Evaluating methodological approaches for measuring park accessibility: a meta-analysis

by

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A REPORT

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Abstract

Inclusive parks are the most successful in serving communities. Park planning projects need to ensure that parks are equally accessible to all population groups. To determine if a park is accessible to all, several factors must be considered, including proximity of parks to users, community demographics, levels of service, and need. Historically, it is seen that marginalized communities typically do not have the same access to parks that are available to other parts of the community. To quantify the levels of accessibility, indices are used widely in park planning process. These indices consist of different measures related to park proximity, area, and surrounding demographic condition. There are different methods of quantifying accessibility using varying definitions of accessibility and data sources. These different accessibility measures and ways to calculate accessibility indices make the planners' task difficult while using them for park planning and improvement projects. The goal of this meta-analysis is to explore the specific measures and methods used to assess accessibility in existing studies. This will allow planners to identify similarities and differences of measures considered within the landscape of park accessibility research.

ParkScore, developed by the Trust for Public Land (TPL), attributes five main categories to the analysis of all parks: acreage, investment, amenities, access, and equity. Accessibility measures adopted by three other studies on park accessibility are evaluated and compared with the measures used for ParkScore. By classifying measures of the three studies within the five categories of the ParkScore analysis, it shows the commonalities and uniqueness of accessibility indices. All studies reviewed contain some measure of acreage, proximity access, and socio-economic equity. No other studies, besides ParkScore, considered investment as a measure of access. Only one study considered safety factors, and one study considered environmental factors. Variation in measures used for calculating accessibility indices are a result of different

definitions of accessibility within the respective study. Planners need to be aware of these variations in park accessibility measures while working on any park planning project.

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Chapter 1: Introduction

Over 50% of the global population resides in urban areas (Zipperer & Pickett, 2012). As this proportion continues to grow so does concern for environmental, and social stressors that lead to health problems (Larson et al., 2016). Urbanization can provide benefits in accessibility to amenities and health care, but not without potential negatives of pollution, health issues, and unequal access to urban parks. Benefits of urban parks include, but are not limited to health and wellbeing benefits, social cohesion, an identity for the community, tourism, biodiversity in the environment, air quality, carbon sequestration, water management, and cooling (Gies, Erica, 2006). Well-being is the positive outcome that is created by a community's perception of their living conditions. Higher levels of accessibility to parks in a community is synonymous with enhanced perceptions of well-being. This perception contributes to the quality of relationships, positive emotions, resilience, and overall satisfaction with one's life (*CDC*, 2018). Growing emphasis on the need for urban health promotion is reliant on the availability of amenities, and connections provided by parks.

In addition to individual benefits, urban parks play a role in the success of sustainable cities. Current sustainability and regeneration strategies have heavy focus on how the built environment can mitigate their effects on the environment, neglecting how green space and reintroduction of natural processes can reverse negative components of development (Chiesura, 2004). A sustainable city encapsulates more than social and abiotic aspects of urban life. It is also important to consider the effects that natural processes, parks, and urban greenspace bring to the city. In addition to environmental benefits, parks are associated with building greater levels of connectivity between their users and the community. This contributes to the emotional

dimension of public participation creating a deeper desire for involvement at the local level (Barnes, 2008).

1.1 Park Accessibility Indices

This study seeks to analyze indices that have been used in previous studies to measure park accessibility and determine what are the most widely considered measures used for park accessibility, as well as how scalable these indices are. Most literature considering park accessibility consists of measures to determine proximity, quality, and socio-economic factors. Common issues in park equity are that marginalized populations have less access to parks, or the most accessible parks for these populations are lower quality in comparison to other demographics. Inequalities also exist in resource allocation for park improvement in low-income and minority communities. This can create disproportionate levels of accessibility to populations that are historically underserved, redefining the landscape and creating new issues in access (*Kinder Institute for Urban Research*, n.d.). Different definitions of accessibility throughout indices can create unique combinations of measurements, but to some extent all indices aim to address issues of the resident's proximity to a park, the quality and safety of the parks, or creating equitable opportunities of access to communities of all socio-economic status.

1.2 The Future of Park Accessibility

Park accessibility indices can help to identify parks in need of maintenance, updates, parks capacity for change, community involvement, user satisfaction, and external benefits for urban environments (Platt, 2006). This research can lead to greater understanding of accessibility of urban parks, as well as helping to determine resource allocation for park

improvement. Once need is established and addressed, parks have potential for self-sufficiency in resources and maintenance by the users in their community. This can have overarching positive effects on urban areas surrounding them and can lead to new standards and solutions for issues plaguing park accessibility in the future (Cranz & Boland, 2004). Park maintenance and allocation of resources require consistent analysis and data must be updated regularly.

In addition to maintenance and resource allocation, changes in walkability, proximity, and transportation networks have potential to effect park access. Creating more walkable streets or new interventions to existing active transportation networks can help mitigate proximity concerns when considering access. Park or greenspace development in areas with the highest density, and inclusive residential development in areas with the highest park density both contribute to fighting issues of park accessibility. This gives the most amount of people access to the most parks. Lastly, when considering accessibility, transit networks can be used to provide access for populations that otherwise would be considered outside of the parks service area. Transportation networks improvements can include better traffic mitigation, more clear signage to parks, more inclusive transit networks, and quality analysis of existing public transit.

1.3 Definitions

Throughout this meta-analysis different terms have varying definitions based on the individual studies. This subsection will elaborate on commonly used terminology within the context of this meta-analysis.

Accessibility: Accessibility in the context of this meta-analysis is defined as how aspects of acreage, investment, amenities, access, equity, and other measures contribute to quantifying level of use (‘ParkScore® 2022 Scoring Metrics’, n.d.).

-Access: Access is defined as proximity-based measures between a population and parks (Williams et al., 2020).

-Accessibility Index/Indices: An accessibility index is a method for quantifying overall access. Indices must contain data that is transferable and scalable (*Accessibility Index - Overview*, n.d.).

-Acreage: Acreage relates to all aspects considering parks by square footage. This relates to the potential for quality of a park ('Understanding A City's Parkscore', n.d.).

-Amenities: amenities are all services or aspects of a park that enhance the users experience and relate to park quality ('Understanding A City's Parkscore', n.d.).

-Equity: equity relates to equality between different socioeconomic and demographic groups (Heckert & Rosan, 2016).

-Investment: investment relates to the total dollar amount of spending per person for park development or improvement ('Understanding A City's Parkscore', n.d.).

The next chapter of this report provides a literature review discussing indices of access focusing on how accessibility, social justice, GIS methods, lasting effects of redlining, demographics of the area, environmental hazards, population density, household income, distance to public parks and quality of parks have been addressed in park accessibility literature. Following that is a methods chapter that elaborate the approach taken for this study, particularly, the articles evaluated in this study and why their interpretation of park accessibility is considered here. This leads to the findings chapter where the actual indices measured in the chosen studies are elaborated and the different methods of determining accessibility applied by them are compared. Lastly, in the conclusion chapter all the findings are summarized, and their

implications for park planning are discussed. It is also discussed how this study could be further expanded and the implications it could have in the future.

Chapter 2: Review of Literature

This chapter presents a literature review that provides the framework and background information needed to conduct a meta-analytic review of park accessibility research. This discussion provides the context of park accessibility and the factors that influence it. The first portion of the literature review explores definitions and language consistently used throughout park accessibility research. Next, this review explains how history has influenced disparities in modern cities and how that is connected to park accessibility. The methods applied by existing park accessibility studies are analyzed looking at how they have considered and studied accessibility. The literature review concludes by looking at the data used to determine accessibility. Finally, the purpose statement and research questions of the current meta-analysis are introduced.

2.1 Accessibility in Cities

The context of accessibility can change on a situational basis, but the broad understanding of accessibility includes the ability that people of a defined population have to accessibility to specific destinations based on mobility through the system network available (Curl et al., 2011). When an area or activity is truly accessible, the user will not realize it. It is when an activity is inaccessible the user will be aware of the flaws that are present. Accessibility has been seen as a goal for planning practices as early as the 1950's, followed by writings throughout the 1970's, and is still considered an evolving field that is continually being researched. Accessibility is often defined as the ease in which one can get to the services they need to flourish and it will remain an aspect close to the core of human existence (Handy, 2020). Accessibility is a broad term with nuanced interpretations. This makes assessing accessibility

complicated, because there are several different measures of how location and other characteristics of an area can affect accessibility.

2.2 Park Accessibility

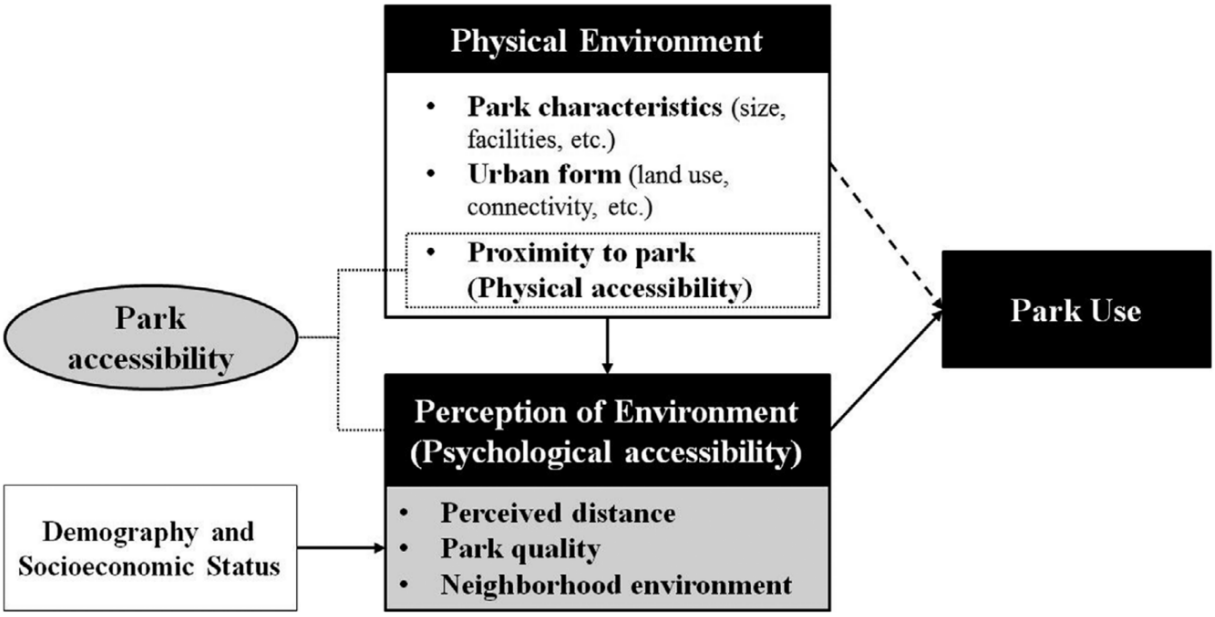
Parks can bring a plethora of benefits including community health improvement, increasing physical activity, facilitating community experiences, improving mental health, environmental benefits, and reducing stress (CDC, 2022). These benefits are only attributed to populations able to use these parks, therefore populations without access to parks would not experience the same benefits that those with park access do. Lack of park access has been proven to reflect geographical divides between inner-cities and suburbs. More specifically, historically marginalized communities such as minority populations or those living under the poverty line do not have the same accessibility to services and amenities in parks (Rigolon, 2016). Consistently throughout literature, it is found that marginalized populations usually have accessibility to parks that are poorly maintained, located in areas perceived as unsafe or dangerous, receives inadequate resources to upkeep, and experience declining levels of park usage (Sister et al., 2010).

Park accessibility is an essential component of city form because of the multitude of uses that a user can experience by the availability of a park. A city's focus should be on encouraging the participation of their citizens in community and public life (Jacobs & Appleyard, 1987). A public park that is open to all members of the community provides cities with the most authentic representation of the culture within the area. When an area does not address concerns of accessibility for certain communities it contributes to less users of the park. This demonstrates shortcomings of authenticity and meaning. Instead, a city should focus on acknowledging,

educating, and correcting moral issues of society that result in disparities throughout the area (Jacobs & Appleyard, 1987).

Park usage is not solely dependent on physical conditions. Improvements to accessibility of a park do not align with a basic cause and effect scenario. Rather this can be characterized as "ex-chemistry", an informal term for the relationship of a group and their perception of change, creating more complex outcomes than just a change and response (Garcia, 1982). This means that park usage is equally dependent on accessibility interventions as it contributes to the community's perception regarding existing park accessibility (Wang et al., 2016). Perception also varies depending on the specific resident. Users of a park will experience unique constraints and heterogeneous perceptions of space depending on their unique situations (MacKenzie et al., 2015). **Figure 1** (MacKenzie et al., 2015) shows a model of how park accessibility is influenced by both the physical environment and the user's perception of the environment. On the other hand, socio-economic status and demography of the user influence one's perception of the environment. The mixture of the individual's perception of park characteristics, urban form, and proximity contribute to their perceived accessibility and thereby define their usage of the park.

Figure 1 - Model of the Relationship Between Park Accessibility and Park Use (MacKenzie et al., 2015)



2.3 Social Justice and Park Equity

Social justice considers populations or areas with a specific intention of redressing the effects of hierarchical inequalities (Reisch, 2002). In the context of this meta-analysis, park equity is considered as a form of social justice issue that looks at how accessibility to parks is determined for all people, specifically looking at how underprivileged populations and areas are addressed. Park equity can be quantified by analyzing relationships between urban park accessibility and the residential populations of the area (Feng et al., 2019). Major differences exist in park quality based on race (Sister et al., 2010). It is found that white populations had the highest access to the most amount of park space, while minorities have the least, specifically Hispanic populations (Sister et al., 2010). On top of the lack of accessibility to park acreage, in predominantly white areas there are more abundant play equipment, basketball, baseball, soccer,

walking and jogging facilities compared to parks in areas of predominantly minority residents (Sister et al., 2010). This reinforces the need for a focus on socio-economic equity when analyzing public parks. Creating parks made for all helps make a more efficient and cohesive urban environment, leading to mutually beneficial opportunities for growth and social mobility (Turner & Rawlings, 2009).

2.4 Accessibility Index

Accessibility is not a part of any traditional transportation models and therefore lacks a formal definition with clear measures of success. Instead, there are several differing considerations of what accessibility relies on in different areas (Bhat et al., 2000). The lack of conventional consideration for the meaning of accessibility has led to several differing accessibility indices. An accessibility index consists of specific measurements related to distance, area, and other features of a facility that are synthesized to quantify levels of accessibility. Finally, the index provides an aggregate value representing the level of accessibility present in areas based on the data analyzed (*Accessibility Index - Overview*, n.d.). There are many varying approaches to measuring accessibility indices. Several methods of indices creation are discussed in the following sections.

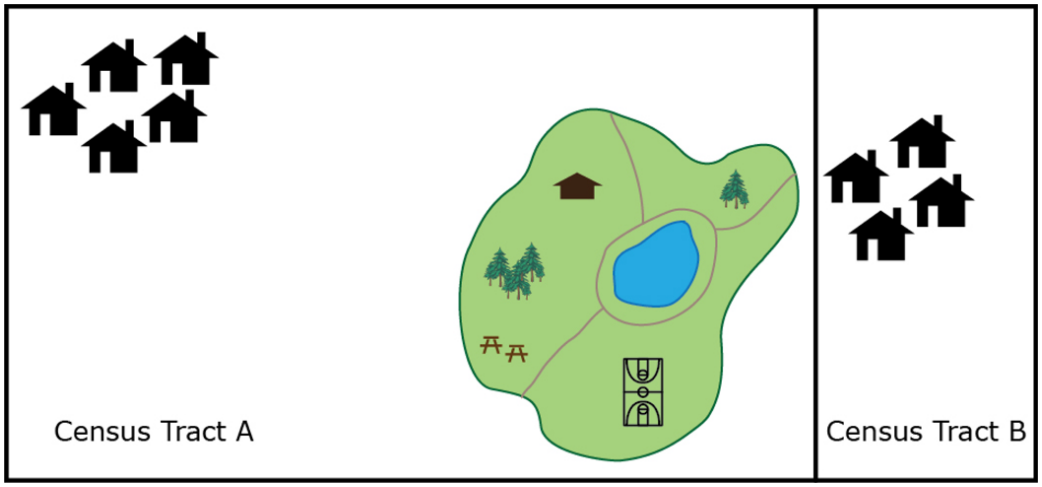
2.5 Methods of Indexing Accessibility Measures

In most cases accessibility indices are conducted using Geographic Information Sciences (GIS), allowing the user to observe data through spatial analysis. In these indexes, various measures of proximity, walkability, and park density are considered. This contributes to differing levels of accessibility, depending on the processes used.

2.5.1 Container approach

The container approach of data aggregation considers the populations of a certain area unit such as census tract or zip code. Any park that is in the same area unit as the populations is considered accessible. This method creates limitations to assessing accessibility. The boundary of the area unit can exclude populations that live directly next to the park because they are technically part of another area unit as shown in **Figure 2 (Miyake et al., 2010)**. Vice versa, a park that is far away could still be considered as part of that area unit and therefore be seen as accessible. There is little ability to create a uniform area unit where the population and size is consistent throughout the analysis (Miyake et al., 2010).

Figure 2 - Limitations of the Container Approach (Miyake et al., 2010)



2.5.2 Buffer Analysis

A buffer analysis consists of creating an area around each park that represents the distance that users of the park would be willing to walk (service area). Populations within the service area have high access to the park in consideration, where populations that exist outside of the service area do not consider that park accessible.

2.5.3 Kernel Density Method

The kernel density method considers the study area as a grid for which the park density for each cell of the grid is aggregated (Miyake et al., 2010). Residents that live within cells of the grid that have higher park density are considered to have more access to parks than residents that live within cells of the grid that have less park density.

2.5.4 Street Network Analysis

The street network analysis considers access based on park service areas in the context of their pedestrian accessible street network (Miyake et al., 2010). Rather than using straight line Euclidean distance, a street network analysis is more accurate and scalable. Relying on Euclidean distance creates an unreliable standard for proximity measures. In rural areas Euclidean distance could create accurate conclusions, but in urban areas it is not ideal because users would not be able to take a straight-line path to their nearest park. In the street network analysis, as well as all previously mentioned methods of accessibility measures, there is no consideration to environmental conditions of usability. Environmental conditions of usability include the perceived safety in the walkable areas, areas less walkable than others, quality of facilities, and perception of usability of the park.

2.5.5 Accessibility Void Method

The accessibility void method considers socioeconomic variables related to disadvantage and vulnerability and how that affects these population's accessibility to parks spatially (Heckert & Rosan, 2016). Socioeconomic factors are chosen to represent at-risk populations who are either expected to have higher levels of need or are impacted differently by lack of accessibility to parks and green infrastructure. Each indices considered represents a level of disadvantage.

This method considers the areas in the most need and can be used to target resource allocation and assign levels of need throughout communities.

2.5.6 Proximity, Safety, and Acreage Analysis

Proximity can also be determined using a method like the street network analysis, considering distance through the lens of the walkable street network. In this model, quality is assessed as parks that are perceived as "safe"; this is concluded by the area surrounding the park's crime level being lower than the city's average crime rate (Williams et al., 2020). Access to acreage is measured using a "congestion-weighted acreage" (Williams et al., 2020). This shows the number of parks within a certain distance to a resident and divides the population amount with access to a given park by the area of the closest park available. This congestion-weighted acreage method provides the available acreage to each resident. These aspects are determined and then compared with each other to find patterns in accessibility.

2.6 Data Availability of accessibility factors

While calculating accessibility index, it is important that the data used is easily retrievable for the target areas. This contributes to the potential for scalability of the accessibility index. Data must be accessible to all, as well as consistently collected for other areas (e.g., census data).

2.6.1 Spatial Park Data

Location data concerning the parks in an area is typically provided by the city's Department of Parks and Recreation. This can also be done using ESRI data providing a shapefile of USA parks, gardens, and forests at the national, state, and local level (*USA Parks* -

Overview, n.d.). Data retrieved from either of these sources is limited by the accuracy of the data but provides the most widely considered accurate and usable spatial data of park location.

2.6.2 Socioeconomic data

Socioeconomic data can be obtained through various sources such as the EPA Environmental Justice Screen Application, US Census data, and ACS (American Community Survey) data. The ACS data is gathered over time and used to measure changing social and economic characteristics, while the decennial census collects basic population count data in every ten years and used for congressional redistricting.

2.6.3 Other data sources

Other data on park accessibility includes aspects of the built environment, and quality measures of the parks that could potentially be overlooked by larger data sets like the census or EPA. This can include local surveys, or data that is collected from the users of a park. This data varies depending on the municipality, but it is made public by the local authority. If not, it is obtainable by contacting the local municipality and requesting the data.

Chapter 3 – Study Method

This report aims to answer the following questions.

1. What are the widely considered factors of park accessibility in the major park accessibility research in the US?
2. How does the current park accessibility research vary by method and data sources?
3. How should planners use park accessibility indices for urban planning and park improvement projects?

Through this study, I aim to explore existing indices used to measure park accessibility by major studies on park accessibility in the U.S. The TPL's ParkScore and three studies on park accessibility are identified for this study following these three criteria:

-Generalizability and transferability of the indices

-Scalability of the indices to apply at the local level

-Uses data from publicly available sources

Trust for Public Land's (TPL) ParkScore, first published in 2012, are now widely used by planners, landscape architects, and park equity advocates to promote park accessibility throughout the U.S. TPL now publishes ParkScore every year that reveals park accessibility levels for nearly 14,000 cities, towns, and communities across the United States (Trust for Public Land, 2023). Considering the wide application of ParkScore, it is evaluated with three major studies on park accessibility and their similarities and differences in methods and data sources are explored. Many of the measures of accessibility are considered in multiple studies, and it is

important to acknowledge their recurrence. The recurrence of similar accessibility measures across different studies highlights the fact that multiple studies agreed to the significance of those measures. This meta-analysis will also investigate how similar measures of accessibility were considered differently and the reasons for that.

In addition to the Trust for Public Land's ParkScore, the three studies considered for this study are.

-Study one, M. Heckert and C. D. Rosan's (2015) article "*Developing A Green Infrastructure Equity Index to Promote Equity Planning."*

-Study two, K Miyake et al.'s (2010) article "*Not Just a Walk in the Park: Methodological Improvements for Determining Environmental Justice Implications of Park Access in New York City for the Promotion of Physical Activity.*"

-Study three, T. G. Williams et al.'s (2020) article "*Parks and Safety: A Comparative Study of Green Space Access and Inequity in Five US Cities"*

For this meta-analysis, it was considered that the accessibility index needs to be transferable, scalable, and uses data from sources that are publicly available. These three studies were chosen because they all have basic measures of park accessibility like the demographics of the area, and the distance to the park, making their approach transferable to other areas. All the studies have used publicly available data sources and applied different methods of indices creation. The unique methods used to aggregate accessibility indices help to show the wide potential for accessibility indices depending on the definition of accessibility for the given research. This meta-analysis considers the Trust for Public Land's 5 main categories used to

determine ParkScore as the basis to categorize all the accessibility measures used in other studies.

3.1 Method to compare park accessibility studies.

Although ParkScore of TPL is the most widely used index of parks accessibility, it does not include the same measures that other studies have used to determine accessibility. Park accessibility is a complex issue, and this meta-analysis will highlight the ways that other studies have considered different accessibility measures as well as their methods of index creation. Accessibility measures used to create indices in all studies will be analyzed as they relate to the five main categories of measures in TPL's ParkScore calculation: acreage, investment, amenities, access, and equity. Definitions of these categories as they are presented in the ParkScore are presented in Table 1. Some of the studies used accessibility measures that are not considered in these five categories, they are included in "Other" category. This meta-analysis aims to consider all measures that affect park accessibility and determine similarities and differences between the existing landscape of park accessibility indexes.

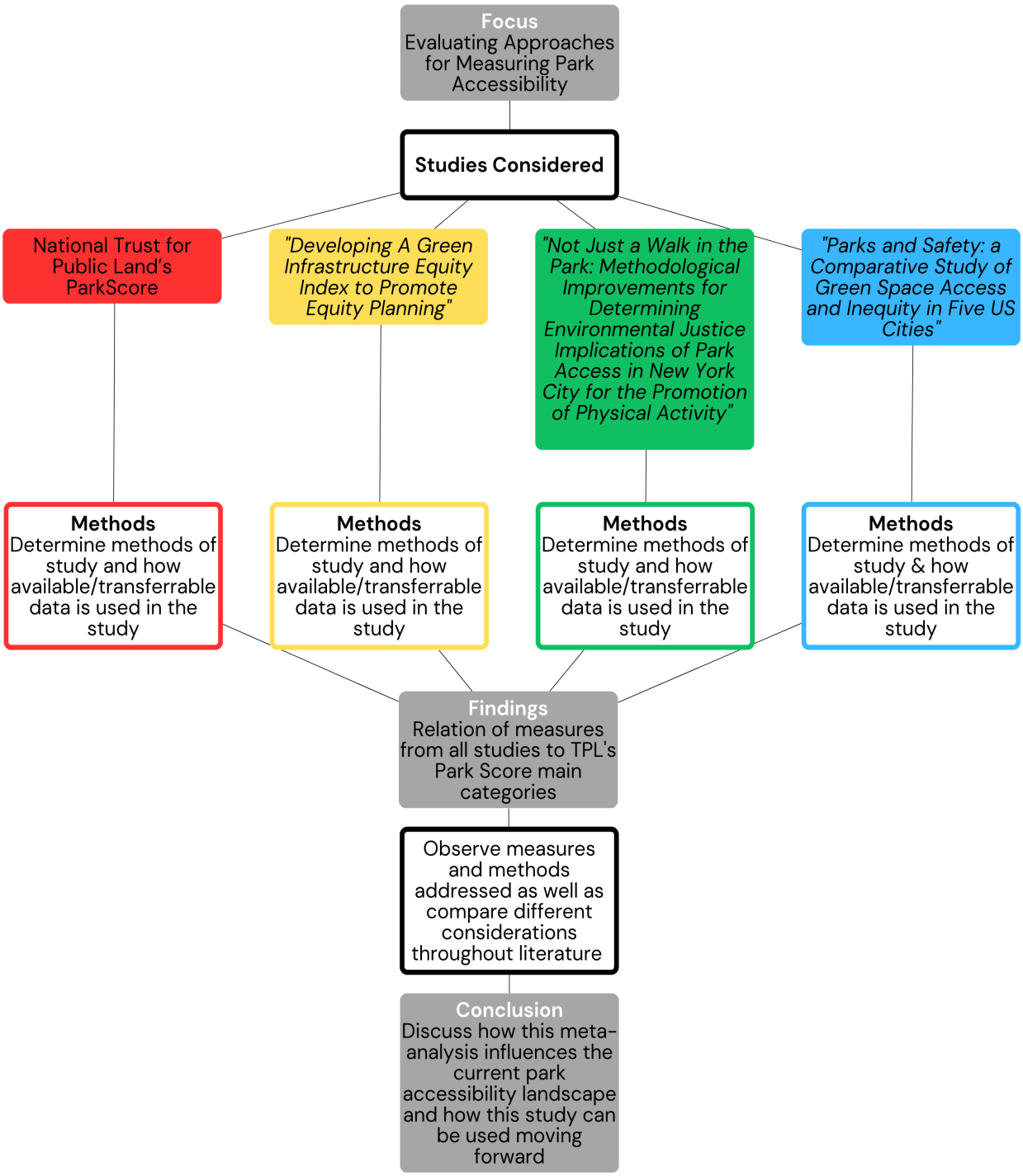
Table 1 - Definitions of the ParkScore's 5 Main Categories

Acreage	Acreage pertains to any metrics that are measured in sq. ft and contribute to the area that is considered a park.
Investment	Investment is used to consider variables that reflect residents' circulation of money back into their community.

Amenities	Amenities consider any aspect or feature of the park that enhances the user's experience of the park and contributes to the sense of place, making a more desirable or useful area.
Access	Access is the proximity to a system or entity, this considers how parks may be reached and the ease in which one can do so.
Equity	Equity is defined as the quality of being fair and impartial, but in this context, it means anything that relates to acknowledging disparities in parks that appear on a socio-economic level.
Other	The other category includes all measures that are not related to the five main ParkScore categories.

A flowchart of methods followed to evaluate the ParkScore index and the three studies are shown in Figure 3. The next section summarizes those studies.

Figure 3 - Study Method



3.1.1 Trust for Public Land (TPL): ParkScore

Currently the most widely used approach for assessing the accessibility of parks comes from TPL and their ParkScore model. A park's ParkScore considers overall accessibility as a combination of five categories: acreage, investment, amenities, access, and equity. TPL is a nonprofit in the US that creates parks and protects land for communities focusing on creating healthy, livable communities for generations to come (Trust for Public Land, 2023). The data used in ParkScore are all collected from the US Census, making all this data public and easily accessible. TPL is considered as one of the most effective efforts for preserving and creating happiness, health, and well-being through accessibility to the outdoors as well as securing over $93 billion in public funding and connecting millions of people with accessibility to the outdoors (Trust for Public Land, 2023).

A City's ParkScore is determined based on how its data compares to data from the 100 largest U.S. cities. Out of the 100 largest U.S. cities the data ranges are separated into brackets, with the lowest brackets receiving the least points and the highest receiving the most (Trust for Public Land, 2023). Each city can get a total of up to five hundred points throughout the five main categories (Acreage, Investment, Amenities, Access, and Equity), this number is normalized to create a ParkScore rating out of 100. The ParkScore index works to identify only concrete aspects of park accessibility and claims that the measures of acreage, services, investment, access and equitable distribution all reflect quality (Trust for Public Land, 2023). This meta-analysis will look at the methods and measures used in ParkScore and compare how their approach relate to those from other studies, finding the most overarching and commonly used aspects of park accessibility.

3.1.2 Heckert and C. D. Rosan (2015): *"Developing a Green Infrastructure Index to Promote Equity Planning"*

After TPL, the first study being considered for its accessibility index comes from M. Heckert and C. D. Rosan (2015): "*Developing a Green Infrastructure Equity Index to Promote Equity Planning"*. This article is cited over one hundred times by other studies on park accessibility. To create an accessibility index, this study used data that is accessible to the public and maintained by the Philadelphia Water Department, the EPA, and the US Census. This paper targets planners, policy makers and stakeholders as their key demographic and encourages their participation in the quest to promote accessibility.

In this study accessibility is defined as equality, need, and demand. Determining that equality is when all populations have the same ease of access to services, with an emphasis on supplying more resources to populations with more need, and meeting the demand expressed by populations (Heckert & Rosan, 2016). The methodology for this paper consists of an index for the City of Philadelphia at the census block group level, looking specifically at what areas are considered "accessibility voids" and using this data to advocate for more green infrastructure focused development in those areas (Heckert & Rosan, 2016). From the areas deemed "accessibility voids" the authors determine the areas that have had no previous green infrastructure focused development. Areas in accessibility voids that also have received no previous green infrastructure interventions are the areas of highest need and require immediate intervention.

This article is unique compared to other studies of park accessibility because of its consideration of environmental data. The purpose of this research is not to the same as other studies considered. Its interpretation is formulated to be considered for a specific goal of

determining areas of need. Rather than considering all areas similarly and determining areas of quality, it aims to recognize areas of the highest need. Data for this study was retrieved from the Census and EPA, so it is available to the public. This environmental focus combined with the other indices in this paper make it unique and worthwhile when considering accessibility index.

3.1.3 Miyake et al. (2010): *"Not Just a Walk in the Park: Methodological Improvements for Determining Environmental Justice Implications of Park Access in New York City for the Promotion of Physical Activity."*

The size of the area as well as population density are major factors when considering accessibility of parks. To consider what variables are the most important towards assessing accessibility, one must establish accessibility goals and for different areas these goals can differ. The next study of Miyake et al. (2010): *"Not Just a Walk in the Park: Methodological Improvements for Determining Environmental Justice Implications of Park Access in New York City for the Promotion of Physical Activity"*, is considered to show how scale can affect variables priorities. This study measures park accessibility in New York City, using an urban environment so vast it creates different priorities when assessing accessibility. This study was chosen largely in part for its unique scale, this creates a measure of accessibility that is not as uniform as other cited studies because it is being done in the most populated city in America (*The 200 Largest Cities in the United States by Population 2023*, n.d.). This study results in a unique definition of accessibility largely based on walkability, the size of park available to residents, and overall accessibility to physical activity sites (Miyake et al., 2010). The significance of this study is shown through being cited by over seventy studies. This study focuses on large cities as well as distribution of parks throughout largely walkable areas. This

study also referred to studies that analyze racial equity and the importance of local accessible parks, so very much aligned with the purpose of this meta-analysis.

K Miyake et al. (2010) used different accessibility measures to create a spatial index applying "street network analysis". This type of analysis is impactful because, rather than using Euclidean distance (measures of distance in a straight line from the destination) this study considers pedestrian accessible walking routes creating more realistic representations of the distance pedestrians will walk (Miyake et al., 2010). A street network analysis is important in the context of this paper because it is scalable throughout all areas. In densely populated areas like New York City the direct distance to a destination compared to its street network analysis can vary more than it would in rural areas, nevertheless throughout all densities even rural the network analysis will provide the most accurate results for proximity.

3.1.4 Williams et al. (2020)*: "Parks and Safety: A Comparative Study of Green Space Access and Inequity in Five US Cities"*

The final study considered in this study is Williams et al. (2020): *"Parks and Safety: A Comparative Study of Green Space Access and Inequity in Five US Cities"*. This study is considered due to the scalability of the approach chosen to measure accessibility. It analyzes the park accessibility across five different major metropolitans. It was written with a focus on interactional and distributional justice considering parks in these areas. It has been cited by over seventy other articles on park accessibility. All the data used in this study came from public ESRI data, information found on open street maps, and Uniform Crime Reports reported to the FBI. This article is important and relatable to this study because of the importance of finding significant variables that can be used in a wide variety of landscapes throughout different urban areas.

Williams et al. (2020) defines accessibility as the proximity, availability, acceptability, affordability, adequacy, and awareness of public green space in relationship to its user. In other studies, safety and crime has not been considered despite being a key component of accessibility and complicating factor of proximity. This study considered crime as a contributing factor of accessibility. This study considered the areas within a 200 m buffer around each green space and crime reports found from the FBI's crime reports for those areas, dividing the amount of crimes in the 200 m buffer by the area of the greenspace and comparing that to the city-wide average crime density (Williams et al., 2020). This methodology is transferable to other cities of all scales because crime data is recorded and compiled by the FBI for all cities and this method considers the crime rate for that city rather than a blanket value used to consider crime throughout all areas.

Chapter 4 - Findings

4.1 Introduction

In this chapter, the results discovered through the methodology detailed in the previous chapter are reported in the following ways. First, a figure accompanied by a table showing how all measures of accessibility relate to the five main categories used by all four studies considered in this meta-analysis. Next, all the categories (Acreage, Investment Amenities, Access, Equity, and Other) are analyzed using a: (a) figure to show how all indices are related within their categories, (b) table that addresses how the indices were determined, (c) written analysis specifying the significance of different measures in each category. Finally, this chapter is concluded with discussing which accessibility measures are significant based on consistency throughout literature, and which measures are unique to a specific study and could be beneficial towards more accurately assessing accessibility.

4.2 Major Categories of Accessibility Measures

This section shows all the measures used in the reviewed studies as they align with the major categories of the TPL. These categories are then broken down individually showing all the measures relate to each of the categories and how each measure was determined. Table 2 will show all the measurements throughout all the reviewed studies.

Table 2 - All accessibility measures considered in the reviewed studies.

Broad Categories used in ParkScore	The National Trust for Public Land's ParkScore. (TPL)	M. Heckert and C. D. Rosan (2015) **(Study 1)**	K Miyake et al. (2010) **(Study 2)**	T. G. Williams et al. (2020) **(Study 3)**
Acreage	Median Park Size, and Parkland Considered as a Percentage of the City	Tree Canopy Cover, Impervious Surfaces, and Amount of Vacant Land	Size of Closest Park, and Combined Size of Parks Within 400 M	Congestion Weighted Acreage
Investment	The Sum of the Total Spending Per Resident	Not Considered	Not Considered	Not Considered

Amenities	Availability of Basketball Hoops, Availability of Off-Leash Dog Parks, Availability of Playgrounds, Availability of Recreation and Senior Centers, Availability of Restrooms, and Availability of Splash Pads and Spray grounds	Not Considered	Number of Physical Activity Sites, and The Combined Number of Different Physical Activities Within 400 M	Not Considered
Access	Percent of Residents Living Within a Half-Mile of a Public Park	Proximity to Traffic, Park Access, and Playground Access	Distance to Closest Park, and The Number of Parks Within 400 M	Distance to the Nearest Park
Equity	A Ratio of	Percent	Racial Makeup	Racial Makeup,

	Nearby Park Space Compared Between White Neighborhoods and Neighborhoods of Color, A Ratio of Nearby Park Space Compared Between Low-Income and High-Income, Percentage of People of Color Living Within a Half-Mile of a Park, and Percentage of Low-Income Households Within a Half-Mile of a Park	Minority, Percent Low-Income, Percent of Adults Who Have Not Completed High School, Percent Under Age 5, Percent over Age 64, and Percent Owner-Occupied		Percent over 65, Percent Under 18, Percent Under Poverty Line, and Gender

Other	Not Considered	Proximity to Traffic, Particulate Matter levels, and Ozone Levels	Not Considered	Distance to Nearest Park with a Crime Rate Lower Than the City-Wide Average, and Population Density

While considering all measures throughout the main categories detailed in TPL's ParkScore, it is important to acknowledge that the equity category had the most total considered indices, followed by Acreage, Access, Amenities, Other, then Investment. Acreage, equity and access are shown to be significant throughout all three considered studies and the ParkScore index. Each of the categories and the accessibility measures considered under them are discussed in the following sections.

4.2.1 Acreage

Figure 4 shows all measures that are within the category acreage. Acreage works as a classification of the quality of the park, as well as providing users with the total amount of park space accessible to them. Table 3 presents how each measure was considered in their respective study.

Figure 4 – All Measures Considered Related to Acreage

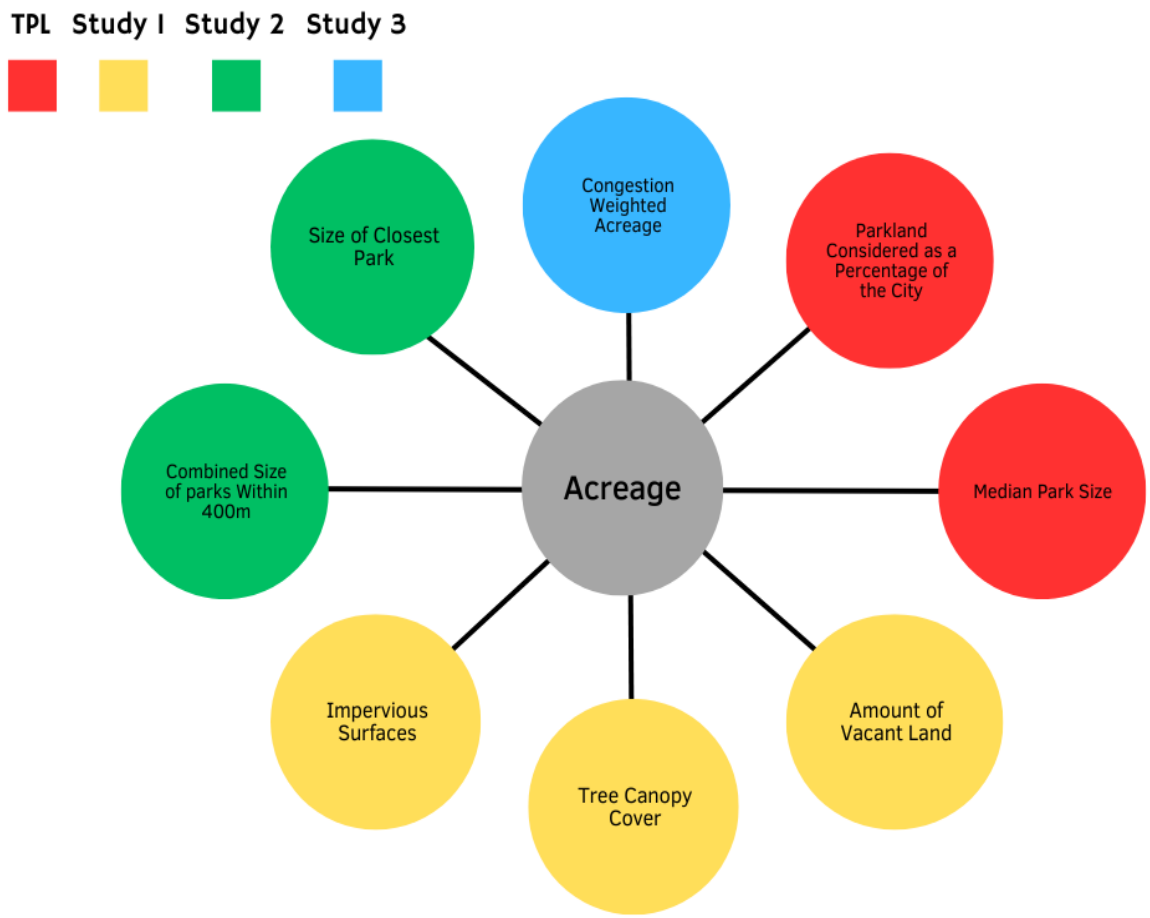


Table 3 - Different Measures of Area or Acreage Considered by Reviewed Studies

Acreage/Area Measures	Details on the measures
Parkland Considered as a Percentage of the City (TPL)	Parkland considered as a percentage is assessed through data collected through annual surveys and this method omits unpopulated areas like railyards, airports, and major bodies of water.
Median Park Size (TPL)	The median park score is calculated with park inventories that are acquired through park-owning agencies within each city.
Amount of Vacant Land (Study 1)	To determine the amount of vacant land, data was retrieved from the City of Philadelphia Water Department. The number of parcels vacant were averaged for each block group to create a percentage. The higher the amount of vacant land signifies a higher amount of need as well.
Tree Canopy Cover (Study 1)	This data was retrieved from a 2008 land cover data set that was provided by the City of Philadelphia. For each block group represented the percentage of tree canopy

	cover was calculated. The city has a benchmark of 30% canopy cover as the standard, so any block that has more than that was determined as being the least disadvantaged when considering tree canopy cover, while any block group with less than 30% was considered more disadvantaged when considering tree canopy cover.
Impervious Surfaces (Study 1)	Impervious surfaces were derived from a 2008 land cover data set that was provided by the City of Philadelphia. This data calculated the percentage of land in each block group that was designated as buildings, roads, and other paved surfaces. All the block group data collected was normalized so that the highest percentage of impervious surface was considered the most disadvantaged, and the lowest percentage of impervious surfaces was considered the least disadvantaged.
Combined Size of Parks Within 400m (Study 2)	This is used to show the overall access to park features in the context of different races. This result was found by creating an odds ratio

	showing the proportion of each race that has parks of three incremental sizes within 400m in comparison to the total population that has parks of three incremental sizes within 400m. For ratios larger than 1 the population is more likely to fall into that category and for ratios less than 1 the population is less likely to fall into that category.
Size of Closest Park (Study 2)	This measure was used to determine the degree of effectiveness existing parks serve the residents within the context of race. This was considered since larger parks are more fitted to serve the roles of the broadest number of people. Results were calculated by creating an odds ratio showing the proportion of each race that has a nearest park of three incremental sizes in comparison to the total population that has a nearest park of three incremental sizes. For ratios larger than 1 the population is more likely to fall into that category and for ratios less than 1 the population is less likely to fall into that

	category.
Congestion Weighted Acreage (Study 3)	This measure consists of the total park area within 800m of each block-level, then divided by the total population of that block-level. This determines the amount of park area per person. The top 20% of parcels with the highest park acreage per person are deemed more accessible, while the parcels in the lowest 20% are deemed the least accessible.

4.2.2 Investment

Figure 5 shows the only measurement applicable to investment. Investment is positively related to park access, as there is higher levels of investment parks are considered to have higher levels of accessibility ('ParkScore® 2022 Scoring Metrics', n.d.). The Trust for Public Land is the only study to consider investments. Table 4 presents the definition of investment measure used in accessibility calculation in ParkScore. This was based on all spending and volunteering per person.

Figure 5 - All Measures Considered Related to Investment

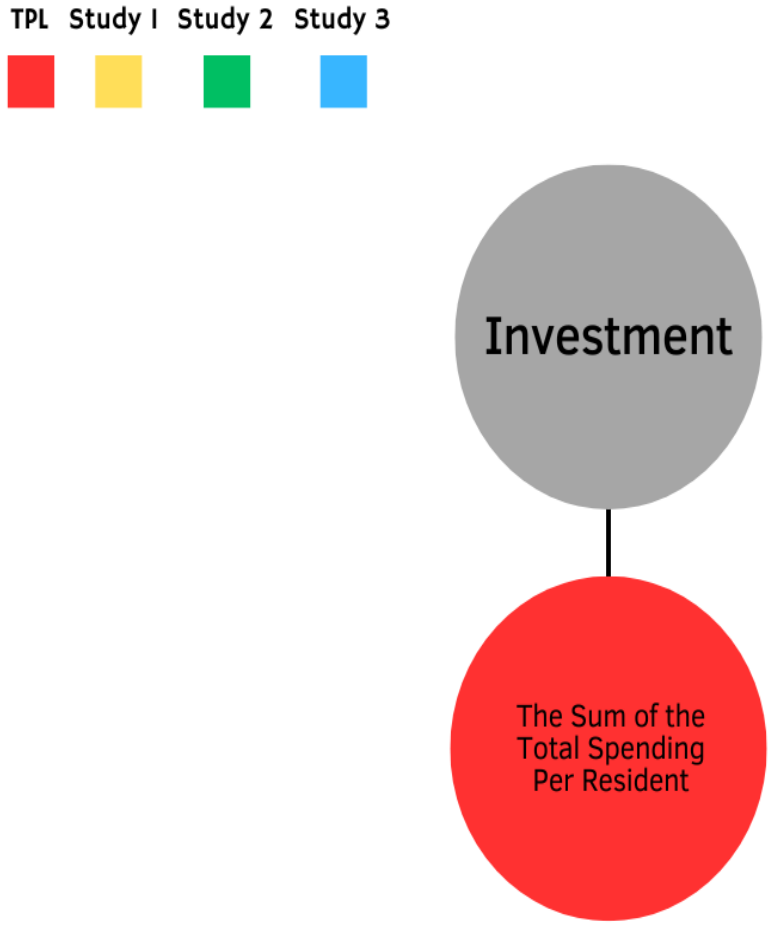


Table 4 - Investment Measures Considered by Reviewed Studies

Investment Measures	Details on the measures
The Sum of the Total Spending Per Resident (TPL)	This is measured based on a 3-year average and is composed of the amount of public spending, nonprofit spending, and volunteer hours. Each city is given up to one hundred points for investments in park-based systems. One hundred being the highest and zero being the lowest

4.2.3 Amenities

Figure 6 shows how access to amenities is considered by the reviewed studies. This is another measurement related to park quality, and it considers that more availability to amenities and service is contributing to more accessible parks according to the studies considered. Table 5 lists the definitions of all the amenity measures used in the reviewed studies. Only TPL and Study 2 (Miyake et al., 2010) considered availability of park amenities as a measure of park accessibility.

Figure 6 - All Measures Considered Related to Amenities

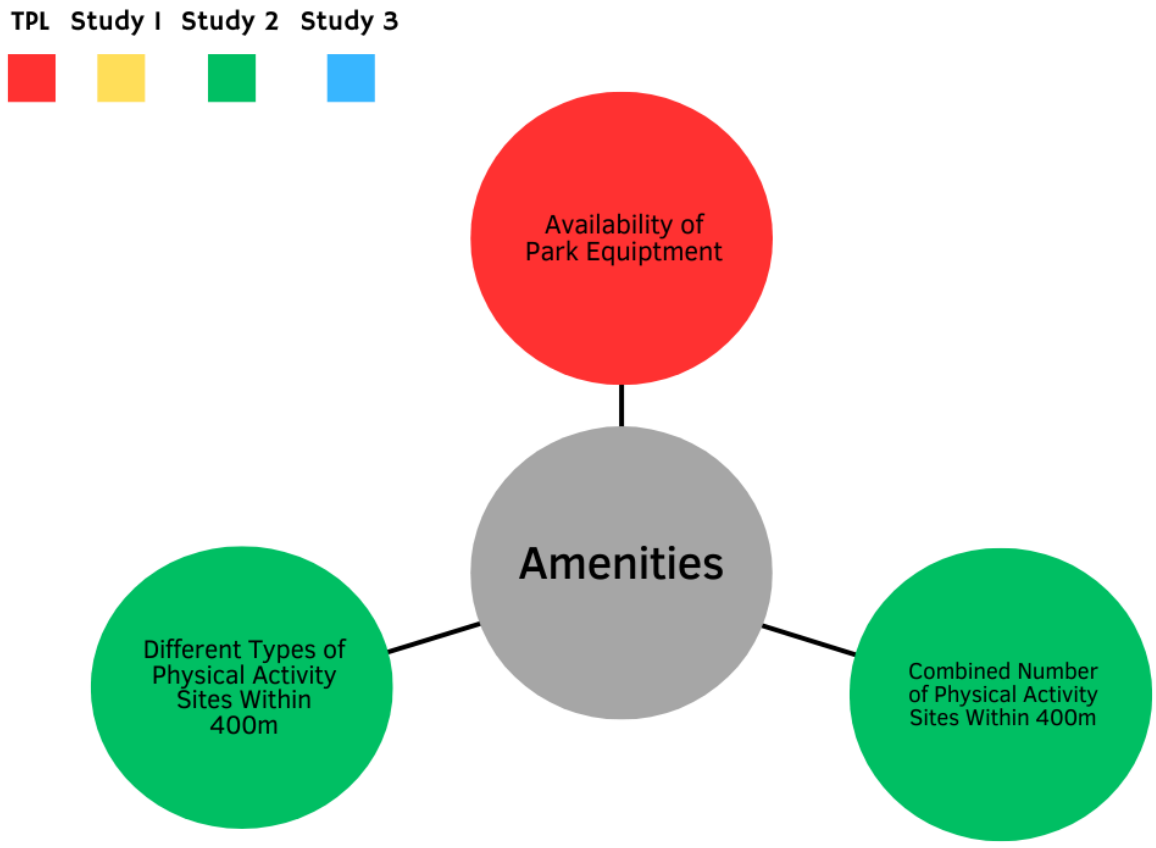


Table 5 - Different Measures of Amenities Considered by the Reviewed Studies

Amenity Measures	Details on the measures
Availability of Park Equipment (TPL)	The park score accessibility index will give up to one hundred points for the availability of basketball hoops, off-leash dog parks, Playgrounds, Recreation and Senior Centers, Restrooms, and Splash Pads/Spray grounds. These amenities were chosen because they were the most popular in parks around the country and represent the most diverse selection of demographics from kids to adults.
Diverse types of Physical Activity Sites Within 400m (Study 2)	The data for this measure was gathered through descriptive statistics that were compiled for every park in the study area and used to express different physical activity needs being met by surrounding parks. Value was determined by an odds ratio showing the proportion of each race that has three incremental levels of diverse types of physical activity sites in comparison to the total

	population that has three incremental levels of different types of physical activity sites. For ratios larger than 1 the population is more likely to fall into that category and for ratios less than 1 the population is less likely to fall into that category.
Combined Number Physical Activity Sites Within 400m (Study 2)	The data for this measure was gathered through descriptive statistics that were compiled for every park in the study area and considering the sum of all activity sites. Value was determined by an odds ratio showing the proportion of each race that has three incremental levels of physical activity sites in comparison to the total population that has three incremental levels of physical activity sites. For ratios larger than 1 the population is more likely to fall into that category and for ratios less than 1 the population is less likely to fall into that category.

4.2.4 Access

Figure 7 shows all measures related to access to parks. The closer a resident life to a park, the more likely they are to use that park. Table 6 presents the definition of all the measures related to access as used by reviewed studies. Measures of proximity-based access are considered in all studies. All studies consider access through a proximity analysis.

Figure 7 - All Measures Considered Related to Access

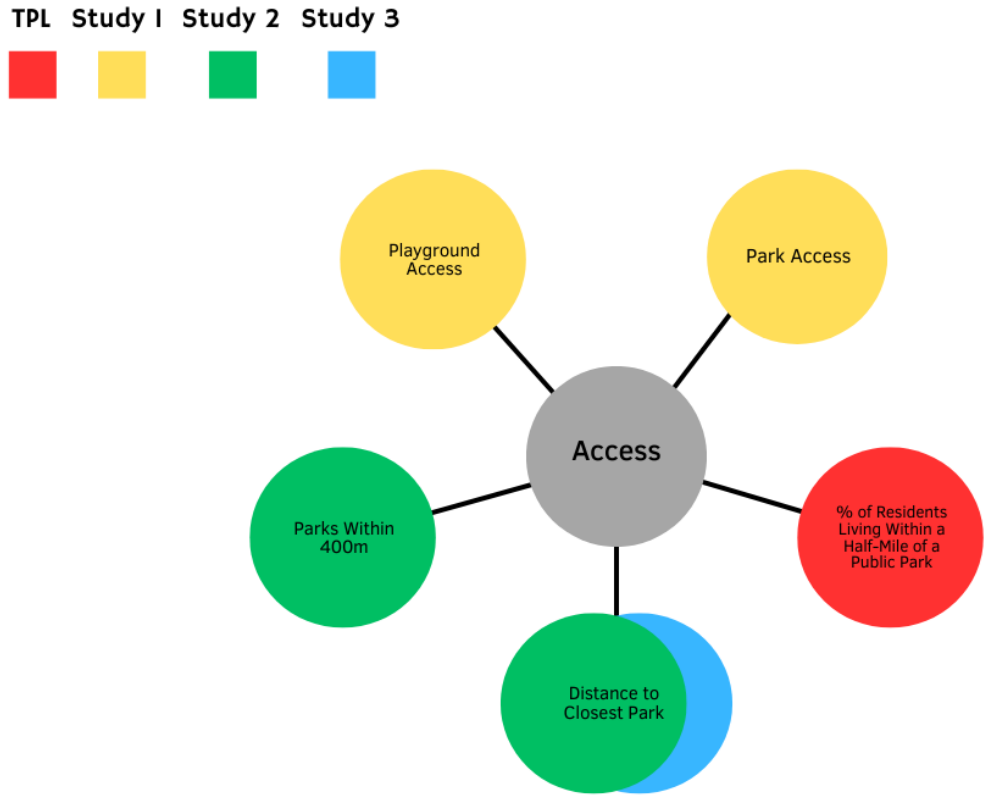


Table 6 - Different Access Measures Considered by the Reviewed Studies

Access Measures	Details on the measures
Percentage of Residents Living Within a Half-Mile of a Public Park (TPL)	The ParkScore considers walkability based on data from a nationwide walkable road network provided by Esri and gives a higher score out of one hundred based on the amount of the population that exists within walking distance (half-mile) of parks.
Playground Access (Study 1)	Playground accessibility was calculated using kernel density method. This data was acquired from The City of Philadelphia Parks and Recreation. The kernel density method determined the parks available within half a mile to residents on the block group level.
Park Access (Study 1)	Park access is based on the city of Philadelphia's sustainability goal of having all residents live within ½ mile of public greenspace. The percentage of land in each block that was within walking distance was used to indicate the total access to greenspace.

Parks Within 400m (Study 2)	This measure was used to determine the number of parks within 400m in context to race. Results were calculated by creating an odds ratio showing the number of parks within 400m of all races. The number of parks were considered using an odds ratio with 3 incremental values 0 parks, 1 park, and 2+ parks in comparison to New York City's average parks within 400m. For ratios larger than 1 the population is more likely to fall into that category and for ratios less than 1 the population is less likely to fall into that category.
Distance to Closest Park (Study 2)	This measure was used to determine the nearest area of green space in context to race. Results were found by creating an odds ratio showing three incremental distances and how they compared to the citywide averages for all races. For ratios larger than 1 the population is more likely to fall into that category and for ratios less than 1 the population is less likely to fall into that category.

Distance to Closest Park (Study 3)	The distance to the nearest park compares block groups assigning one is to block groups in the bottom 20% with the furthest distance to a park and a zero to block groups that are part of the nearest 20%.

4.2.5 Equity

Figure 8 presents all the equity measures considered in the reviewed studies. Equity measures can be used to look for potential disparities in park accessibility. Table 7 provides the definition of all equity measures used in the reviewed studies. The equity category has the most individual measurements of accessibility, and each study considered equity.

Figure 8 - All Measures Considered Related to Equity

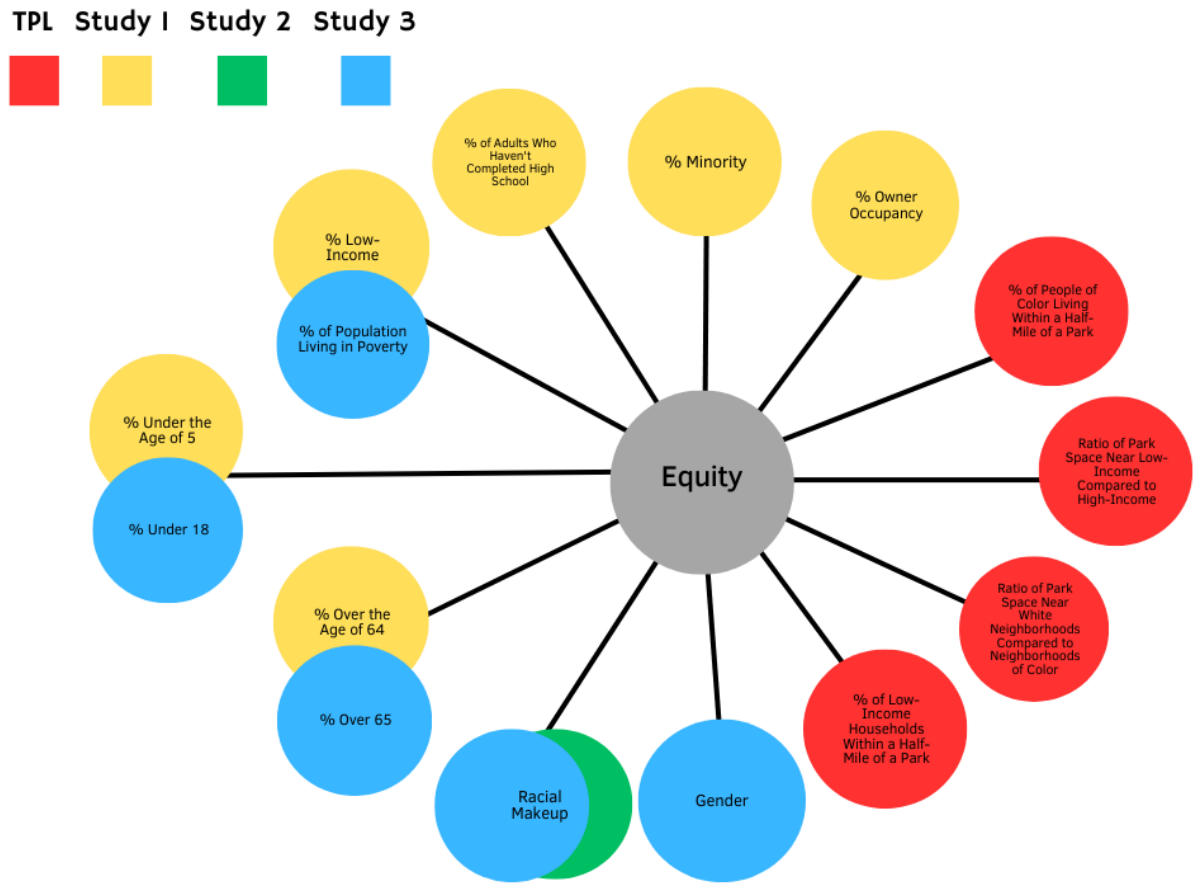


Table 7 - Different Equity Measures Considered by the Reviewed Studies

Equity Measures	Details on the measures
Ratio of Park Space Near Low-Income Neighborhoods Compared to High-Income Neighborhoods (TPL)	This measure shows how neighborhoods with the highest concentration of low-income compare to neighborhoods with the highest populations of high-income regarding their access to a walkable park (within half-mile).
Ratio of Park Space Near White Neighborhoods Compared to Neighborhoods of Color (TPL)	This measure shows how neighborhoods with the highest concentration of people of color compare to neighborhoods with the highest populations of white residents regarding their access to a walkable park (within half-mile).
Percentage of People Living Within a Half-Mile of a Park (TPL)	This value considers walkability based on data from a nationwide walkable road network provided by Esri and gives a higher score out of one hundred based on the amount of the population that exists within walking distance (half-mile) of parks.
Percentage of Low-Income Households Within a Half-Mile of a Park (TPL)	This measure is assessed with positive correlation to the number of low-income

	populations living within a half-mile of a park. This attributes higher access to parks that are accessible to low-income populations.
Percentage Owner Occupied Dwellings (Study 1)	This is the percent of occupants who are owners of their dwelling. This data is slightly skewed due to the number of colleges present in the Philadelphia area that are exclusively renters. Park investment is typically less from areas that are renters. Areas with more owner-occupied units get a higher normalized park score.
Percentage of Minority Populations (Study 1)	This measure is determined by the percent of people who do not identify as white alone. Historically higher minority populations are synonymous with lower accessibility to green infrastructure (Bullard, 1993). More need for park accessibility will be attributed to areas with higher minority populations
Percentage of Adults Who Have Not Completed High School (Study 1)	This measure considers the residents education levels. The higher the population that has not completed college the more

	potential there is for an accessibility void to be present.
Percentage of Low-Income Residents (Study 1)	Percent low-income consists of the percent of residents living in households with an income less than twice the federal poverty threshold. When income is lower typically accessibility to equitable green infrastructure is less (Bullard, 1993).
Percentage of Population Living Below the Poverty Line (Study 3)	Data for income was considered at the block-level and used to determine what percentage of low-income people lived within half a mile of a park. This measure was used to assess proximity, crime, and congestion
Percentage of the Population Under 5 (Study 1)	This measure is considered as a percentage out of one hundred. The higher the population under-five the more required green infrastructure, and therefore creating a larger accessibility void.
(Percentage of the Population under 18 (Study 3)	Data for age was considered at the block-level and used to determine what percentage of people under eighteen in relation to their

	proximity, crime, and congestion.
Percentage of the Population Older Than 64 (Study 1)	This measure is considered as a percentage out of one hundred. The higher the population over sixty-four the more required green infrastructure, and therefore creating a larger accessibility void.
Percentage of Population Older Than 65 (Study 3)	Data for age was considered at the block-level and used to determine what percentage of people under eighteen in relation to their proximity, crime, and congestion.
Racial Makeup (Study 2)	This data was gathered from the Census 2000 and used as the independent variable. This created the lens for which all other classification factors were examined, consisting of Non-Hispanic Whites, Non-Hispanic Black people, Non-Hispanic Asians, and Hispanics.
Racial Makeup of Area (Study 3)	This study uses block-level demographic data from the 2010 US Census and includes racial and ethnic compositions. This was considered using percentages of White, Black, and

	Hispanic residents and their relation to proximity, crime, and congestion.
Gender (Study 3)	This measure uses block-level demographic data from the 2010 US Census and includes gender compositions. This was considered using percentages of female populations and their relation to proximity, crime, and congestion.

4.2.6 Others

Figure 9 presents measurements that were unique and were not considered in the five broad categories of ParkScore calculation. This can lead to accessibility indices with more unique measurements. Table 8 presents the definitions of these measures. Despite being only considered in one study, these measures also need attention in accessibility calculation. Study 1 (Heckert & Rosan, 2016), and Study 3 (Williams et al., 2020) are the 2 studies that had measurements unique to these studies only. This shows that possibilities for accessibility indices are more than what widely used.

Figure 9 - All Indices Other Measures not included in the five broad categories of ParkScore.

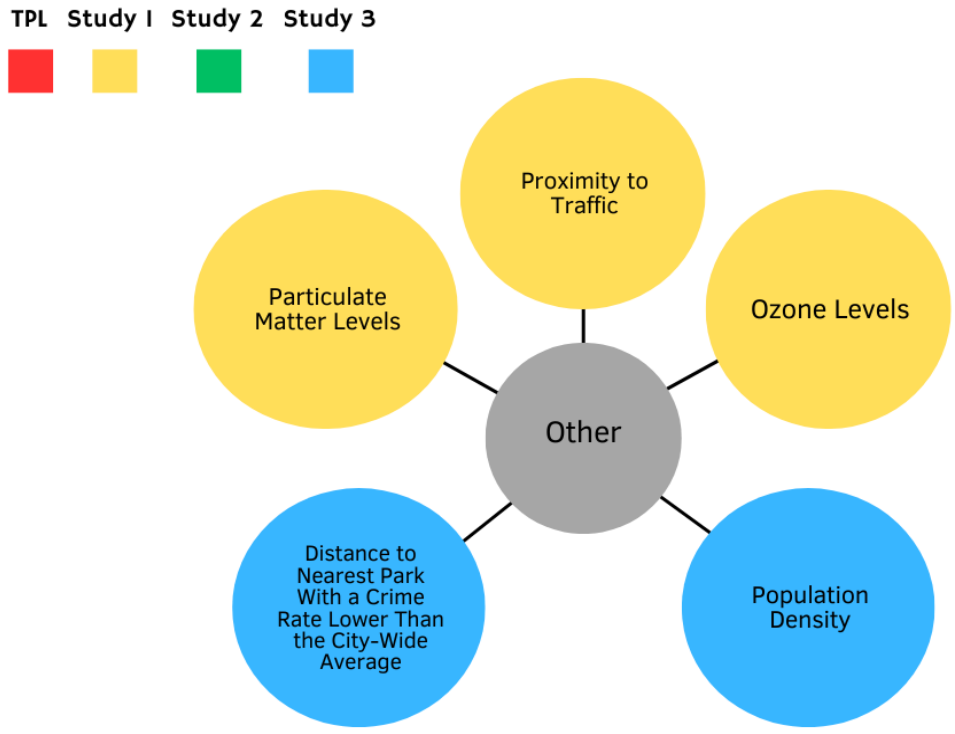


Table 8 - Other measures (not included in five categories of ParkScore) considered by the reviewed studies.

Other measures	Details on the measures
Proximity to Traffic (Study 1)	This variable was taken from the EPA's Environmental Justice Screen Application. Closer proximity to traffic is associated with higher levels of pollution. This creates a larger accessibility void.
Ozone Levels (Study 1)	This variable was taken from the EPA's Environmental Justice Screen Application. The higher the ozone levels the higher the accessibility void.
Particulate Matter levels (Study 1)	This variable was taken from the EPA's Environmental Justice Screen Application. The higher the particulate matter level the greater the accessibility void.
Population Density (Study 3)	Population density consists of the people per square kilometer. This measure deems that block-groups nearer to parks are more beneficial when they have a higher population

	density because that means there are more people that have access. This measure is analyzed in relation to proximity, crime, and congestion.
Distance to Nearest Park with a Crime Rate Lower Than the City-Wide Average (Study 3)	This measure considered the areas within a 200 m buffer around each green space's crime reports found from the FBI's crime reports, dividing the number of crimes in the 200 m buffer by the area of the greenspace and comparing that to the city-wide average crime density. For all values determined there are 2 scores, one for their relationship to any park and another for their relationship to a "safe" park or one that has a crime rate below the city average.

4.3 Significant Measures of Park Accessibility

Measures of park accessibility were consistent throughout multiple studies. In this subsection, those significant measures are listed, and their usage by the reviewed studies are discussed with the goal of illuminating the need to include them when creating a comprehensive index to measure park accessibility and equity.

4.3.1 Measures Considered Throughout All Indices

-Distance to Closest Park

Proximity is a factor that is often prioritized when considering accessibility, this measure was consequently considered by all studies analyzed. K Miyake et al. 's (2010), & T. G. Williams et al.'s (2020) articles had the most similar methods of determining proximity to parks. In Study 2 (Miyake et al., 2010), this measure consisted of determining the residents whose nearest park was not within walkable access (800+ meters) highlighting areas of need, while Study 3 (Williams et al., 2020) compared the blocks which were in the top 20% of proximity to the nearest greenspace to the blocks that were in the bottom 20% and therefore the furthest from greenspace, with higher values given to the blocks closest assessing more successful areas in this aspect (Williams et al., 2020). The recurrence of proximity throughout considered studies illuminates significance in proximity measures when developing an accurate index to determine accessibility.

-Percentage Low Income

Income was determined as a factor of equity throughout the TPL's ParkScore, Study 1, and Study 3. Study 1 (Heckert & Rosan, 2016), and Study 3 (Williams et al., 2020) looked specifically at the percentage of low-income and the percentage of population living in poverty. In Study 1, income was determined as a limiting factor when a block group's population had a

higher percentage of residents whose income was less than twice the federal poverty threshold and how these block groups correlated to their index of park density (Heckert & Rosan, 2016). Study 3 analyzed how populations below the poverty line related to proximity to any park and parks deemed safe (Williams et al., 2020). The TPL's ParkScore considered the ratio of park space available to low-income populations compared to the park space available to high-income populations, and the percentage of low-income populations within a half-mile of a park. The recurrence of income measures shows the significance of it as a factor worth considering when assessing equity.

-Age

Age was considered as a factor of equity in both Study 1, and Study 3. Study 1 (Heckert & Rosan, 2016) and Study 3 (Williams et al., 2020) both included the percentage of people under a certain age and senior citizens. Age is a notable factor of accessibility, because senior citizens and children have different definitions of accessibility, therefore an effective index should focus on a specific age range. Study 1 considered population from age 5-64 (Heckert & Rosan, 2016), and Study 3 considered age 18-65 (Williams et al., 2020).

-Racial Makeup

Accessibility based on race was considered throughout the TPL's ParkScore and all 3 Studies, but was most similarly analyzed in Study 2 (Miyake et al., 2010) and Study 3 (Williams et al., 2020). Both of these studies used populations of multiple races in order to determine accessibility, Study 2 looked at the distance to the closest park, number of parks within 400m, size of closest park, combined size of parks within 400m, combined number of physical activity sites within 400m, and combined number of different types of physical activity sites withing 400m. While Study 3 looked at the different races that existed within half a mile of parks

(Miyake et al., 2010; Williams et al., 2020). Study 1 (Heckert & Rosan, 2016) considered race in a less specific way allowing more room for interpretation. This study just considered the percentage of the population that did not identify as only white (Heckert & Rosan, 2016). Race is important to consider when conducting an accessibility analysis, because marginalized minority populations usually have lower accessibility to parks (Bullard, 1993).

4.3.2 Unique Measures Not Considered Within the 5 Main Categories (Other)

-Proximity to Traffic

This measure was considered in Study 1 (Heckert & Rosan, 2016) where the data came from the EPA's Environmental Justice Screen Application and was determined by the count of vehicles per day at major roads within 500m of the nearest park or the nearest road beyond 500m divided by the distance in meters. It is shown there is an increased risk of premature death by residents that are located near a major highway or urban road (Heckert & Rosan, 2016). On the other hand, pollution and environmental factors in general are not considered in any other studies besides study 1 (Heckert & Rosan, 2016). Environmental factors should be included within a comprehensive index analysis because these factors contribute to sustainability and the resilience of the park, meaning it contributes to how the park will function through time. It can help determine how parks with more egregious environmental problems can fail to improve quality of life for users over time (Rigolon et al., 2021).

-Particulate Matter (PM) Levels

This measure was used in Study 1 (Heckert & Rosan, 2016) and was found from the EPA's Environmental Justice Screen application. It is determined by the amount of particulate matter (PM 2.5) above the annual average as measured by the EPA Office of Air and Radiation. This particular factor considers air quality on the most specific and accurate level, areas with lower

quality can lead to less park usage and are typically synonymous with less vegetation leading to more extreme climatic events and more damages to the park over time (Paoletti et al., 2011)

-Ozone Levels

This measure was also included in Study 1 (Heckert & Rosan, 2016)and was collected from the EPA's Environmental Justice Screen application. It is determined by the summer seasonal average of daily 8-hour Ozone concentration in air parts per billion, as measured by the EPA Office of Air and Radiation. It has been proven that throughout Los Angeles, California public park space most accessible to black populations and populations largely employed in manufacturing industries are associated with negative ozone concentrations proving that ozone quality does follow a social gradient in that area (Su et al., 2011). This shows disparities throughout accessibility to environmentally safe parks and therefore is a significant measure to be considered.

-Population Density

Population Density was considered in Study 3 (Williams et al., 2020) and no other studies reviewed had any spatial density considerations. Denser populations have complex relationships to minority populations, residents living below the poverty threshold, areas with limited education and areas with limited English language speakers (Maroko et al., 2009). Due to the ties that population density has to other measures, it should be deemed significant in park accessibility index calculation.

- Crime Rate

Safety of parks can negate all other factors mentioned throughout the current meta-analysis. A park can score high in all measures of park accessibility and accessibility, but if it is not deemed safe by surrounding populations it will lead to disparities of use throughout the community.

When a resident perceives a park as being safe, they are 4.6 times more likely to visit the park consistently and participate in activities surrounding the park (Lapham et al., 2016). Safety of parks or lack thereof is a measure worth considering and has potential to be the most significant measure that was not considered by other studies.

Chapter 5 - Conclusion

Using the Trust for Public Land's ParkScore as the foundation, this meta-analysis analyzed the measures of park accessibility that are the considered in three other major studies on park accessibility. The studies were chosen to represent a broad landscape of accessibility indices. The most widely considered measures of park accessibility are, proximity, acreage, and socio-economic factors. Although the reviewed studies used different methods for accessibility calculation, they agree to one fact that accessibility to parks cannot be determined by any one factor. All studies considered how measures of accessibility relate to each other, and how those measures can be aggregated to quantify accessibility index.

Each study had unique definitions of access, but they are all centered around the ease of which a user can get to a park. Based on the study context, the measures were aggregated differently, and their relationships became the resulting indices. The studies either focused specifically on unique locations or were very universally applicable for any area. The current meta-analysis illustrated the adaptability potential for accessibility indices. Depending on the specificity of the definition of accessibility and the setting, indices can be used to show areas with higher and lower levels of access. This research provides evidence and understanding of data collection, and potential methods to calculate accessibility throughout any community. Methodological approaches in park accessibility research varies from accessibility void method, street network analysis, to safety and acreage analysis. The data used within these methods is gathered from the U.S. Census, EPA, ESRI data, local jurisdictions, and FBI crime data.

Planners should use park accessibility indices first by defining accessibility goals in the context of their area. Once this is done, methods and measurements can be chosen based on how effectively the goals can be addressed. Socio-economic and demographic measurements were the

most abundant throughout the reviewed studies. Since the ParkScore and all three studies focused on addressing equity within park accessibility, it is expected that they would include socio-economic and demographic measurements.

5.1 Next Steps

Findings of this meta-analysis can be used to show the scalability and transferability of accessibility indices. This can also serve as an introduction for those looking to conduct their own accessibility indices applicable for their respective area. This study lays out all options for data gathering and analysis based on the studies reviewed. Moving forward, this can lead to identify areas that are lacking in accessibility to parks. This can potentially be used to determine resource allocation to parks or infrastructure surrounding parks to increase access. In addition, this research can also be used to determine which parks are the most closely aligned with their park accessibility goals. The parks that have the highest positive correlation to their goals can be considered as a successful park. Planners can use methods present in this study to determine successful parks and identify ways to mimic their success for other parks in their target community.

5.2 Limitations

This meta-analysis only considers 3 studies in addition to the ParkScore, and it does not show all possible measures that are considered within park accessibility research. Another limitation of this study is the lack of clarity in method descriptions and data retrieval approach in the ParkScore. It is not a peer reviewed study and does not have the clearest definitions of methodology and data collection. This study also does not consider all definitions of accessibility and all possible methods used to determine accessibility indices. A comprehensive literature search and extensive content analysis can help identify all those accessibility measures and

methods used in park accessibility research throughout the world. Future studies can attempt such approach, resulting in a more all-encompassing index repository. Future studies can use this research to create their own indices and gain better understanding of what aspects contribute to quantifying accessibility.

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