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Can we measure equitable access at the intersection of social and natural systems? A look at the spatial and social distribution of urban parks

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Can we measure equitable access at the intersection of social and natural systems? A look at the spatial and social distribution of urban parks

by

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Dedication

To Garrett, my favorite park pal.

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Abstract

Can we measure equitable access at the intersection of social and natural systems? A look at the spatial and social distribution of urban parks

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The University of Texas at Austin, 2020

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Parks are embedded in our urban life, providing ecosystem services, health benefits, and social capital. However, not every community has access to urban parks, and many researchers and activists have questioned whether access is equitable across communities. The methods themselves, which determine equitable access, are inherently inaccessible because they utilize proprietary software which cannot be easily replicated. This study seeks to develop a framework to assess equitable access using open source spatial technologies, specifically Python and QGIS. This work addresses the following questions: 1) How is equitable access currently defined, and is this definition adequate at identifying those without equitable access?; 2) Are parks equitably accessible to vulnerable communities (e.g., children, the elderly, women, low-income households, ethnic minorities)?; and 3) Based on the definition of equitable access used in this study, which subsets of the population are not receiving access? Using Austin, Texas as a case study, it was found that less than half of Austin's population lives within a quarter mile of a park (45.2%). Consistent with literature, in this study racial minorities (specifically, Hispanic and Latinx) and low-income communities had the greatest access to parks with 47% and

48.5% respectively. This study also determined that Austin's north-central and south-central regions are most in need of parks. As such, park officials should focus on increasing access to those areas. The open-access framework created will provide practitioners with a quick method to identify demographics that are being served. This enables city planners and officials to understand demographic trends to better improve equitable access across their city. The open-access nature of the framework lends itself to the application of a variety of equity mapping and spatial injustice studies, such as the identification of transit and food deserts in metropolitan areas.

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Chapter 1: Introduction

Much like public utilities or public infrastructure, public parks are considered a necessity for city life (Latham & Layton, 2019). Urban parks provide ecosystem services such as reducing air pollution, serving as flood control, regulating microclimates, providing opportunities for food production, and increasing biodiversity (Douglas & James, 2015, Chapter 11; Kabisch et al., 2016). In addition to their environmental benefits, parks provide health benefits to those living near them (Chiesura, 2004; Larson et al., 2016). Studies have linked obesity rates in a city—particularly among children—to the spatial distance between studied populations and parks (Herrick, 2008; Wolch et al., 2011). Exposure to green spaces has shown lower risks of mortality caused by cardiovascular disease and increase life expectancy rates. (Gascon et al., 2016). A study by Engemann (2019) found children who are exposed to green space continuously from their birth through the age of 10 showed lower levels of developing mental illnesses during their adolescent and adult years. Engemann (2019) concludes that residents of densely urbanized spaces are particularly vulnerable for developing mental illnesses due to the pace of life, traffic congestion, and lack of ecosystem services. This suggests children and other vulnerable populations living in urbanized areas could benefit from easy access to green spaces in their everyday life. Further, planners should consider that different populations require different amenities. For instance, children, teens, and adults require vastly different amenities in order to be properly serviced by urban green spaces (Engemann et al., 2019; Soga & Gaston, 2016). Parks designed for children include amenities such as playgrounds and splash pads whereas parks designed for adults may include tennis courts and lap pools. It is important that people have access to not only a green space, but also a park with varying amenities spanning leisure activities, social activities, and physical activities. As the population ages or new populations with differing demographics move in, planners and managers must evaluate how their parks are serving the dynamics of the communities intended to serve.

Recognizing the value of parks has shifted peoples' view of urban public parks as merely an amenity towards viewing public parks as a true necessity for community building and increasing public health in recent decades (Walker, 2004; Byrne & Wolch, 2009; Gómez et al., 2015; Baur & Tynon, 2010). Because public spaces are funded or managed by governmental agencies, all citizens should have equal access to this public good, and planners should aim to mitigate structural inequities in our infrastructure (Heynen et al., 2006; Bryant & Callewaert, 2008). While equal distribution of parks across a city may seem the fairest solution at the surface, it has become evident to environmental justice advocates that this does not result in equitable access, for "not all parks are created equal" (Rigolon, 2016). A park's size, amenities, maintenance, funding, location, and function can both positively and negatively impact the surrounding community (Rigolon & Németh, 2019). As cities try to increase park access, they must keep such factors in mind, along with historic land use patterns, current community needs, and future environmental challenges. The current literature provides various methods for assessing park access; however, an open-source framework has yet to be introduced. If we claim to value equitable access for our parks, then should we not also expect equitable access to the methods by which we measure and distribute information on access? In order to achieve equitable access, our methods for urban planning and decision making must also be equitable. Therefore, we must evaluate our current methods of researching accessibility and see if they align with the tenants of spatial equity and environmental justice. This study seeks to evaluate our definition of equitable access by questioning the methods and tools we use to define "equity" and by answering the following questions: 1) How is equitable access currently defined, and is this definition adequate at identifying those without equitable access?; 2) Are parks equitably accessible to vulnerable communities (specifically, children, the elderly, women, low-income households, and ethnic minorities)?; and 3) Based on the definition of equitable access used in this study, which populations are not receiving access?

LITERATURE REVIEW

For this study two sects in literature were explored: the benefits of parks and current equitable access studies (see Figure 1). Previous conservation research has focused on wilderness areas and places outside of the urban environment; however, there is increasing recognition towards the positive effects of urban public parks (Chiesura, 2004; Baur & Tynon, 2010; Childers et al., 2015; Childers et al., 2015; Soga and Gaston, 2016). Many scholars have started to evaluate the role of nature in shaping the form and function of the urban landscape and how humans, in turn, shape the landscapes around them; this is conceptualized within urban ecology as ecology *for* cities (Douglas & James, 2015; Childers et al., 2015). As our cities continue to grow, it is imperative they evolve to meet the needs of those dwelling within them, both human and non-human. This has led to pushback against the historic separation between society and nature and a call for integration by increasing green spaces in our cities (Cole et al., 2013; Childers et al., 2015; Douglas & James, 2015). In addition to the health and wellness benefits gained by interacting with nature, parks are a way to build community, form coalitions, engage in our political systems, and reinforce environmentally friendly behaviors (Soga & Gaston, 2016). The socio-ecological system theory suggests that our social systems and environment are influenced by the ecological system around them, and reciprocally changes in our social systems influence ecological systems (Cole et al., 2013; Douglas & James, 2015, Chapter 3; Virapongse et al., 2016). If we see nature and society as more connected (as the literature advises) urban public parks may be viewed as an essential resource as well as an integral part of our urban landscape (Soga & Gaston, 2016).

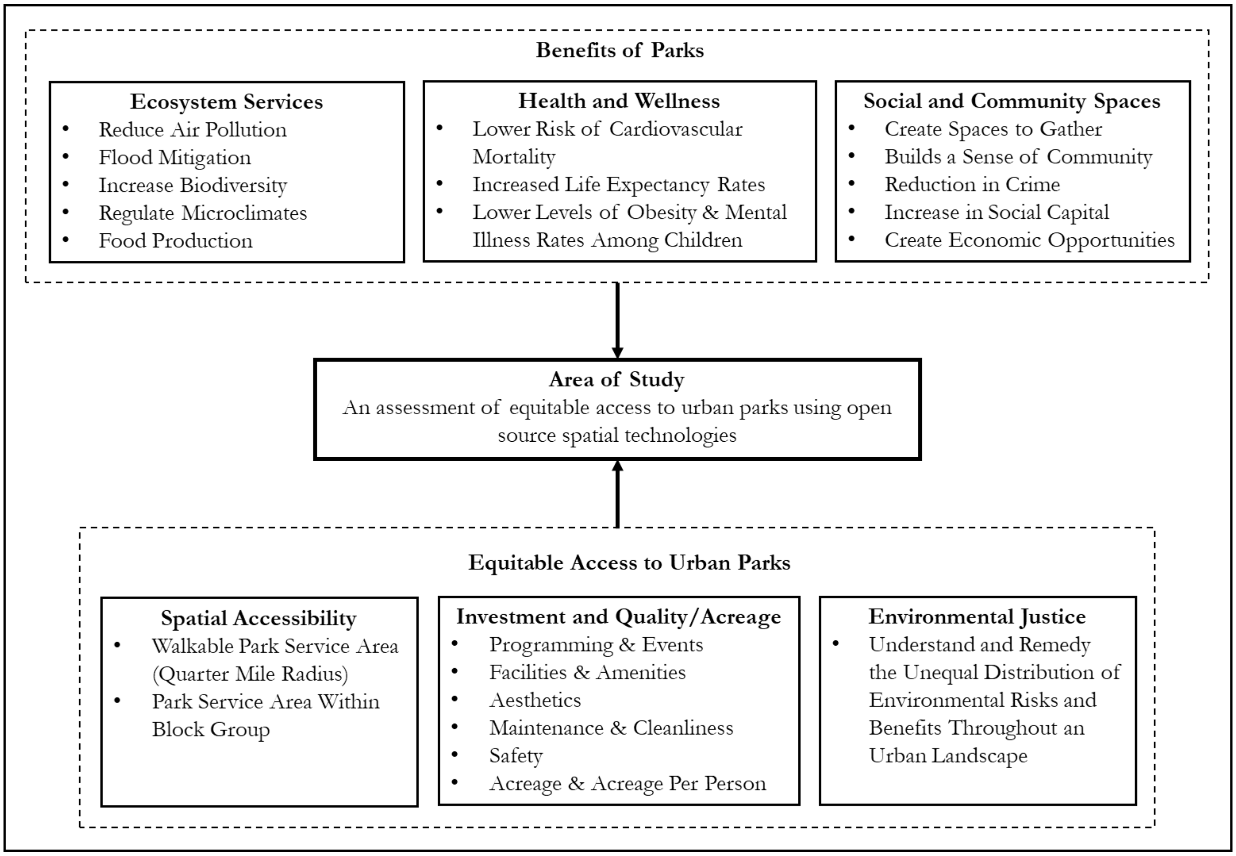

Figure 1: The literature review shows a gap in equitable access frameworks

While parks provide ample opportunity for both mental and physical health, people often have negative perceptions of parks; fear of crime within parks keep many vulnerable communities from visiting these spaces (Bogar & Beyer, 2016; Chiesura, 2004). Additionally, the creation or revitalization of parks and green spaces has been linked to gentrification of areas and neighborhoods nearby, referred to as green gentrification, making vulnerable populations warry of park projects (Rigolon & Németh, 2019; Wolch et al., 2014). Prominent examples of this effect include New York City's

High Line or the 606 Trail in Chicago (Rigolon & Németh, 2019; Bliss, 2019). In each of these cases a greenbelt park was created on abandoned rail lines and gentrification occurred in adjacent neighborhoods. These negative effects are oftentimes more difficult to quantify but nonetheless should be considered when conducting park access studies or engaging in park planning efforts. Parks vary in their size, function, and amenities, and these factors determine who chooses to use a park. Researchers have noted the features which define a park (e.g. number of trails or benches) should be guided by requests from residents of the community to ensure they are the primary beneficiaries of the park, and to mitigate the effects of green gentrification (Boone et al., 2009; Chiesura, 2004; Jacobs, 1961; Kabisch et al., 2016; Rigolon, 2016; Rigolon & Németh, 2019; Wolch et al., 2014). For example, the 11th Street Bridge Park project in Washington, D.C. has taken steps to engage stakeholders and create a plan for affordable housing prior to the design and construction of the new park (Sustainability & Strategies, 2019).

Knowing that urban parks are essential for the resilience and sustainability of cities, the focus has begun to shift towards determining whether these benefits have been equitably distributed across cities (McPhearson et al., 2015). This has led researchers to view park access through the lens of environmental justice (Boone et al., 2009; Rigolon, 2016; Schlosberg, 2004; Wolch et al., 2014). Environmental justice is a social movement and research field that aims to understand and remedy the unequal distribution of environmental risks and benefits throughout an urban landscape (Bryant & Callewaert, 2008; Chakraborty, 2016). As the body of research and advocacy has grown over the past 30 years, scholars and communities have begun to use the environmental justice framework to view urban parks as a public good, and as such, they should be equitably accessed throughout a city. “Equity mapping” or “spatial equity” has sought to use mapping techniques to determine trends in socio-demographic and socioeconomic groups and their spatial relation to various resources and services (Rigolon, 2016; Chang & Liao, 2011; Talen, 1997). The goal of combining environmental justice with spatial analysis is to advance and challenge urban planning and policy to “produce more equitable urban environments for everyone” (Heynen et al., 2006). There is a rising need to integrate the work done by social scientists, environmental justice advocates, and spatial analysts to gain an understanding of the necessary management needs for natural resources (Bryant & Callewaert, 2008). The spatial disparities present in our communities today have not occurred by accident. It is important to note the uneven distribution of environmental benefits is largely institutional; it is a systemic issue born out of the past and current political and structural inequities (Heynen et al., 2005; Byrne & Wolch, 2009; Boone et al., 2009).

The literature has largely defined equitable access to urban parks through three parameters: park proximity (the number of residents living within a certain distance to a park), acreage (park acreage per capita or the percentage of park area relative to the total urban area), and quality (amenities, function, or programming offered) (Abercrombie et al., 2008; Rigolon, 2016; Chen et al., 2019). Recent work has also included addressing factors such as “park need,” focusing on vulnerable communities, and “park crowding” (acreage per person or people per acre of parkland), to achieve equity mapping (Chen et al., 2019; Rigolon, 2016; *Standards for Outdoor Recreational Areas*, 2020). Figure 2 shows the many factors which define equitable park access. Planners must decide how to effectively weigh these factors when trying to increase park access (Giles-Corti et al., 2005). The effects of park crowding will continue to have larger impacts on our cities as they densify, and demographics shift spatially. National studies done by the Trust for Public Land have also incorporated park funding and spending into their analysis (2019).

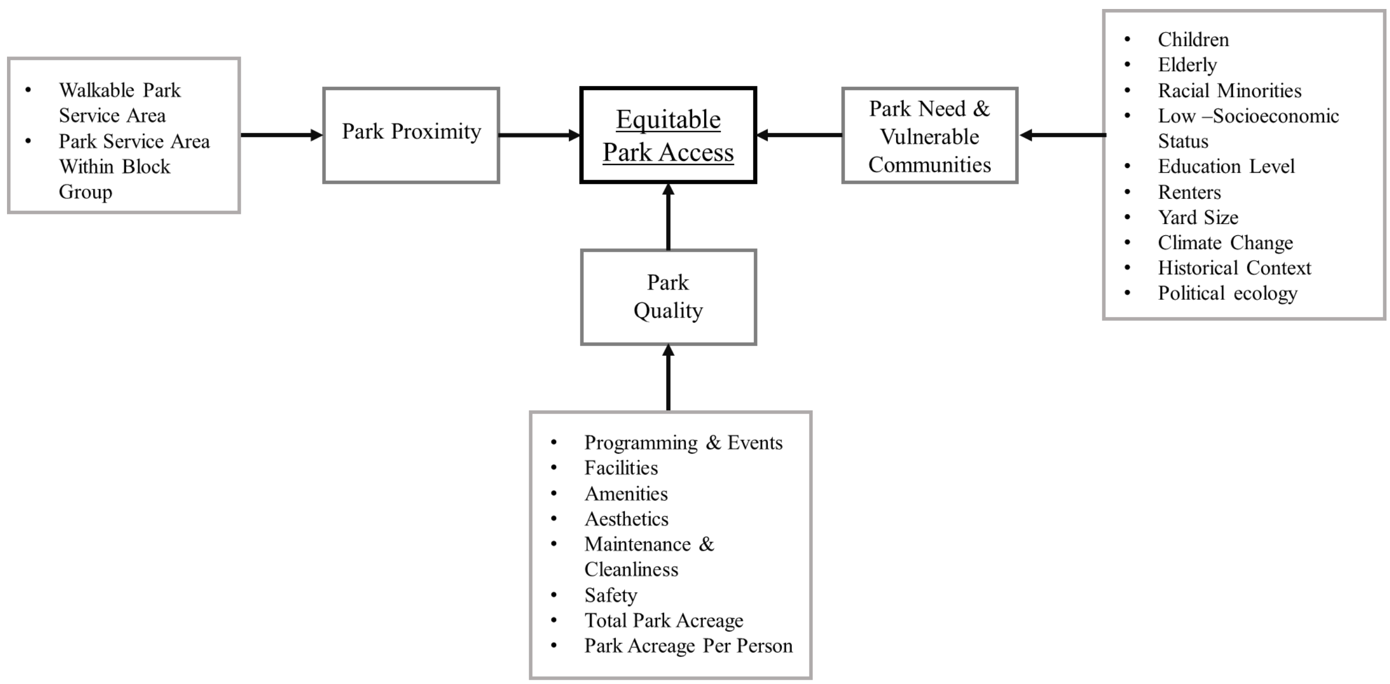

Figure 2: Factors considered for achieving equitable access; Adapted from Chen et al., 2019

Furthermore, there is great variation in the scale at which these studies are conducted, from the national level to the municipal level. The national level studies show inequity to access follows income and racial lines, with those in a lower socioeconomic status and minorities receiving unequal access (Rigolon, 2016; Boone et al., 2009; Chen et al., 2019; Abercrombie et al., 2008). However, when analyzing a city at a local level, a more nuanced picture arises. In order to gain a holistic sense of access to parks, it is important to consider the various scales in which we are working and how this may affect the narrative of who has access to parks (Boone et al., 2009). By analyzing the data at the census block group scale as well as seeing access at the city level, insights may emerge about which demographic groups are most in need of park access. Because each city has varied political, economic, and social structures and distributions, researchers suggest conducting localized studies to determine whether disparities in access exist within a city regardless of national trends (Abercrombie et al., 2008).

Cities also vary in their degree of economic segregation, which affects the degree of equitable access in the city (Rigolon, 2016; Boone et al., 2009; Chen et al., 2019; Abercrombie et al., 2008). Chen (2019) found a decrease in park quality as both poverty rates and rental prices increase. The segregation and gentrification rates in a city are impacted by a city's historical injustices, which subsequently influence current environmental and spatial injustices (Boone et al., 2009; Brand, 2015; Herrick, 2008). It is then critical to include relevant information such as historical land use patterns, urban planning policy, and future developments when assessing park access. This will allow decision makers and planners to make informed decisions on how to increase access to all their citizens. Therefore, focusing on the local scale will yield differences in the measures of equitable access to urban parks (Abercrombie et al., 2008; Chen et al., 2019; Rigolon, 2016). As our cities grow and change, the way we view equity will change as well (Brand, 2015). Replicable equitable access models are crucial for evaluating the past, current, and future distribution of parks. However, current studies on park access are not reproducible, nor do they allow for others to apply their methods to other cities because they use proprietary software such as ArcMap.

Non-profit organizations such as the Trust for Public Lands have attempted to shed light on park accessibility in the largest cities in the U.S., setting a half-mile walk to a park as a national standard to determine access (Harnik & Martin, 2019). The "10-Minute Walk" project by the Trust for Public Land conducts an equitable access study with results readily available to the public (The Trust for Public Land, 2019). The study, which began in 2012, utilizes park data from cities across the country and ranks the top cities based on park acreage, investment, amenities, and access, defined as the number of citizens in the city living within a 10-minute walk of a park through a city's network (The Trust for Public Land, 2019). The organization works with parks and recreation departments in cities to acquire data and runs its analysis using ESRI software and demographic forecasts. While this is a great resource for those wanting an overview of access across the United States, this tool does not provide holistic information. In the past, the Trust for Public Land focused primarily on acreage, access (proximity), investment (park spending per resident) and quality measures (number of splashpads, basketball courts, etc.) and assigned a "Park Score" generated by these measurements (The Trust for Public Land, 2019). This, however, does not address the degree of equitable access to parks in each city. The study by the Trust for Public Land does not address how these amenities are distributed spatially across economic and social demographic boundaries. The use of proprietary software has limited replicability and limits accessibility of information. Research on equity mapping and equitable access has lacked an accessible framework open to those in and outside of academia. There is also a need for methods that can easily incorporate updated data to produce equity maps on a regular basis. In turn, our study fills a gap by creating a framework that will allow for a replicable, transparent, and holistic spatial equitability study of park access.

This study creates a framework (see Figure 3) that practitioners can use to conduct an inventory of their parks and the communities they are serving without having to rely on proprietary technology. Currently equitable access is defined by narrow and static frameworks; however, the framework designed in this study can evolve as the definition of equity changes. This inventory provides a snapshot of access and enables us to answer the pressing research question of which vulnerable populations are not receiving access. Managers and planners can then focus their resources on providing access to these communities.

Chapter 2: Methods

Figure 3 shows the equitable access framework which begins by first defining what factors (see Figure 2) lead to achieving equitable access. Upon determining these factors (i.e. park proximity, park quality, park need), the next step is to acquire data from publicly available government databases. Once the data has been acquired it was cleaned and merged spatially. Using the areal appropriation method (a distance-based spatial analysis technique) census block groups that are park deficient were identified (Kearney & Kiros, 2009). It is important to note that because equity is constantly changing, a flexible framework—such as the one presented in this study—lends itself to more equity driven solutions (Chakraborty 2016). Additionally, each city varies in its resources and available data. Since cities vary in the data and services they provide, the goal of this equitable access framework is to be as adaptable as possible. To accomplish this flexibility, the framework is based off a script capable of inputting a variety of data as well as working with very limited data. To build a framework which can be used and accessed by anyone with appropriate technical expertise, open source technologies are implemented (e.g. Python 3.7.4, Jupyter Notebook 6.0.1, and QGIS 3.10). All scripts (data cleaning, data merging, and analysis) were written within Jupyter Notebook. Jupyter Notebook was chosen because it provided a simple data management structure as well as clarity of script writing for those new to coding or the Python language. The Python scripts in Jupyter Notebook produced various shapefiles and data tables from the input data and were exported into QGIS for data visualization. In its current form, the Python script and Jupyter Notebook files are hosted on a GitHub repository so others may reproduce or replicate the study with their own data set (Ibarra, 2019/2020). Additionally, the code is hosted on figshare, an online repository, for others to download (Ibarra, 2020). Both GitHub and figshare contain documentation for how the methods were conducted and instructions for replicating the study.

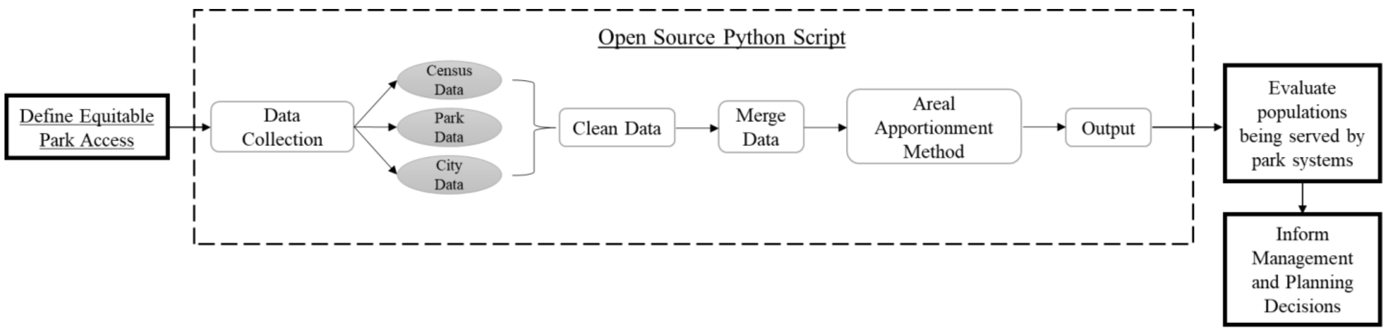

Figure 3: This Equitable Access Framework allows for flexibility within the methods by first setting a clear definition of equity and then by utilizing open source technology to carry out the analysis

DATA AND MEASURES

To maintain equity in our analysis, all the data used in this study is open to the public. U.S. Census Bureau American Community Survey demographic estimates 2013-2017 at the census block group level in Austin, Texas (n=558), the smallest geographical unit available, were used. The communities explored in this study are children under 5, children under 18, adults over 65, women, households with income levels below the Federal Poverty Level guidelines, Hispanics and Latinos. Hispanics and Latinos were chosen as the target racial minority group in this study because the demographic split of the study area is largely defined by the Hispanic and Latinx population (Robinson, 2016).

Because census data and park location and acreage are publicly available, the first factor to evaluate access is park proximity. Based off previous studies, park proximity is measured by determining a quarter mile (400 meters) radius from the park boundary. A quarter mile service area, otherwise referred to as a service area, is determined to be an appropriate walking distance for our target demographic communities, specifically children and elderly adults (Rigolon, 2017; Boone et al., 2009). Because our definition of equitable access includes a park proximity measure of a quarter mile service area, we are not interested in evaluating equitable access for "destination" parks, where people drive to access the park (Boone et al., 2009). Instead, we are interested in providing people with daily contact to public parks. Furthermore, the vulnerable communities we are interested in targeting typically do not have access to private transportation and thus would need to be able to walk to their local park. Designing parks to serve a quarter mile walking distance serves to reduce car trips and is consistent with many cities' stated goal of encouraging the health and wellbeing of city residents.

A variable service area is created to act as a comparison to the quarter mile service area. The variable service area is based on how cities currently evaluate access, whereas the quarter mile service area is an ideal planning goal. The park service areas, described in Table 1, are based off guidelines established by the City of Austin Parks and Recreation Department and varied by park type and acreage (Lewis et al., 2019;

Wittenmyer, 2018). Golf courses and natural preserves are not included because have little to no public access or recreational facilities (Lewis et al., 2019).

Table 1: The service areas, for the variable service area scenario are based on the park type or park acreage

Park Type	**Service Area**
Pocket Parks – Less than 2 acres	Quarter Mile
Select School Playgrounds	Quarter Mile
Neighborhood Parks – Between 2 and 30 acres	One Mile
District Parks – Between 31 and 200 acres	Two Mile
Metropolitan Parks – Greater and 200 acres	Two Mile
Greenbelts	Two Mile

Once the service area around each park are created, a_i, park proximity is calculated using the areal apportionment method to determine which census block groups do not have access to a park (Figure 4; Kearney & Kiros, 2009). For each census block group that intersects the park service area, a weighted value is calculated by dividing the park service area, a_i, by the area of the entire census block group, a_b:

$$Weight = \frac{Area\ of\ Park\ and\ Census\ Geographical\ Unit\ Intersection\ (a_i)}{Area\ of\ Census\ Geographical\ Unit\ (a_b)}$$

This weighted value is then multiplied by the population within the census block group to get the total number of individuals served by the park:

$$Population\ Served = Weight \times Population\ within\ Geographical\ Unit$$

Finally, a normalized value is calculated by dividing the total population served by the park acreage, a_p:

$$Population\ Served_{Normalized} = \frac{Population\ Served}{Area\ of\ Census\ Geographical\ Unit\ (a_b)}$$

For a park overlaying more than one census block group, each section is calculated individually, and the populations served in each census block group are combined to determine the total population served for the park (Figure 4).

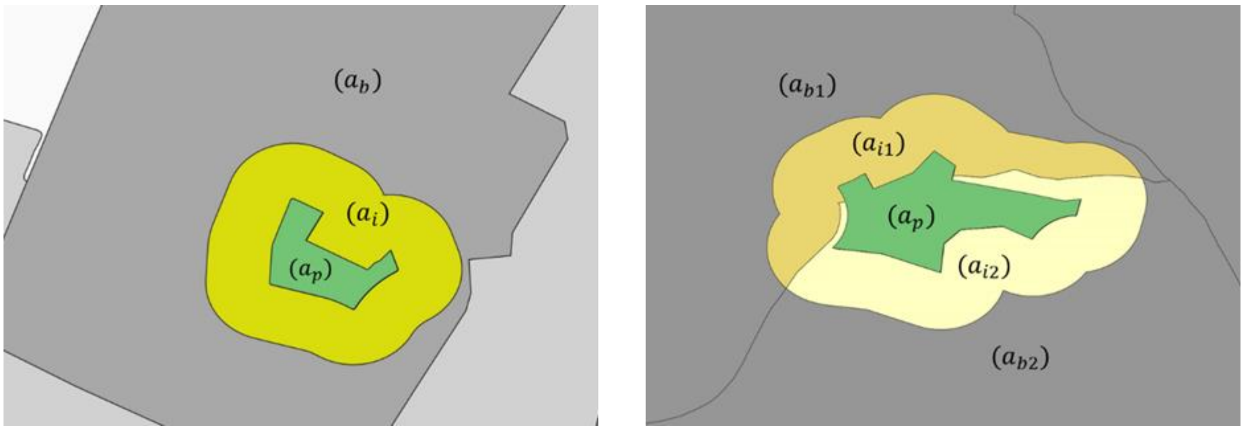

Figure 4: Areal apportionment method; The park on the left is completely within a census block group while the park on the right overlays more than one block group.

Because this framework currently applies to urban areas, we assume even distribution of the population within each census block group. In order to justify this assumption, we used the smallest geographical census unit available. Additionally, we chose to focus our study area to the full jurisdiction city limits as opposed to the entire metropolitan area. Full jurisdiction refers to all areas where the city government provides full municipal services, including parks. Only urban parks owned or maintained by the city government and located within the full jurisdiction boundary are included in this study. All park data such as acreage and geolocation are gathered from the study area's open data portal. Another limitation of this study is that it does not identify physical barriers (e.g. highly trafficked roads, waterways, fences) within a park's service area, and therefore we cannot assume absolute walkability within the service area. To account for this, we will not use a half-mile service area for analysis, as it introduces more potential physical barriers than a quarter-mile service area. As we have not included infrastructure such as roads, a network analysis could not be performed and all distances are linearly based. Additionally, several variables relating to equity (e.g. park investment, quality, safety, maintenance) are excluded from the study to keep the model simplified for ease of replicability. Finally, it is important to note that the 2017 ACS 5-year estimates used in this study are an average of demographic data collected between 2013 – 2017. Therefore, when using ACS 5-year estimates as opposed to ACS 1-year estimates, the demographic changes will appear slower than the rate of change occurring in real time.

To test the framework, we used Austin, Texas as our case study. Austin, Texas was selected for the following reasons: 1) racial spatial distribution, 2) sustained population and economic growth, and 3) uneven spatial distribution of the effects of climate change across the City (Office of Sustainability et al., 2014).

CASE STUDY: AUSTIN, TEXAS

Austin is well-known for its urban trails and access to recreation spaces such as Zilker Park and Barton Springs (Herrick, 2008). However, the question of accessibility in Austin is one that is fraught with controversy (Herrick, 2008). While the city is known in part for its green spaces, its history of racial segregation has shaped the built environment and remnants of this segregation are still felt to this day (Herrick, 2008; Tretter, 2012). The most prominent infrastructure, Interstate Highway 35 (I-35) cuts right through the center of the city, and was erected to physical divide minority neighborhoods from white neighborhoods; it serves as a reminder to the spatial, racial, and cultural divide present in the City (Herrick, 2008; Tretter, 2012).

Austin has experienced a surge in its population and economy over the past two decades. Between 2010 and 2018, the city experienced a 23% increase in population (U.S. Census Bureau, 2019). In 2019, the city was once again named the number one city in terms of population and economic growth (America's Fastest-Growing Cities, 2020). This growth has brought changes in both demographics and the built environment. Increases in traffic, air pollution, gentrification, and density have affected all aspects of life in Austin, including urban park access (Herrick, 2008). Florida et al. (2015) found Austin as having the greatest levels of overall economic segregation among the largest metropolitan areas in the United States.

Over the past 30 years, Austin, Texas has seen a surge in population and demographic trends returning towards "urban life" with families and lower income communities being replaced by a younger, more affluent class living in the city's core (Busch, 2015; Robinson, 2016). Gentrification (especially in the east side of I-35) has amplified issues of equity for many Austin residents (Herrick, 2008; Tretter, 2012). This increased development in the city's center led to the displacement of historically marginalized communities living in East Austin. Gentrification of the Eastside began in the late 1990's when western urban sprawl was halted by legislative protection of the Edwards Aquifer (Busch, 2015). The low-density housing and development common in the Northwest areas of the city are not replicated in the now gentrified area of Central Eastside. Instead, the Eastside primarily experienced the redevelopment of existing properties, which brought both increased density and significant displacement of long-time residents. The proportion of African Americans and Latinos living in East Austin has decreased as the population has grown younger, whiter, and more affluent (Busch, 2015; Robinson, 2016). Despite this gentrification, the Eastside and South Eastside of Austin still hold the city's highest percentage of minorities and lowest income households (City of Austin Parks and Recreation Department, 2019). City officials have placed focus in East Austin over the past few years as it is evident the divide created by I-35 has left that part of Austin lacking in services and amenities received by the western part of the city (Herrick, 2008). The dynamic growth and complicated social and political history in Austin make the city an ideal choice for understanding the current methods for determining equitable park access.

Chapter 3: Results and Discussion

Once our analysis was visualized as maps in QGIS, a clear depiction of the spatial discrepancy in the service areas between the quarter mile and variable service areas began to emerge. As expected, the two scenarios, as visualized in Figures 5 and 6, produced different results in park access. The quarter mile service area serves approximately 45.2% of the total population in Austin, while the variable service area scenario serves approximately 99.6% of the total population being served by one or more parks.

Quarter Mile Service Area

The quarter mile service area scenario included 273 park units, ranging from 0.07 to 1,885.4 acres in size. Because all parks are given a quarter mile service area, there is no need to distinguish between park type. Of the 273 parks, the average park size is 48.4 acres and the median size is 7.8 acres. Out of the total population in the study area, 45.2% live within a quarter mile of a park. 556 census block group units out of the 558 in the study had all or a portion of their population without park access.

Out of the population served, 64.5% are non-Hispanic or Latinx, 48.4% are White, and 35.6% are Hispanic or Latinx. Out of the total study area population, 45.2% of children under 5, 43.9% of children under 18, and 44.3% of adults over 65 are served by a park in this scenario. 45.9% of households in the study area are served within a quarter mile of a park.

To capture all households below the Federal Poverty Level for a three-person household of $21,720, all households making less than $25,000 are combined into one bracket (Department of Health and Human Services & Office of the Secretary, 2020). 48.47 % of households with an income below $25,000 are within a quarter mile of a park. 45.9% of household with incomes between $25,000 and $49,999 are served, 44.9% of households with incomes $50,000 to $74,999, 45.6% of households with incomes $75,000 to $99,999, 44.9% of households with incomes $100,000 to $149,999, and 45.1% of households with an income of $150,000 or more are within a quarter mile of a park.

VARIABLE SERVICE AREA

The variable service area scenario included 276 park units, ranging from 0.07 to 1,885.4 acres in size with the average park size at 47.9 acres and the median park size at 7.65 acres. There were 25 pocket parks (quarter mile service area), 91 neighborhood parks (one mile service area), 14 district parks (two mile service area), 25 metropolitan parks (five mile service area), 50 greenbelts (five mile service area), 22 school parks (quarter mile service area), and 49 “other” parks which are given a service area based on their acreage size. Out of the total population in the study area, 99.6% are serviced within the variable service area scenario.

Of the population served, 65.7%, are non-Hispanic or Latinx, 49% White, and 34.3% Hispanic or Latinx. 99.6% of children under 5, 99.5% of children under 18, and

99.5% of adults over 65 are served by a park in this scenario. 99.6% of households in our study area are served with the variable service area scenario.

To capture all households below the federal poverty threshold of $21,720, all households making less than $25,000 were again combined into one bracket (Department of Health and Human Services & Office of the Secretary, 2020). 99.8% of households with an income below $25,000 are within the service area of at least one park, slightly higher than the percentage of households served for the entire city. 99.7% of household with incomes between $25,000 and $49,999 are served, 99.6% of households with incomes $50,000 to $74,999, 99.7% of households with incomes $75,000 to $99,999, 99.4% of households with incomes $100,000 to $149,999, and 99.2% of households with an income of $150,000 or more are within the service area of a park.

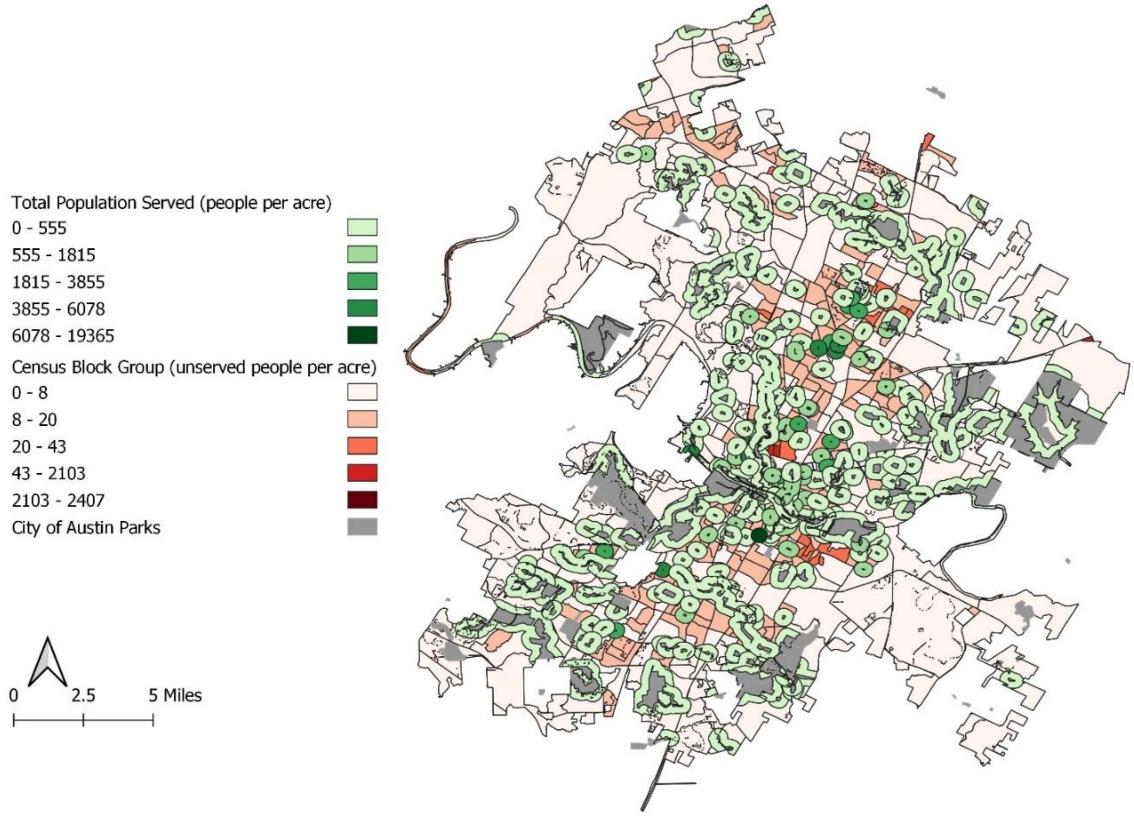

Figure 5: The map above shows the quarter mile service areas for each park in Austin, Texas and the amount of people per acre served by the park. The census block groups in the pink to red hues indicate areas without park access, with the dark red signifying areas with a dense population void of access; Population brackets defined by Natural Breaks Classification (Jenks)

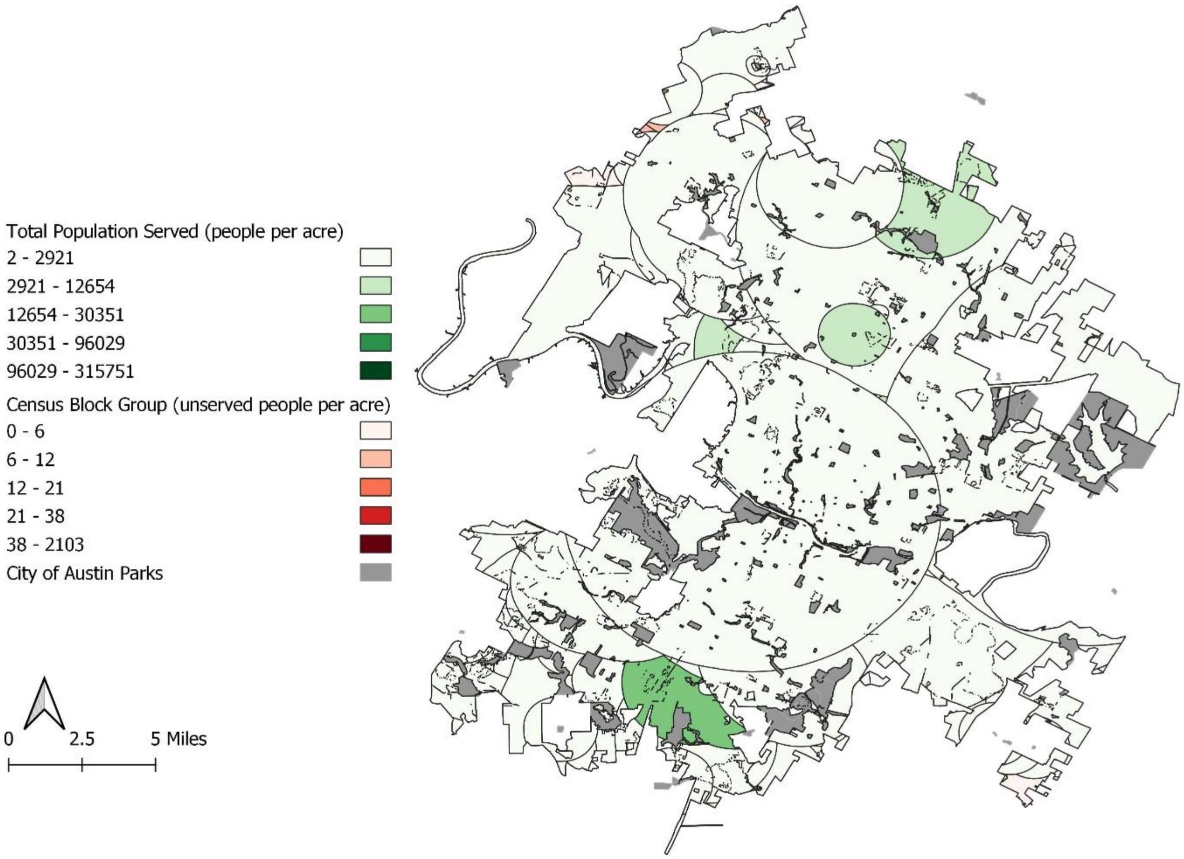

Figure 6: The map above shows the variable service areas for each park in Austin, Texas and the amount of people per acre served by the park. The census block groups in the pink hues indicate areas without park access (Northwest and Southeast corners of the map) ; Population brackets defined by Natural Breaks Classification (Jenks)

PRACTICAL IMPLICATIONS

Less than half of the population in Austin lives within a walkable distance (a quarter mile) to a park (45.2%). Consistent with other studies, we did not find that minority communities (in this case Hispanic and Latinx communities) have less access to parks than non-Hispanic communities (Abercrombie et al., 2008; Chen et al., 2019; Rigolon, 2016). In fact, Hispanic and Latinx communities had the highest percentage of access at 47% as compared to non-Hispanic populations at 44.2%. Both groups are largely distributed in East Austin where over the past 10 years the city has focused on increasing the amount of park space (Lewis et al., 2019; Herrick, 2008; Tretter, 2012). This, along with the city trend of an increasing Hispanic population (Robinson, 2016), may explain why these two groups are the most served in Austin when using a quarter mile service area. Interestingly, the lowest household income bracket, below $25,000, had a 2.6% higher percentage of households served (48.5%) than the total amount of households. This finding is consistent with Boone et al. (2009) who found low socio-economic status (SES) groups live closer to parks in Baltimore. One possible reason for this is due to low SES groups moving into the urban core, where urban parks are more prevalent, following “white flight”. With gentrification creating a reversal of the “white flight” in many urban areas, it will be critical for cities to continue to evaluate which communities are underserved by their park system. The results for Hispanic and low-income communities in this study vary from national models and further underscores the importance of localized studies (Abercrombie et al., 2008; Trust for Public Lands, 2019).

The variable service area scenario resulted in a high rate of the population served with 99.6% of the population being served by at least one park. It is clear in Figure 6 that the city is almost entirely covered by a park service area. This was expected because with the variable service area scenario most parks (180 out of 276) have a minimum service area of 1-mile and many have service areas as large as 5-miles. Using a service area over ½ mile cannot be considered walkable (Harnik & Martin, 2019), so using a 5-mile service area for greenbelts and metropolitan parks ignores the fact that significant portions of the population cannot reap the benefits from these parks daily or even weekly. The variable service area scenario incorrectly assumes vulnerable communities have the ability and resources to access parks that are farther than a mile from where they reside. It is important to note a fixed service area for a small park will be larger (proportionally) than that of a larger park. Consequently, one can expect greenbelts and pocket parks to have higher rates of service per acre than parks with a larger area. The variable service area attempts to address this problem by giving larger parks a larger service area. However, the inflated results for the total population served indicates the weight given to district parks, greenbelts, metropolitan parks may not accurately represent the true service reach of these park types. If park officials wish to continue to use the variable service area scenario it would be helpful to lower the service area values for neighborhood, district, metropolitan parks, and greenbelts. Additionally, the high overall ratio of people per acre in this scenario means that by the standards set by the City of Austin, many of the parks will experience overcrowding as they are expected to have a greater service area (City Park Acres per 1,000 Population, 2015). Similar to the quarter mile service area scenario, the lowest income bracket is the highest served household income bracket. However, Since the variable service area scenario covered nearly 100% of the city, park access was equal across all groups. This again underscores the fallibility of using the variable service area because it does not consider the difficulty vulnerable communities may face in getting access to a park that is farther than a quarter mile from where they reside. When compared to the quarter mile service area scenario, which showed less than half of the population had access, it is clear the variable service area will overestimate how a city is performing with regards to park proximity. If the goal is to achieve equitable access to urban parks, then using variable service areas will not yield equitable results.

The devised framework shows that Austin is serving demographic groups equitably. Both the quarter mile and variable service area scenarios produced results for the populations served with demographic distributions matching the distribution of demographics in the city. This means that although Austin may be underperforming in the number of residents being served as a whole, the city overall is serving its different communities roughly equally. However, there are still a few communities which lacked equitable access to a park within walking distance. Both the quarter mile service area and the variable service area are underserving children in Austin as compared to the rest of the population, with children under 18 being the group least served. This is concerning as children have the most to gain from living near parks (Engemann et al., 2019). Additionally, they are often limited in their transportation options and thus require services within a safe walking distance. The parks department should therefore focus on creating more school parks or focusing on areas that have a higher percentage of children. In additional to identifying the underserved groups, the two scenario maps in tandem can show managers and planners which areas of the city are devoid of parks, as well as which parks are currently overcrowded or underutilized. Our results showed Austin is in most need of parks in the north-central and south-central regions of the city. This framework has helped determine where people are not being served by a park and which groups are underserved. Park officials can then focus on those areas and address those 54.8% of people who do not have walkable access to a park.

THEORETICAL IMPLICATIONS

This framework provides practitioners with a quick output that shows which demographics are being served relative to the entire population, utilizing equitable tools and methods. Creating an open-source database and model allows for the flexibility needed in future equitability studies. As new data is released, an open source methodology would be able to produce timely results with the updated data. Whereas many of the past studies on park access have used census data that is now ten to twenty years old, this framework allows for easy modifications as new data becomes available. With many cities experiencing demographic shifts from gentrification and urbanization trends, past studies conducted may no longer represent the current state of park access in our cities. Therefore, there is a need for a methodology that can easily incorporate updated data to produce equity maps on an annual basis. By conducting yearly equitable access studies, planners can better decide where to locate future parks and where to prioritize resources by tracking demographic changes. This allows city planners and officials to understand what trends may be occurring in their city to make decisions to help sustain or improve equitable access. Our model contributes a practical and accessible solution for evaluating equitable park access in urban environments.

FUTURE WORK

Although this study only looked at park proximity as one of the equitability factors, the flexibility of the code allows for multiple factors and data to be analyzed. Due to time and data constraints, additional factors such as gentrification, affordable housing, funding distribution, park quality, and community engagement are not included. Future studies may consider the use of social media data to collect and include more equitability factors. Additionally, the use of social media data can help researchers and practitioners identify which equitable access factors are most important to the communities they are trying to serve. The current framework assumes equal population distribution throughout the service area. In order to open this framework to larger scales (which would include less dense populations), future work may include incorporating land use information to employ Dasymetric mapping techniques. Finally, future work may include adapting this framework to study a variety of equity mapping and spatial injustice studies that identify gaps in access to essential urban resources, such as healthcare facilities and affordable, healthy food.

Chapter 4: Summary

Based on our case study city, Austin, Texas, it was determined that less than half of Austin's population lives within a quarter mile of a park (45.2%). Consistent with previous literature, in this study racial minorities (specifically, Hispanic and Latinx) and low-income communities had the greatest access to parks with 47% and 48.5% respectively. This may be a result of concentrated efforts by the city to create new parks in historically Hispanic and Latinx neighborhoods as well as the growth of these populations in Austin (Lewis et al., 2019; Herrick, 2008; Tretter, 2012; Robinson, 2016). At 43.9%, children under 18 are the least served group in Austin as compared to the population as a whole. To address this inequity, the parks department should consider creating more school parks or focusing land acquisition efforts in areas with a higher percentage of children. Meanwhile, the variable service area produced subjective results due to the arbitrary nature of the service area designation, leading to a 120% overestimation of the total population served by a park. Additionally, the variable service area scenario incorrectly assumes the ability of vulnerable communities to access parks outside of a reasonable walkshed of a quarter mile. This study highlighted the need to refrain from the use of variable service areas when evaluating equitable access to urban parks.

The open-access framework created in this study provided a quick method to identify demographics that are being served and geographic regions void of parks. The use of open-access methods also enables city planners and officials to conduct equitability studies on an annual basis, allowing for an understanding of demographic trends. This may assist city planners and managers in the improvement of equitable access across their city. As new data becomes available, such as park funding or updated census information, the new data can be easily integrated and analyzed using the established framework. Furthermore, the open-access nature of the framework lends itself to the application of a variety of equity mapping and spatial injustice studies, such as the identification of transit and food deserts in metropolitan areas. The reproduceable nature of the framework and the ability for others to build off this work underscores the importance of using these open source software tools when studying access.

Equitable access is currently defined by narrow and static frameworks. By using an open source framework such as the one in this study, methods for analyzing equitable access can adapt as the definition of equity continues to change. If we study and advocate for equitable access, then we must ensure our solutions and frameworks are equitable as well. This study is a step in the equitable direction.

Appendix

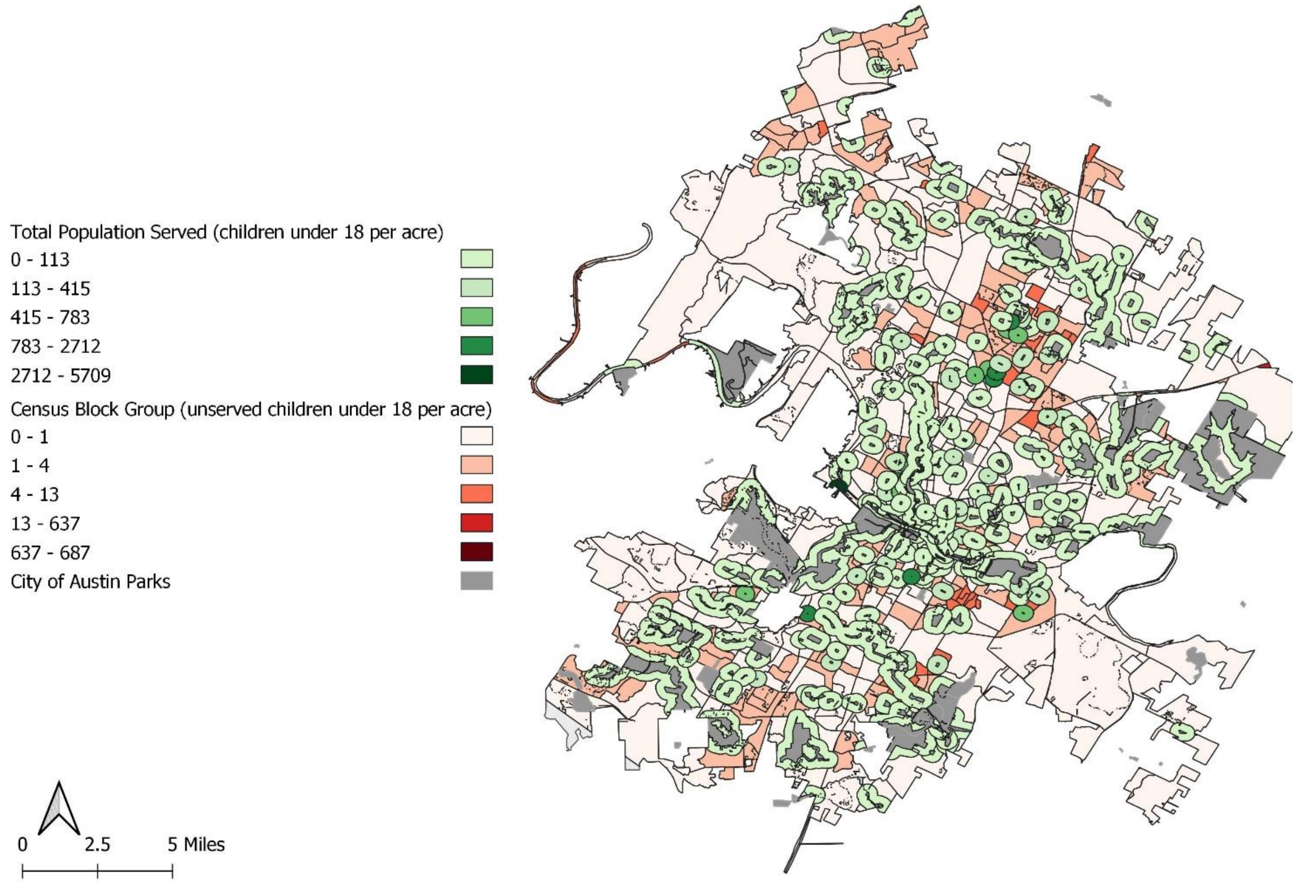

Figure 2: Quarter Mile Buffer - Park Service Map for Children Under 18

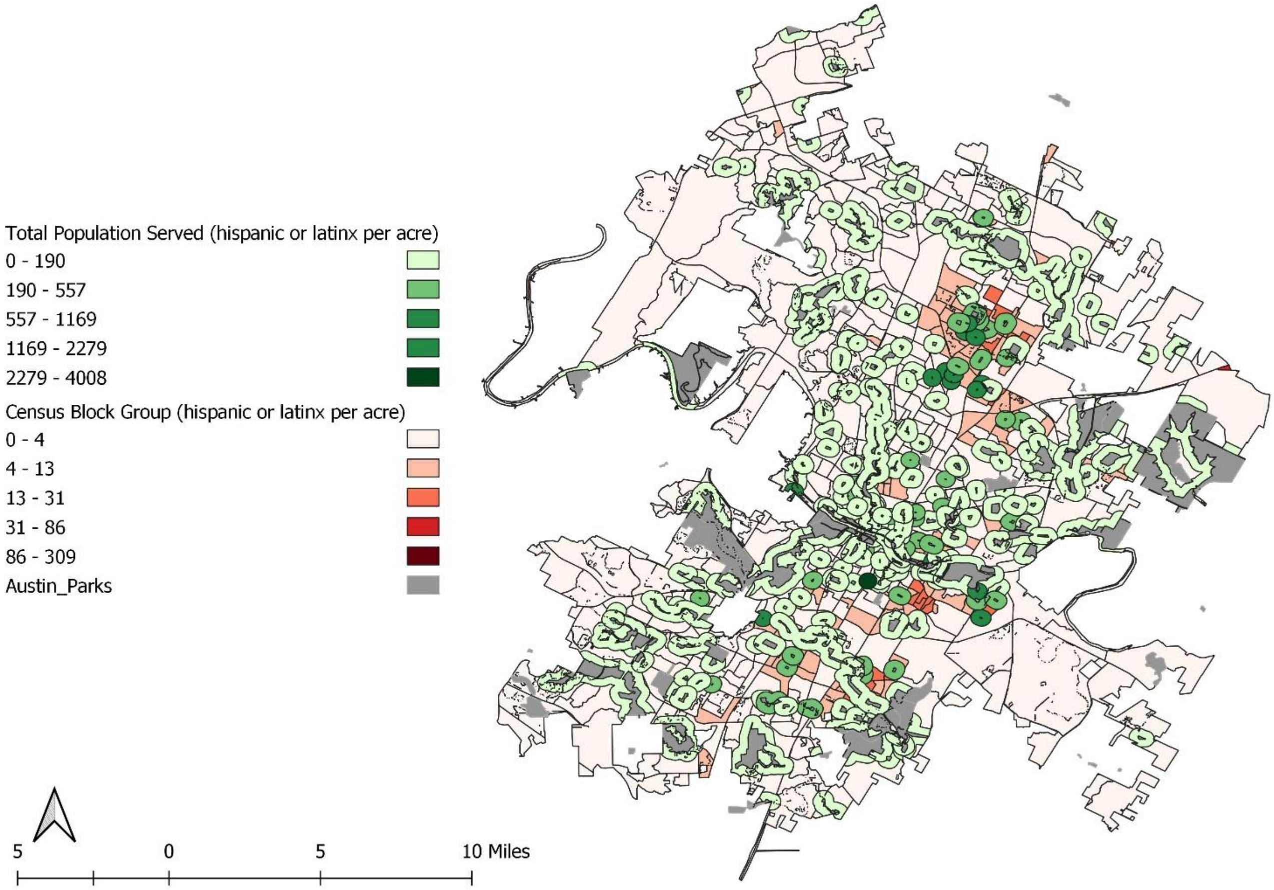

Figure 3: Quarter Mile Buffer - Park Service Map for Hispanic and Latinx Communities

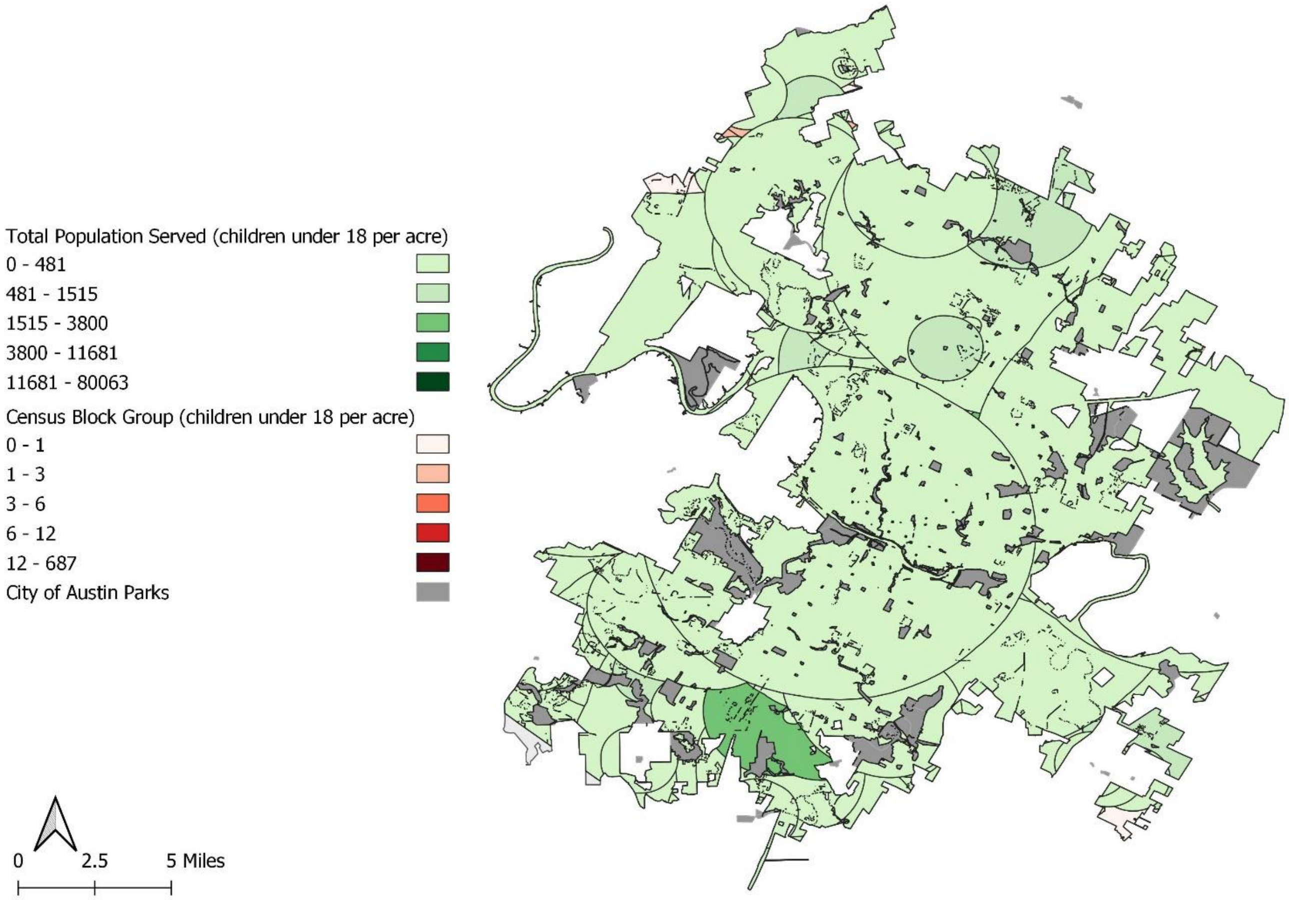

Figure 4: Variable Mile Buffer - Park Service Map for Children Under 18

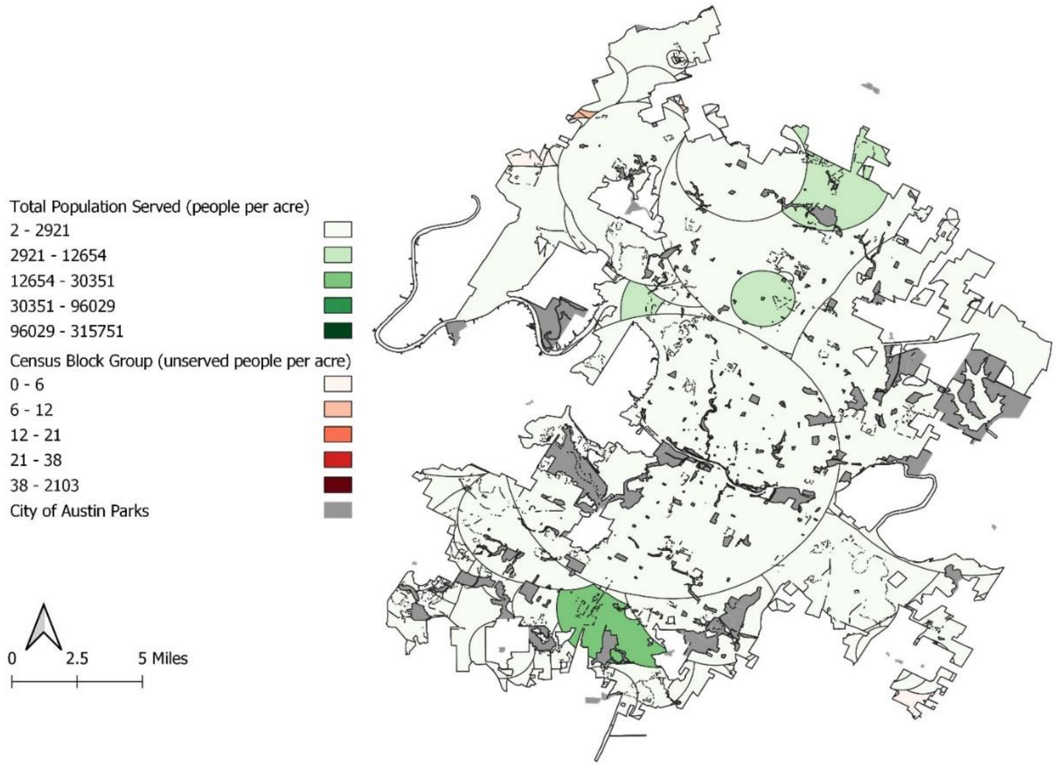

Figure 5: Variable Mile Buffer - Park Service Map for Hispanic and Latinx Communities

Table 2: Quarter Mile Service Area - Percent Served by Race

	Total Population	Percent of Total Population	Total Population Not Served	Total Population Served	Percent of Total Population Served	Demographic Split of the Population Served
Entire Population	912,169	-	499,880	412,289	45.20%	-
Non-Hispanic or Latinx	600,338	65.81%	334,623	265,715	44.26%	64.45%
White; Non-Hispanic or Latinx	447,487	49.06%	247,801	199,686	44.62%	48.43%
Hispanic or Latinx	311,831	34.19%	165,257	146,574	47.00%	35.55%

Table 3: Quarter Mile Service Area - Percent Served by Age

	Total Population	Percent of Total Population	Total Population Not Served	Total Population Served	Percent of Total Population Served	Demographic split of the Population Served
Entire Population	911843	-	499,554	412,289	45.21%	-
Children Under 5 Served	60309	6.61%	33,064	27,245	45.18%	6.61%
Children Under 18 Served	192361	21.10%	107,998	84,363	43.86%	20.46%
Adults Over 65 Served	78400	8.60%	43,668	34,732	44.30%	8.42%
Woman and Children Under 5	480870	52.74%	264,909	215,961	44.91%	52.38%
Woman and Children Under 18	548236	60.12%	303,362	244,874	44.67%	59.39%

Table 4: Quarter Mile Service Area - Percent Served by Household Income

	Total Households	Percent of Total Households	Total Households Not Served	Total Households Served	Percent of Total Households Served	Demographic split of the Households Served
All Households	359355	-	194,553	164,802	45.86%	-
Less than $25,000	63976	17.80%	32,964	31,012	48.47%	18.82%
$25,000 to $49,999	77483	21.56%	41,939	35,544	45.87%	21.57%
$50,000 to $74,999	65434	18.21%	36,044	29,390	44.92%	17.83%
$75,000 to $99,999	43651	12.15%	23,752	19,898	45.59%	12.07%
$100,000 to $149,999	54084	15.05%	29,829	24,255	44.85%	14.72%
$150,000 or more	54727	15.23%	30,025	24,702	45.14%	14.99%

Table 5: Variable Service Area - Percent Served by Race

	Total Population	Percent of Total Population	Total Population Not Served	Total Population Served	Percent of Total Population Served	Demographic split of the Population Served
Entire Population	912169	-	4,088	908,081	99.55%	-
Non-Hispanic or Latinx	600338	65.81%	3,401	596,937	99.43%	65.74%
White; Non-Hispanic or Latinx	447487	49.06%	2,750	444,737	99.39%	48.98%
Hispanic or Latinx	311831	34.19%	687	311,144	99.78%	34.26%

Table 6: Variable Service Area - Percent Served by Age

	Total Population	Percent of Total Population	Total Population Not Served	Total Population Served	Percent of Total Population Served	Demographic split of the Population Served
Entire Population	911843	-	4,088	907,754	99.55%	-
Children Under 5 Served	60309	6.61%	270	60,039	99.55%	6.61%
Children Under 18 Served	192361	21.10%	1,060	191,301	99.45%	21.07%
Adults Over 65 Served	78400	8.60%	365	78,036	99.53%	8.60%
Woman and Children Under 5	480870	52.74%	2,205	478,665	99.54%	52.73%
Woman and Children Under 18	548236	60.12%	2,632	545,604	99.52%	60.10%

Table 7: Variable Service Area - Percent Served by Household Income

	Total Households	Percent of Total Households	Total Households Not Served	Total Households Served	Percent of Total Households Served	Demographic split of the Households Served
All Households	359355	-	1,489	357,866	99.59%	=
Less than $25,000	63976	17.80%	111	63,865	99.83%	18%
$25,000 to $49,999	77483	21.56%	242	77,241	99.69%	22%
$50,000 to $74,999	65434	18.21%	235	65,200	99.64%	18%
$75,000 to $99,999	43651	12.15%	149	43,501	99.66%	12%
$100,000 to $149,999	54084	15.05%	328	53,756	99.39%	15%
$150,000 or more	54727	15.23%	424	54,303	99.23%	15%

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