THE GREEN PARADOX

GENTRIFICATION & GREENNESS IN THE MILE HIGH CITY

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I want to express gratitude for my advisor Sara and her invaluable encouragement throughout this project.

The following project is dedicated to my childhood home in Northwest Denver and the three people who fill my life with so much love: Mom, Dad, & Clara

ABSTRACT

Urban greenness is becoming increasingly significant in shaping cities' identities and pushing for environmental sustainability amidst rapid urban transformations. This study delves into the relationship between urban greenness and gentrification in Denver, CO, from 2010 to 2020. Denver, in recent years known for its rapid gentrification, provides a compelling setting to explore the evolving role of urban greeness amidst demographic shifts. Utilizing aerial imagery and GIS techniques, we assess the quantity and quality of greenness across Denver's neighborhoods over the past decade. We investigated the investment in green initiatives across these neighborhoods, drawing on data provided by the city of Denver. Gentrification was analyzed through a composite index considering median household income, , racial demographics, rent prices, and property values. Employing ArcGIS, we mapped both greenness and gentrification to uncover spatial patterns and correlations. The findings reveal a nuanced relationship between greenness and gentrification, with some neighborhoods demonstrating strong associations, while others suggest alternative drivers of demographic change. Statistical analyses underscore a positive correlation between changes in greenness and demographic shifts, indicating a dynamic interplay between urban greenery and neighborhood transformation. In essence, this research aims to comprehensively analyze , map, and understand Denver's evolving landscape through the lens of urban greenness.

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INTRODUCTION

Money does not grow on trees, but in the context of U.S. cities the two are surely connected. From estate gardens to extravagant urban parks, nature in the city is woven with the threads of affluence, shaping cities where green indicates wealth in more ways than one. Focusing on this relationship, this project delves into the connection of urban greenness on gentrification, housing marker, and socio-demographic changes in Denver, Colorado. As a city, Denver has experienced an exponential surge in both cost of living and gentrification, solidifying its position as one of the most expensive and rapidly gentrifying U.S. cities in recent decades (NCRC). The recent growth of the city leaves room to understand what is driving change. Gentrification is a complex issue that brings in a lot of potential causes. While urban greenness is only one of many factors that can contribute to gentrification, its role is increasingly crucial in the recent drive to make cities more environmentally sustainable in a rapidly warming world. This research seeks to unravel the dynamics of green gentrification in Denver, shedding light on the city's evolving urban identity and its ongoing challenges in balancing the demands for urban greenness and equity.

GENTRIFICATION IN DENVER:

Denver has experienced rapid growth, paralleled by a significant rise in gentrification (NCRC) (UDP). The change in the city can be seen by longtime residents and in the numbers that can maps Denver's growth in comparison to other U.S. cities. In research completed by the National Community Reinvestment Coalition (NCRC), approximately 27 percent of neighborhoods in Denver are experiencing gentrification, making it the second-most gentrified city in the United States, trailing only behind San Francisco (NCRS). Longtime residents face the consequences of the rapid change. Front Porch, a local news outlet of Denver, features an interview with Dr. Tim Thomas, director of the UC-Berkley supported Urban Displacement Project. The article underscores the significance of long-term resident displacement in gentrified neighborhoods, emphasizing the potential loss of cultural identity and community cohesion (Heuberger, 2023). Dr. Thomas explains how this phenomenon can reshape neighborhood dynamics, introducing new political or social dimensions that alter the landscape of the area. Denver, over the past decades, has seen big change in population and neighborhood demographics. This change can be seen on the streets and in the character of neighborhoods (Heuberger, 2023).

GREENESS IN DENVER:

As Denver grows, the city's urban greenness is diminishing. Greenness in Denver is sparse. The city that was once coined a "city within a park" now lacks parks within the city. The Denver Post's analysis reveals a concerning trend: the disappearance of green space in Denver is outpacing many other cities. Between 1974 and 2018, paved-over areas increased from 19 percent to 48 percent of the city (excluding Denver International Airport), with projections indicating that up to 69 percent of the city could be paved or covered by 2040 (Finley, 2019). This level of "imperviousness" is surpassed only by New York and a handful of other large cities. The analysis of Denver furthers by finding that

Denver's 155-square-mile area incorporates 6,238 acres of parks and open space, constituting approximately 6.2 percent of the total area (Finley, 2019). However, according to Trust for Public Land rankings, which utilize an 8.2-percent figure for Denver, this proportion ranks as the lowest among major U.S. cities (Finley, 2019). Colorado is often connected to the idea of the outdoors, while as a state this may hold true, the capital city of Denver is increasingly having fewer parks and urban greenness.

Denver residents are becoming increasingly aware of the challenges of living in a city that continues to lose greenspace. Specifically, The Denver Post draws attention to the River North neighborhood ("RiNo"), which boasts only 9% tree canopy coverage compared to the city's 24% average. Interviews with residents conducted by The Denver Post depict the neighborhood as uncomfortably hot and devoid of shade during summer months. While some residents recognize the potential for more trees, plants, and green spaces to exacerbate gentrification, which has already been a concern as RiNo evolves, this does not imply that residents should resign themselves to living in areas lacking in greenery.
The city of Denver acknowledges concerns from residents and experts and plans exist to combat this issue. These plans include the Game plan, Tree-Planting Pledges, major projects including the 5280 green loop and the river mile. Another greenness project was declared in 2006, to plant 1 million trees by 2025, since its creation the project has shifted to focus more of the Quantity of the city's tree canopy rather than just the number of trees. Beyond the city efforts, there are many greenness projects in the books in Denver, CO.

Two major projects include The River Mile and the 5280- Green Loop. While the exact details of these projects are years out, they fall under the increase efforts to address Denver's lack of greenspace. These projects combined fall under the realm of greening Denver but on various scales. Denver plans to implement more parks and greenspace into the city over a 20-year stretch. The plans stem from the city's Game Plan for a Healthy City (the "Game Plan") that is on creating projects including parks, gathering places, and activities that are easily accessed, well-maintained and equitable in every neighborhood of Denver. This mission is commendable and also questions how it has and it planned to be carried out to balance implanting greenspace without changing neighborhoods.

BENEFITS OF URBAN GREENESS

The positive impacts of urban greenness are abundant. Urban greenness can drastically improve the quality of life of the people, animals, and plants in the city. In short, urban greenness contributes to environmental sustainability by enhancing biodiversity, improving air and water quality, mitigating the urban heat island effect, and promoting physical and mental well-being (Kondo et al. 2018, 445). The concept of green infrastructure also underscores the significance of nature-based solutions in addressing challenges related to climate change and enhancing the quality of life in urban areas. While urban greenness projects may pose challenges related to gentrification and equity, their positive impacts highlight the importance of finding a balance between development that does not displace rapidly growing and warming cities.

This project aims to address the challenge of juggling introducing greenness to benefit residents and the environment while not displacing long term residents. The objectives are to examine local relationships between urban greenness and gentrification within Denver and NDVI, connect to gentrification in Denver's neighborhoods over the past decade?
The research looks to build off existing research and initiatives that Denver is prioritizing. Two of these initiatives include The Parks and Recreation: Game Plan and Denver's Neighborhood Equity (with the goal of implementing greenness in Denver) & Stabilization program aiming at protecting neighborhoods at risk of displacement.
The research is conducted by examining the relationship of urban greenness and gentrification patterns of Denver's neighborhoods through the lenses of GIS (Geographic Information Systems) and statistical analysis. The urban greenness in this research has been characterized in the form of public green projects and normalized difference vegetation index ("NDVI"). This project will add more insight into the existing relationship between gentrification and greenness while hoping to highlight the challenges and solutions to implementing green space in the context of Denver, CO

LITERATURE REVIEW

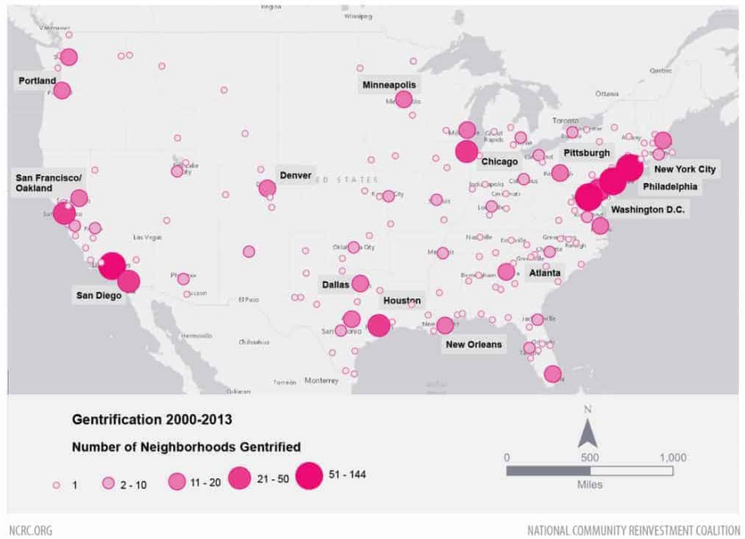
GENTRIFICATION:

Urban gentrification is significantly impacting housing affordability in the US, leading to the displacement of numerous residents, and altering the composition of communities.

Gentrification is a term used in an abundance of fields, but the assumed meaning of this term can cause some ambiguity. The term "gentrification," coined by Ruth Glass in 1964 to describe the transformation of historically lower-class London neighborhoods, has evolved over the years but her observations still hold true. (Glass 1964, xviii). Ruth's observations still hold true in many cases on Gentrification and began the continued impacts of Gentrification. For this study, "Gentrification" is defined as the process of urban change transforming a low-value neighborhood into a high-value one (Finio 2022). This transformation typically involves an influx of new investment and new residents with higher incomes and educational attainment into a neighborhood over a brief period, (Finio 2022). The definition, is one of the first steps for building a basis to further explore and understand the term in the context of this research,

Gentrification has made a mark on the fabric of U.S. cities. The term goes years back and the phenomenon reaches far highlighting instances across decades and regions. An early instance of gentrification in the US occurred in Georgetown, Washington D.C. The George Washington's era city evolved from a historical into a dilapidated and inexpensive residential area what was labeled the city's "slums" (Goldfield and Brownell 1990, 420). By the 1920s, post-World War I, the neighborhood underwent a transformation, gaining renewed prestige as wealthier families moved in, altering its demographic and visual landscape (Gale, 31, 2021). This revitalization, led to the eviction of long-time residents, marking the initial stages of gentrification in the U.S. Georgetown as one of many cities. The trend expanded to other East Coast neighborhoods, including Greenwich Village in New York and Boston's Beacon Hill from 1915-1945, characterized by the revitalization of older homes, a shift towards higher income households, and a decrease in working-class and minority residents (Gale, 31, 2021). The cases of Gentrification through time have spread through time, including cities like Philadelphia, Charleston, and New Orleans—according to Ross (2014, 58, 87). Research finds that location is not the determinant but rather gentrification is linked to a city's age and built environment. (Gale, 113, 2021). Gentrification can be identified nationwide but it is a phenomenon that is driven by the context of the city and neighborhoods.

FIGURE 1: GENTRIFYING CITIES WITHIN THE U.S.



Current research highlights the varying levels of gentrification seen across U.S. cities. The data displayed in Figure 1 spans from 2000-2013 specifically looking at the changes within the U.S. census tract level of cities. The tracts that are gentrifying more are larger and darker in color. The two cities with highest percentages of gentrifying tracts include San Francisco with 31.2% gentrifying tracts and Denver with 27.5% ones. This research focused on the demographic changes between the specific years of 2000-2013 (NCRC). The National Community Reinvestment Coalition is comprised of various organizations and non-profits aimed at advocating for underserved communities at risk of displacement, this nationwide research was completed by NCRC in 2013. While this gives valuable context, the causes and impacts in each city is space to be further understood.

Gentrification is harmful to the equity and cultural fabric of cities. Gentrification consequences include issues such as displacement, exclusion, alteration of public spaces, division, and homogeneity (Kohn 2019). Gentrification displacement contributes to the exclusion of lower-income individuals and families, who are priced out of housing and amenities in gentrifying areas. Additionally, the transformation of public spaces to suit the preferences of wealthier newcomers further marginalizes existing residents. Social divisions emerge as gentrification progresses, heightening tensions between newcomers and longtime inhabitants and exacerbating existing inequalities. Ultimately, gentrification can lead to the creation of homogeneous neighborhoods, devoid of socioeconomic and cultural diversity, as wealthier individuals replace displaced residents, reshaping the fabric of urban communities. Controlling these negative effects is crucial for preserving urban diversity and community identity.

The causes of gentrification vary from regions, cities, and neighborhoods. Going back to Ruth Glass, and her research early on, she cites that the cause of Gentrification is complex and multi-faceted. Today while the exact causes are debated across the field, agreed upon factors to gentrification include economic influences like new investments and urban policies to social and cultural forces, housing market shifts, urban renewal projects, and infrastructure improvements (Zuk et al. 2018, Hyra 2016, Loughran 2022). These factors collectively play a role in neighborhood transformation and contribute to the effects of past disinvestment, furthering the gentrification process (Loughran, K, 2022). Economic influences, such as new investments and urban policies, play a significant role. For example, in cities like San Francisco's Mission District or Brooklyn's Williamsburg neighborhood, gentrification has been driven by a combination of factors such as rising property values due to tech industry influx, cultural shifts favoring trendy neighborhoods, and city-led revitalization efforts (Loughran, K, 2022). Urban development and infrastructure projects have also played a significant role in gentrifying neighborhoods across various cities. For example, the redevelopment of Atlanta's Olympic Park for the 1996 Summer Olympics led to a wave of gentrification in Downtown, Midtown, and the Old Fourth Ward (Gustafson, 2013). In Portland, the conversion of warehouses into loft apartments and the creation of parks, galleries, and boutiques in the Pearl District attracted young professionals and artists, driving up property values and displacing lower-income residents. Furthermore, initiatives like the Belt Line in Atlanta, which repurposed abandoned railway tracks into a multi-use trail and transit corridor, and the redevelopment of Washington, D.C.'s Southwest Waterfront into The Wharf, a mixed-use development, have also contributed to gentrification by attracting affluent residents and tourists, thus increasing housing costs and displacing many low-income residents (Anderson, 2019)These examples underscore how urban development and infrastructure projects can transform neighborhoods but also exacerbate issues of inequality and displacement. The final investigation into existing literature lies in understanding how gentrification is measured, mapped, and studied. From the street view, it can be noticed over the years as buildings flip, and lots develop. Beyond the changes seen from walking down a block, Gentrification is seen in the numbers, across censuses and city data. The specific data that existing research uses in Gentrification is often characterized and measured by crime rate reduction, or changes in the following factors: median household income, percentage of college graduates, percentage of renters, percentage of people of color, median gross rent, and median home value (Rigolon, Nemeth 2019). Gentrification often correlates with reductions in crime rates as wealthier residents move in and invest in the area's infrastructure and security, leading to improved safety perceptions and actual crime reduction. Median household income is the midpoint of all household incomes in a specific area. Gentrification typically leads to an increase in median household income as higher-income individuals move into a neighborhood, potentially displacing lower-income residents and altering the socioeconomic makeup of the area. housing costs.

The percentage of college graduates measures the proportion of residents in a neighborhood who have attained a college degree. Gentrification often results in an influx of highly educated individuals, contributing to an increase in the percentage of college graduates in the area as well as potentially driving up housing costs. The percentage of renters in a neighborhood reflects the proportion of residents who do not own their homes but instead rent them. Gentrification may lead to a decrease in the percentage of renters as property values rise, making homeownership more financially viable for wealthier individuals and potentially displacing renters. Percentage of people of color measures the proportion of residents in a neighborhood who identify as people of color. Gentrification often correlates with the displacement of communities of color due to rising housing costs and increased investment in predominantly white or affluent areas. Median gross rent refers to the median monthly rent paid by renters in a specific area. Gentrification can result in an increase in median gross rent as housing demand rises, leading landlords to raise rents to capitalize on the influx of wealthier residents. Renters are at more risk of being displaced. Median home value is the midpoint of all home values in a particular area. Gentrification typically leads to an increase in median home values as the demand for housing in the neighborhood rises, driven by higher-income individuals moving in and investing in property renovations and improvements.

URBAN GREENNESS:

The definition of urban greenness and what falls into this category proves to go beyond a black-white meaning. There is a growing amount of research studying urban greenness and greenspace in many disciplines. While many interdisciplinary studies mention greenspace, only half of 125 reviewed articles explicitly define greenspace. (Taylor and Hochuli, 2017). For this project, "Urban Greenness" refers to city spaces integrating vegetation, including parks, gardens, backyards, urban forests, street trees, and green spaces. This definition, shaped by existing urban research, rejects simplistic distinctions, promoting a more nuanced understanding of urban greenness. (Taylor and Hochuli, 2017). While parks and community gardens are immediate associations, the research defines urban greenness beyond simplistic distinctions and encompassing a broader understanding of green spaces in urban environments. This definition serves as a base for further discussion and methods to measure the variable of greenness within the specific context of urban design and landscape architecture.

BENEFITS OF URBAN GREENESS:

Urban greenness serves as a cornerstone for enhancing the quality-of-life inhabitants, wildlife, and plant life alike. Through fostering biodiversity, urban green spaces provide vital habitats for various species, contributing to the preservation of ecological balance within the city. The positive impacts of urban greenness extend to the realm of human well-being, as access to green spaces has been linked to improved physical health outcomes and enhanced mental well-being, offering respite from the stresses of urban living (Kondo et al., 2018, p. 445). For instance, the implementation of green infrastructure projects such as community gardens, pocket parks, and green rooftops not only beautifies urban landscapes but also serves as crucial hubs for community engagement and social cohesion.

Community-led initiatives like urban gardening programs not only promote sustainable food production but also foster a sense of ownership and stewardship among residents, bolstering social bonds and fostering a sense of belonging within neighborhoods. Additionally, initiatives to retrofit urban areas with permeable pavements, bioswales, and rain gardens demonstrate a commitment to sustainable urban development by mitigating stormwater runoff and reducing the risk of flooding, thereby enhancing the resilience of communities to climate change impacts.

GREEN GENTRIFICATION:

Projects promoting urban greenness and investments in neighborhood greenery are lesser-known risk factors contributing to gentrification, resulting in what is termed as 'green gentrification'. Green Gentrification is defined as a phenomenon wherein efforts to enhance urban green spaces inadvertently displace socioeconomically vulnerable communities. (Cucca, R., Friesenecker, M., & Thaler, T. (2023). The body of literature on green gentrification is expanding. In a recent meta-analysis of gentrification risk factors in US and European cities, urban greenness has been identified as a significant driver. This study analyzes cities gentrification patterns and specifically highlights whether cities are experiencing gentrification connected to green gentrification, The study found that the U.S is at higher risk compared to European cities to be affected by greenness as a driver of Gentrification (Anguelovski et al. ,2022).

In the US, projects that aim to implement urban greenness into a neighborhood can quickly drive rents up and push out the communities these projects once aimed to benefit. One of the most notable projects that has shown this pattern is the Highline in New York City. First opening in 2009, the 1.45-mile-long elevated pedestrian park reaches from Gansevoort Street to 34th Street in Manhattan developed from the rail line was once was once surrounded by the working-class neighborhood of Chelsea (La Farge 2014). The project increased nearby housing values by 35%, particularly for properties closest to the initial section and those above the first floor. (Black & Richards, 2020). The Highline might be one the most easily identifiable instances of urban greenness that can be directly attributed to a large-scale green infrastructure project and might take the spotlight but is in no way an exception.

Community gardens are another part of urban greenness that can be linked to gentrification. A quantitative study conducted in St. Louis Missouri shows that community gardening plays a role in ecological gentrification in this city. The positive association between community gardening and gentrification in St. Louis from 2000 to 2010 was evidenced by an increase in high socioeconomic status residents. This suggests a relationship wherein the introduction of community gardens can unintentionally contribute to gentrification, emphasizing the importance of institutional support to counteract such spatially unjust outcomes. (Braswell 2018, 809–822). Community Gardens and The Highline are two very different types of greenness in the city, but the literature fills in other cities that have experienced green gentrification. One study found nature preserves, greenways, gardens, and recreational spaces show varied roles in gentrification, with some demonstrating positive associations across a range of U.S. cities. These cities include but are not limited to Austin, Seattle, and Detroit, (Triguero-Mas et al., 2022). This research shows that cities can show a varying degree of green gentrification and cities do not stand as the only cause for the demographic shifts.

GREENSPACE PARADOX THEORY:

Greenspace is important and has a multitude of benefits to urban environments but is proven to be a driver of gentrification. This dilemma can be summed up by the Greenspace Paradox Theory. In the U.S., individuals with lower incomes and people of color often live in the city center or low-income suburbs, where green spaces are either limited or of low quality (Wolch, Byrne, and Newell, 2014). While the intention behind adding more greenspace to these neighborhoods may be positive, these changes often lead to the displacement or marginalization of low-income residents in the short or long term. Wolch, Byrne, and Newell (2014) describe this phenomenon as the "Green space paradox." The green space paradox, and the definition outlined drive the research the way this problem within the context of Denver.

THE CONTEXT OF DENVER

Denver is a unique example due to its history and climate. All these factors inform and explain the modern-day green space paradox today. Denver was established in 1858, during the push for Gold, (Leonard and Noel, 2016). The Gold brought people to Denver, but the city did not grow or take form that could be recognized today until the turn of the century. (Leonard and Noel, 2016). In this time is when green became the new gold and there was effort and planning put into the greenspace in the city. Along with other U.S. cities, the City Beautiful Movement transformed Denver's Architecture and Landscape. In 1907, George Kessler, a colleague of Fredick Law Olmstead made a comprehensive plan for the city of Denver, (Norgren and Noel, 2016). The plan that can be seen in Figure 2, shows the plans for parks that can be recognized to this day. On the North side the plan drew out Sloan's Lake, Rocky Mountain Lake, and Berkeley Lake. In the central part of the city, City Park, Cheeseman Park, and Washington Park are in bold. Amongst the major parks, neighborhood parks and playgrounds are scattered throughout the city. This historical plan helps better understand the initial planning efforts and capital put towards greenspace in the city. While the locations of these parks and roads stay the same. The neighborhoods that make up the city, including demographics, have changed a lot since the early 1900s. Denver's history is the basis for the city and the greenness in Denver seen today.

Fast forward to the modern day, the same parks can be found but now neighborhoods have transformed. The next section lays out existing understanding of Denver and the relationship between the wealth, greenness, and gentrification. Many of the existing maps and data within Denver are completed by the city of Denver or local news sources, like the Denver Post. The following sections is a summary of some of the analysis of wealth, gentrification, and tree canopy within Denver.

FIGURE 2: KESSLER COMPREHENSIVE PARK PLAN 1909

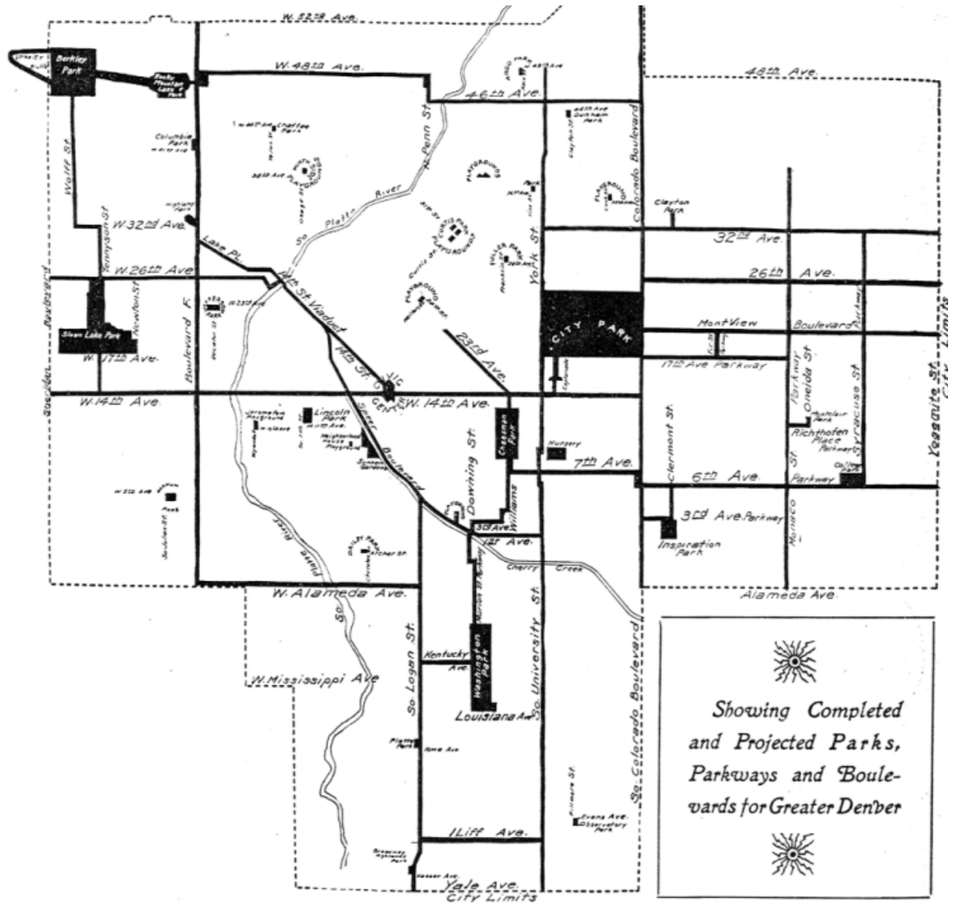


FIGURE 3: TREE CANOPY & INCOME LEVELS – 2013

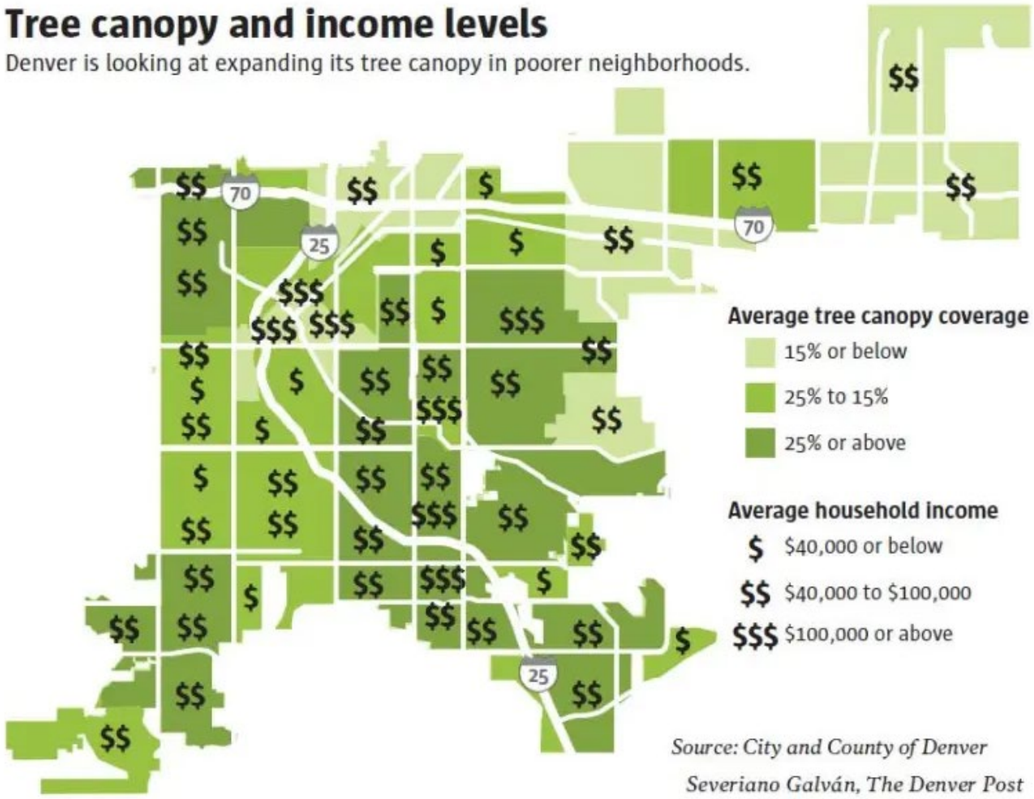


Figure 3 illustrates a positive correlation between average household income and the percentage of tree canopy cover in Denver neighborhoods. In neighborhoods where the average household income exceeds $100,000, there appears to be a higher concentration of tree canopy cover compared to neighborhoods with lower income levels. This suggests a potential socio-economic disparity in access to urban green spaces, with wealthier neighborhoods enjoying more extensive tree coverage. The map sets up the understanding for 2013 and the relationship of greenness to wealth. With Denver's quickly changing dynamics it leaves room to understand how the change in wealth and greenness goes beyond the just one year.

FIGURE 4: TRACTS VULNERABLE TO GENTRIFICATION

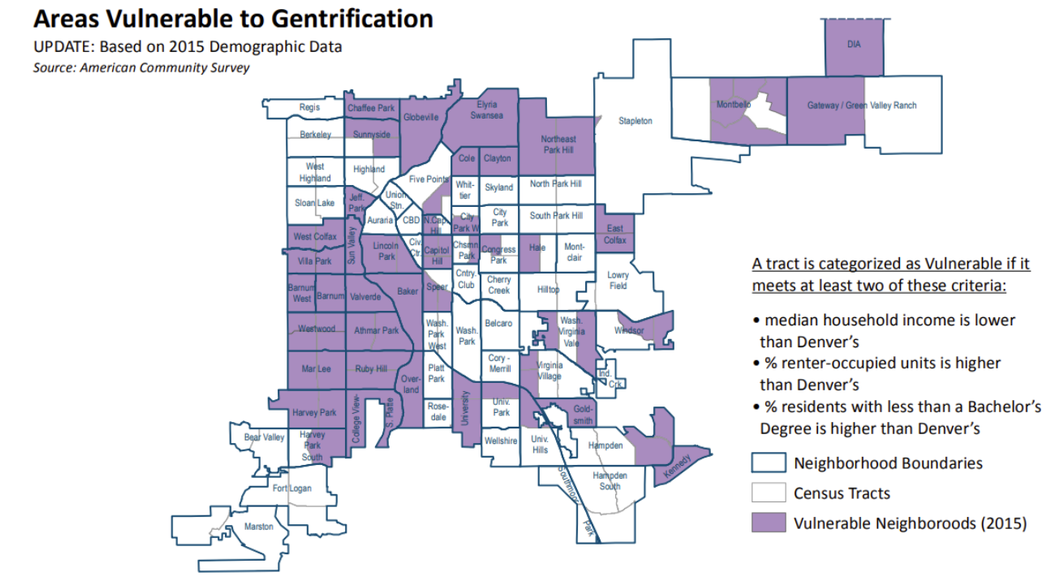


Figure4 illustrates the level of gentrification in different neighborhoods in Denver. According to this map, the neighborhoods highlighted in purple are vulnerable to Gentrification based on the combination of indicators. This study shows that the City of Denver compares the city average in factors to tracts. The indicators include household income, renter-occupied units, and the amount of people with a bachelor's degree. The map shows gentrification in the year 2015.

Both Figures 3 and 4 depict maps and analyses illustrating gentrification and greenness within a single year. The maps combined set a precedent for combining different indicators to better understand and visualize the level of gentrification within neighborhoods. On the other hand, the maps only represent one year of data. The pattern of the existing research mostly only analyzes one year of greenness and demographic data. The existing research in the context of Denver leaves room to understand the changes in greenness through a given period beyond just one year.

Overall, there is a cause to explore greenness and gentrification in the context of Denver based on existing research in the field. Across the U.S gentrification is an abundantly explored topic with historical and modern-day examples. Greenness in the cities is rising in projects like the Highline, community gardens, and street trees. The call for greenness comes from not only the health benefits but the quickly changing environment. Within the city of Denver, research shows a strong pattern of gentrification across many neighborhoods. With the rapid change in demographics there is also room to explore the specifics of what is causing Denver's gentrification and in the lens of this research greenness is the specific cause that looks to expand on the existing analysis in Denver.

RESEARCH METHODS

OVERVIEW:

We used a quantitative method to investigate the research question. The quantitative approach included using Geographic Information System (GIS) to map gentrification and greenness data for neighborhoods across Denver. The correlation between these data was assessed using Statistical Package for Social Sciences (SPSS). GIS integrates geographic information with various data layers, creating visual representations like tables, graphs, and maps. This program uncovers patterns and relationships while also creating maps that represent gentrification and greenness and the combination of the two throughout Denver neighborhoods.

The data was pulled from multiple sources and datasets including the city of Denver's GIS department, Open Data Catalog, U.S. Census data, and American Community Survey.
This study encompassed the following steps: Mapping and Indexing Gentrification, Mapping and Understanding Greenness and statistically evaluating the correlation between these factors.

MAPPING & INDEXING GENTRIFICATION IN DENVER:

The following indicators were chosen to highlight the levels of change seen in each neighborhood: % of change in average household income, % of change in the population of people of color, % of change in the median home value, % of change in the average rental cost. These indicators were informed by existing research in mapping Gentrification done by the Urban Displacement project and the city of Denver.
The socio demographic data was sourced from the U.S. Census Bureau and the American Community Surveys (ACS), spanning multiple years (2009-2020). These sources provide comprehensive insights into various socio-economic factors indicative of gentrification processes within urban areas. The U.S. Census Bureau conducts the Decennial Census every ten years, providing a broad overview of demographic changes across the nation. Additionally, the American Community Surveys, conducted annually by the Census Bureau, offer more frequent updates and detailed information on various socio-economic indicators. The data extracted from these surveys typically covers a range of years, allowing for longitudinal analysis to track changes over time. The extracted data from the surveys included median household income, educational attainment, housing tenure, racial demographics, rent prices, and property values.

The extracted data was cleaned up in Excel before being used in ArcGIS. This data cleaning procedure included removing outliers, handling missing values, and standardizing variables across different survey years. Once cleaned, the data was organized into a format suitable for mapping and statistical analysis.

TABLE 1: GENTRIFICATION INDICATORS

Theme	Indicator	Description
Gentrification		
1	% Change of Avg. HH Income	This indicator illustrates the economic changes that have occurred in each neighborhood over the past decade. Income is a strong indicator based on existing studies on Gentrification.
2	% Change of People of Color	Demographic changes that have occurred in each neighborhood over the past decade, particularly the change in the percentage of non-White residents show what stage on gentrification neighborhoods are experiencing.
3	% Change in Median Home Value	The values of houses are a big indicator of the degree to which neighborhoods are changing economically. The change between the years will contribute to the understanding of the degree to which neighborhoods are gentrifying.
4	% Change in Average rental cost	Renters are the most at risk of being displaced and rent costs increasing indicate displacement and signs of gentrification in these neighborhoods

Each of these Indicators were mapped for the neighborhood across Denver.
After cleaning the four gentrification indicators, we conducted a component analysis to make a new gentrification factor culminated from the above indicators. First, each of these indicators were ranked for 74 neighborhoods. Out of 78 neighborhoods, we excluded four neighborhoods from this calculation. Auraria, Kennedy, Sun Valley, and Valverde were not included in the index because of inconsistencies, and missing data for one or both years from American Community Survey. Since the change across two years is an important part of analysis, the sample size was reduced to 74 instead of all 78 neighborhoods. Each neighborhood was then ranked between 1 and 74 based on their level of impact on gentrification. For each neighborhood, the gentrification factors were calculated by summing up the ranking numbers and dividing them by 4 (the number of gentrification indicators). The scale and ranking for each factor are described below as the change indicates different conclusions depending on the indicator.

AVERAGE HOUSEHOLD INCOME:

(Sourced from American Community Survey)
The percentage of change in the median household income is an indicator of gentrification and the increase of wealth in a neighborhood. The neighborhoods are ranked from 1-74 based on the percent change in the median HH income. With the ranking of 1 this means the neighborhoods have seen no or negative change in wealth from 2010-2020, indicating this is not a pattern seen in the neighborhood. Neighborhoods ranked 74 show the highest change in income. Neighborhoods ranked with a higher value are showing patterns of gentrification and will score higher in the index.

PEOPLE OF COLOR:

(Sourced from American Community Survey)
The ranking system for this indicator operates on a scale from 1 to 74 with neighborhoods demonstrating a higher percentage or rate of change in the presence of people of color ranked at the top (i.e., closer to 74). These neighborhoods indicate a displacement of people of color, suggesting a significant shift in demographic composition linked to gentrification. On the other hand, neighborhoods where there is an influx or stable presence of people of color, or where there is no substantial change, are ranked lower on the list, closer to 1, reflecting less observed gentrification-related shifts.

MEDIAN HOME VALUE:

(Sourced from American Community Survey)
Home value is one of the indicators to look at in the housing market. Neighborhoods that have seen the highest increase in housing prices show higher amounts of gentrification. The ranking system works by neighborhoods experiencing the most substantial increases in housing prices ranked higher (closer to 74). These neighborhoods reflect pronounced gentrification patterns, characterized by notable appreciation in property values. Conversely, neighborhoods with minimal or negative changes in median home value are ranked lower on the scale, closer to 1, indicating less housing market shifts.

MEDIAN RENT:

(Sourced from American Community Survey)
Similar to home value, the rise in rental prices drive changes associated with gentrification. the ranking system for median rent extends from 1 to 74, with neighborhoods witnessing significant increases in rental prices ranked higher (closer to 74). These neighborhoods exhibit pronounced gentrification trends fueled by escalating rental costs. Conversely, neighborhoods with minimal or negative changes in median rent are ranked lower on the scale, closer to 1, reflecting fewer observed gentrification shifts.

The scores for each neighborhood, ranked by each factor, were aggregated and divided by four (the total number of indicators) to calculate an average score for each neighborhood. Based on this score, the data is then mapped and consolidated to identify neighborhoods with the highest rankings in the combined index.

MAPPING AND UNDERSTANDING GREENNESS

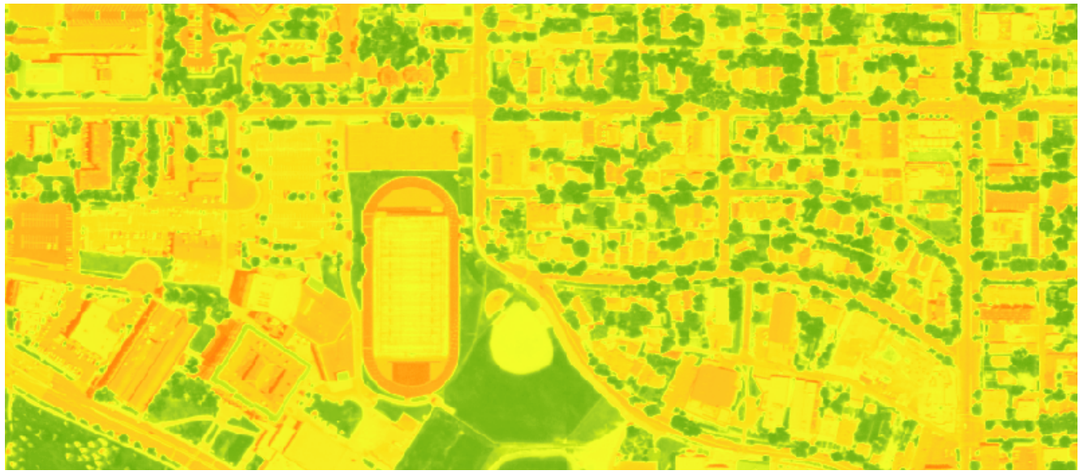
We used two measures of greenness: 1) The average budget that each neighborhood has spent on urban greenness development between 2010-2017. This data was provided by Denver Parks and Recreation department. 2) Normalized Difference Vegetation Index (NDVI) for each neighborhood for the years 2010 and 2020. In Table 2, the indicators are described in depth.

This data was obtained and developed from the US Geological Survey database-Earth Explorer. Together, these indicators look to understand the variation of greenness changes across Denver neighborhoods over the past decade. The city of Denver data looks at the Investment into greenness at the neighborhood level. The NDVI helps reach beyond data documented by the city and county of Denver. This indicator encompasses the quality and quantity of street trees, size of parks, size of backyards in each neighborhood.

TABLE 2: GREENESS INDICATORS

Theme	Indicator	Description
Greenness		
1	Denver Parks and Recreation Greenness Projects Average urban greenness budget	This data includes the year, budget, and neighborhoods that these projects were completed in. The data is available from 2010 up to 2017 and helps map projects that the city of Denver defines as Greenness.
2	Normalized difference vegetation index (NDVI)	NDVI values indicate vegetation health, with higher values representing denser plant growth and lower values representing stress on vegetation (Agenagnew & Gessesse, 2019).

FIGURE 5: NDVI REFERENCE IMAGE



APPLYING NDVI:

Normalized Difference Vegetation Index (NDVI) assesses vegetation presence and density by measuring the difference between near infrared and visible light reflected by plants. Chlorophyll absorbs visible light, while leaf cell structure reflects near-infrared light, (NASA, 2017). NDVI values indicate vegetation health, with higher values representing denser plant growth and lower values representing vegetation under stress (Agenagnew & Gessesse, 2019).

The NDVI was calculated using aerial imagery from National Agricultural Imagery Program (NAIP) and then extracted and analyzed using the following GIS processes. First, we extracted and imported all NAIP Imagery for Denver into GIS. A new raster file was created out of the NAIP imagery. We made sure that the Raster has 4 bands. The NDVI was calculated from bands 3 & 4. Once the NDVI was calculated, we used the Zonal Statistics tool to calculate the mean NDVI within each neighborhood boundary.

The Zonal Statistics to Table command and Table to Excel preparation enable the NDVI mean to be analyzed alongside other statistics.This same process was done for both 2011 and 2020.

NAIP Imagery was sourced from Earth explorer, a USGS run database. 2011 and 2020 were chosen because they had the most consistency between the two. These years also demonstrated the most similarity in their average rainfall. (To ensure the accuracy of the NDVI comparison, it is suggested to select imagery from years that exhibit the same amount of rainfall.) To ensure the consistency of the NDVI factors, photos from the month of July were selected for each year, and all Denver neighborhoods were from the same batch of photos.

NDVI is represented in the values from green to red. The greener an area, the greener the values shown up in the NDVI map. On the contrary, values closer to negative 1 are represented by darker orange hues on the map. Bodies of water, for instance, do not absorb infrared, so they appear in the dark orange color on the map. One important distinction is that from an aerial view, NDVI recognizes that not all green areas indicate vegetation. For example, if a roof is painted green or if there's an artificial turf field, it won't correlate with a high NDVI score as it's not vegetation but rather a materiality feature. Figure 5 is a picture of an artificial turf field from North High School in Denver, CO. The field itself does not show values that indicate vegetation, even though it might appear "green" from a bird's-eye view. This image also provides a close-up view of the NDVI, demonstrating how trees and backyards can be analyzed at this scale and the ways that GIS is able to visually show the differences.

Once the NDVI is processed for each year, the changes in the mean NDVI for each neighborhood was calculated using the following formula for the percent change

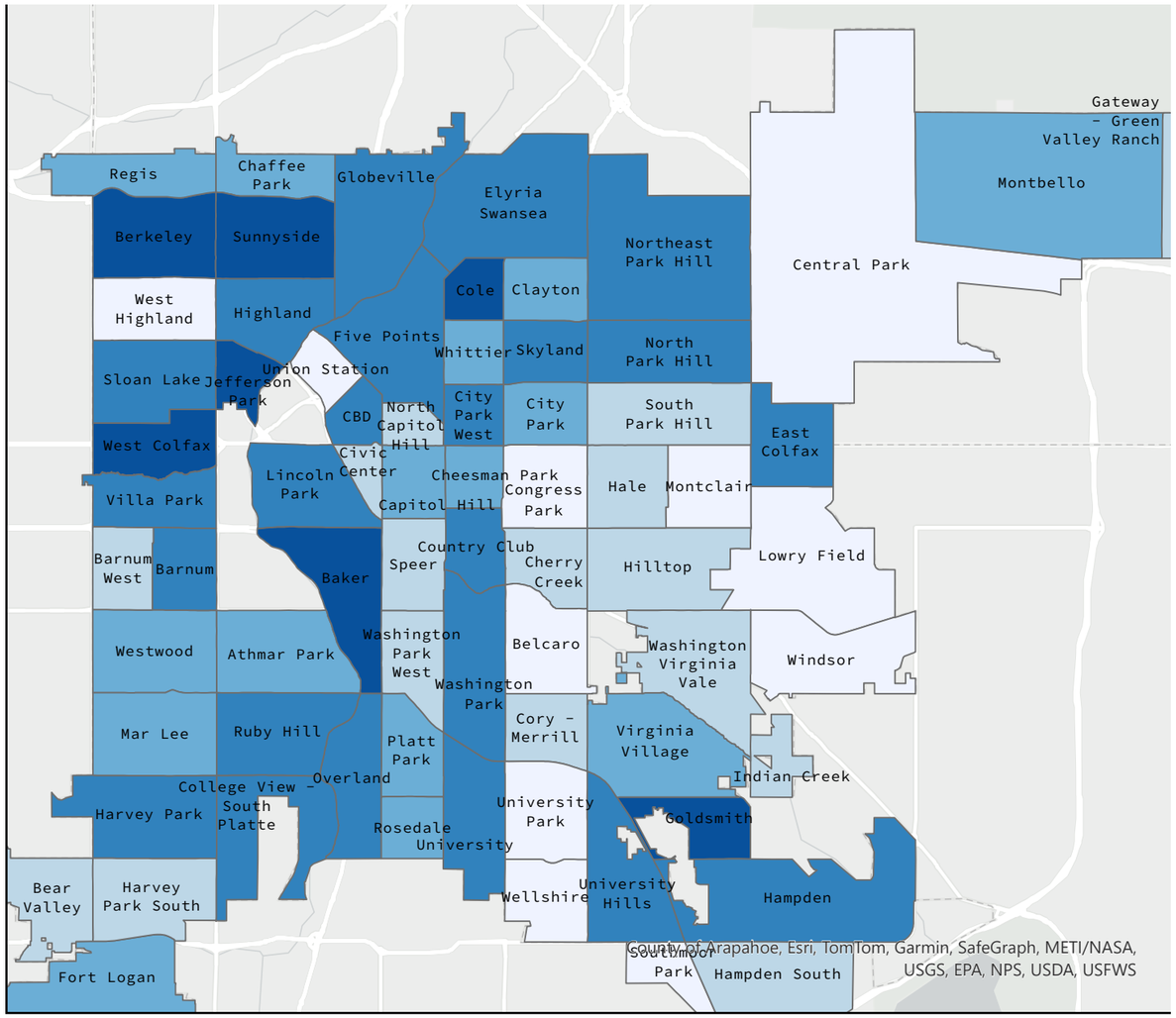
$$\frac{(\text{NDVI Value for year 2020} - \text{NDVI value for year 2011}) * 100\%}{\text{NDVI value for year 2011}}$$

The map of the gentrification index and the maps of greenness were visually and statistically analyzed. Beyond the surface level visual comparisons, the statistical correlation between the gentrification and greenness data was assessed using IBM® SPSS® Statistics 28., The attribute table extracted from the gentrification index and the data tables for greenness are combined and then imported into SPSS to determine if there is correlation.

The Correlation function in SPSS was utilized to test the Gentrification Index and all the Greenness variables, with confidence intervals set to 95%. This value was used to define the type of relationship, whether it be a positive or negative correlation. Ranging from -1 to 1, the value indicates the strength and direction of the correlation: -1 signifies a perfect negative correlation, 1 indicates a perfect positive correlation, and 0 denotes no correlation.

RESULTS

FIGURE 6: NEIGHBORHOODS & GENTRIFICATION INDEX SCORE



KEY:

- No Gentrification (Score Range: 1.25 - 20.25)
- Low Gentrification (Score Range: 20.25 - 31.75)
- Moderate Gentrification (Score Range: 31.75 - 42.0)
- Advanced Gentrification (Score Range: 42.0 - 54.75)
- Intense Gentrification (Score Range: 54.75 - 70.0)

GENTRIFCATION INDEX RESULTS:

Figure 6 maps Denver neighborhoods based on their gentrification scores. The neighborhoods were categorized into five classes representing the degree of gentrification experienced from 2010 to 2020. The darker values signify neighborhoods undergoing significant gentrification, while lighter shades suggest areas with fewer observable patterns of gentrification. The neighborhoods that show the highest level of gentrification are West Colfax, Jefferson, Berkeley, Cole, & Goldsmith. These neighborhoods are distributed throughout the city. The full list of all 74 neighborhoods and their corresponding gentrification score is included in the Appendix. Other neighborhoods further down the list have either remained stable throughout the 2010-2020 period or exhibit patterns of wealth diminishing, which would not classify them under the gentrification category.

GREENNESS RESULTS:

In the following maps, the total greenness budget and the average greenness budget between the years 2010 and 2017 were mapped for Denver neighborhoods (figure 7 & 8). The values are calculated by aggregating the budget for all the projects within each neighborhood.

In figure 7, The darker shades of pink indicate neighborhoods that have seen higher investment into park projects, while there are some neighborhoods that saw no investments during the period. According to figure 3, the following neighborhoods experienced the highest level of greenness investment between 2010 to 2017: Central Park, City Park, Clayton, Five Points, Ruby Hill, Overland, & Hampden.

Figure 8 depicts the map of average greenness project budgets across Denver neighborhoods from 2010 to 2017. The average budget allocation per project was determined by dividing the total budget expended within each neighborhood by the corresponding number of projects completed during that period.

Based on this map, the neighborhoods with the highest average budget per project include Washington Park West, Central Park, Clayton, Skyland, Five Points, & Elyria Swansea.

In comparison to Figure 3, this map highlights similar neighborhoods such as Central Park, Clayton, and Five Points. However, it also highlights other neighborhoods like Washington Park that are not indicated in the total budget.

FIGURE 7: NEIGHBORHOODS & TOTAL GREENESS BUDGET

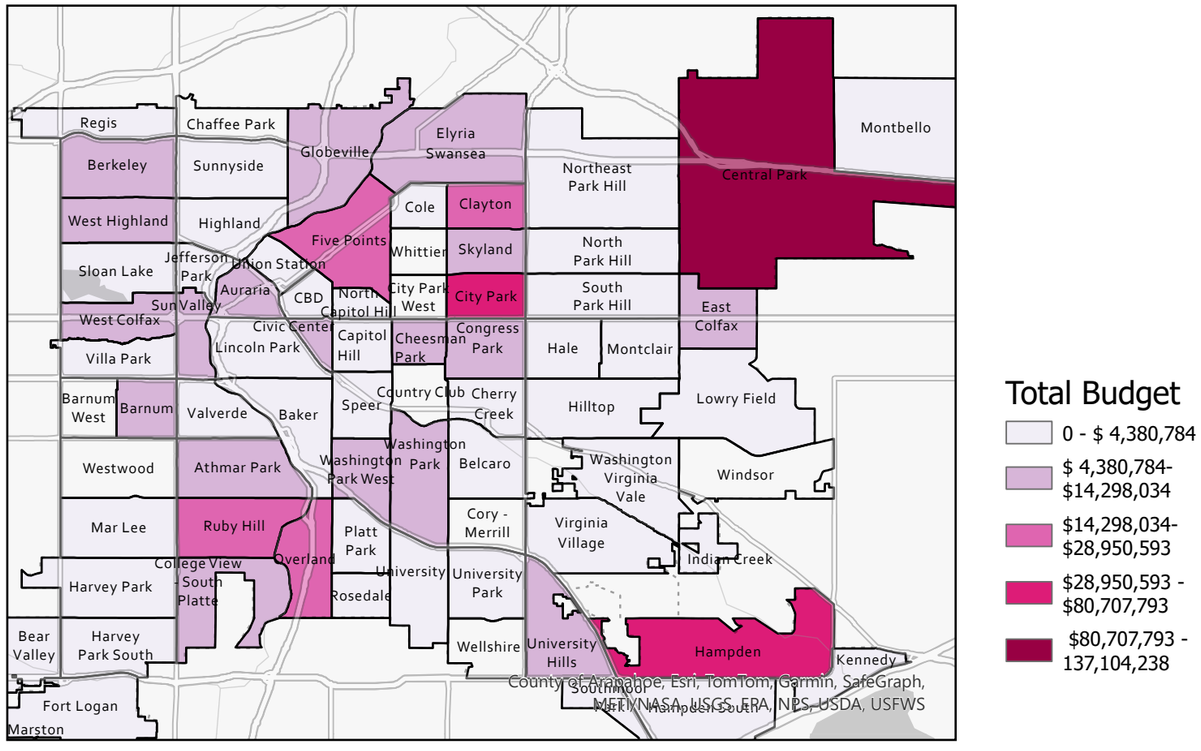


FIGURE 8: NEIGHBORHOODS & AVG PROJECT BUDGET

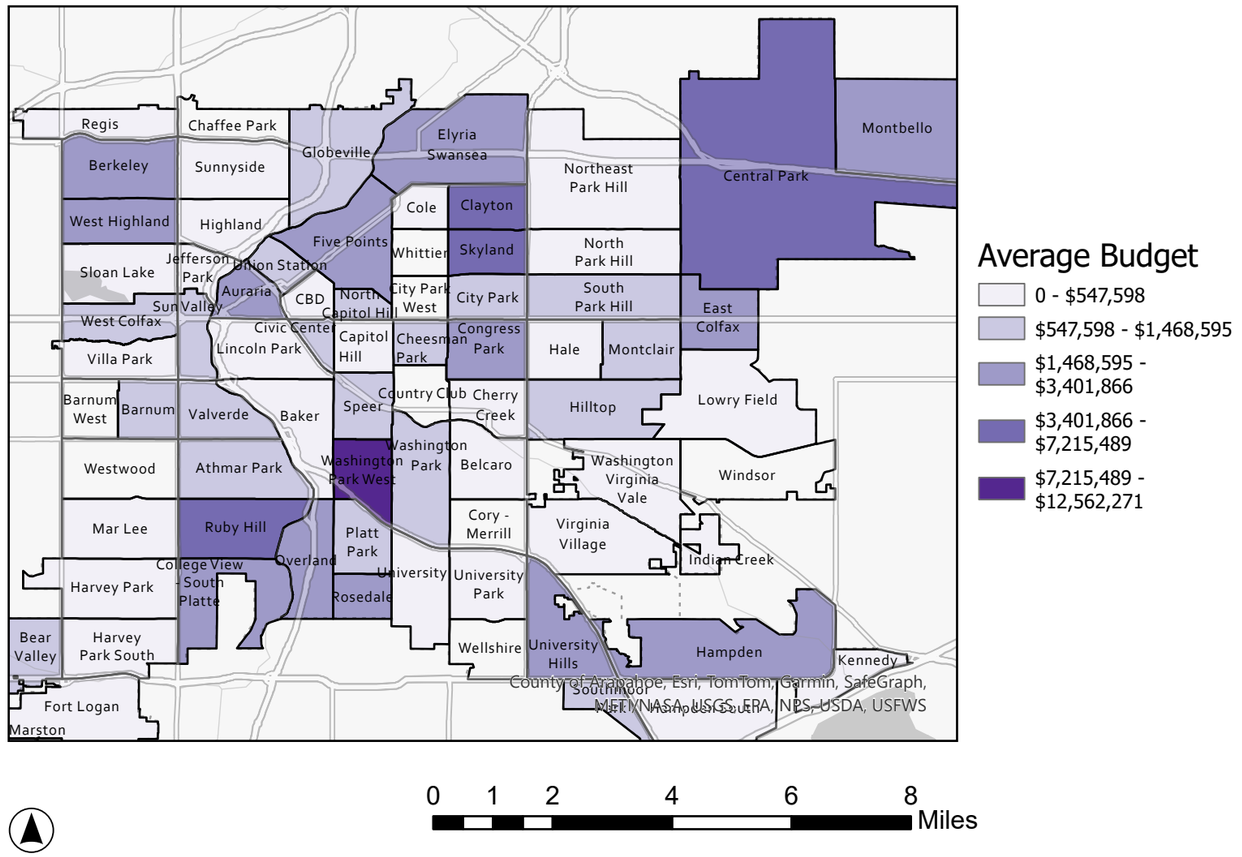
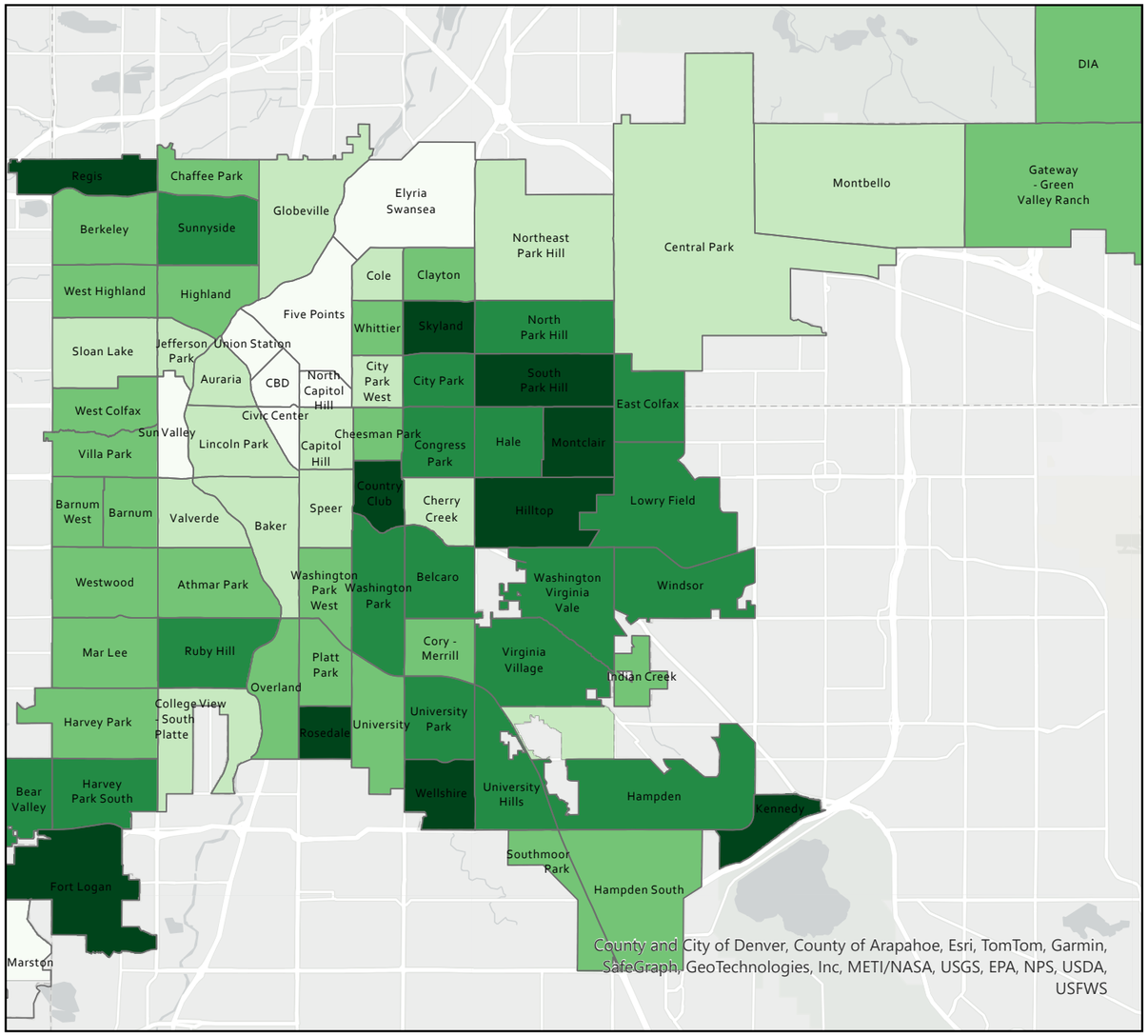


FIGURE 9: 2011 MEAN NDVI DISTRIBUTION



0 1 2 4 6 8 Miles

KEY- NDVI Mean

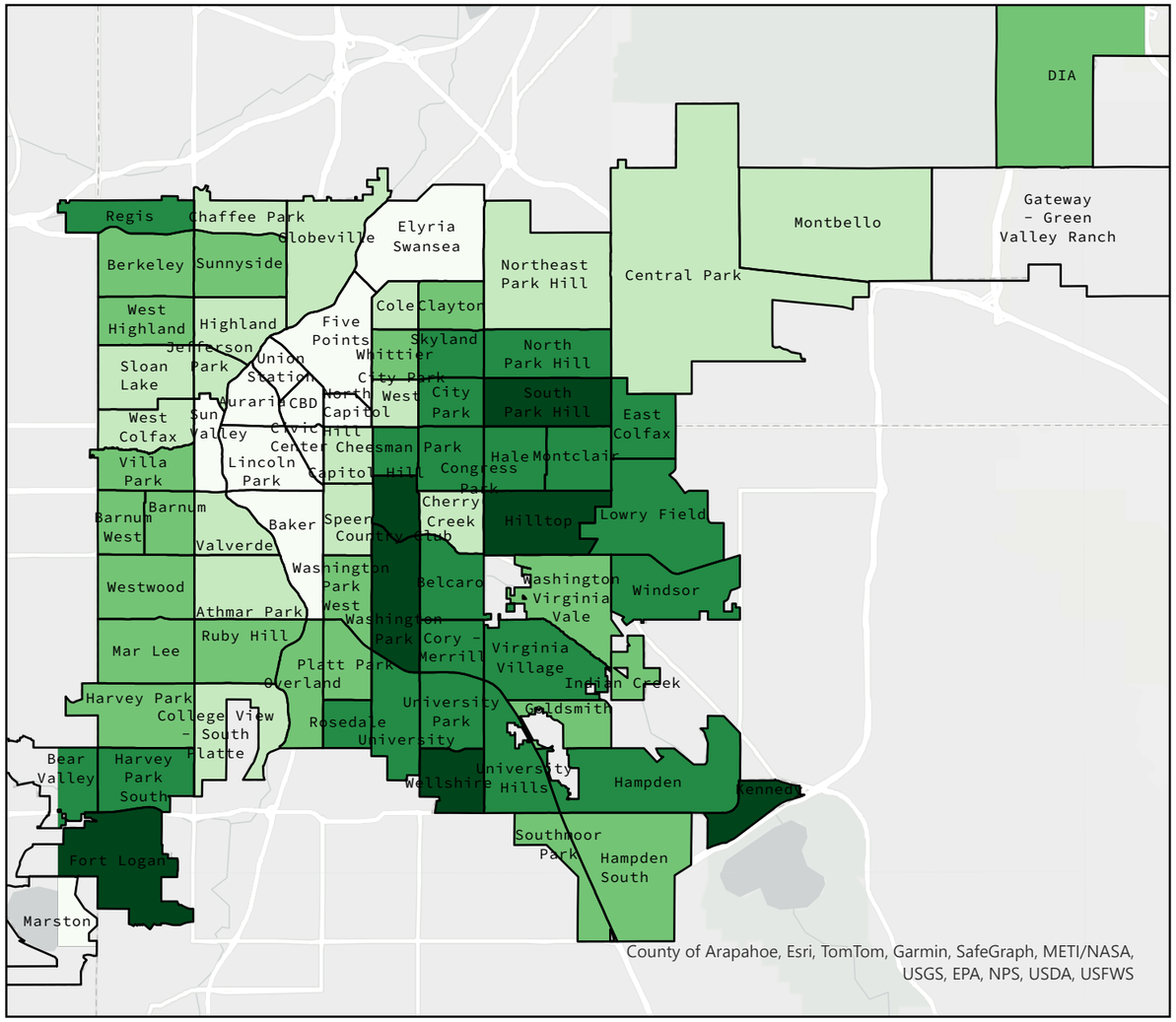
- -0.568 - -0.104
- -0.103 - 0.005
- 0.006 - 0.064
- 0.065 - 0.114
- 0.115 - 0.222

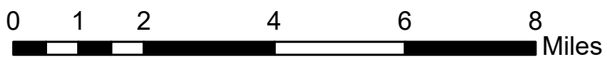
DESCRIPTION – FIGURE 9

The darker green indicates neighborhoods with higher levels of NDVI, implying that these neighborhoods have a higher level of vegetation (trees and ground cover).

While the neighborhoods with lower scores in the mean NDVI appear lighter. Neighborhoods such as Kennedy, Hilltop, Skyland, and Fort Logan boast some of the highest NDVI mean values, ranging from 0.144 to 0.222. In Denver, the neighborhoods with the highest NDVI mean values signify areas abundant in greenery and vegetation, indicative of healthier ecosystems and greater environmental quality. On the other hand, neighborhoods with the lowest NDVI mean values, such as Marston, CBD (Central Business District), North Capitol Hill, Globeville, and Five Points, exhibit values below zero, ranging from -0.568 to -0.240 in the year 2011.

FIGURE 10: 2020 MEAN NDVI DISTRICT





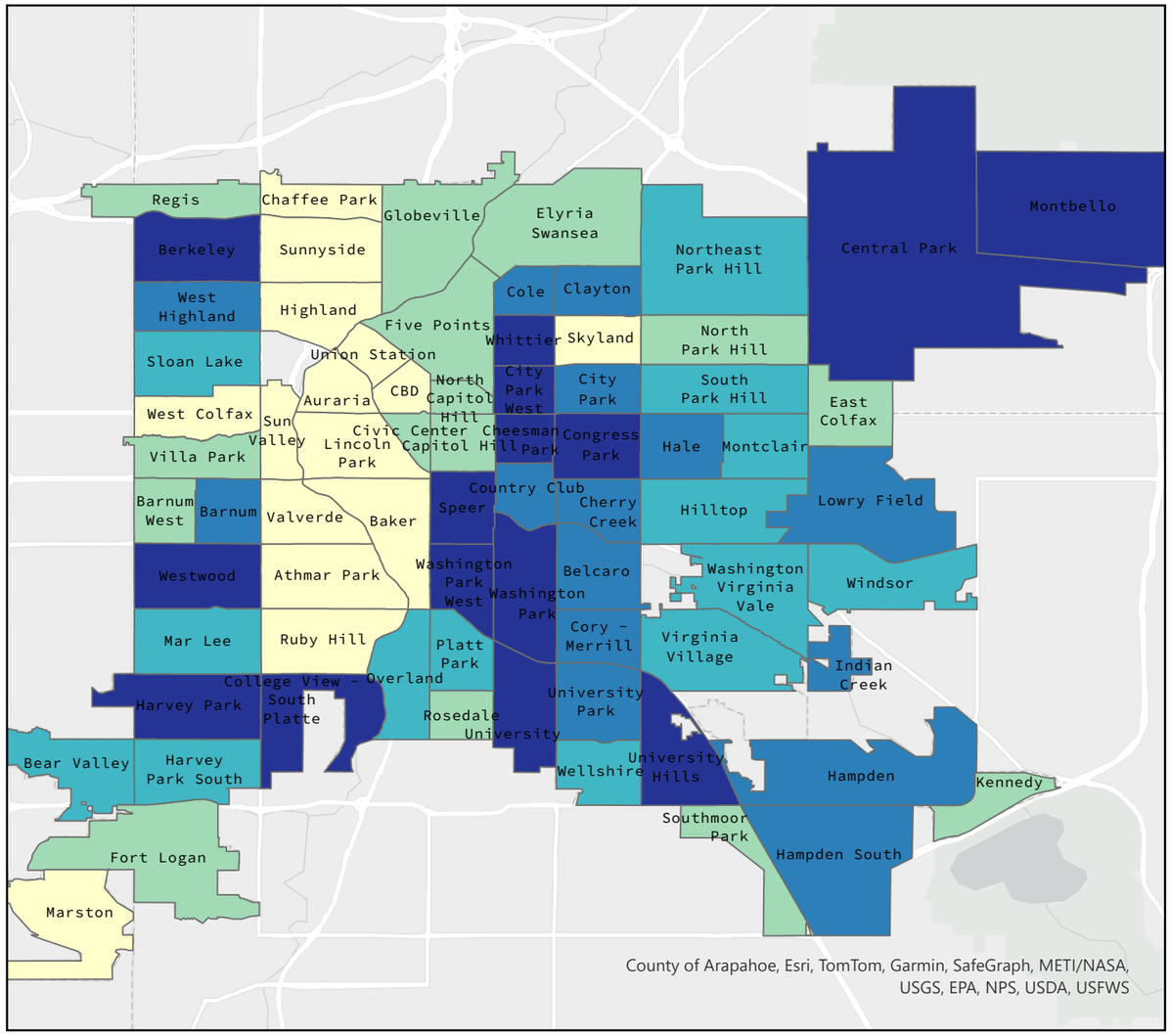
KEY- NDVI Mean

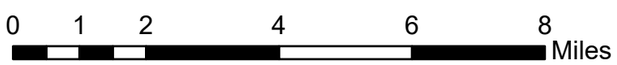
- -0.451 - -0.058
- -0.057 - 0.039
- 0.04 - 0.115
- 0.116 - 0.189
- 0.19 - 0.298

DESCRIPTION – FIGURE 10

Figure 10 shows the mean Normalized Difference Vegetation Index (NDVI) values for Denver's neighborhoods in 2021. Hilltop, Wellshire, and Country Club boast notably high NDVI mean scores this year, ranging from 0.225 to 0.256. These figures underscore the lush vitality of these areas, attributed to extensive parklands, verdant boulevards, and meticulous landscaping practices. Conversely, neighborhoods such as Marston, CBD (Central Business District), and Union Station exhibit markedly lower NDVI mean values, ranging from -0.453 to -0.140, indicative of limited vegetation cover and potential environmental stressors. These findings suggest dense urbanization, concrete-dominated infrastructure, or environmental degradation, all contributing to reduced greenness levels in these locales.

FIGURE 11: CHANGE IN NDVI 2011-2020





PERCENT CHANGE IN NDVI

- -91 - 21
- 22 - 54
- 55 - 84
- 85 - 110
- 120 - 400

DESCRIPTION – FIGURE 11

The change of NDVI between 2011 and 2021 has been shown in figure 11. According to this map, the following neighborhoods have experienced an increase in greenness in the past decade: Berkeley, Montebello, Congress Park, and others. Conversely, the areas outlined in blue have shown no increase or decrease in greenness. The map was created from Appendix Table X that shows the mean NDVI of each neighborhood and percent change in NDVI.

The following table categorizes the neighborhoods and the level of change seen in their NDVI mean through the years.

TABLE 3: DESCRIPTION LEVELS OF NDVI CHANGE

Change in Mean NDVI	Neighborhoods
Significant Increase	Goldsmith, College View - South Platte, Whittier, Washington Park West, Skyland, Sun Valley, Westwood, Speer, Regis, Ruby Hill, Overland, Northeast Park Hill, Montbello, Mar Lee, Lincoln Park, Hilltop, Globeville, Fort Logan, City Park West, Chaffee Park, Bear Valley, Baker
Moderate Increase	Washington Park, University Park, University Hills, University, Virginia Village, South Park Hill, Southmoor Park, Cory - Merrill, Clayton, Cheesman Park, Capitol Hill, Barnum West, Barnum, Athmar Park, Berkeley, Belcaro
Slight Increase	Windsor, West Highland, Valverde, Villa Park, North Park Hill, North Capitol Hill, Montclair, Harvey Park South, Hampden South, Gateway - Green Valley Ranch, Elyria Swansea
Stable	West Colfax, Union Station, Sloan Lake, Riverside, Marston, Indian Creek
Slight Decrease	Sunnyside, Central Park, Clayton, Berkeley, Athmar Park
Moderate Decrease	Washington Virginia Vale, Villa Park, Valverde, University Hills, University Park, University, Sun Valley, Rosedale, North Park Hill, Lincoln Park, Gateway - Green Valley Ranch, Five Points, East Colfax, Cole, CBD, Auraria
Significant Decrease	Globeville, City Park, Cherry Creek

NDVI & AVERAGE BUDGET:

The change of NDVI between the measured period and the average budget per greenness project highlights some similar neighborhoods. Both maps (Figure 10 and 4) include Central Park, Montebello, West Washington Park, and Berkely as neighborhoods that both have seen a rise in greenness as illustrated from NDVI and rank at the top of average greenness projects. The maps also show that neighborhoods that did not show a significant increase in NDVI which at the same time did not receive a high amount of greenness budget from the city of Denver. The notable differences between these two maps include instances where certain neighborhoods experienced an increase in NDVI but did not receive significant investment in the neighborhood. These neighborhoods include Baker, Cole, and Whittier. These neighborhoods saw an increase in greenness but not as a result of new public greenness projects. These differences reveal that neighborhoods experiencing an increase in NDVI are not solely due to new parks; factors such as street trees and higher private property maintenance may also contribute.

AVERAGE BUDGET & GENTRFICATION:

the neighborhoods that both rank high in gentrification and high in the budget spent on greenness projects include Berkely, Montebello, Elyria Swansea, Clayton, Five Points, East Colfax and West Colfax. From the figures, it's evident that while some of the top neighborhoods experiencing gentrification during the specified time frame also witnessed high investment in greenness projects, this correlation is not universal across all neighborhoods. Neighborhoods that ranked high in the gentrification index but did not appear significantly in the average greenness budget include Cole, Jefferson Park, Ruby Hill, Whitter. This suggests that gentrification is not tied to greenness in all neighborhoods. Overall, there appears to be a link, but it's not a rule that neighborhoods with a high amount of gentrification also show higher averages in the budget of greenness projects during the selected decade. Other gentrification risk factors, such as new capital improvement projects play a role in gentrification in these neighborhoods.

CHANGE IN NDVI & GENTRFICATION:

Upon comparing the maps, it is evident that there are neighborhoods that experienced a high amount of gentrification and a large increase in NDVI. These neighborhoods include Berkeley, Whittier, Cole, Montbello. On the contrary, some neighborhoods indicated high levels of Gentrification but ranked low in change in NDVI. Baker and Sunnyside are two neighborhoods that fall into this category.
Based on the maps, there is a basis for a potential connection between the Gentrification Index and the various measures of greenness, but this relationship cannot be fully explained from the maps. The next part of the results aims to better understand this relationship through statistical analysis of the data displayed in the GIS maps.

TABLE 4: CORRELATION FACTOR ANALYSIS

Correlations

Variable		Correlation
Gentrification	NDVI MEAN	0.681
	TOTAL_BUDGET	0.074
	AVG_BUDGET	0.003

Missing value handling: PAIRWISE, INCLUDE. C.I. Level: 95.0

STATISTICAL CORRELATION ANALYSIS

The correlation between the gentrification score, NDVI and average greenness budget was examined using SPSS. The following table shows the correlation factors between these variables.

The correlation analysis shows that the gentrification factor has a positive correlation of 0.681 with the changes in NDVI, suggesting that the changes in the amount of greenness has a strong relationship with the increase in gentrification. This correlation also suggests that in the gentrifying neighborhoods the health of greenness advances because of a better maintenance.

There is a weak positive correlation of 0.074 between gentrification and the total budget spent on projects, indicating a slight tendency for higher gentrification levels to be associated with larger total budgets. However, the correlation with the average budget is almost non-existent at 0.003. The absence of a statistically significant correlation between the greenness budget and gentrification could be attributed to the lag between the implementation of new projects and the onset of gentrification. Additionally, the limited dataset is another factor that may influence this lack of significant association. These findings hint at links between gentrification, vegetation health, and budget allocation, but further investigation is needed to understand the nuances of these relationships.

RESULTS – SUMMARY

The analysis reveals key insights into the dynamics of gentrification, greenness investment, and NDVI changes in Denver neighborhoods from 2010 to 2020. Gentrification scores were aggregated and averaged, identifying the top 25 gentrifying neighborhoods. Greenness investment was mapped, highlighting areas with significant budget allocation. NDVI maps indicated variations in vegetation levels, with neighborhoods like Hilltop showing high NDVI mean values. Correlation analysis indicated a positive relationship between gentrification and NDVI mean, with a weak positive correlation to total budget but almost none with average budget, suggesting complex dynamics requiring further exploration.

DISCUSSION & RESULTS

DISCUSSION:

The intricate relationship between urban greenness, gentrification, and socio-demographic shifts in Denver, Colorado reveals a multi-faceted dynamic that cannot be reduced to a single causal factor. While the connection between gentrification and urban greenness is evident in some cases, it is essential to recognize that gentrification is a complex process influenced by various socio-economic, political, and environmental factors.

The findings of the research suggest that while there is a correlation between gentrification and urban greenness in certain neighborhoods of Denver, there are instances where gentrification occurs without significant changes in greenness. This aligns with previous research indicating that gentrification cannot be attributed solely to one factor, (Anguelovski et al. ,2022). It underscores the importance of considering a range of variables when studying neighborhood change and urban development.

Another important note is that sometimes new developments take away existing green spaces. There are neighborhoods in Denver that showed a decrease in greenness. . The maps indicate that while greenness correlates with gentrifying neighborhoods, it's not always the case. Gentrification is a complex process that can involve other factors and may even take over spaces that were once undeveloped.

The process of gentrification promotes new development which can lead to more buildings and impervious surfaces as neighborhoods take on previously undeveloped land
To further enhance our understanding of gentrification in Denver, future research could explore additional factors beyond greenness, such as housing policies, economic development initiatives, transportation infrastructure, and cultural amenities. Mapping these factors alongside urban greenness could provide a more comprehensive picture of the forces driving neighborhood change in the city. As mentioned in the literature review, many factors contribute to gentrification, and the role of greenness can be understood and proved by analyzing the other factors in each neighborhood.

Moreover, while Denver has implemented initiatives like the N.E.S.T (Neighborhood Equity and Stabilization) program to identify neighborhoods at risk of displacement, there remains a need to ensure that efforts to increase urban greenness are conducted in a way that does not exacerbate existing disparities or further contribute to gentrification. This highlights the importance of adopting equitable planning strategies that prioritize the needs of long-time residents and vulnerable communities. Based on these findings, the city of Denver can coordinate efforts between greenspace and greenness initiatives with gentrification control initiatives, focusing on identifying and safeguarding neighborhoods vulnerable to gentrification.

Additionally, the limitations of the research, such as the narrow focus on a single decade and the need for more robust data collection methods, suggest avenues for further exploration. Future iterations of the study could expand the period and incorporate a more comprehensive set of variables to capture the complexity of gentrification processes. Furthermore, refining the measurement of urban greenness, such as considering factors like access to greenspace in parks and examining the role of private funding in green infrastructure development, could provide a more nuanced understanding of its impact on neighborhood change.
In summary, while the relationship between urban greenness and gentrification in Denver is complex and multifaceted, ongoing research and thoughtful planning efforts can help navigate the challenges and opportunities associated with urban development in the city. By considering a range of factors and prioritizing equity and sustainability, Denver can strive towards a more inclusive and resilient urban future.

CONCLUSION:

The relationship between urban greenness and gentrification in Denver reflects a multi-faceted dynamic influenced by various socio-economic and environmental factors. While the presence of green spaces may contribute to gentrification in certain neighborhoods, it's crucial to recognize that gentrification is a complex phenomenon driven by a confluence of factors such as economic investment, infrastructure development, and cultural shifts. Expanding the scope of research to include other causes of gentrification beyond greenness would provide a more comprehensive understanding of the interplay between different forces shaping Denver's neighborhoods.
Factors such as transportation accessibility, job opportunities, and housing policies may also play significant roles in driving gentrification trends.
Furthermore, while initiatives like the Game Plan for a Healthy City demonstrate a commitment to addressing the lack of green spaces, there is a need to ensure that these efforts are implemented equitably. It is essential to consider the potential impact of green infrastructure projects on existing residents, particularly those in vulnerable communities who may face displacement or exclusion because of gentrification.

In addition to mapping neighborhoods at risk through programs like N.E.S.T, efforts should be made to actively involve local communities in the planning and development of green spaces. Community-driven initiatives can help ensure that green infrastructure projects are tailored to the specific needs and preferences of residents, fostering a sense of ownership, and promoting social cohesion.

As the research highlights the limitations of focusing solely on a decade's worth of data, future studies could benefit from a longitudinal approach that examines gentrification and urban greenness trends over an extended period. This longitudinal perspective would enable researchers to identify long-term patterns and better understand the evolving dynamics of gentrification in Denver. The definition and measurement of urban greenness could be refined to capture a more nuanced understanding of access to green spaces. This could include assessing factors such as the quality and accessibility of parks, the distribution of green infrastructure investments, and the presence of community gardens or urban forests.

Overall, the discussion underscores the need for a comprehensive approach to urban development that prioritizes both environmental sustainability and social equity. By addressing the challenges posed by gentrification while harnessing the benefits of urban greenness, cities like Denver can create vibrant, inclusive communities that thrive in the face of rapid urbanization and climate change.
This project aims to address the challenge of juggling introducing greenness to benefit residents and the environment while not displacing long term residents. The objectives are to examine local relationships between urban greenness and gentrification within Denver and NDVI, connect to gentrification in Denver's neighborhoods over the past decade?
The research looks to build off existing research and initiatives that Denver is prioritizing. Two of these initiatives include The Parks and Recreation: Game Plan and Denver's Neighborhood Equity (with the goal of implementing greenness in Denver) & Stabilization program aiming at protecting neighborhoods at risk of displacement.
The research is conducted by examining the relationship of urban greenness and gentrification patterns of Denver's neighborhoods through the lenses of GIS (Geographic Information Systems) and statistical analysis. The urban greenness in this research has been characterized in the form of public green projects and normalized difference vegetation index ("NDVI"). This project will add more insight into the existing relationship between gentrification and greenness while hoping to highlight the challenges and solutions to implementing green space in the context of Denver, CO

APPENDIX

	NBHD_NAME	ACS_2010_HOME_VALUE	ACS_2020_HOME_VALUE	PER_CHANGE	INDEX SCORE
66	University Park	$ 539,750.00	$ 641,350.00	18.8	1
7	Belcaro	$ 681,900.00	$ 847,900.00	24.3	2
59	Speer	$ 336,166.67	$ 427,650.00	27.2	3
42	Lowry Field	$ 454,800.00	$ 606,900.00	33.4	4
13	Cherry Creek	$ 605,400.00	$ 818,900.00	35.3	5
47	North Capitol Hill	$ 312,350.00	$ 424,400.00	35.9	6
78	Windsor	$ 181,700.00	$ 249,450.00	37.3	7
58	Southmoor Park	$ 384,200.00	$ 528,300.00	37.5	8
37	Hilltop	$ 650,350.00	$ 904,500.00	39.1	9
70	Washington Park	$ 539,400.00	$ 752,500.00	39.5	10
44	Marston	$ 254,800.00	$ 355,467.00	39.5	11
46	Montclair	$ 348,100.00	$ 495,350.00	42.3	12
73	Wellshire	$ 503,400.00	$ 724,600.00	43.9	13
38	Indian Creek	$ 195,100.00	$ 283,000.00	45.1	14
60	Central Park	$ 416,050.00	$ 607,417.00	46.0	15
3	Baker	$ 302,000.00	$ 445,900.00	47.6	16
71	Washington Park W	$ 416,200.00	$ 619,200.00	48.8	17
63	Union Station	$ 472,000.00	$ 703,600.00	49.1	18
27	Fort Logan	$ 284,200.00	$ 430,200.00	51.4	19
12	Cheesman Park	$ 256,350.00	$ 389,667.00	52.0	20
20	Congress Park	$ 417,200.00	$ 637,567.00	52.8	21
69	Virginia Village	$ 274,075.00	$ 419,225.00	53.0	22
6	Bear Valley	$ 238,500.00	$ 368,800.00	54.6	23
77	Whittier	$ 307,000.00	$ 479,700.00	56.3	24
33	Hampden South	$ 293,300.00	$ 463,500.00	58.0	25
57	South Park Hill	$ 436,200.00	$ 690,200.00	58.2	26
35	Harvey Park South	$ 220,100.00	$ 348,500.00	58.3	27
51	Platt Park	$ 391,900.00	$ 629,250.00	60.6	28
22	Country Club	$ 729,600.00	$ 1,178,200.00	61.5	29
72	Washington Virginia	$ 266,166.67	$ 431,575.00	62.1	30
32	Hampden	$ 223,500.00	$ 362,960.00	62.4	31
64	University	$ 342,000.00	$ 557,100.00	62.9	32
31	Hale	$ 322,850.00	$ 530,933.00	64.5	33
48	North Park Hill	$ 304,150.00	$ 500,250.00	64.5	34
75	West Highland	$ 348,300.00	$ 581,950.00	67.1	35
28	Gateway - Green Va	$ 190,850.00	$ 319,625.00	67.5	36
9	Capitol Hill	$ 230,733.33	$ 394,433.00	70.9	37
36	Highland	$ 323,500.00	$ 557,333.00	72.3	38
65	University Hills	$ 241,100.00	$ 416,200.00	72.6	39
53	Rosedale	$ 317,400.00	$ 548,100.00	72.7	40
56	Sloan Lake	$ 341,950.00	$ 593,133.00	73.5	41
26	Five Points	$ 303,800.00	$ 528,767.00	74.1	42
30	Goldsmith	$ 273,800.00	$ 480,500.00	75.5	43

NBHD_ID	NBHD_NAME	2010_POC_PER	2020_POC_PER	PER CHANGE	RANKING
7	Belcaro	5.2	15.6	200.55	1
73	Wellshire	6.5	19.2	197.15	2
53	Rosedale	12.8	29.3	128.96	3
37	Hilltop	11.3	22.5	98.37	4
13	Cherry Creek	10.1	15.4	52.07	5
66	University Park	18.8	28.2	50.33	6
16	Civic Center	17.6	26.2	49.35	7
58	Southmoor Park	10.0	14.3	42.58	8
51	Platt Park	13.6	19.1	40.27	9
46	Montclair	20.2	26.9	33.33	10
9	Capitol Hill	20.2	24.9	23.00	11
59	Speer	14.9	17.6	18.08	12
23	DIA	62.7	72.3	15.34	13
47	North Capitol Hill	21.8	24.9	14.21	14
42	Lowry Field	27.5	31.4	14.09	15
10	CBD	26.5	30.2	13.78	16
41	Lincoln Park	53.9	60.3	11.72	17
21	Cory - Merrill	13.8	15.0	8.79	18
19	College View - South Pla	80.8	87.3	8.03	19
71	Washington Park West	13.6	14.6	7.76	20
38	Indian Creek	32.7	35.2	7.75	21
72	Washington Virginia Vale	39.7	42.3	6.72	22
75	West Highland	21.3	22.7	6.69	23
20	Congress Park	17.9	18.9	5.44	24
5	Barnum West	76.2	79.1	3.85	25
78	Windsor	46.0	47.7	3.77	26
48	North Park Hill	47.6	49.3	3.48	27
52	Regis	38.3	39.5	3.07	28
28	Gateway - Green Valley F	77.6	80.0	3.02	29
67	Valverde	85.3	87.1	2.02	30
45	Montbello	89.6	90.9	1.46	31
65	University Hills	21.5	21.8	1.39	32
76	Westwood	88.6	89.8	1.31	33
33	Hampden South	28.6	28.9	1.12	34
57	South Park Hill	25.5	25.7	0.86	35
24	East Colfax	63.1	63.4	0.63	36
26	Five Points	35.7	35.9	0.39	37
44	Marston	30.2	30.3	0.29	38
25	Elyria Swansea	87.9	87.4	-0.54	39
35	Harvey Park South	59.5	58.7	-1.31	40
43	Mar Lee	77.1	75.7	-1.88	41
63	Union Station	17.4	16.9	-2.81	42
64	University	21.5	20.8	-3.26	43
32	Hampden	35.0	33.7	-3.65	44
54	Ruby Hill	78.7	75.7	-3.78	45
60	Central Park	28.9	26.9	-7.10	46
17	Clayton	75.4	69.9	-7.29	47
4	Barnum	82.7	75.2	-9.09	48
49	Northeast Park Hill	82.2	74.4	-9.47	49
29	Globeville	72.5	64.8	-10.61	50
14	City Park	22.1	19.8	-10.70	51
31	Hale	26.5	23.6	-10.76	52
69	Virginia Village	30.9	27.5	-10.92	53
77	Whittier	53.4	47.5	-11.04	54
15	City Park West	36.7	32.5	-11.44	55
34	Harvey Park	68.9	60.8	-11.66	56
1	Athmar Park	77.9	68.8	-11.74	57
70	Washington Park	10.9	9.6	-12.08	58
62	Sunnyside	61.0	53.0	-13.02	59
55	Skyland	57.8	49.3	-14.67	60
8	Berkeley	34.3	29.0	-15.58	61
11	Chaffee Park	63.3	52.8	-16.59	62
27	Fort Logan	42.2	34.7	-17.92	63
18	Cole	72.7	59.5	-18.13	64
12	Cheesman Park	16.6	13.6	-18.18	65
30	Goldsmith	45.3	35.7	-21.17	66
22	Country Club	9.3	7.1	-23.31	67
6	Bear Valley	53.7	41.1	-23.52	68
74	West Colfax	63.9	48.1	-24.68	69
3	Baker	47.9	34.5	-27.97	70
36	Highland	33.6	23.5	-30.06	71
56	Sloan Lake	40.4	26.6	-34.17	72
39	Jefferson Park	60.3	35.2	-41.54	73
50	Overland	43.6	25.1	-42.42	74

NBHD_ID	NBHD_NAME	ACS_2010_HOME_VALUE	ACS_2020_HOME_VALUE	PER_CHANGE	INDEX SCORE
66	University Park	$ 539,750.00	$ 641,350.00	18.8	1
7	Belcaro	$ 681,900.00	$ 847,900.00	24.3	2
59	Speer	$ 336,166.67	$ 427,650.00	27.2	3
42	Lowry Field	$ 454,800.00	$ 606,900.00	33.4	4
13	Cherry Creek	$ 605,400.00	$ 818,900.00	35.3	5
47	North Capitol Hill	$ 312,350.00	$ 424,400.00	35.9	6
78	Windsor	$ 181,700.00	$ 249,450.00	37.3	7
58	Southmoor Park	$ 384,200.00	$ 528,300.00	37.5	8
37	Hilltop	$ 650,350.00	$ 904,500.00	39.1	9
70	Washington Park	$ 539,400.00	$ 752,500.00	39.5	10
44	Marston	$ 254,800.00	$ 355,467.00	39.5	11
46	Montclair	$ 348,100.00	$ 495,350.00	42.3	12
73	Wellshire	$ 503,400.00	$ 724,600.00	43.9	13
38	Indian Creek	$ 195,100.00	$ 283,000.00	45.1	14
60	Central Park	$ 416,050.00	$ 607,417.00	46.0	15
3	Baker	$ 302,000.00	$ 445,900.00	47.6	16
71	Washington Park W	$ 416,200.00	$ 619,200.00	48.8	17
63	Union Station	$ 472,000.00	$ 703,600.00	49.1	18
27	Fort Logan	$ 284,200.00	$ 430,200.00	51.4	19
12	Cheesman Park	$ 256,350.00	$ 389,667.00	52.0	20
20	Congress Park	$ 417,200.00	$ 637,567.00	52.8	21
69	Virginia Village	$ 274,075.00	$ 419,225.00	53.0	22
6	Bear Valley	$ 238,500.00	$ 368,800.00	54.6	23
77	Whittier	$ 307,000.00	$ 479,700.00	56.3	24
33	Hampden South	$ 293,300.00	$ 463,500.00	58.0	25
57	South Park Hill	$ 436,200.00	$ 690,200.00	58.2	26
35	Harvey Park South	$ 220,100.00	$ 348,500.00	58.3	27
51	Platt Park	$ 391,900.00	$ 629,250.00	60.6	28
22	Country Club	$ 729,600.00	$ 1,178,200.00	61.5	29
72	Washington Virginia	$ 266,166.67	$ 431,575.00	62.1	30
32	Hampden	$ 223,500.00	$ 362,960.00	62.4	31
64	University	$ 342,000.00	$ 557,100.00	62.9	32
31	Hale	$ 322,850.00	$ 530,933.00	64.5	33
48	North Park Hill	$ 304,150.00	$ 500,250.00	64.5	34
75	West Highland	$ 348,300.00	$ 581,950.00	67.1	35
28	Gateway - Green Va	$ 190,850.00	$ 319,625.00	67.5	36
9	Capitol Hill	$ 230,733.33	$ 394,433.00	70.9	37
36	Highland	$ 323,500.00	$ 557,333.00	72.3	38
65	University Hills	$ 241,100.00	$ 416,200.00	72.6	39
53	Rosedale	$ 317,400.00	$ 548,100.00	72.7	40
56	Sloan Lake	$ 341,950.00	$ 593,133.00	73.5	41
26	Five Points	$ 303,800.00	$ 528,767.00	74.1	42
30	Goldsmith	$ 273,800.00	$ 480,500.00	75.5	43

NBHD_ID	NEIGHBORHOOD	GENTRIFICATION SCORE	RANKING
74	West Colfax	70	1
39	Jefferson Park	69.5	2
8	Berkeley	60.75	3
18	Cole	60.5	4
30	Goldsmith	60.5	5
62	Sunnyside	59.5	6
3	Baker	56.75	7
29	Globeville	54.75	8
19	College View - South Platte	53.5	9
36	Highland	53.25	10
49	Northeast Park Hill	53	11
50	Overland	52.5	12
41	Lincoln Park	50.75	13
56	Sloan Lake	50	14
32	Hampden	49.5	15
54	Ruby Hill	49.5	16
15	City Park West	49.25	17
68	Villa Park	48.75	18
10	CBD	48.5	19
22	Country Club	48.5	20
26	Five Points	48.5	21
25	Elyria Swansea	48.25	22
48	North Park Hill	48	23
70	Washington Park	47	24
4	Barnum	46.75	25
64	University	46.25	26
24	East Colfax	45	27
34	Harvey Park	44.75	28
55	Skyland	44.25	29
65	University Hills	43.5	30
12	Cheesman Park	42	31
17	Clayton	42	32
1	Athmar Park	40.5	33
69	Virginia Village	40.25	34
52	Regis	39.5	35
27	Fort Logan	38.75	36
76	Westwood	38.75	37
9	Capitol Hill	38.5	38
51	Platt Park	37.25	39
45	Montbello	37	40
77	Whittier	36.5	41
11	Chaffee Park	34	42
14	City Park	34	43

NBHD_ID	NBHD_NAME	2010_POC_PER	2020_POC_PER	PER CHANGE	RANKING
7	Belcaro	5.2	15.6	200.55	1
73	Wellshire	6.5	19.2	197.15	2
53	Rosedale	12.8	29.3	128.96	3
37	Hilltop	11.3	22.5	98.37	4
13	Cherry Creek	10.1	15.4	52.07	5
66	University Park	18.8	28.2	50.33	6
16	Civic Center	17.6	26.2	49.35	7
58	Southmoor Park	10.0	14.3	42.58	8
51	Platt Park	13.6	19.1	40.27	9
46	Montclair	20.2	26.9	33.33	10
9	Capitol Hill	20.2	24.9	23.00	11
59	Speer	14.9	17.6	18.08	12
23	DIA	62.7	72.3	15.34	13
47	North Capitol Hill	21.8	24.9	14.21	14
42	Lowry Field	27.5	31.4	14.09	15
10	CBD	26.5	30.2	13.78	16
41	Lincoln Park	53.9	60.3	11.72	17
21	Cory - Merrill	13.8	15.0	8.79	18
19	College View - South Pla	80.8	87.3	8.03	19
71	Washington Park West	13.6	14.6	7.76	20
38	Indian Creek	32.7	35.2	7.75	21
72	Washington Virginia Vale	39.7	42.3	6.72	22
75	West Highland	21.3	22.7	6.69	23
20	Congress Park	17.9	18.9	5.44	24
5	Barnum West	76.2	79.1	3.85	25
78	Windsor	46.0	47.7	3.77	26
48	North Park Hill	47.6	49.3	3.48	27
52	Regis	38.3	39.5	3.07	28
28	Gateway - Green Valley F	77.6	80.0	3.02	29
67	Valverde	85.3	87.1	2.02	30
45	Montbello	89.6	90.9	1.46	31
65	University Hills	21.5	21.8	1.39	32
76	Westwood	88.6	89.8	1.31	33
33	Hampden South	28.6	28.9	1.12	34
57	South Park Hill	25.5	25.7	0.86	35
24	East Colfax	63.1	63.4	0.63	36
26	Five Points	35.7	35.9	0.39	37
44	Marston	30.2	30.3	0.29	38
25	Elyria Swansea	87.9	87.4	-0.54	39
35	Harvey Park South	59.5	58.7	-1.31	40
43	Mar Lee	77.1	75.7	-1.88	41
63	Union Station	17.4	16.9	-2.81	42
64	University	21.5	20.8	-3.26	43
32	Hampden	35.0	33.7	-3.65	44
54	Ruby Hill	78.7	75.7	-3.78	45
60	Central Park	28.9	26.9	-7.10	46
17	Clayton	75.4	69.9	-7.29	47
4	Barnum	82.7	75.2	-9.09	48
49	Northeast Park Hill	82.2	74.4	-9.47	49
29	Globeville	72.5	64.8	-10.61	50
14	City Park	22.1	19.8	-10.70	51
31	Hale	26.5	23.6	-10.76	52
69	Virginia Village	30.9	27.5	-10.92	53
77	Whittier	53.4	47.5	-11.04	54
15	City Park West	36.7	32.5	-11.44	55
34	Harvey Park	68.9	60.8	-11.66	56
1	Athmar Park	77.9	68.8	-11.74	57
70	Washington Park	10.9	9.6	-12.08	58
62	Sunnyside	61.0	53.0	-13.02	59
55	Skyland	57.8	49.3	-14.67	60
8	Berkeley	34.3	29.0	-15.58	61
11	Chaffee Park	63.3	52.8	-16.59	62
27	Fort Logan	42.2	34.7	-17.92	63
18	Cole	72.7	59.5	-18.13	64
12	Cheesman Park	16.6	13.6	-18.18	65
30	Goldsmith	45.3	35.7	-21.17	66
22	Country Club	9.3	7.1	-23.31	67
6	Bear Valley	53.7	41.1	-23.52	68
74	West Colfax	63.9	48.1	-24.68	69
3	Baker	47.9	34.5	-27.97	70
36	Highland	33.6	23.5	-30.06	71
56	Sloan Lake	40.4	26.6	-34.17	72
39	Jefferson Park	60.3	35.2	-41.54	73
50	Overland	43.6	25.1	-42.42	74

SPSS DATA TABLE

BHD_ID	NBHD_NAME	G_INDEX	PERCENT_CHANGE	TOTAL_BUDGET	AVG_BUDGET
1	Athmar Park	27.2	5	$8,081,601.19	$1,154,514.
2	Auraria	0	19	$9,028,000.00	$3,009,333.
3	Baker	18	18	$304,156.50	$76,039.
4	Barnum	19.2	96	$7,177,697.99	$897,212.
5	Barnum West	60.2	50	0	
6	Bear Valley	40.6	82	$2,247,821.36	$749,273.
7	Belcaro	73	90	$0.00	$0.
8	Berkeley	18.8	186	$14,094,345.13	$1,761,793.
9	Capitol Hill	41.2	51	$275,000.00	$275,000.
10	CBD	32.8	4	$52,394.17	$52,394.
11	Chaffee Park	34.2	-35	0	
12	Cheesman Park	37.4	181	$7,293,014.97	$1,041,859.
13	Cherry Creek	51	92	$494,266.29	$123,566.
14	City Park	41.6	103	$69,054,065.13	$1,468,595.
15	City Park West	27.8	131	0	
16	Civic Center	49.4	25	$10,900,248.00	$1,090,024.
17	Clayton	26.4	113	$28,950,593.07	$5,790,118.
18	Cole	10.4	91	$50,000.00	$50,000.
19	College View - Sou	37.2	367	$9,178,055.08	$2,294,513.
20	Congress Park	54.2	137	$11,189,673.16	$2,237,934.
21	Cory - Merrill	45.8	103	0	
22	Country Club	34.4	98	0	
23	DIA	58	84	$300,000.00	$300,000.
24	East Colfax	39.4	33	$10,975,000.00	$2,195,000.
25	Elyria Swansea	27	47	$11,386,610.99	$1,626,658.
26	Five Points	25.4	29	$25,399,654.34	$1,693,310.
27	Fort Logan	34.8	32	$1,073,590.00	$536,795.
28	Gateway - Green V.	60.6		$80,707,793.98	$5,044,236.
29	Globeville	15.4	46	$5,836,729.03	$833,818.
30	Goldsmith	17.2	1423	0	
31	Hale	49.4	96	$132,163.09	$66,081.
32	Hampden	30.2	103	$53,808,067.87	$1,681,502.
33	Hampden South	50.6	95	$2,623,735.25	$437,289.
34	Harvey Park	25.6	130	$990,000.00	$495,000.
35	Harvey Park South	52.2	65	$394,547.00	$197,273.
36	Highland	23.8	-91	$52,547.00	$26,273.
37	Hilltop	54.4	56	$3,233,327.00	$808,331.
38	Indian Creek	51	109	$225,000.00	$225,000.
39	Jefferson Park	4.6		$241,156.00	$241,156.
40	Kennedy		34	$1,155,662.41	$128,406.
41	Lincoln Park	36.4	1	$2,203,515.00	$314,787.
42	Lowry Field	59	92	$2,130,327.00	$266,290.
43	Mar Lee	41.2	73	$1,009,820.00	$252,455.
44	Marston	50.2	21	$4,000,000.00	$1,000,000.
45	Montbello	35.6	194	$2,056,796.14	$2,056,796.
46	Montclair	57.8	59	$600,327.00	$600,327.
47	North Capitol Hill	47.6	27	$725,750.00	$725,750.
48	North Park Hill	30.8	45	$63,597.44	$63,597.
49	Northeast Park Hill	14	66	$3,751,224.00	$416,802.
50	Overland	21.2	63	$17,444,156.62	$2,492,022.

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