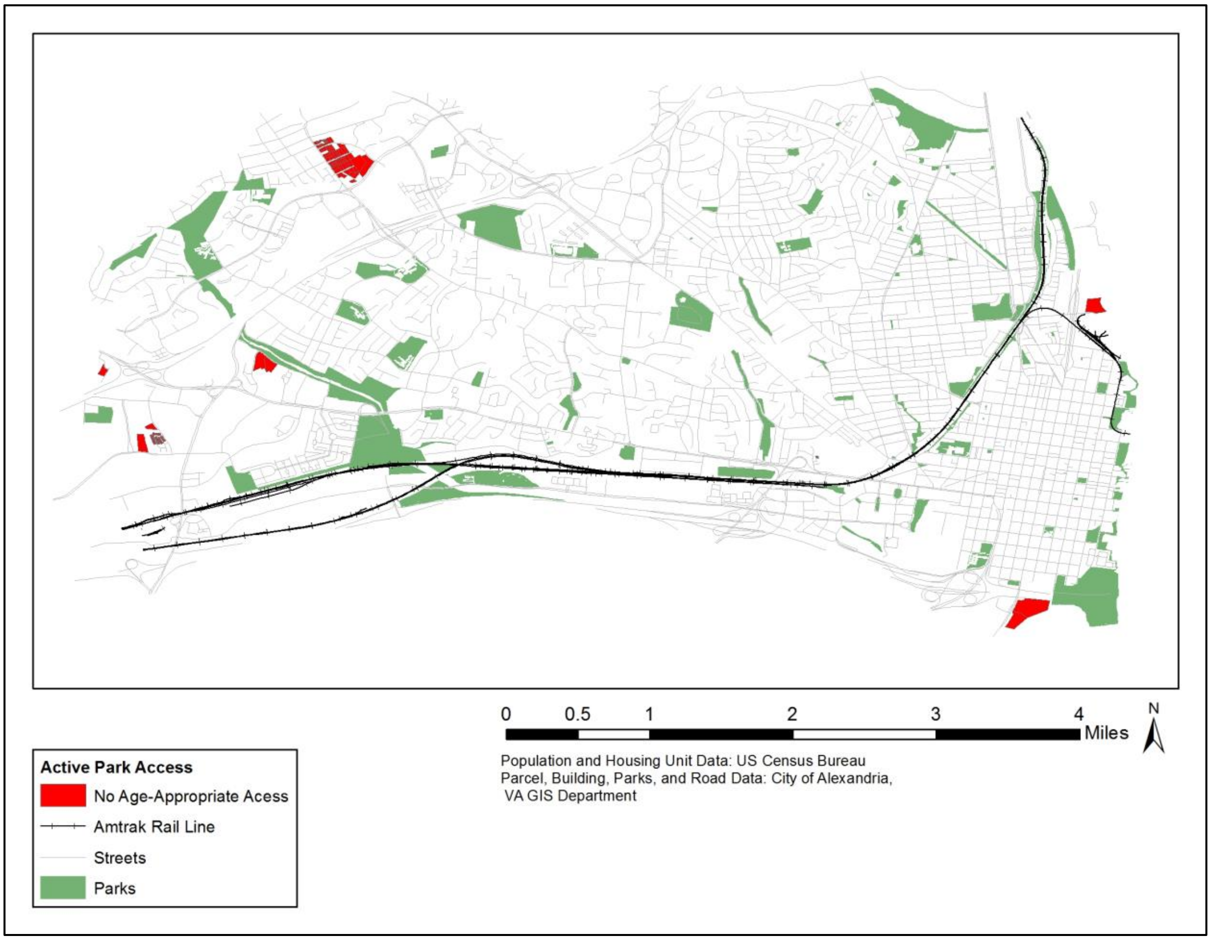
Figure 15 Histogram of Accessible Active Park Acres for Youth Ages Ten to Seventeen



4.2. Areas with No Active Park Accessibility

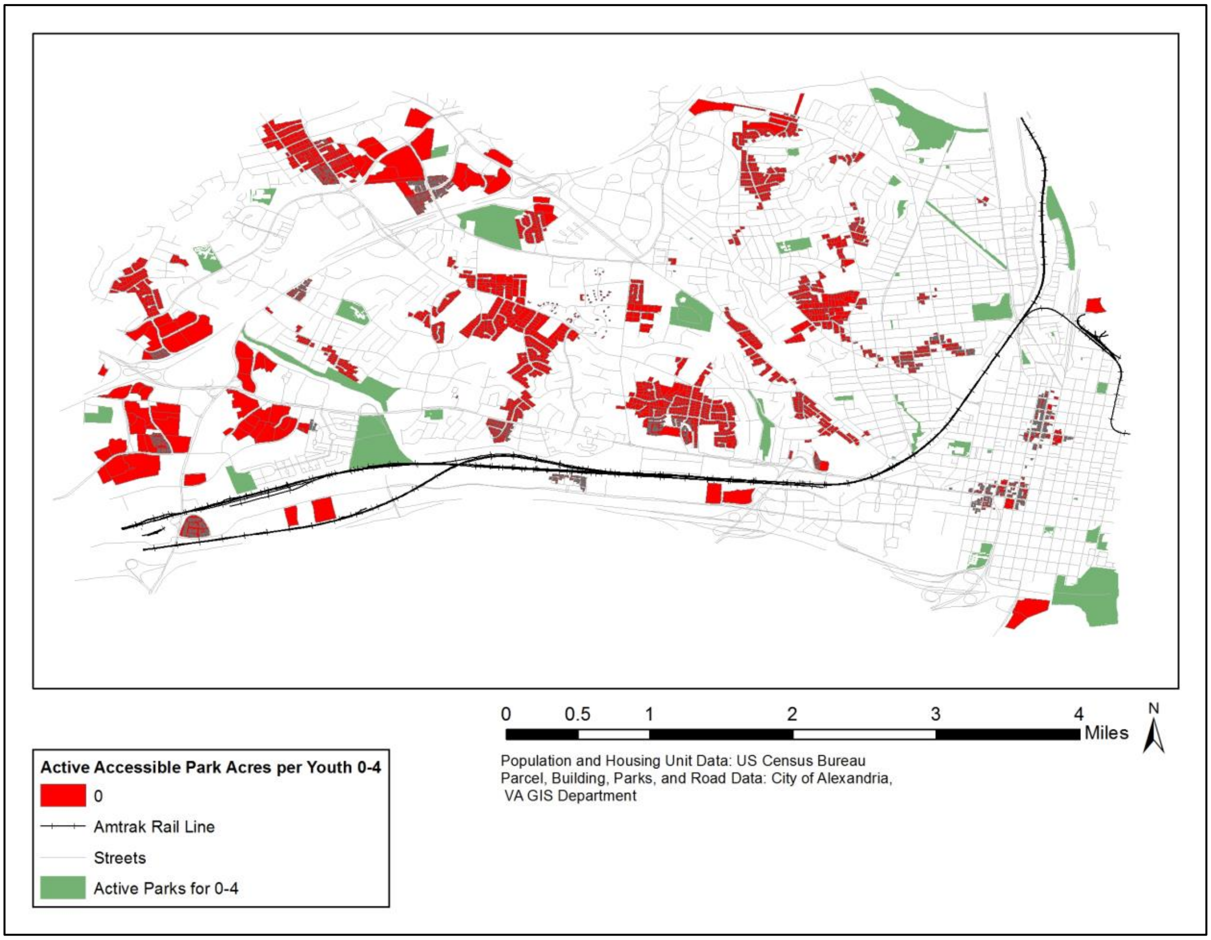
The study also identified residential parcels with no active park accessibility. These areas stand out more clearly when they are the only parcels mapped as in Figure 16 below. There are 132 residential parcels in Alexandria with no access to active play parks for youth of any age. There are no age-appropriate active play parks for youth ages zero to four within 0.25-mile, within 0.5-mile for youth from five to nine, and within one-mile for youth ten to seventeen. These 132 parcels result from selecting the parcels which have no active park acres within their age-appropriate service areas. Considering that there are over 22,000 residential parcels, this is a rate of less than one-hundredth of a percent. These parcels only have an expected youth population of 110 children. This shows how well the park locations were planned to enable access. Highways bound most of the parcels with low access, reducing the available service area.

Figure 16 Residential Parcels with No Age-Appropriate Active Park Access



The youngest age group has the most children with no active park access. Figure 17 below shows the location of the 4,161 parcels with no access to active play features. These parcels represent 3,086 youth. As discussed earlier, the parcels with no access are clustered based on road networks designed for low traffic volume at the expense of pedestrian accessibility. Cul-de-sacs and highways restrict the service area significantly with limited routes for travel.

Figure 17 Residential Parcels with No Age-Appropriate Park Access for Youth Ages Zero to Four



Children aged five to nine have a total of 1,922 parcels and 584 children with no access to active play features. The oldest age group has the best accessibility with only 1,336 parcels and three expected children without access to active play parks. Figures Figure 21 and Figure 22 in Appendix A show the residential parcels with no age-appropriate access to active play park features for the three age groups. Each of the age groups follow a similar pattern. Residential parcels with no access are concentrated in areas with poor road networks. Highways and cul-de-sacs prevent few options for pedestrian travel.

4.3. Analyzing Park Congestion

Park congestion measures how many youths are within the service area per park acre. It allows for the comparison of differently-sized parks by normalizing to the park acre. Two factors affect park congestion: youth serviced by the park and park size. The more highly congested parks have many serviced youth and a small park size. Large, spread out parks will be inherently less congested as their size reduces the congestion calculation.

As expected, the smaller parks in Alexandria have the most congestion for youth from zero to four-years-old. Figure 18 below shows that the large parks have low congestion while some of the smaller parks in the southeast have higher congestion. This is because some parks are as small as a quarter acre, which lends to higher congestion. The highly congested parks in the northeast section of the map are directly next to large apartment complexes with a high number of children. Although there are some densely populated parcels in the west directly next to parks with active play features, the methodology of this study used the parcel centroid as the determining factor if the parcel was within the parks service area. While those living on the side of the apartment complex nearer to the park would be within walking distance, the parcel was ruled outside the service area.

Figure 18 Park Congestion for Youth Ages Zero to Four

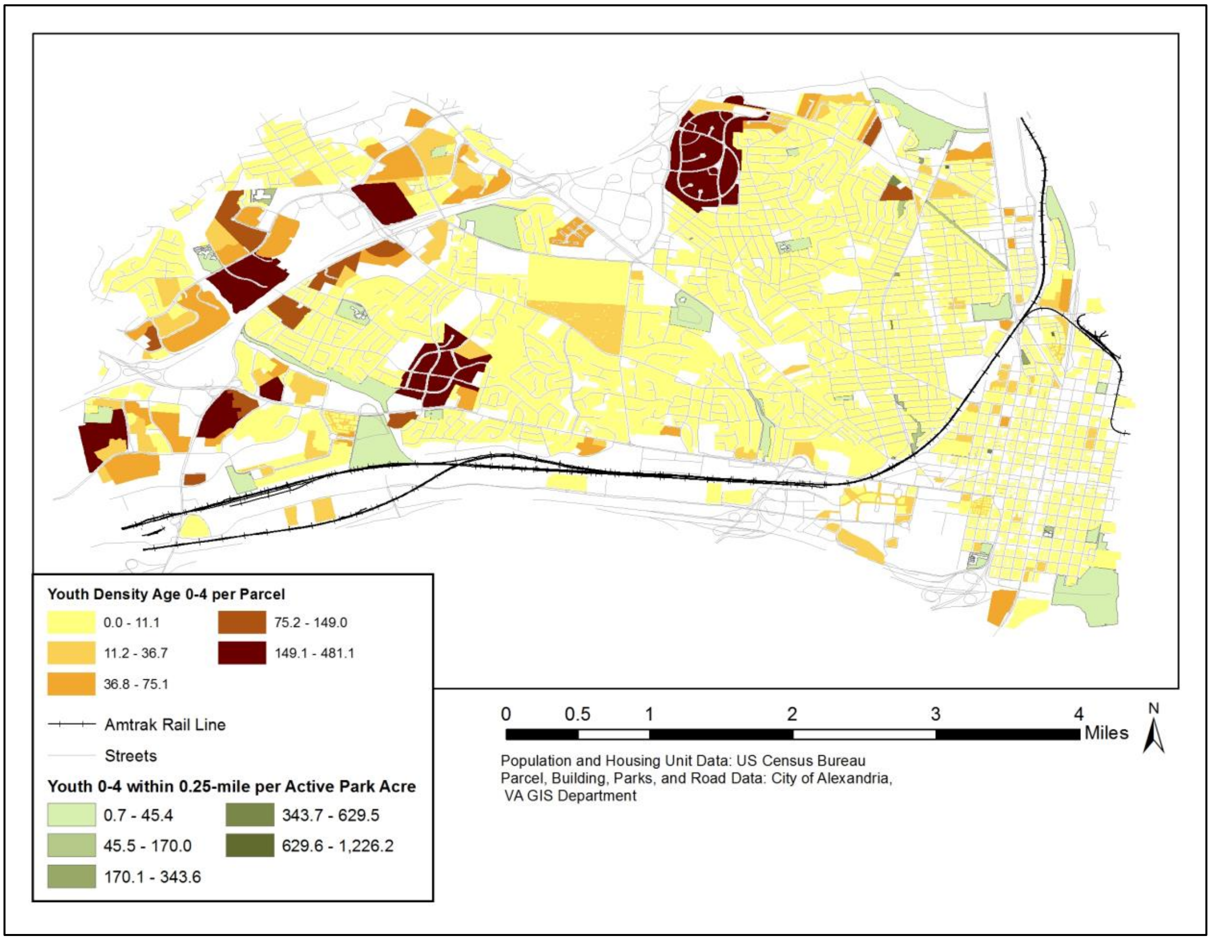
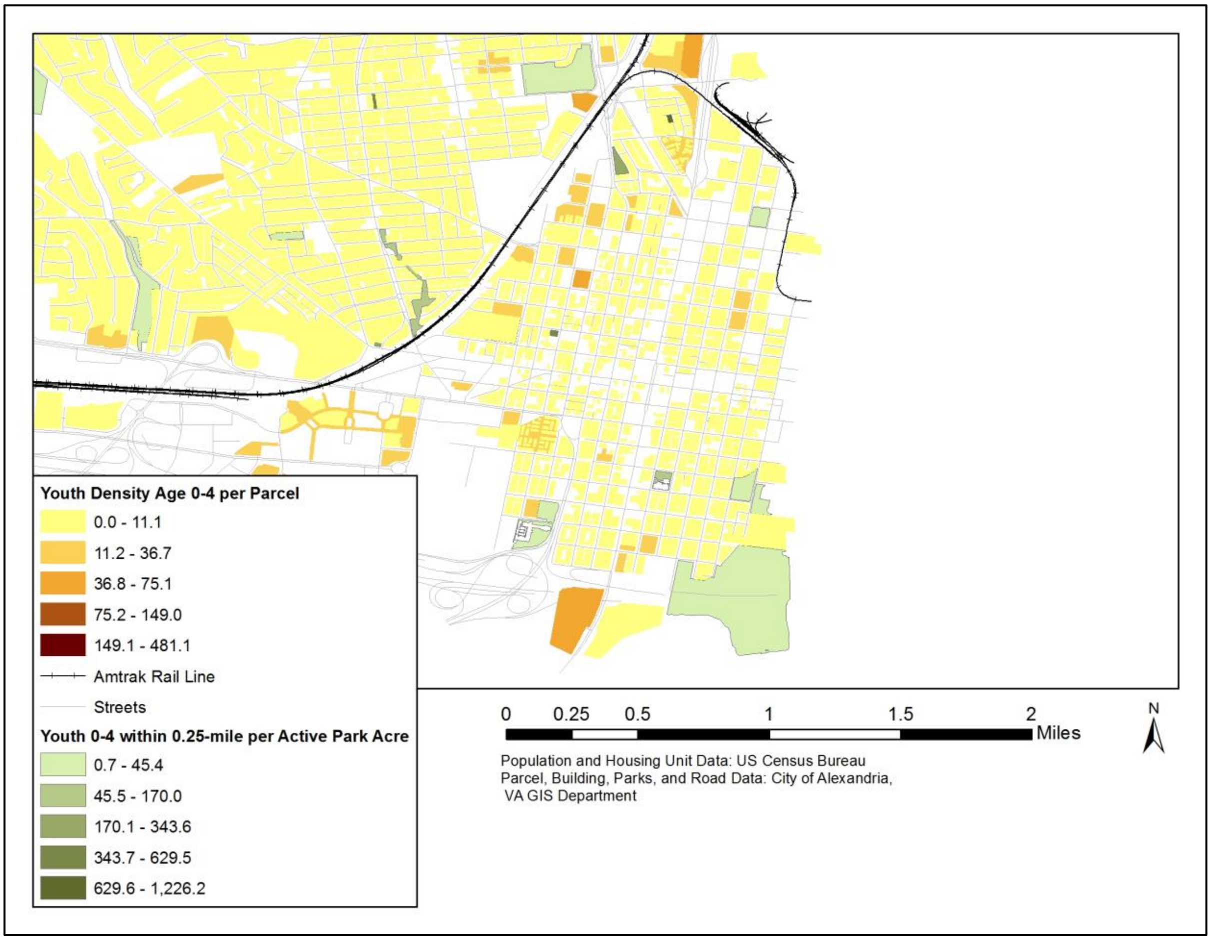


Figure 19 below shows a closer view of the smaller parks within the downtown area. While there are not many children living within their service areas, these parks are small and thus have a higher congestion calculation.

Figure 19 Park Congestion in Downtown for Youth Ages Zero to Four



Figures Figure 23 and Figure 24 in Appendix A show the park congestion maps for youth ages five to nine and ten to seventeen. They follow similar patterns as the youngest age group. The total numbers of youth serviced increase due to the expanded travel distance.

4.4. Conclusion

Alexandria has distributed its active play features through its parks well. This leads to more opportunities for children to get outside and play. Good access to parks has been shown to be one method of fighting the youth obesity that is a rising problem in the United States. Alexandria can further improve park accessibility with the addition of playgrounds in zero access areas, giving 1,500 children easy access to active play features. Alexandria can also work to encourage active play by children through outreach programs.

These 1,500 children are not completely without access to active play features. While they do not have park access from their homes, their schools likely have some type of active play features. Encouraging the children to play while at or after school can help encourage positive well-being, social interaction, and development.

Chapter 5 Discussion and Conclusion

The purpose of this study was to analyze the active play park accessibility for youth in the City of Alexandria, Virginia. The study dasymetrically mapped the youth population across the residential parcels with three age groups: zero- to four-years-old, five- to nine-years-old, and ten- to seventeen-years-old. Parks were classified into different active park classifications based on age-appropriate active play features. The study created service areas for each park at three distances corresponding to the three age groups of the study: 0.25-mile, 0.5 mile, and one-mile. Combining the service areas with the residential data allowed for calculating the park acreage accessible for each age group. This final park acreage accessibility calculation shows that Alexandria has distributed its parks and active play features well, where only 132 parcels have no age-appropriate access to active play parks. This is less than one-hundredth of a percent of all residential parcels in the city.

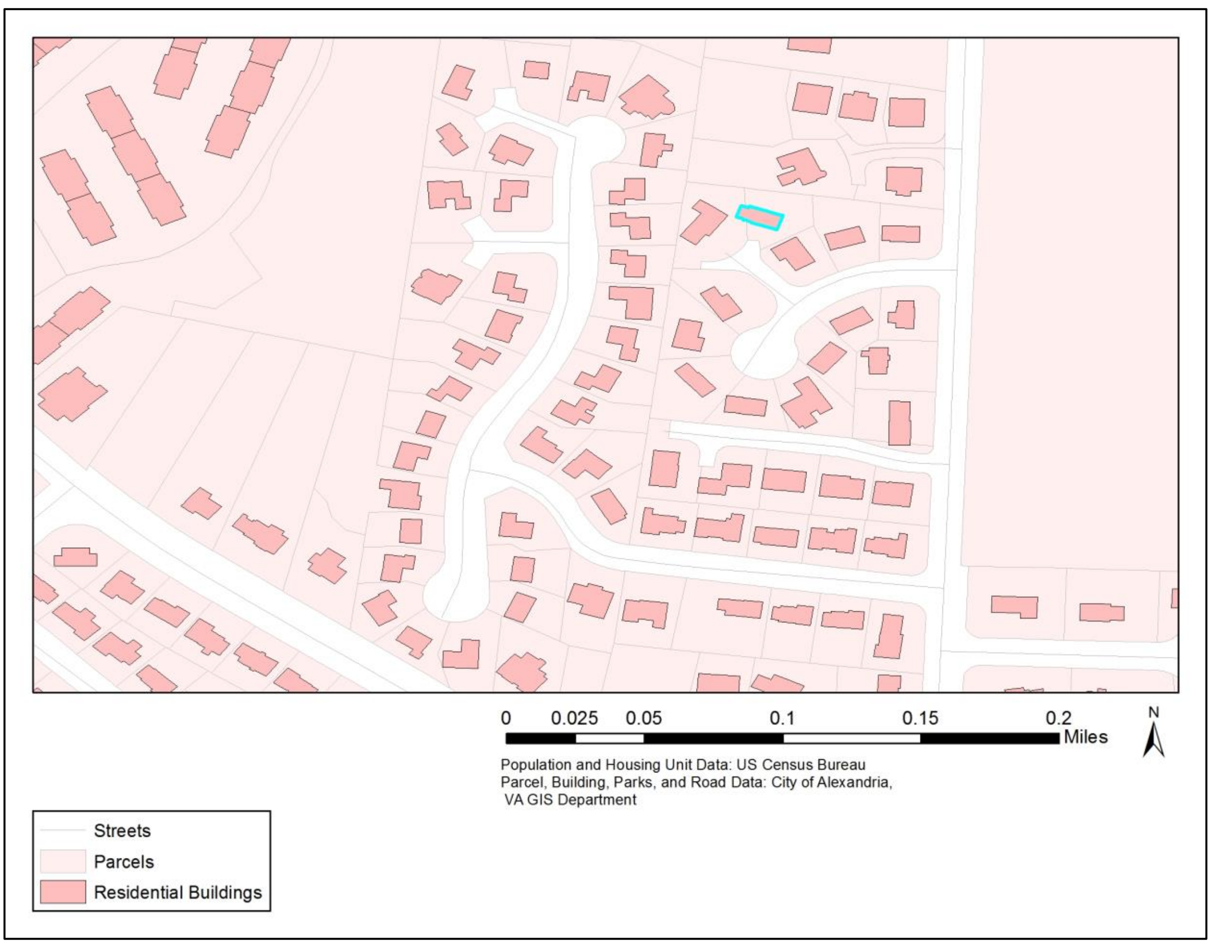
5.1. Lessons Learned

This study expanded into several areas that had not been combined in previous works. As such, there were two main categories of lessons learned: dasymetric mapping and park features and access point selection.

5.1.1. Lessons Learned from Dasymetric Mapping

There were several lessons learned throughout the study. Using dasymetric mapping to better represent where the city youth were expected to live provided many bumps along the way. The data available did not support the concept as initially conceived. Techniques to work around the problem had to be developed. The first problem was that the data from the GIS Department did not have the desired fields, specifically the housing units in each residential parcel. This made the process more complex. The workaround developed by using the building shapefile to identify the number of housing units worked well. One problem that was highlighted was that some building occurred in multiple parcels. This introduced some small error as the housing units were then counted twice. Figure 20 below highlights a building that is mapped in two parcels. The highlighted building is a single-family home that crosses parcel lines. The process of spatially joining residential buildings to parcels brought a housing unit to both parcels. The parcel on the left ended up with two housing units. The time required to verify the location of each building in the over 22,000 residential parcels in the city was beyond the scope of this study.

Figure 20 Closeup of Buildings in Multiple Parcels



This study began by using census tract population data from 2010. The data was initially selected because it was the last complete census conducted. Although this data was not the best data for the study, it served a useful purpose in developing the methodology by which the dasymetric mapping would be executed. The readily available dasymetric mapping literature did not translate directly to this project, as the data structures were different. The early census tract data allowed for experimentation on the order of tools applied and available options for each tool. The study used ACS population estimates from 2015 in the final version. While the margin of error might have increased slightly due to the uncertainty of the Census Bureau's American Community Survey 5-year estimates, it is more current than the ten-year census. The five-year estimate is the most precise estimate published by the Census Bureau. Using the data from 2015 also enabled the close matching of housing and parcel data. The housing data was also published in 2015.

Changing data sources from census tracts to census block groups also increased the precision of the study. While this caused work to be repeated, it resulted in a more accurate representation of where the youth were expected to live. Since the purpose of the study is to analyze how accessible active play parks are to the youth population, census block groups provided the best source data. Manipulating the larger quantities of data for the block groups data went smoothly as the process had been developed and tested with the census tract data.

5.1.2. Lessons Learned in Identifying Park Features and Access Points

The availability of overhead imagery significantly helped with identifying park access points. Chapter 5.3 Suggestions for Future Work addresses ways in which this process can be improved. However, comparing the background imagery in ArcMap with Google Earth imagery was sufficient to identify likely access points. Still, it was not possible to identify every access point without site visits. Overhead imagery and available road shapefiles do not always show the existence of sidewalks, paths through yards, or holes in fences, which can be used to access, the park from non-standard points. Extensive field work would be required to accurately place all access points to each of Alexandria's parks and was beyond the scope of this study.

5.2. Limitations

This study used several assumptions and accepted limitations. The study only used parks as identified by the Alexandria Parks Department website. These public areas have equal access for all. Private parks and features such as playgrounds on apartment complex grounds were not included.

A second limitation was the inclusion of the full size of the park in calculations for access. This assumes that the entire park is dedicated to the active play feature. A more accurate representation would be to provide several area fields within the park data file. Additional fields should include acres of active play features by age group. By calculating the available acres with the full size of the park instead of the actual size of the play features, active park access is overstated.

A major limitation is the difficulty of generalizing entire age groups behavior. While necessary for this study, stratifying the distance a youth and/or their parent would travel to a park is inherently inaccurate. The distance relies on a multitude of factors. It is likely that parents are willing to put their very young children who cannot walk far on their own in a stroller and walk a further distance as exercise for the adult or social interaction with other parents. Each family makes its own decision on how far they are willing to or allow their children to travel to a park to play. A single parent family may have different emphasis on parks than a family with a stay at home parent or a family with two working parents and a caretaker for the child. The age of the caretaker, whether a parent, older sibling, other relative, or hired help will also affect the travel distance. A grandparent with their own health issues will not be willing to take a child as far as a young, stay at home, fitness-enthusiast parent.

The ages of other children, either in the household or a playgroup, also will affect what parks and distances are available. If a family has two children with a five-year age gap, they will likely concentrate of visiting parks with play features for both children. They may also focus on one child to ensure that they have access to their preferred play activity. Personal preference of both the youth and parents will also affect where they choose to visit.

A final limitation of the study is a common limitation with all accessibility studies. This study looks at a single point in time, specifically 2015, based on the population data. It is impossible to obtain the data on where each youth lives in the city in near real-time. This study is based on the expected population at a single point in time. It relies on the assumption that youth are evenly distributed across housing units it the city.

5.3. Suggestions for Future Work

There are several ways to improve this process. Due to time constraints, several assumptions were made during this study. One problem with how this study was conducted is that the study assumed that the entirety of the park was available as an active play feature when calculating available active play acres per expected youth. A 60-acre park may include sports fields, basketball courts, and a playground while remaining primarily woods by acreage. It is not accurate to calculate that the entire 60-acres are available for toddlers as a playground. In this example, the playground may only cover 0.25-acres, the basketball courts 0.5-acres, and four-acres of playing fields. The fields for total size, active play size for zero to four, active play size for five to nine, and active play size for ten to seventeen would be: 0.25-, 4.25-, and 4.5-acres respectively. This would ensure that the calculated available acres per expected child would be more accurate than this study. The outliers of residential parcels with thousands of acres of accessible active parks would be removed, and a more realistic output would result. This would require measurement of the space taken up by active play features in each park. Two techniques are easily identified; mapping through overhead imagery and site-visits and spatial data collection. The best balance between accuracy and time required would dictate the ratio of technique used. An additional benefit of site visits is verification of the park data stated by the Parks Department. Playgrounds and playing fields can be identified more accurately based on age appropriateness.

A second topic for future work is to include the results from this study as inputs in a site selection study for new parks or new active play park features. As retail stores analyze population data to ensure that a new store services a previously underserved community, city planners should use areas of poor accessibility to help plan new parks and features.

A third interesting future topic is to stratify the expected youth population by other socioeconomic factors. These studies should consider if race, religion, or family income affect accessibility. Since some of the areas with poor access have large numbers of housing units, this suggests that lower-income families, who are more likely to live in large apartment complexes, might have lower access to active play parks. This study does not have sufficient evidence to support this hypothesis, but it would be easy to follow a process similar to this study. The primary difference is when conducting the dasymetic mapping, future authors should segment based on race and family income in addition to age. This can be accomplished by selecting census data that includes race and family income.

This study used roads with a speed limit of less than or equal to thirty-five miles per hour as a proxy for the pedestrian network in the city. The data from the city GIS Department is good for vehicular transportation but does not include sidewalks or other common pedestrian routes such as pedestrian bridges or tunnels. A method to gain a more accurate assessment of accessibility to active play features is to build a pedestrian transportation network for the city. A potential source for this information is OpenStreetMap. This open source website has many updated shapefiles and other data. OpenStreetMap has sidewalk information on many cities, including Washington, District of Columbia. Through several spot checks throughout the city, it does not have sidewalk data for streets in Alexandria (OpenStreetMap contributors n.d.). Repeating this study's process in other cities with sidewalk or pedestrian network data should result in a more accurate representation of pedestrian accessibility.

A final option for future study is the inclusion of private play features. Some apartment complexes include playgrounds, pools, and basketball or tennis courts as amenities. This would affect accessibility to active play features. Some apartment buildings from this study that have no access could have access to playgrounds in reality. Adding private active play features as an alternative to parks could change the results of the study. A method of accounting for the fact that these features are not public would have to be developed.

5.4. Future Applications

The primary application for this study is the analysis of active park accessibility in Alexandria, Virginia for youth ages zero to seventeen. The results of the study show the areas with no or poor accessibility. The parks and recreation department can consider this in planning and upgrading active play features throughout the city. This study identified 211 residential parcels with no age-appropriate active play features available and over 4,000 parcels with no active play access for newborns to four-years-old. This study completed the first step to fix the problem, identifying the areas of most need. Since several clusters readily stood out, the parks department should look at adding active play features for toddlers to the parks within 0.25-miles of these clusters. This simple fix can immediately add access for over 1,300 children under four. Since playgrounds are the only active play feature acceptable to this age group in this study, adding playgrounds will have an immediate impact. Some playgrounds require less than twenty feet on a side.

Another application of this specific study is for the city to analyze the service areas. For long, skinny service areas, the opportunity exists to expand the reach by changing the pathways open to children. This could include sidewalks running from the back of a cul-de-sac to another neighborhood. This study focused only on using roads as effective travel networks.

The framework for this study can be replicated across the country. Some changes might be necessary based on the structure of the available data. Some cities may already include the number of housing units in their parcel files. In such a case, several steps in this study would be unnecessary.

5.5. Overall Conclusions

While there are still some refinements necessary to the process developed by this study, they are focused on local differences in data. In Alexandria, the number of housing units was not included as attributes in the parcel shapefile. This may not be the case throughout the country where this study process can be applied. This study recommends that local governments include this attribute in their parcel shapefiles. It will make analysis more accurate and faster to perform.

This process can be replicated in any community that has or can derive the required data: residential parcels with housing unit data, population data at the census block group or census tract level, and park data including active play features. The results of this process show where communities can focus their park planning. It highlights areas that may already have a park, but no active play features, or areas where a new park with active play features can affect the outdoor play of many children.

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Appendix A

This appendix shows the residential parcels with no access to age-appropriate active play parks within each age group.

Figure 21 No Active Park Access for Youth Aged Five to Nine

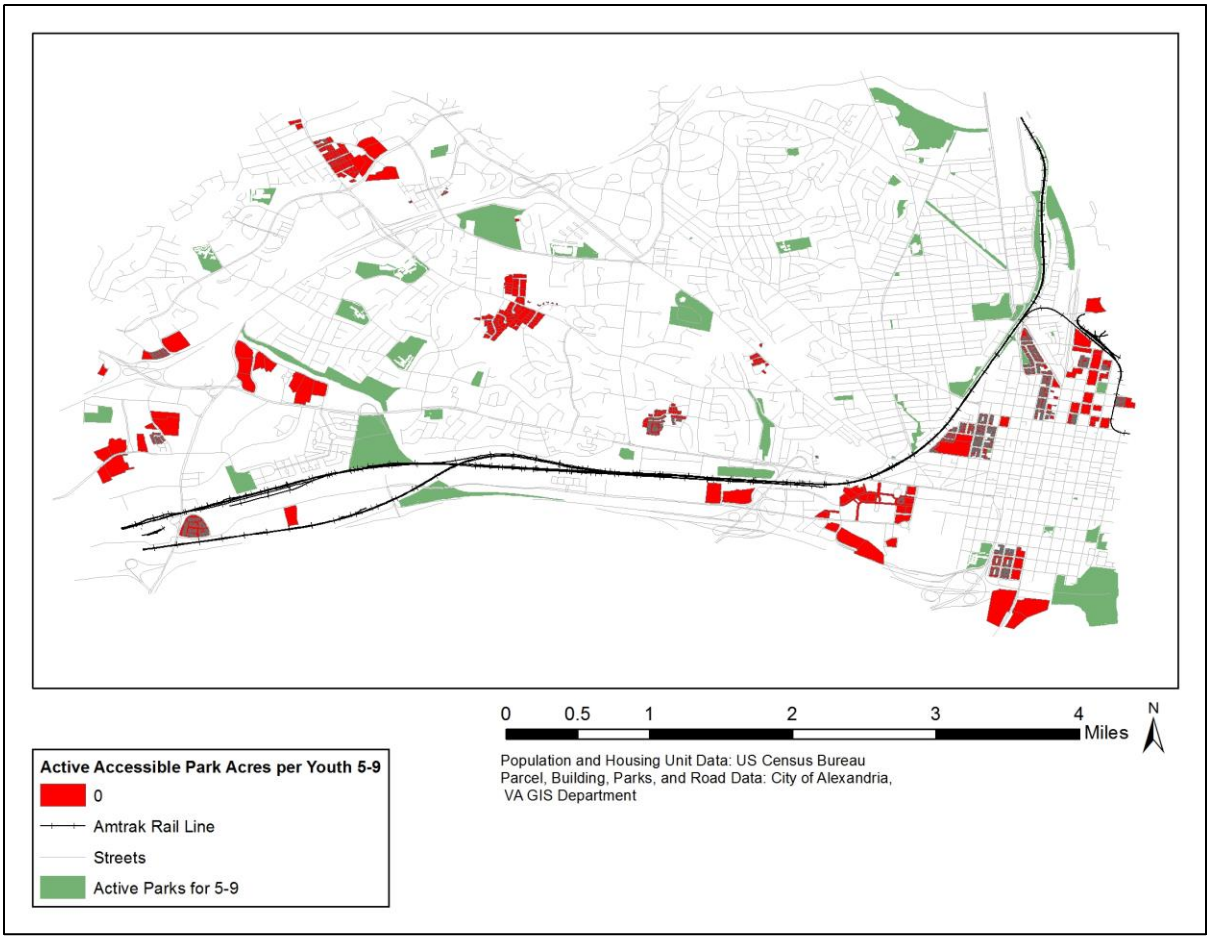

Figure 22 No Active Park Access for Youth Aged Ten to Seventeen

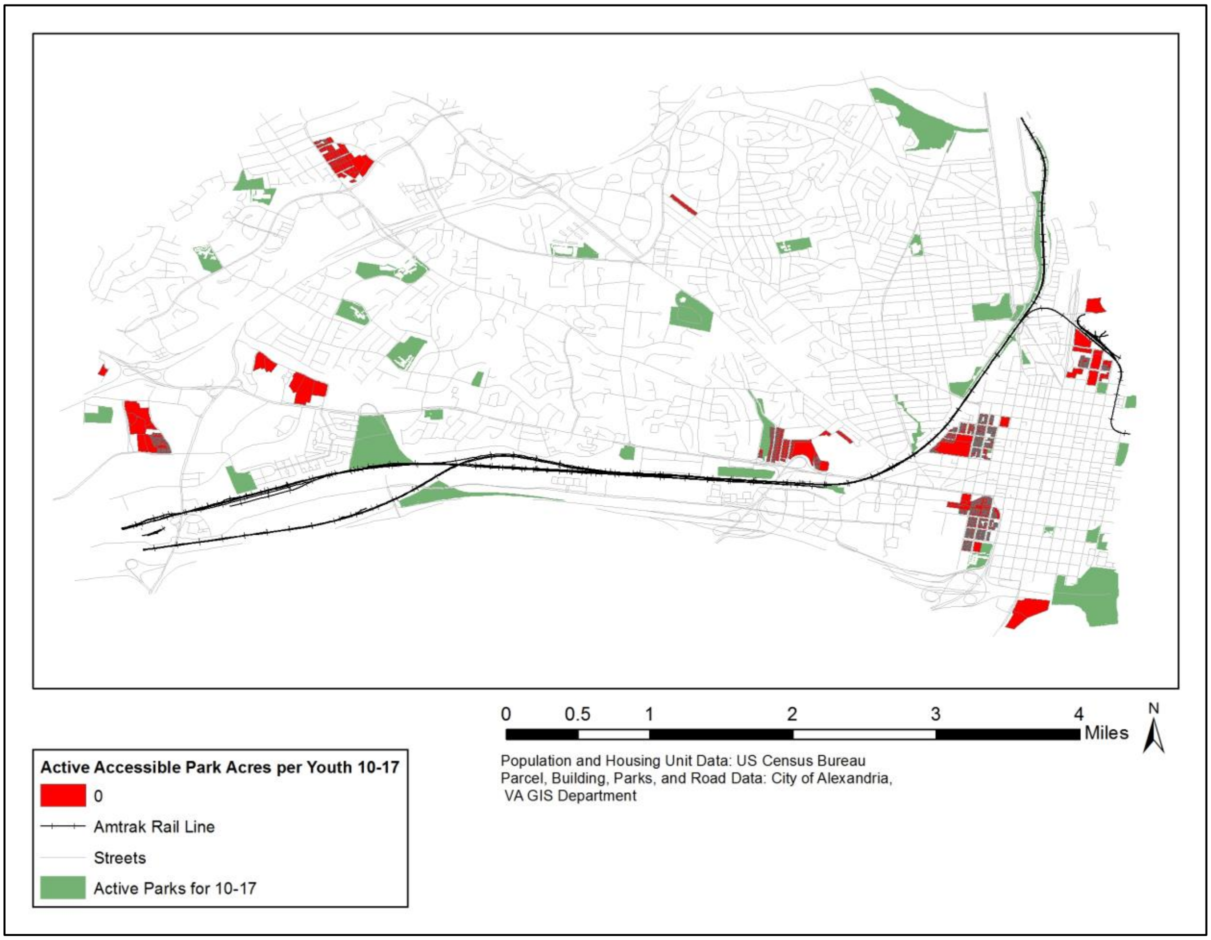

Figure 23 Park Congestion for Youth Ages Five to Nine

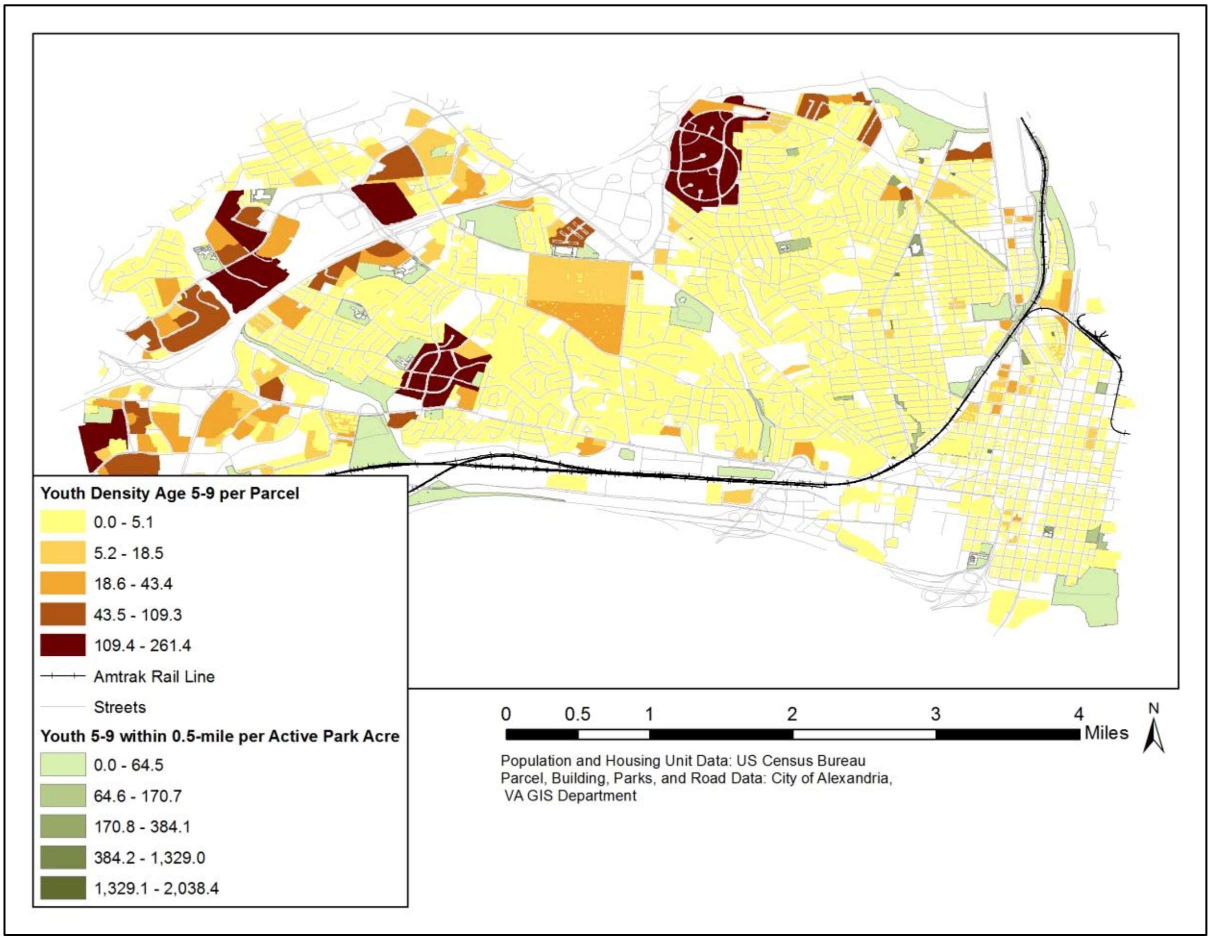

Figure 24 Park Congestion for Youth Ages Ten to Seventeen