

**An Assessment of the Relationship Between
Food Deserts and Green Space: A Case Study in Seattle**

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ABSTRACT

Access to healthy, affordable food and greenspace in cities are crucial for human health, as they improve quality of life and overall health of human beings. However, in the United States, the accessibility to grocery stores is not evenly distributed, and many low income areas are deprived of grocery access. The same can be said with greenspace; urban environments are typically population-dense with structures covering many parts of the city, this meant that greenspaces tend to be reserved for those that can afford living around green areas. Poorer individuals often have less access to greenspace in a city. This study investigates accessibility of these facilities in the city of Seattle, Washington to see how it compares to other cities that have done similar studies. To do this, I used ArcGIS to create a map pinpointing each facility's location and compared the data to the annual median household income in the city for each neighborhood. I found that Seattle has exceptional greenspace access, with almost all areas being at least 1 mile away from a park maintained by the Seattle government. In terms of food access, food deserts in the northern areas are located around neighborhoods with high income (>\$159,658 - \$200,001), while food deserts in southern areas are located around neighborhoods with low income (\$12,543 - \$68,705). Future research should aim to examine the quality of food available in each grocery store, as well as the quality of the parks surrounding the area.

KEYWORDS

Food desert, greenspace, income, accessibility, public health, geographic information systems

INTRODUCTION

Food desert is the term used to define regions lacking in access to healthy and affordable foods, such as fruits and vegetables, as well as other nutritious options (Widener and Shannon 2014). This has been a widespread problem, as many households in the United States have to rely on cheap, processed food with low nutritional value (Amin, et al. 2021). Over the past two decades, obesity has become one of the world's most prominent public health problems, and has been linked to more deaths worldwide than malnutrition (Bridle-Fitzpatrick 2015). Obesity has been shown to be directly related to the presence of food deserts, as they are considered environments that, paradoxically, may encourage excess caloric consumption due to low-income individuals not being able to access nutritious food and/or transportation (Bridle-Fitzpatrick 2015). There have been ongoing debates and studies about how, precisely, food deserts exist, and the characteristics of the places they tend to exist in (Bridle-Fitzpatrick 2015). Acknowledging that food deserts are not accidental and may relate to other infrastructural issues, such as the placement of green space in a city is essential will improve our understanding on how certain environments negatively impact financially disadvantaged individuals.

While food deserts remain a serious ongoing problem in the United States, it only plays a part in a much bigger problem. To further understand how environments can impact vulnerable communities, it is important to learn how green space plays a role in this too. There has been evidence that interaction with nature positively impacts human wellbeing (Taylor and Dieter 2017). It not only affects wellbeing, but also positively impacts one's quality of life aspects, such as physical and psychological health, social interaction, rate of crimes, and economical value of property (Nasution and Zahrah 2012). However, studies have shown that with increasing urbanization, combined with a spatial planning policy of densification, people are forced to live in environments with barely any green resources (Maas et al. 2006). This especially affects people from low socioeconomic groups, as they are unable to move to greener areas outside the cities. Additionally, this problem has also been amplified with the increase in privatization of public open space in urban areas, and research has shown that while people are still able to do social activities, they are physically segregated (Nasution and Zahrah 2012). Privatization becomes an issue when they are used in accordance with the profit oriented tradition, where these areas become a series of racially and economically segregated private enclaves (Nasution

and Zahrah 2012). Looking back at the problem with the aforementioned food deserts, it is clear that the locations that these problems are prominent in are not purely coincidental, and that there are other factors that come into play.

The lack of green space, combined with the presence of food deserts in low income areas, show that these factors play huge roles in contributing to obesity, and other health problems. This is especially prominent in urban spaces such as Seattle, which is the location this paper aims to study. The Pacific Northwest has been experiencing a rapid increase in urban development, with roughly 1,100 new residents moving into the Seattle area every week (Baals 2020). This rapid development is the reason as to why Seattle has become an area of interest for the study of the potential relationship between food deserts and green space. This study aims to understand the relationship between those two factors, and whether or not they are directly related, as well as the kind of demographic that is impacted by the lack of access to them.

With this study, I aim to gain more insight on how environments can negatively affect surrounding communities by examining Seattle's supermarket presence and the amount of green space available. I seek to understand the overlap between food desert areas and areas with lack of green space in Seattle. This question will be answered through the study of 3 smaller questions: where are places with food deserts and green space? When mapped out, are there areas where there is an overlap between them? If so, what is the annual median household income of these areas? With these questions, I hypothesize that there will be some overlap between food deserts and lack of green space, but not very prominent. This is because Seattle is part of the Pacific Northwest, which is considered to house the world's most productive forests (Case, et al. 2021). These areas' residents would then have lower average income compared to the people living with easier access to those spaces. These questions will be answered through the use of a mapping software, such as ArcGIS, and this study will be an analysis of the data found through the software. Supermarket locations and park locations can be found in the ArcGIS library, which will then be used to map out food deserts and lack of green space by mapping out areas that have no access to these facilities within one mile. Additionally, income data for these residents will be examined through the use of the 2020 census data, which can be found from existing sources.

EXTENDED INTRODUCTION

Study Site: King County, Seattle, Washington

This study analyzes the unequal allocation of resources in the City of Seattle, or more specifically, King County, Washington in the United States. It is one of the fastest growing major cities in the US; however, economic prosperity and wealth in the area have not been allocated equally. It is structured to be advantageous to wealthier individuals. This is significant, as comparing its White residents to its residents of color shows that there are massive income and wealth disparities, and as is the case with other major US cities, the inequality in Seattle has been ingrained in the economic and social growth since the city's inception (White and Singh 2021). The city is made up of 7 Council Districts, with each council representing several neighborhoods, at a total of 139 neighborhoods (Seattle, 2022), all of which will be grouped as "wealthy" and "not wealthy" for this study. Low-income residential neighborhoods are often placed within more negative destinations, compared to high income neighborhoods (Thornton et al. 2016). It has also been proven that neighborhoods with lower wealth and also a large proportion of racial/ethnic minorities had worse crosswalk amenities and worse intersection control features (Thornton et al. 2016). In other words, wealth often plays a role in an individual's quality of life and overall health, which also includes whether or not an individual can afford areas with adequate access to food and green space (Dahman, et al. 2010). While the city has been rapidly growing in population, it is also surprising to note that there has not been a lot of research done for either food deserts or green space access in Seattle. Considering that these factors play a major role in health outcomes to individuals, it is important to think about whether or not resources are distributed or placed equally among all neighborhoods.

The City of Seattle has acknowledged that green spaces have significant environmental, economic, and social benefits, and aims to ensure equitable access to parks by developing new ones (Seattle, 2021). The city has acknowledged the benefits of green spaces, which is why it is important to ensure equitable access. While efforts to develop more parks for equitable access to all, the city has had more trouble with food accessibility, saying that the food bank network lacks necessary information and resources to meet demand (Chan et al. 2019). This study hopes to address this issue and help resolve it by mapping out current available grocery stores so that

further development in adequate areas can be done.

Income as a Contributor

Income is a significant component in determining an individual's access to sufficient resources, whether it would be food, or the land they have to inhabit. However, wealth inequality, or an unequal distribution of wealth, has been especially relevant in recent years, and this results in some individuals benefiting while others pay the costs (Farley 2002). Wealth plays a large role in an individual's quality of life and overall health. This study aims to investigate the relationships between income and food access, as well as income and access to green space, since both of those factors directly relate to health outcomes. This can be seen in several epidemiological studies, such as Maas et al.'s (2006) study that came into the conclusion that on average, residents with abundant green spaces tend to have better health, and Bridle-Fitzpatrick's (2015) paper, which stated that differential access to healthy foods has been hypothesized to contribute to disparities in eating behaviors and health outcomes. Noting this, one can also conclude that wealth contributes to an individual's physical access, or distance to essential resources. This study will also look into these issues to see if these hold true for the City of Seattle in Washington by comparing average annual incomes of each neighborhood and observing whether or not "wealthy" or "not wealthy" neighborhoods land in the overlaps between food deserts and areas lacking in green space.

Methodology

A GIS Based Approach

GIS, or a geographic information system, is a tool used to process geographic data. Being able to utilize, collect, and analyze data, GIS can serve multiple purposes, as it uses a variety of data, such as geological and human-related statistical data (Mohamed et al. 2021). Recently GIS has taken on a more significant role in accessibility studies. Not only is it used to display information graphically, it is also used for statistical analysis. For example, Pearce et al. 's (2006)

study uses GIS to find the association between locational access to essential facilities (such as education and food shops) with the health status of residents in New Zealand. Statistical analysis isn't always present in studies, however, and one can use GIS to create a series of maps that show their data elements in a straightforward manner, so the writers and the readers can observe spatial overlaps in these data sets and come to a conclusion (McEntee and Agyeman 2010). This study will use a combination of both methods, with the latter being used to observe overlaps between areas lacking in adequate access to food, and areas lacking in green space, and the former being used to observe three different types of correlations: correlation between distance to food access and wealth, distance to green space and wealth, as well as distance to green space and distance to food access.

METHODS

Pinpointing the location grocery stores and parks

First, to visually observe the locations of each grocery store in Seattle, I input each location point into Microsoft Excel with help from Google Maps, detailing their coordinates in the map. A total of 44 grocery store locations were pinned on the map. Second, to observe locations of Seattle Parks, I have obtained geodata from the Parks and Recreation sector of the Seattle government website, which showcased a total of 515 parks. This process allowed me to visualize the locations of each facility from a wider lens, as they are now mapped out on a single map in GIS.

Overlaps between food deserts and lack of green space

To examine if there are overlaps between food deserts and areas lacking in greenspace, I created a couple of 1-mile dissolved buffer layers around each location of grocery stores and parks. I considered areas outside these buffers as areas lacking in the aforementioned facilities. These layers represented areas where food deserts and greenspace deserts overlapped.

Relationship between wealth and overlaps

To see the relationships between the communities' wealth and the overlaps, I analyzed income data taken from the US Census from 2021 to observe the different levels of income. For this study, I will use annual median household income as a measure of wealth. I then mapped out the incomes into GIS. To make this process easier, I also created a map that detailed all 119 neighborhoods in Seattle. I categorized each neighborhood as either "wealthy" or "non-wealthy". The "non-wealthy" neighborhoods consist of neighborhoods with the median neighborhood household income of less than \$50,000, while the "wealthy" neighborhoods (though they mostly consist of the middle class) are neighborhoods with median household incomes of more than \$50,000. This is because per capita income in 2019 in Seattle was \$59,835 (United States Census Bureau), and I wanted to set a similar standard. Using observation, I could see if the areas with low food and greenspace access tend to have lower median household income.

RESULTS

Location of supermarkets and parks

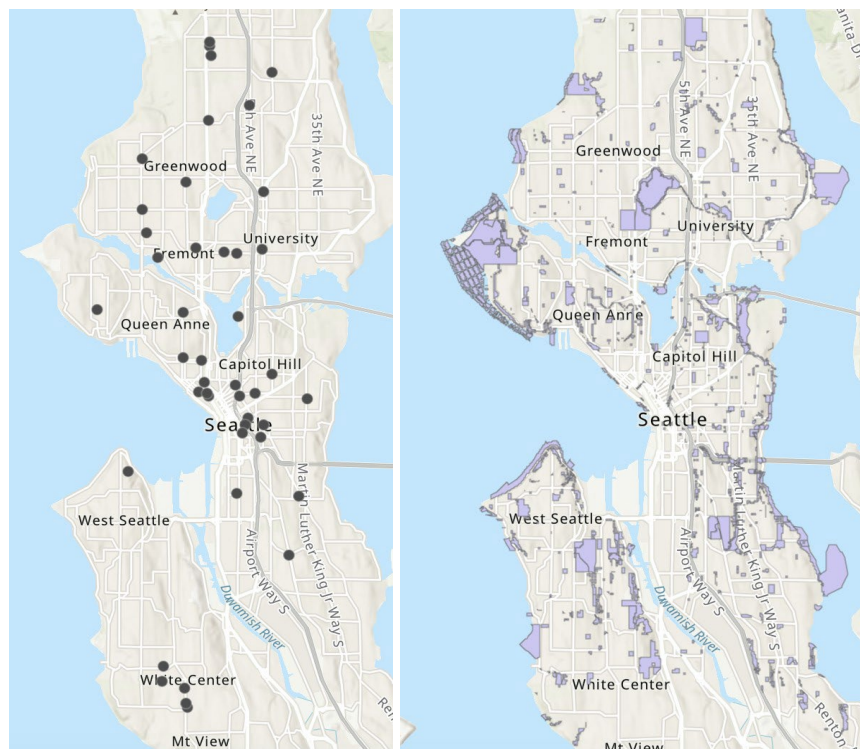


Figure 1: Map of Seattle with grocery store and park locations.

Using GIS and Excel, I was able to plot locations of each grocery store and park in the Seattle area. This is shown in the two pictures above. Grocery stores are marked as points, while parks are marked using symbols, covering the entire park area. Using this data, I found that grocery stores tend to cluster in the central parts of the city (centralized). I can see that the edges of the city and South Seattle have a noticeable lack of grocery store access. On the other hand, parks are more evenly distributed, and opposite to the grocery stores, bigger parks are seen on the edges of the city.

Overlaps between food deserts and lack of green space

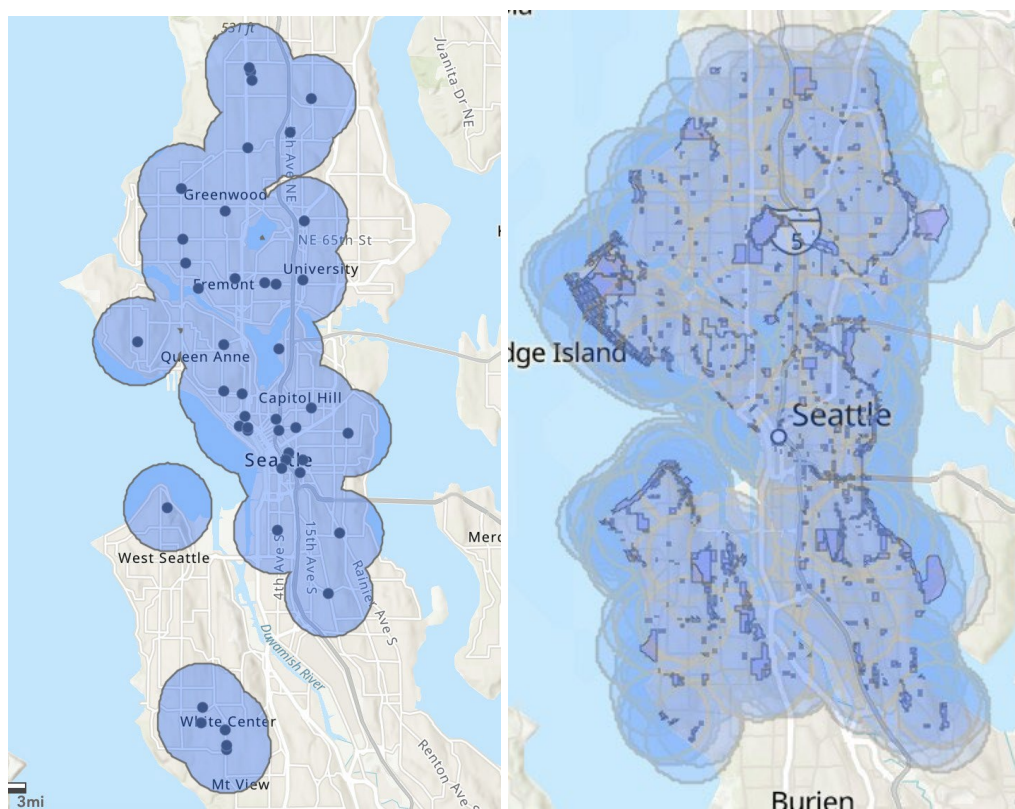


Figure 2: Map of Seattle with buffers around each grocery store and park location.

Using the buffer tool in GIS, I created buffers of 1 mile for each grocery store and park location. While there are some spaces not occupied by the buffers for grocery stores, this was not the case with parks, with almost 100% covering the entire city area. The total area of the grocery store buffers is 58.85 square miles, and Seattle's land area is 83.78 square miles (2010 US Census), which means that grocery stores cover 70.24% of the entire city.

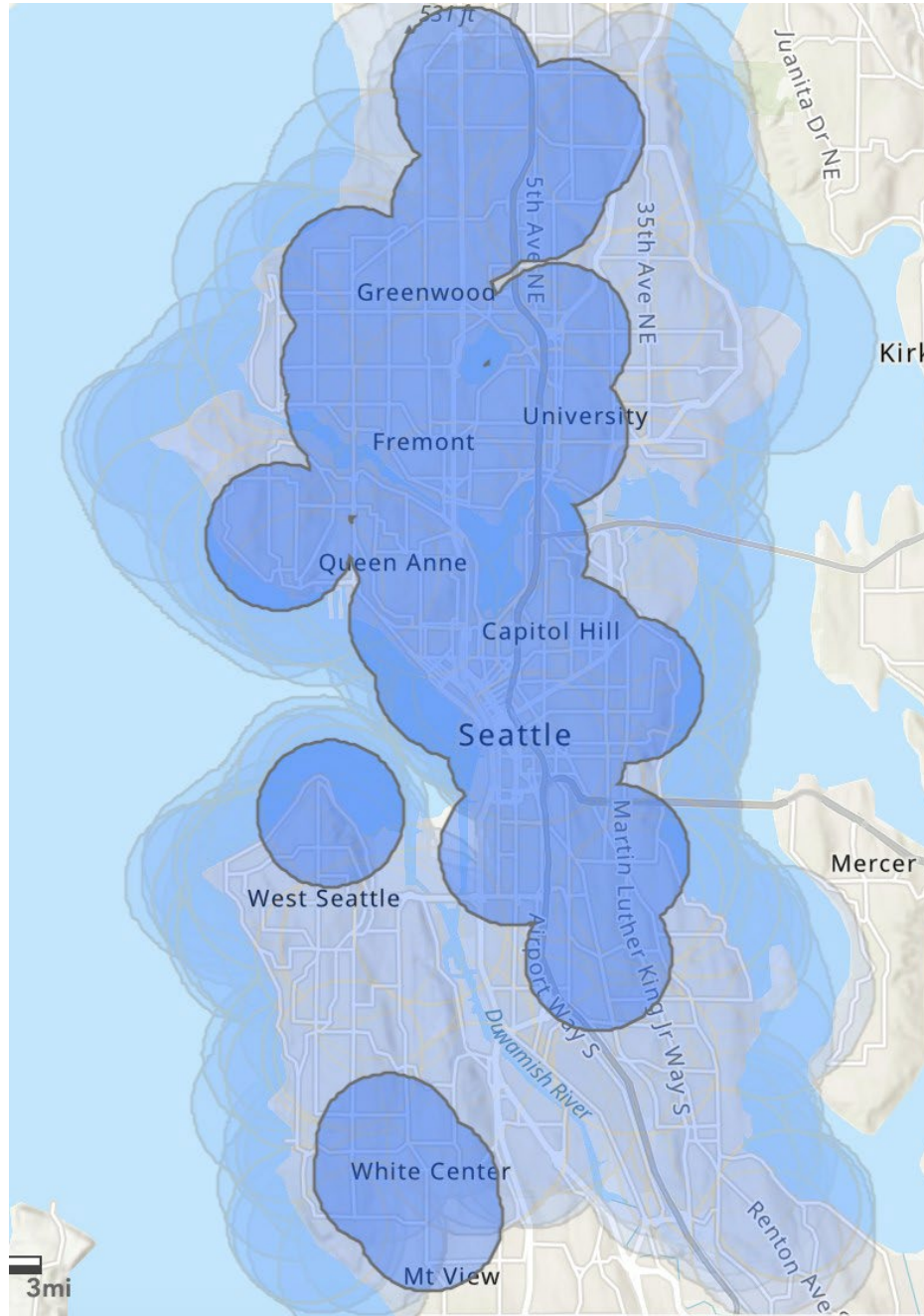


Figure 3: Map of Seattle with buffer layers merged together.

When both types of buffers are merged into one layer, with the buffers of grocery being the darker ones compared to the park buffers, it is seen that all but one area in the middle of the map is covered with both the buffers. This small area in the middle has neither park nor grocery store because it is a port, specifically the 18th terminal of the Port of Seattle.

Relationship between wealth and overlaps

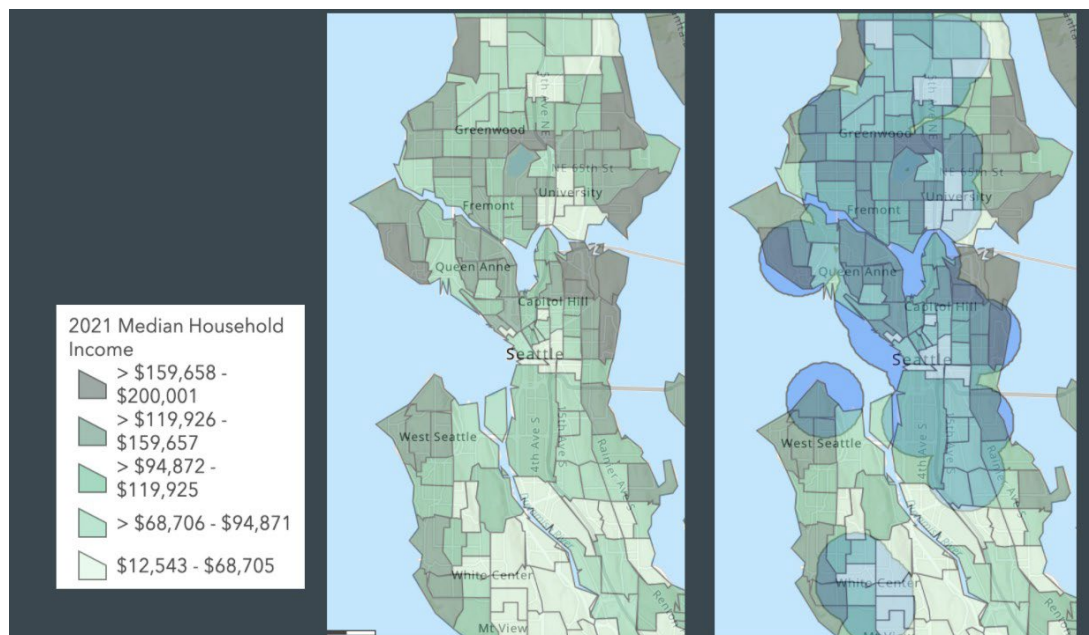


Figure 4: Map of Seattle with median household income mapped and grocery store buffers layer visible.

After mapping annual median household incomes from each area of the city using 2021 US Census data, I found that the results differed from the hypothesis I stated earlier. While South Seattle tends to follow the trend that lower income communities have less access to grocery stores, this is not the case in the central area of the city. It is seen that the edges of North Seattle have very high household incomes (>\$159,658-200,001), yet access to grocery stores is lower. Most of the city is populated with wealthy neighborhoods (over \$50,000 in annual income).

DISCUSSION

Food deserts have been defined as poor urban areas, where residents cannot buy affordable healthy food (Walker et al. 2010), and eliminating these deserts has become a priority issue in food policy at the national level, proving just how important it is to find solutions to lessen the presence of food deserts in the United States (Jiao et al. 2012). Urban green space is also as important as the accessibility of healthy food, as it provides support to a range of urban biodiversity and can improve quality of life of the humans residing in these cities (Nesbitt et al.

2019), and just like food deserts, the positive qualities of green spaces have made it important for cities to implement strategies the supply of urban green space, especially in park-poor neighborhoods (Wolch et al. 2014). This paper aims to study the placement of parks and grocery stores in the city of Seattle, Washington, as well as see if income has played a role in the location of these facilities. In this discussion section I will contextualize the spread of food and green space access in Seattle, see if the consequences of continued growth of the city infrastructure and density has had negative impacts on the city, and discuss the annual median income of the people living in areas with high and low green space and food access. I found that certain parts of the city are at a higher risk of inadequate access to grocery stores, but green space seems to be evenly spaced throughout. I have hypothesized that areas away from the city would have less access to grocery stores, while parks are more evenly distributed, and that the annual median household income of people in food deserts would be less than the income of people living in central areas. However, this is not the case as the results have shown that Seattle is not lacking greenspace, and that there are several neighborhoods with low annual median income (\$12,543-68,705) living in areas that have adequate food access. These results show that I may have generalized Seattle to be similar to other areas of the country that might have opposite results. This study was done in hopes to demonstrate the limitations of living in an urban area and what a city can do to limit accessibility issues for as many residents as possible.

The Spread of Green Space and Grocery Stores

US histories of property development are intertwined with histories of ethno-racial oppressions, which in turn also affect philosophies of land-use systems and design (Wolch et al. 2014). To see whether or not there are parts of the city that lack food access and/or adequate green space access, I recorded locations of notable grocery stores and parks in ArcGIS. Food access in this case refers to access to a nearby grocery store, and green space access refers to access to a nearby park. The results that came from using this method shows that grocery stores are more stratified in the central areas of Seattle, while parks have been shown to be more evenly spread out. Although the outer areas lack food access compared to the central areas, that is not to say that these areas are completely devoid of any facilities. Surprisingly, the results indicate that almost all parts of the city are within one mile of a park. An exception is a small

area in between Central Seattle and West Seattle, but it is a given as this area consists of a port, specifically the 18th terminal of the Port of Seattle. This shows that Seattle can be considered an exception to the statement made by Wolch et al. (2014), that states that green space is not always equally distributed within cities, and how it is stratified based on multiple factors such as age and gender. This may be due to the fact that Seattle is part of the Pacific Northwest, which is considered to house the world's most productive forests (Case et al. 2021), trees are much more abundant in these areas compared to other parts of the United States. However, this is not the case with grocery store locations, which seem to fit in with other states, such as Iowa, in a study conducted by Morton and Blanchard (2007), where non-metro residents have been shown to experience challenges in accessing healthy food options. Overall, while this is evidence that some areas of the city are more prone to having less food access, lack of access to green space is barely seen, which shows that the residents have no problem finding open space for recreational activities.

Consequences of Continued Urban Growth

To find out if there is a direct connection between areas that have less food access and areas that are lacking in green space, I observed whether or not overlaps between the two can be seen. Since Seattle is very different from other studied areas in that green space within one mile is accessible everywhere, areas that are lacking in both food access and green space are nonexistent. This goes in line with the study done by Nesbitt et al. (2019), which also found that the spread of park areas in cities like Chicago and Seattle to be wide, compared to cities such as Houston and Jacksonville. The United States has experienced rapid urbanization, fueled by industrialization, which has the potential to result in improved access to a variety of facilities, including healthcare, education, and an overall increase of standard of living (Baals 2020). However, if rapid urbanization is managed poorly, it will lead to an array of negative impacts on local ecosystems and environments (Baals 2020). In the United States, the term sprawl refers to converting green lands such as forests and wetlands into built environments beyond the edges of urbanizing them at an alarming pace (Robinson et al. 2005). Seattle has been reported to be subject to urban sprawl (Robinson et al. 2005), which holds a significant association with the likelihood of a census tract being a food desert (Hamidi 2019). In other words, Seattle is

vulnerable to having food deserts because of rapid urbanization. Overall, the lack of food access may not be directly related to greenspace in Seattle, while there are some areas that insinuate that it might not be the case, the overlaps between these two factors do not seem major or noteworthy.

Found Patterns of Inequity

Interestingly, while it is true that central regions have more neighborhoods with high income, there is a surprising amount of neighborhoods that have lower income too, at around \$12,543-\$68,705; my results suggest that in the northern and central regions of the city, the neighborhoods that have higher annual median household income tend to have lower access to food. This can especially be seen on the east side of University Village, where the areas with no supermarkets have an annual median household income of >\$159,658-\$200,001. On the other hand, in the Southern areas, places with lower household income have less access to grocery stores. The central parts of Seattle is similar to statements made in the study by Macintyre et al. (2008), that noted how poorer neighborhoods receiving less access to food is a general assumption that is not always true, and that the spatial distribution of resources by deprivation can vary between different types of resources, location, and time periods. However, this is inversely true to the study by Morton and Blanchard (2007), that states that food desert areas share a common set of characteristics in contrast to non food desert areas, including higher individual and family poverty rates, and lower annual median family incomes, further proving that Seattle is an exception to a lot of food desert study areas. Green space is not included in this argument as it covers almost all parts of the city.

Central Research Question Synthesis

This study aims to find out whether inadequate access to food and greenspace is targeted towards areas with lower income, and what I found was that while it is true that the central parts of the city noticeably has more grocery stores, wealth is not a big deciding factor for these locations as grocery stores are located in both low and high income areas in the center. However, wealth plays a bigger role further down the map, as it can be seen that lower income areas tended

to have lower access to grocery stores. Green space in the city is evenly distributed, with outer parts of the city having bigger and more concentrated park areas, and wealth not being a deciding factor for it.

Limitations and Future Directions

The population estimates of supermarket and greenspace access are only limited to the conditions in Seattle. As stated before, most of the residents are able to access a park within a mile of any location in the city, and low-income communities are more likely to live in an area with grocery store access. This also suggests that grocery stores in the city tended to be located in areas with a mixed-income population. However, this is not the case with a lot of food desert study areas, and Seattle is an exception to many studies that have stated that food deserts are mainly located in low-income and minority neighborhoods from the absence of a supermarket (Walker et al. 2010). The fact that green space covers almost all of the city contradicts my initial predictions, as it is often not the case with most areas in the United States.

In addition, this study does not include prices or quality of products provided in the grocery store, and assumes that the grocery stores listed offer produce and other types of healthy food. This study may not have included every store in the city; smaller stores that might not appear on Google Maps or in Census data may not be included, and green spaces in the city only included parks listed by the Seattle Parks and Recreation through the Seattle Government website. Future studies may consider to assess the quality and price of food supplied in the grocery stores. Looking more into each grocery store and contacting the government of Seattle directly may be done in the future to prevent lack of data on certain areas.

Broader Implications and conclusions

With rapid urbanization taking place in cities, I fear that residents may feel like they would not have access to a lot of land, and instead be surrounded by areas with no healthy food available. The aim for this study was to demonstrate the limitations of living in an urban area, such as the inequitable access to healthy food and green space in certain areas. Choosing Seattle as the study site was done so that I would be able to shed some light on the problems this city

might have had, since it is not often explored. Conducting this study shows that Seattle seems to be going in the right direction, as green space is accessible to all the residents in all parts of the city, and low-income groups had good access to a grocery store, showing that grocery stores are often located in mixed-income communities. The city is still improving, as it continues to put effort into expanding access to these two facilities through a variety of programs. I hope that by shedding some light on how the city has placed its parks and facilities, other cities suffering from lack of greenspace and food access would be able to take this as an example to improve their situations.

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