The Hidden Potential of Denver's Industrial Spaces to Address Environmental Inequity

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Abstract

Lower-income communities, and communities of color face several disadvantages in terms of access to greenspace and proximity to hazardous industrial facilities, a phenomenon termed 'environmental inequity'. However, there has not been significant research into codified landscape standards and policies in city zoning ordinances that may allow, or even perpetuate, this relationship. In order to address this, research was conducted into the makeup of Denver in terms of race, ethnicity, income, zone district, and land cover, followed by a thorough analysis of the city zoning ordinance. Proportions of zone district type and land cover were measured in several study areas, comparing the measure of these metrics by race/ethnicity and median household income in Denver. Applicable landscape standards as defined in zoning ordinance were also analyzed for relevant exemptions, particularly within commercial and industrial zones. Findings showed significant differences in zone district and land cover makeup, with lower-income Hispanic/Latino areas displaying disproportionately higher percentages of industrial zones, impervious surfaces, and disproportionately lower percentages of natural land cover such as tree canopy and prairie. These patterns held not only when looking at overall study areas, but also when looking at smaller, quarter-mile buffers around only residential zones in each study area. Results from zoning ordinance analysis show significant exemptions in several sections for industrial uses. Revisions to the zoning ordinance document in identified sections could be hugely beneficial in altering measured land cover. Increasing standards for metrics such as greenspace and natural land cover on industrial sites has the potential to begin to alleviate environmental inequity experienced by Denver's lower-income and Hispanic/Latino communities.

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1. Introduction

When I began conducting research that looked into the relationship between race/ethnicity and environmental inequity in Denver, I thought that it was only the principle of injustice that motivated me. I felt that it was wrong that Hispanic/Latino communities were located so close to industry, and the mere idea of it was what pushed me to conduct this research. However, as I began to think about it more, I realized that wasn't true at all. I had observed this relationship firsthand, and the experiences I had as a child in Denver and the surrounding area shaped the passion I have for studying environmental inequity.

My experience in Denver began visiting my grandparents and my other family members when I still lived in an affluent, majority-white suburban subdivision in Minnesota. I loved visiting them, and when my mother moved my family to Colorado, we were there all the time—holidays, birthdays, days home sick from school. But I knew that as much as my mother, brother, sister, and I loved spending time there, our family wasn't going to live there too.

What I was observing as a child was the result of environmental inequity. My grandparents and extended family lived sandwiched between an oil refinery, freight trucking facilities, and the Rocky Mountain Arsenal Superfund site in Commerce City, Colorado. I knew that I didn't like that area, and I preferred my suburban house in Minnesota, with the creek flowing through its backyard. At that point, I wasn't aware of the relationship I was observing. I was even less aware of *why* this phenomenon occurred.

I was experiencing at that moment the relationship that I had inadvertently found myself studying. Why was it that communities of color and low income communities had so much less in terms of greenspace and natural areas, and so much more in terms of exposure to industrial facilities? I knew as a child was I was viewing didn't make sense, and it certainly wasn't fair. I love my family more than anything, and it isn't fair that their neighborhood should look so different from any other.

Once I came around and realized that the inequity I was studying was so personal and formative for me, I began to look desperately for a solution. A true fix-all would be to re-site industry away from any residences to reduce exposure. Despite the fact that doing so is nearly physically impossible for a myriad of reasons—it would take years or decades to accomplish just the physical task of moving all of these structures and their various components—there comes the issues of proximity. When an industrial site is a person's place of work, does it not make more sense for them to be closer? This, after all, eases the burden of commuting, and the related one of finding public transportation or using bike lanes to get to work (both of which are horribly underrepresented in low income communities of color, but that is quite literally another section altogether). Not to mention, if industry were simply moved, the property values of these areas would rise accordingly. A similar process would occur with the addition of more parks and greenspaces in the area (Wolch et al., 2014).

So, if we cannot fix the problem of location itself, or remedy the lack of greenspace with additional public spaces without inadvertently pushing out the residents we had so hoped to help. Therefore, we return to the question, what can actually be done about it? The answer I present does not come close to solving the systemic problems facing low income communities of color. Answers there come in the form of sweeping reforms, deep analysis of ingrained bias in the way we govern and plan. Essentially, every way we currently operate our society would need to change at some scale. Instead, the solution could be very small, a leverage-point at the systems scale. A simple change in wording and requirements for policies applicable to all built spaces could have far-reaching effects for low-income communities of color.

2. Background

Historic, Political, and Economic Factors Affecting Underserved Communities in Denver

The disparity in proximity to natural areas between affluent and under-served communities is a reflection of systematic discrimination on the basis of race, ethnicity, and economic status. Institutionalized bias has become deeply ingrained in urban planning (Stafford and Ladner, 2007), often accompanied by exploiting non-white ethnic groups, as well as socioeconomically disadvantaged white populations (Hayden, 2014). The removal of indigenous peoples from their ancestral lands is one of the earliest and most culturally significant factors in the historic exclusion and exploitation of ethnic groups in the process of creating urban settlements in the United States (Sandercock, 1998). the history of discrimination in the United States can be linked to the development of nearly all urban areas in both architectural and spatial arrangement (Sandercock, 1998)
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Industrial Growth in Globeville and Elyria-Swansea

Denver's urban development, especially that of its economy, is closely tied to the exploitation of its most economically disadvantaged residents. An area of Denver that has long been home to communities of color and low-income households, the Globeville and Elyria-Swansea neighborhoods (Fig. 2.1) clearly present this pattern of development. A few decades after Denver's incorporation in 1858, the South Platte river area that is now home to Globeville and Elyria-Swansea emerged as an ideal location for industrial development, thanks to its flat landform and proximity to waterways. During the 1880s, this area north of central Denver became home to a multitude of smelting operations, as well as meat packing and processing plants (Conservation Colorado, 2020). The smelters were eventually conglomerated under ASARCO (American Smelting and Refining Company). Individuals and families that migrated from rural Colorado for job opportunities in developing industries in Denver often found themselves living near these sites, taking advantage of cheaper employee housing offered by the companies they came to work for. These working families and individuals were often Hispanic/Latino, presenting one of the first major cases of communities of color living in environmentally hazardous conditions.

Globeville and Elyria-Swansea

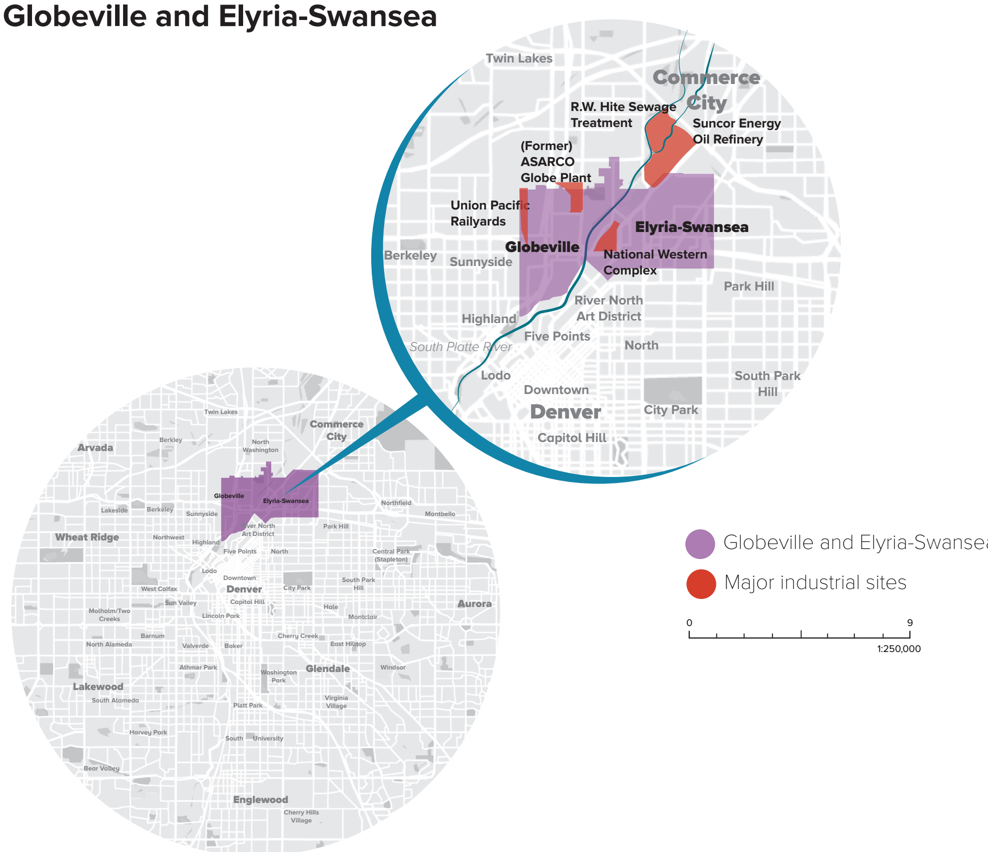


Fig. 2.1 Globeville and Elyria-Swansea neighborhoods along the South Platte River and important historic and/or current adjacent industrial sites.

Near the turn of the 19th century, the South Platte area (referenced in Fig. 2.1) experienced a shift from primarily smelting operations to agricultural industry (Conservation Colorado, 2020). Labor strikes and related damage to one of the major smelting/refining plants in the area caused its closure and eventual demolition. (Conservation Colorado, 2020), although most heavy refining maintained continuous operation. The first stock show, held at Denver Union Stockyards, ushered in the agricultural industry's presence and was followed shortly thereafter by the expansion of the now-National Western Complex (Historic Denver, 2021). The location of livestock in this area further diminished desire to live in the area, as the odor from stockyards was especially potent in decreasing values. Lenders deemed the stockyards a 'detrimental influence' (Denver Public Library, Western History and Genealogy Department, 2015), and these areas were later redlined. Low-income families living in the area at the time suffered from degrees of economic immobility as a result of their low property value, leaving them unable to escape the increasingly polluted area. Major projects were also being completed in the urban center of Denver during the late 1800s and early 1900s. These projects were large flagship parks many of which are still notable today, including Washington Park, City Park, and Cheesman Park (Rigolon and Nemeth, 2018). These projects reinforced the investment of economic resources into highly prestigious, white-owned properties in the city center, in stark contrast to the industrial development occurring in communities of color at the city's edge.

To make matters worse for those living in the Globeville Elyria-Swansea area, the locally-infamous Purina factory was built in 1930. For those living in these towns, their neighborhood was now not only dominated by heavy metal refining and livestock, but a massive and markedly pungent pet-food factory. The proximity of this neighborhood populated largely by people of color and lower-income households to undesirable and dangerous facilities was now, quite literally, cemented.

Timeline of Events and Historic Changes in Denver

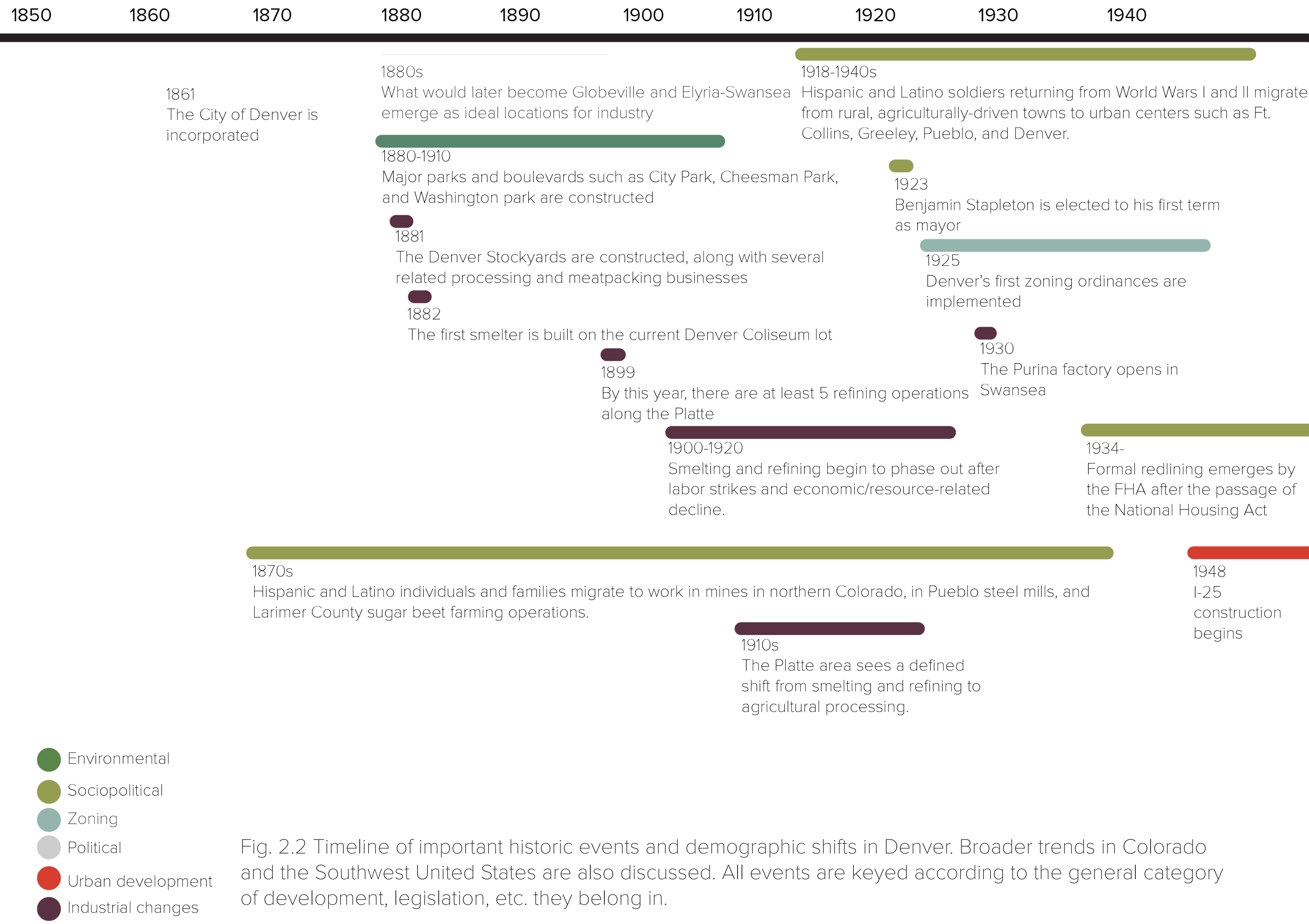
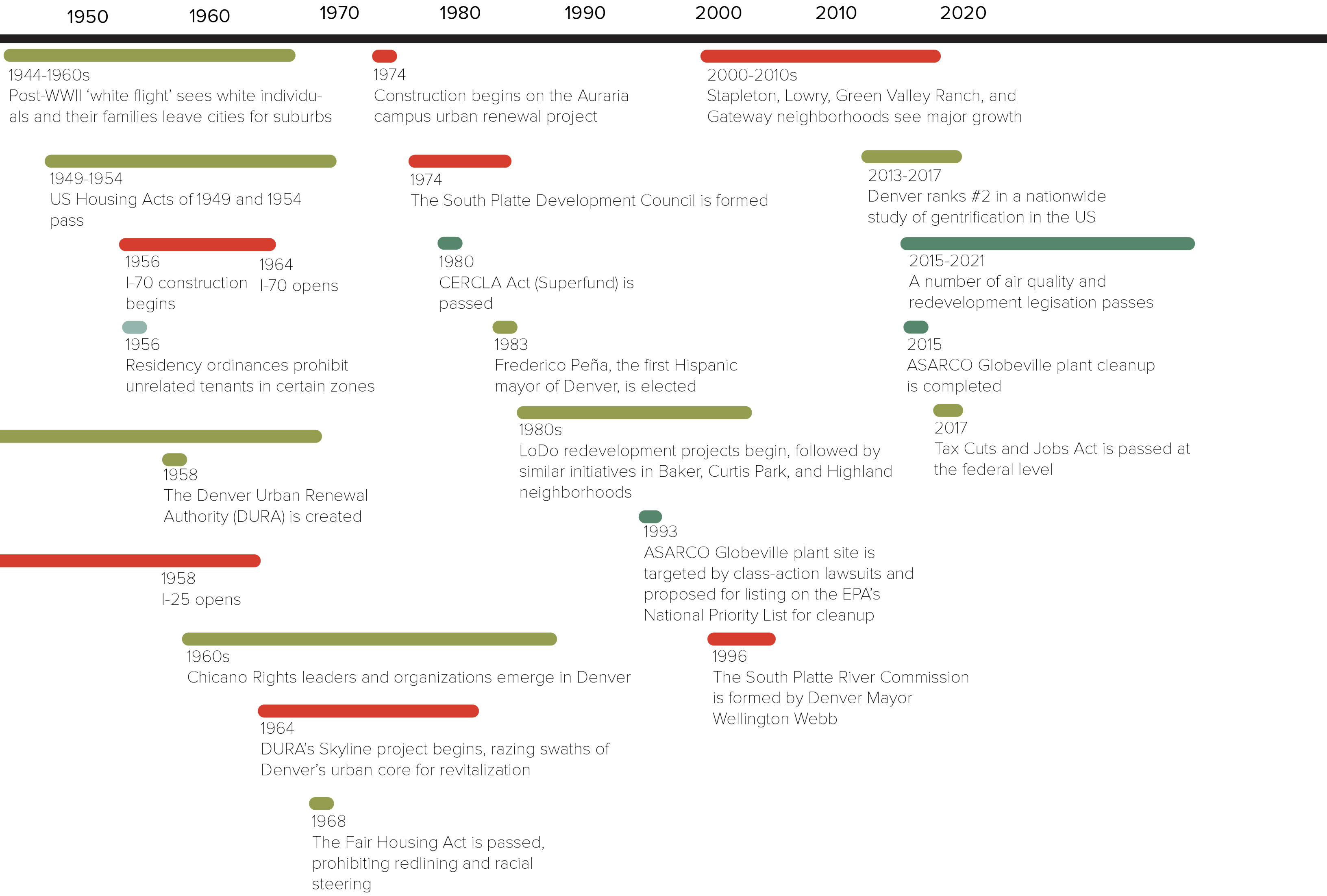


Fig. 2.2 Timeline of important historic events and demographic shifts in Denver. Broader trends in Colorado and the Southwest United States are also discussed. All events are keyed according to the general category of development, legislation, etc. they belong in.

Emerging Demographic and Sociopolitical Trends

Post-WWII, people of color continued to migrate from rural towns to urban centers in Colorado, such as Ft. Collins, Greeley, Pueblo, and Denver. Concurrent migration by white families to suburbs, "white flight", saw decreases in tax revenue in the city that made investments in parks or greenspaces in these area somewhat unfeasible (Leonard and Noel, 1990). White and affluent populations left the cities to live in less-polluted, newer neighborhoods farther from the city, made accessible by personal automobiles (Rigolon and Nemeth, 2018). The construction and eventual opening of Interstate Highways Interstate 25 (I-25) and Interstate 70 (I-70) negatively impacted these nearby communities as the main highway corridors ran directly through the neighborhoods in the South Platte area, introducing more intensive construction and heavy traffic. Highways have historically been observed to negatively impact communities of color, and it is argued by some at



the construction of highways in American cities served to reinforce racial boundaries (Karas, 2015).

During this era, several discriminatory housing practices common in American cities were also underway in Denver. One of these practices was discriminatory lending on mortgages and homeowner's insurance policies that resulted in the exclusion of minority homeowners from predominantly white suburbs. This practice, known best as redlining, kept people of color from moving to suburbs in the same way that their white counterparts were (Report #9, Summary, Re-survey of Denver, Colorado by the Division of Research & Statistics). Fig 2.3 shows Denver's lending districts as they were defined in 1938. Redlining served to widen the separation of minority groups in American cities (Hillier, 2003). Racial steering— the practice in which real estate brokers guided home-buyers toward or away from prospective neighborhoods based on their race or ethnicity, was made illegal in 1968 by the Fair Housing Act, but was still largely practiced in Denver before that date and continued to some

Redlining in Denver

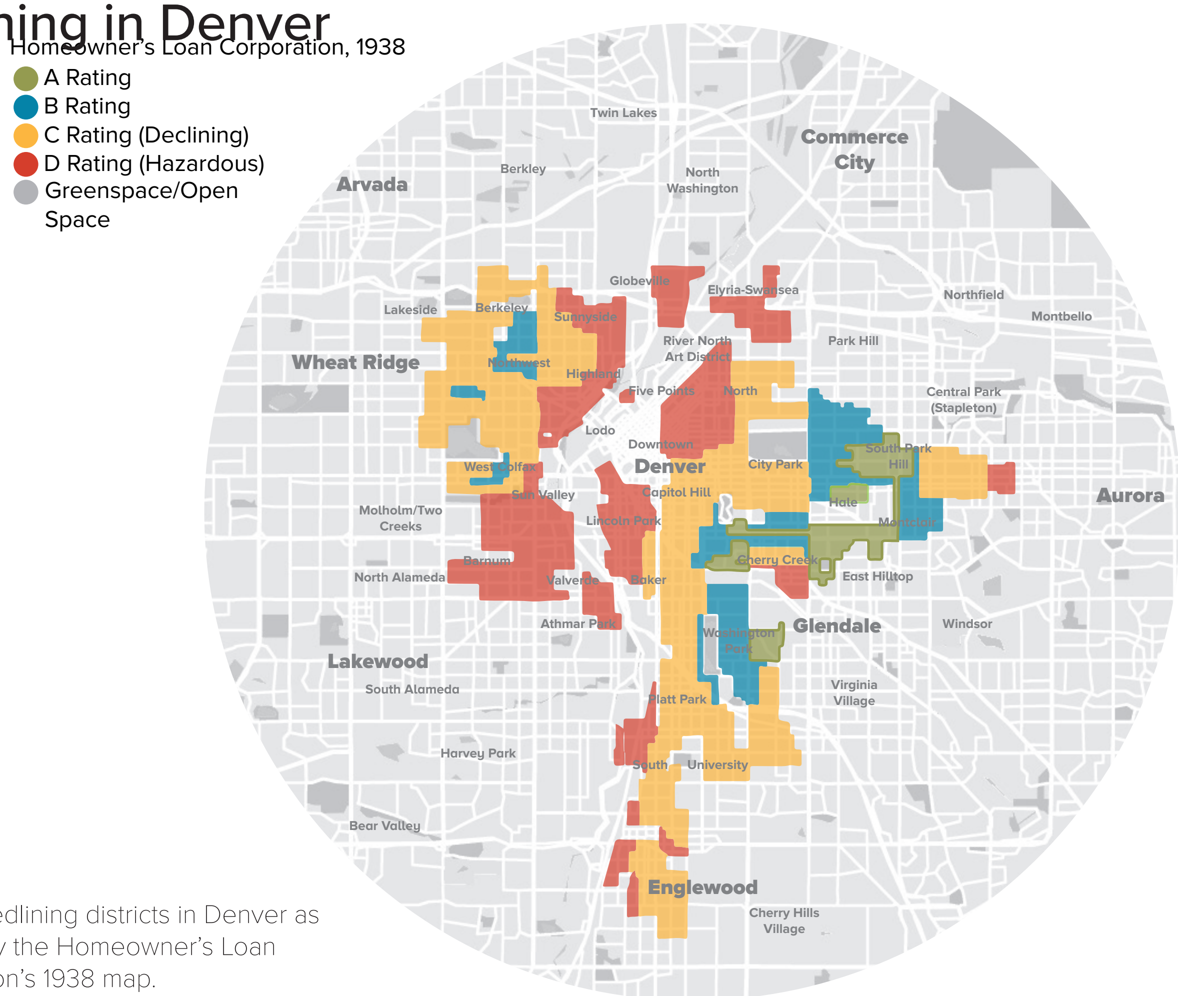


Fig. 2.3 Redlining districts in Denver as defined by the Homeowner's Loan Corporation's 1938 map.

degree after (Rigolon and Nemeth, 2018) With the movement of affluent white residents to suburbs, people of color were able to move in some numbers back to cities, taking advantage of available real estate in the city further from industrial areas (Rigolon and Nemeth, 2018). This increased their proximity to moderately sized parks somewhat, but living near large flagship parks such as City Park, Washington Park, and Cheesman Park was still out of economic reach.

Efforts were made starting in the 1960s to improve rights and living conditions for people of color in Denver. The emergence of Chicano Rights leaders and organizations in the area such as Corky Gonzales and The Crusade for Justice presented opportunities for Hispanic and Latino people to gain visibility in political office, eventually resulting in the election of Denver's first Hispanic mayor, Frederico Peña in 1983. This was especially notable, given that communities of color are generally represented less in their respective local and regional governments (Bird, 2005).

Legislation during the late 20th century sought to remedy the environmental damage caused by industrial operations nationwide. The CERCLA Act (Comprehensive Environmental Response, Compensation, and Liability Act) in 1980 formed the Superfund program in order to remediate environmental hazards in the United States. The act made way for the growing environmental justice movement and further legislation addressing these hazards, such as the EPA National Priority List (NPL) in 1983, designating several hundred sites in the US that would qualify for long-term actions funded by the Superfund program. As of February 2021, there are over 200 Superfund sites in Colorado, with sites in Denver listed on the NPL. The ASARCO Globe plant in Globeville was proposed for this list in 1993 for cleanup. Residents of Globeville and the Colorado Department of Public Health and Environment filed lawsuits against ASARCO in this year, and were ultimately successful. ASARCO was issued a $28 million dollar fine, and tasked with a cleanup of the site and adjacent area that lasted until 2015.

Urbanization and Gentrification

The latter half of the 20th century in Denver saw efforts to prioritize urban renewal, with numerous projects initiated that attempted to 'clean up' areas that had up until that point been considered a detriment, a process that was occurring in many American cities at the time (Avila ad Rose, 2009). On a national level, the US Housing Act of 1949 formalized the effort in American cities to address declining housing in urban centers that occurred following the flight to the suburbs that had occurred previously in the decade (American Planning Association, 2021). The act outlined how federal finances would help to establish revitalized urban centers, and focused specifically on new construction as a means of achieving this goal. Later legislation signals the focus of this redevelopment on eradicating informal housing, especially the Housing Act of 1954, which provided thousands of units of public housing that would be available to families relocated due to the erasure of their previous neighborhood. The establishment of DURA, the Denver Urban Renewal Authority, in 1958 marked the beginning of this transition to reinvestment into the urban core of Denver.

The first, and arguably, most impactful urban renewal project undertaken in Denver, the Skyline project, began in the early 1960's. Large swaths of downtown Denver were razed starting in 1964 in preparation for new buildings that would enhance urban infrastructure, prestige, and visual appeal, as well as bring new economic growth to the city (Page and Ross, 2017). The Skyline project paved the way for many urban redevelopments in Denver, including the Auraria campus project that created the combined downtown campuses for Metropolitan State University and the University of Colorado Denver. The campuses now exist on the site of the Auraria neighborhoods that once housed several communities of color, but was deemed poor and deteriorating, and that was feared might 'overrun' the city if not curbed in its growth (Conrad and Carmichael, 1941). In the early 1970's, the Auraria campus project removed residents and businesses from the area, demolishing nearly everything but protected historic structures, and shifted the ownership of the Auraria site to the State (Conrad and Carmichael, 1941). Focus was then turned to the South

Platte River area, and the neighborhoods that surrounded it. The South Platte Development Council, the first of several councils and committees dedicated to redevelopment of this area, was formed in 1974 (South Platte River Corridor Project, 2000).

However, beginning in the late 1970's federal funding shrank significantly, thereby minimizing DURA's role in the latter part of that decade and during the 1980s. With that transition also came new methods of redevelopment, ushered in by the LoDo redevelopment and the preservation-focused approach that was embraced by Mayor Pena (Page and Ross, 2017). In contrast to the earlier Skyline and Auraria redevelopment projects, LoDo began to bridge the gap between demolition-focused revitalization and historic-minded and conscientious infill.

The major caveat to this investment into Denver's urban core was the gentrification that resulted, a term initially coined in the 1960's by British sociologist Ruth Glass; "One by one, many of the working class quarters have been invaded by the middle class - upper and lower." As redevelopment projects began, those that previously lived in areas slated for demolition were forced to find alternate housing, and once the projects were completed, property values were much too high for low-income residents to afford. Thus, neighborhoods began to shift demographically once again, as affluent and white residents returned to the city, drawn by completed revitalization projects. While the LoDo project may have been a better alternative to the Skyline and Auraria projects in terms of architectural and community preservation, it's gentrifying influence was significant, and set the standard for gentrification of numerous other Denver neighborhoods, including the Central Platte Valley, Baker, and Curtis Park (Clark, 1984, 1985; Schill and Nathan, 1983; Schuster, 1997).

Many neighborhoods have since been gentrified, including Five Points, and others are increasingly vulnerable to this process (Urban Land Institute, 2018). According to a study by the National Community Reinvestment Coalition, Denver ranks second in the nation in gentrification based on their metrics. Legislation in the 21st century, such as the 2017 Tax Cuts and Jobs Act, allows investors in low to moderate income areas deference on capital gains taxes, continuing to incentivize investment and redevelopment in these neighborhoods and the gentrification that accompanies it (Rubino, 2020). According to research conducted between 2007 and 2015, median household income and average wages remain in place while average rents in Denver increase by up to 32%, and the cost of a single-family homes rises by up to 41% (Svaldi, 2015).

The complex issue of gentrification that arises when attempting to improve the built environment of low income neighborhoods is sometimes exacerbated by park development (Wolch, et al., 2014), leaving community leaders wondering what can be done to improve their neighborhoods without pushing residents away.

Effects of Urban Greenspaces

Implementation of landscape features that respond to local, social, cultural, economic, and environmental attributes presents many benefits for each of these sectors. Regardless of scale, inclusion of vegetation and natural areas in urban contexts is beneficial to those in proximity, and have the potential to maximize those impacts if mandated equitably in municipal zoning ordinances.

The environmental health of urban landscapes can be improved through the presence of natural areas, and their benefits are wide-ranging and impactful. Urban landscapes promote higher diversity of plant and animal species (Müller, Kamada, 2011), which is inherently beneficial for ecosystem resilience (Folke et al., 2004). Vegetation in urban areas has also been shown to improve air quality (Escobedo, Nowak, 2009). Urban environmental conditions are further improved by natural areas through the reduction of surface temperatures (urban heat island effect, or UHI) that is correlated with increased vegetation and natural areas (O'Malley et al., 2015), and economic advantages occur through this cooling effect in the reduction of cooling costs for buildings (O'Malley et al., 2015). UHI mitigation is also aided by higher tree canopy cover levels (Sailor, 1995), a hallmark of well-implemented landscape strategy. Urban trees themselves, when used as an element of urban greenspaces present numerous positives for ecological health, through carbon sequestration and soil conservation (Dwyer et al., 1992).

Stormwater management in urban sites incorporates improved landscape features in its own function within urban ecosystems. Green infrastructure utilizes systems of bioswales, retention basins, detention basins, rain gardens, and other features can help to manage water on the site and adjacent areas, as well as mitigate the intensity of flooding (Benedict, McMahon 2002). Impervious cover can also be reduced through the addition of well-designed green landscape features, further improving stormwater management in cities by allowing water to percolate and be absorbed by organic matter rather than turning to only runoff (Pincetl, Gearin, 2005). Through non-conventional methods of stormwater management such as green infrastructure in urban greenspaces, municipalities have the potential to save significant portions of budget typically dedicated to traditional infrastructure for stormwater conveyance (Barbosa et al., 2012).

Integration of natural areas into the urban fabric improves not only the ecological health of the area, but human health as well. Several studies have shown the positive relationship between greenspace and the health of those in proximity to it. These benefits include reduction of stress (White et al., 2013), facilitation of physical activity through provision of exercise venues and equipment, and improved recovery from surgery (Ulrich, 1984). Lower rates of morbidity and higher longevity have also been correlated with close proximity to green areas (Verheij et al., 2008; Takano et al., 2002). Access to natural areas and greenspace has also been linked to improvements in mental health (Alcock et al., 2014) such as anxiety and mood disorders (Nutsford, Pearson, Kingham, 2013).

Social factors are even shown to be positively related to natural areas, and social cohesion has been demonstrated to follow this pattern (de Vries et al., 2013; Thompson et al., 2012). Findings suggest that the aesthetic values of vegetation make their surrounding area perceivably more pleasant, thereby increasing potential social interactions among users (Dwyer et al, 1992). Community engagement hubs centered around green areas are found to be effective at increasing community interconnectedness, although the development of these spaces should be driven by expressed community needs (Burrage, 2015).

Economic benefits of improvements to urban landscapes are numerous, as landscape functions and their direct economic impact via reduction in service costs have the potential to defray costs typically shouldered by both individuals and municipalities. Cooling costs may be reduced due to shading from mature trees (Dwyer et al., 1992). Expenditures associated with traditional stormwater management infrastructure can be lessened through implementation of green infrastructure (McPherson, 1992). Carbon sequestration and storage that occurs due to urban trees and landscape features presents quantifiable savings for both large and small municipalities (Elmqvist et al., 2015). Screening of highway noises is also a function of urban landscapes, and can minimize the cost of conventional highway noise screens, such as those typically made of concrete or masonry that require significant investments to construct (McPherson, 1992). Natural areas also help to alleviate air pollution and particulates in urban contexts, and in doing so reduces costs associated with not only pollution mitigation, but also healthcare expenditures that may be incurred due to exposure to air pollutants (Rao et al., 2014). Generally, by promoting healthy lifestyles and serving as a factor in improving mental and physical health, economic investment in natural areas may help to alleviate costs related to healthcare for individuals and communities (McPherson, 1992).

Existing Zoning Ordinance and Landscape Standards

Zoning ordinance, at its most basic level, are that dictate the spatial arrangement of buildings in cities and towns. It creates a map of a municipality, defining boundaries for what types of buildings and spaces will exist there. However, the impact of zoning ordinance has the potential to mandate beneficial aspects of landscape composition. Within the building codes of many cities, there is also a landscape ordinance that defines the requirements for landscaped areas.

Within the Denver Metro area, commercial areas account for a significant percentage of land cover. In addition, commercial areas reflect disparities between high and low-income areas in the types of businesses situated near residential zones, as well as in other metrics such as impervious cover and surface temperature. Selecting commercial zones as the area of focus allows large businesses and economic drivers to be held accountable for improvements in the landscape in all neighborhoods, without placing undue financial burden or responsibility on those living in residential zones. While residential zones make up the largest percentage of land cover in Denver, selecting these ordinances as the focus for improvement would hold individual homeowners and landlords responsible for landscape improvements and maintenance, raising costs for renters, incurring home improvement costs, and potentially gentrifying these areas.

Landscape standards, as they are defined in zoning ordinance, provide a legal standard for landscape design that acknowledges site conditions, enhances green infrastructure, and works to improve the ecology of the urban environment, among many other beneficial components (Abbey, 1998). A brief diagram of typical terms used in zoning ordinance can be found in Fig. 2.4.

In Denver, Article 10. General Design Standards provides the most detailed information on landscape standards, and is the document analyzed within this research. Other documents do have pertinent information regarding landscape guidelines, including but not limited to Chapter 57 - Vegetation, within the Denver Code of Ordinances.

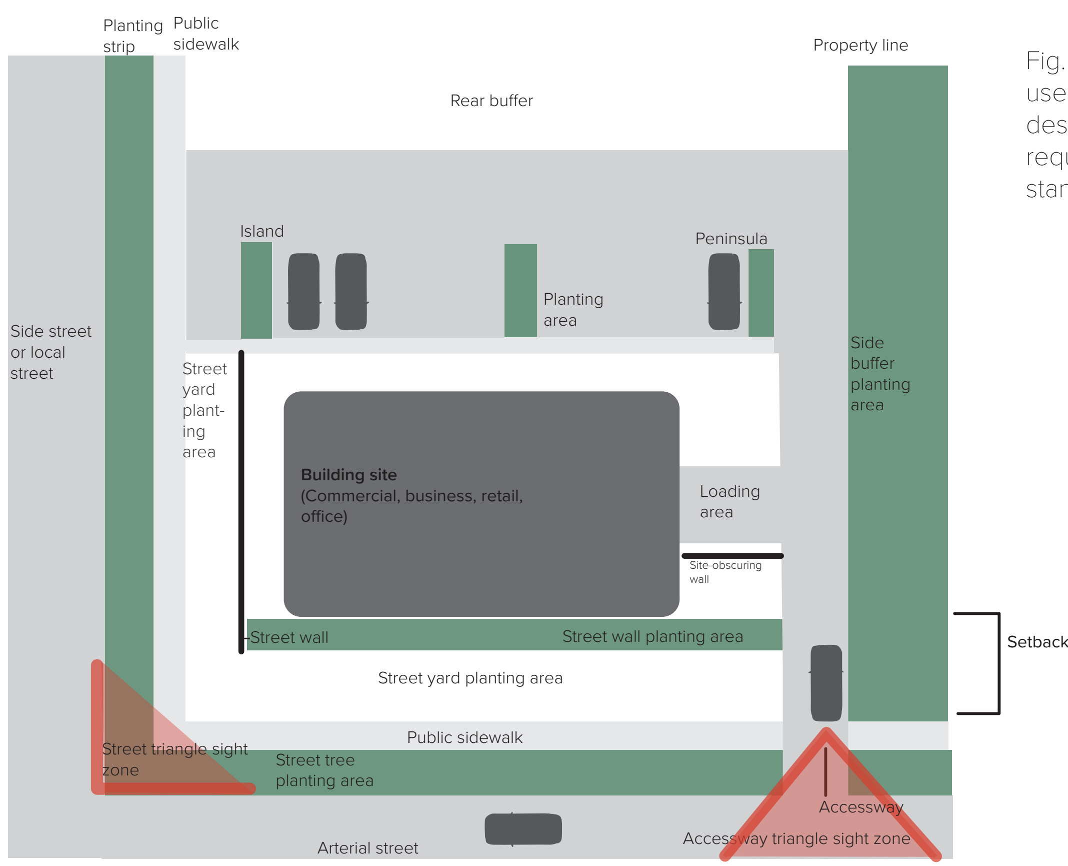


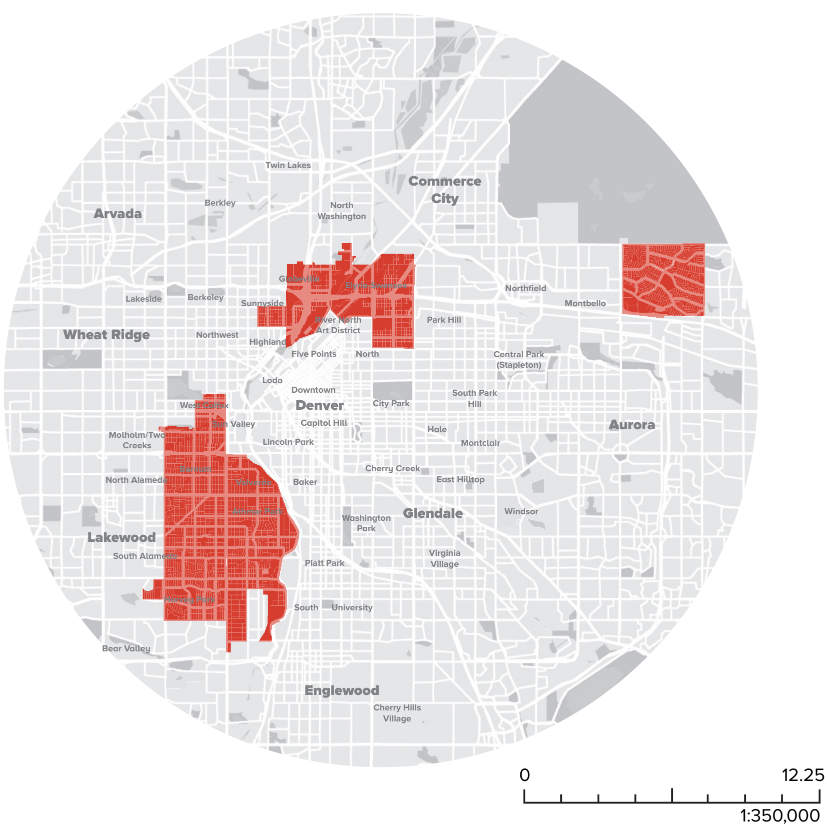
Fig. 2.4 Common terms used in zoning ordinance to describe parts of a site and requirements for landscape standards.

3. Methodology

Mapping and Demographics

In order to determine the relationship between race/ethnicity, income, and zoning distribution, several study areas were selected based on defined criteria (see Fig. 3.1). For the purposes of this study, race/ethnic composition are focused on Hispanic/Latino populations and non-Hispanic white populations. United States Census American Community Survey 5-Year data was used to determine race/ethnicity at the state, county, and tract level. Two study areas were determined at this level, one consisting of census tracts (statistical subdivisions of a county that aim to contain roughly 4,000 inhabitants [U.S. Census Bureau]) where the percentage of self-identified non-Hispanic white population is 49% or greater, and one consisting of tracts where the percentage of self-identified Hispanic/Latino population is 49% or greater.

His. Low Study Area



NHWhite Low Study Area

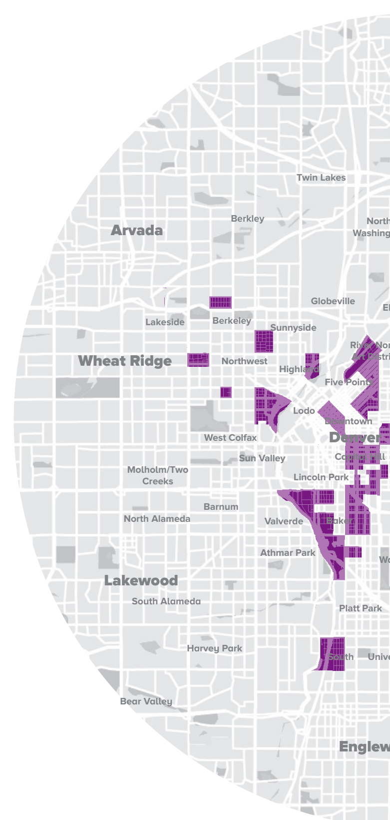
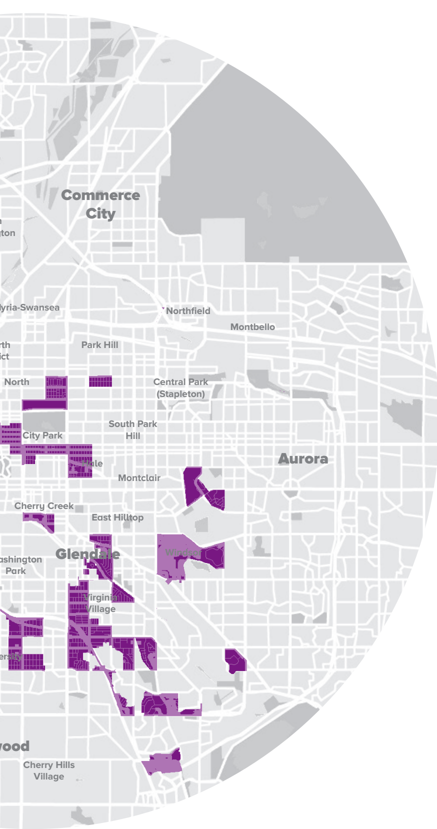


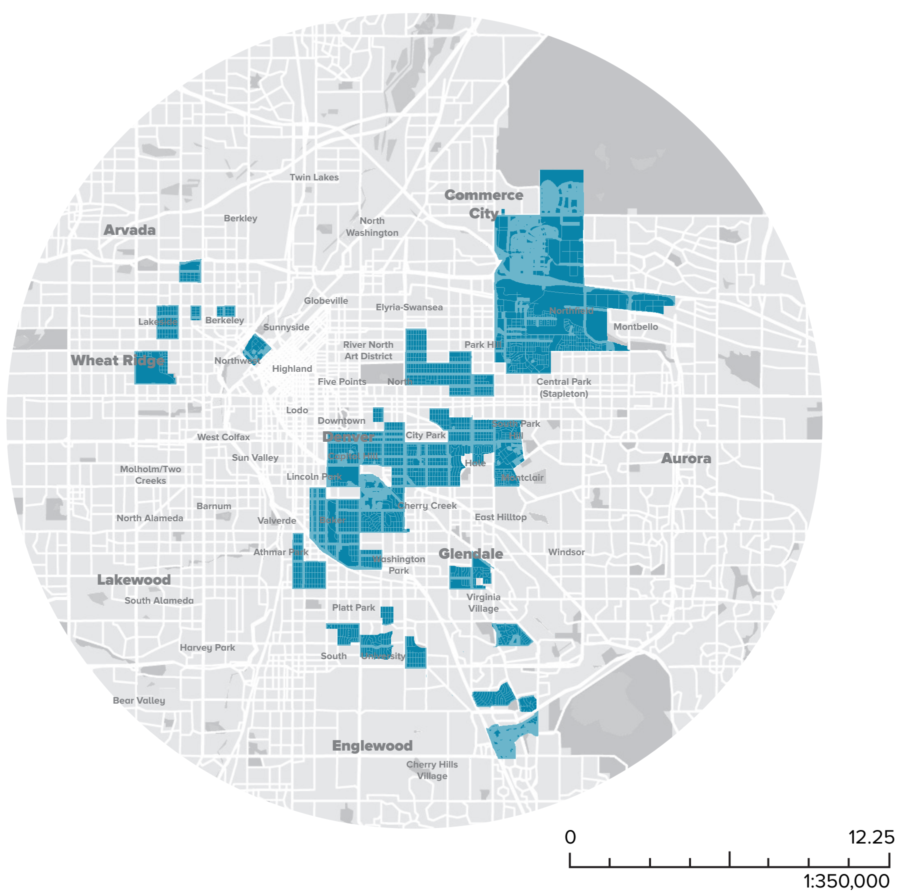
Fig. 3.1 Study areas used in research as defined by criteria on income and racial/ethnic makeup. His. Low boundaries are defined by
is >49%. NHWhite Low boundaries are defined by Census block groups where the median income is also less than $55, 630 and w
groups where the median income is greater than $95, 240 and where the percentage of individuals who identify as non-Hispanic w

Median household income serves as the second criteria. This information is obtained from 2016 ACS Median Household Income data at the Block Group Level. Block Groups contain clusters of blocks within a census tract that generally contain between 600-3,000 inhabitants (U.S. Census Bureau). This dataset provides a more detailed view of the composition of median household incomes within a given tract that has already been identified as fulfilling the criteria for racial/ethnic makeup. Income in this study is separated into two categories, one of lower median household income and one higher.

The lower threshold defines block groups where the median household income is less than or equal to $55,630. This value has been selected because it is the upper bound of the second-lowest class in a Natural Breaks, or Jenks, data classing system. Utilizing such a classing system allows classes to be formed based on natural breaks in the data, creating classes through a process that minimizes each class's average deviation from the mean, simultaneously maximizing the deviation of the class from the means of each other class. This ensures that variance within classes is reduced, and variance between classes is maximized, also called Goodness of Variance Fit (Jenks, 1967). The value $55,630 is also a representative fig-



NHWhite High Study Area



Census block groups where the median income is less than $55, 630 and the percentage of people who identify as Hispanic or Latino
here the percentage of individuals who identify as non-Hispanic white is greater than 49%. NHWhite High is defined by Census block
hite is also greater than 49%

ure for the median household income of more economically-disadvantaged communities, as the median household income for Denver in 2018 is $63,793, and the 250% value of the Department of Health and Human Services Poverty Guideline for a household of 3 is $51,050. Therefore, utilizing the value of $55,630 ensures that the median household income in the block group is below the median household income for Denver, and near the 250% poverty figure. The upper income threshold defines the higher-income study areas, and is composed of block groups where the median household income is greater than $95,240. This value has been identified based on the upper three classes in the same 7 class natural break. Instead of using the upper two classes as in the lower-income group, the upper three classes represent a more comparable population size in respect to the lower-income study area.

Using these criteria, three areas of study were identified. The first study area consists of census tracts where the percentage of population of non-Hispanic white residents is greater than 49% and the median household income of every block group within the tract is greater than $95,240. This area is referred to as 'NHWhite High' in appendices and data figures. The second consists of tracts where the percentage of population of non-Hispanic white residents is greater than 49% and the median household income of every block group within the tract is less than $55,630. The third study area is composed of tracts where the percentage of Hispanic/Latino identifying residents is greater than 49%, and where the median household income of every block group within the tract is less than $55,630. A fourth study area where the percentage of Hispanic/Latino population is greater than 49% and where the median household income of every block group is greater than $95,240 was searched for, but there are no census tracts in Denver where both of these conditions are satisfied.

Using these study areas, zone type distribution was calculated first. From the many specific zoning designations in Denver, zone districts are categorized into the following types: Residential, Commercial Mixed Use, Industrial, Open Space, PUD (Planned Unit Development), and O-1 (consisting of airports, recreational uses, parks, cemeteries, reservoirs, community correctional facilities, and other public and semi-public uses housed in buildings) (City and County of Denver, 2020). Comparing the area of these zoning designations within study areas is insufficient in determining the proportion of each designation relative to the size of the study area, so all comparisons were made using percentages of total study area size. Data on zoning type was sourced from the City of Denver Open Data Catalog. In addition, the zone type distribution of Denver as a whole was also calculated to serve as a baseline measurement.

Zone type distribution of each study area gives an accurate picture of what the composition of each area is in terms of land use. However, the presence of industrial or commercial areas in an area doesn't necessarily imply an impact on residents if these facilities are not nearby. In order to evaluate the relationship between proximity of zone types and residents, zone district type composition was calculated within a 0.25 mile buffer zone surrounding any residential zones in the study area.

Attributes associated with zone district types were determined by analyzing land cover information within each study area. Land cover data measurement provides information about the way zone district type specifications manifest themselves in the built environment in terms of the following categories: structures, impervious surfaces, water, prairie/grassland, tree canopy, turf/irrigated land, and barren land. Data on land cover was obtained from the Denver Regional Council of Governments (DRCOG) Regional Land Use Land Cover Project. This dataset provides information on land cover at a resolution of 1 meter, gathered using high-resolution aerial imagery.

Land cover data was lastly used to evaluate the composition of the same residential buffer area studied through zone district type distribution, This adds an additional layer of information about how landscape regulations manifest themselves in terms of the physical built environment.

Zoning and Landscape Standards

The second component of study used is analysis of Denver's zoning code. Specifically, Article 10. General Landscape Standards will be examined. Within this document, standards for built attributes of zone districts are defined, along with any exceptions made for specific zoning designations. While the document consists of almost a dozen divisions concerning site development, only a few have been selected, as they are the most relevant to the interest of the study. The divisions and sections being analyzed here for defined standards and their exemptions are:

Division 10.2, General Design and Facility Standards, Sections 10.2.1 Intent, 10.2.2. Applicability, 10.2.3. General Site and Facility Standards

Division 10.3, Sections 10.3.4. Pedestrian Access & Circulation

Division 10.4, Sections 10.4.2. General Applicability, 10.4.3 Bicycle Parking, and 10.4.6 Vehicle Parking Design

Division 10.5, Sections 10.5.1. Intent, 10.5.2. General Standards, 10.5.4. Landscape Standards, 10.5.5. Fences and Walls, 10.5.6. Retaining Wall Requirements, 10.5.6. Screening Requirements

Zone District Type	Neighborhood Context	Zone District Group	Zone Description
Commercial Mixed Use	Urban Center	C-CCN	Cherry Creek North
		C-MS	Urban Center - Main Street
		C-MX	Urban Center - Mixed Use
	Special Campus	CMP	Campus
	Downtown	D-AS	Downtown - Arapahoe Square
		D-C	Downtown Core
		D-CPV	Downtown - Central Platte Valley
		D-GT	Downtown - Golden Triangle
		D-LD	Lower Downtown
	Special Airport	DIA	Denver International Airport
	General Urban	G-MS	General Urban - Main Street
	Urban Edge	E-CC	Urban Edge - Commercial Corridor
		E-MS	Urban Edge - Main Street
		E-MX	Urban Edge - Mixed Use
	Special Industrial	I-I	General Industrial
		I-MX	Industrial - Mixed Use
	Master Plan	M-IMX	Master Planned - Indusrtial Mixed Use
		M-MX	Master Planned - Commercial Mixed Use
	Special O-1	O	Public and semi-public uses
	Suburban	S-CC	Suburban - Commercial Corridor
		S-MX	Suburban - Mixed Use
	Urban	U-MS	Urban - Main Street
		U-MX	Urban - Mixed Use
Industrial	Special Industrial	I-A	Light Industrial
		I-B	General Industrial
O-1	Special O-1	O-1	Open Zone District
Open Space	Special Open Space	OS	Open Space
PUD	Special PUD	PUD	Planned Unit Development
Residential	Urban Center	C-RX	Urban Center - Residential Mixed Use
	General Urban	G-MU	General Urban - Multi Unit
		G-RH	General Urban - Row House
		G-RO	General Urban - Residential Office
		G-RX	General Urban - Residential Mixed
	Urban Edge	E-MU	Urban Edge - Multi Unit
		E-RH	Urban Edge - Row House
		E-RX	Urban Edge - Residential Mixed
		E-SU	Urban Edge - Single Unit
		E-TU	Urban Edge - Two Unit
	Master Plan	M-RH	Master Planned - Row House
		M-RX	Master Planned - Residential Mixed Use
	Urban	U-RH	Urban - Row House
		U-RX	Urban - Residential Mixed Use
		U-SU	Urban - Single Unit
		U-TU	Urban - Two Unit
	Suburban	S-MU	Suburban - Multi Unit
		S-RH	Suburban - Row House
		S-SU	Suburban - Single Unit

Fig. 3.2 Descriptions of zone district groups, their neighborhood contexts, and the system in which they are classified into the categories used in research to identify zone type distribution

4. Results

Mapping and Demographics

Zone District Type Findings

In terms of overall zone district type distribution, one of the most striking figures is the proportion of industrial zones in the His.Low area (a little more than 19%) when compared to NHWhite High and NHWhite Low (about 6% and 12% respectively). Denver County as a whole, on the other hand, is composed of only about 7% industrial zone district types (see Fig 4.1). The proportions of PUD and O-1 zone district types is relatively similar between all study areas, in that they are all quite small, making up less than 2% of each study area. Residential zone district types are also somewhat similar between study areas, as all range between 55-62% residential zone district types. Commercial mixed use proportions all range between 10 and 17%, whereas Denver's proportion of commercial mixed use zone district types is about 41%. This suggests that the majority of commercial mixed use sites in Denver County exist outside of the defined study areas. Open space zone district types, the remaining category, vary widely between study areas, with the NHWhite High area, NHWhite Low, and His. Low areas consisting of about 16%, 15%, and 7% respectively. Denver County consists of about 9% open space as a whole.

Similar patterns present themselves on a more dramatic scale when examining zone district types within a 0.25 mile buffer from residential zones (see Fig. 4.2), and give a more accurate representation of land use for those who live in these areas. The His. Low study area consists of more than twice the percentage of industrial zone district types (14%) than NHWhite High (5.5%) and NHWhite Low (5%). The disparity in open space composition evident in overall study area composition also exists in the residential buffer areas, with the His. Low study area containing 7.6% open space, NHWhite Low containing 14.7%, and NHWhite High containing 15.5%. Commercial mixed use proportions remain relatively equal, at

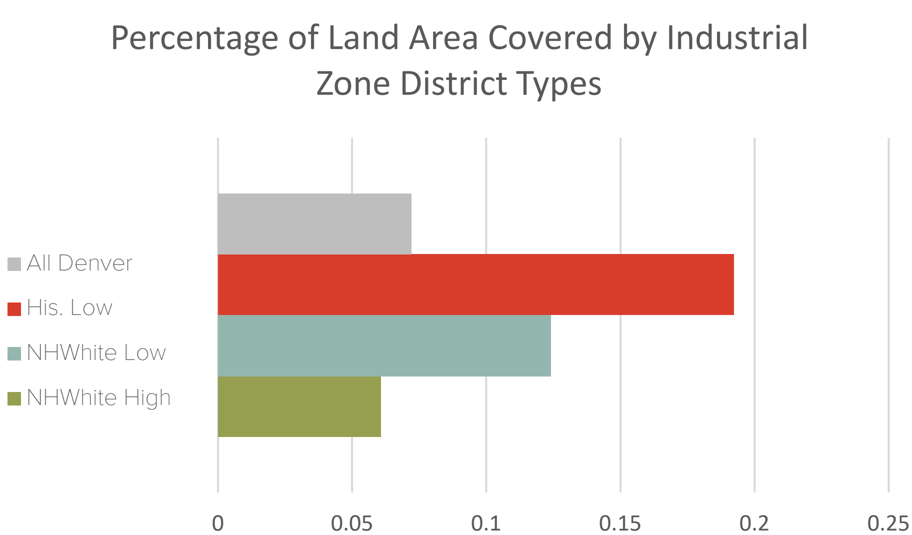


Fig. 4.1 Percentage of land area within each study area that consists of sites that consist of industrial zone district types.

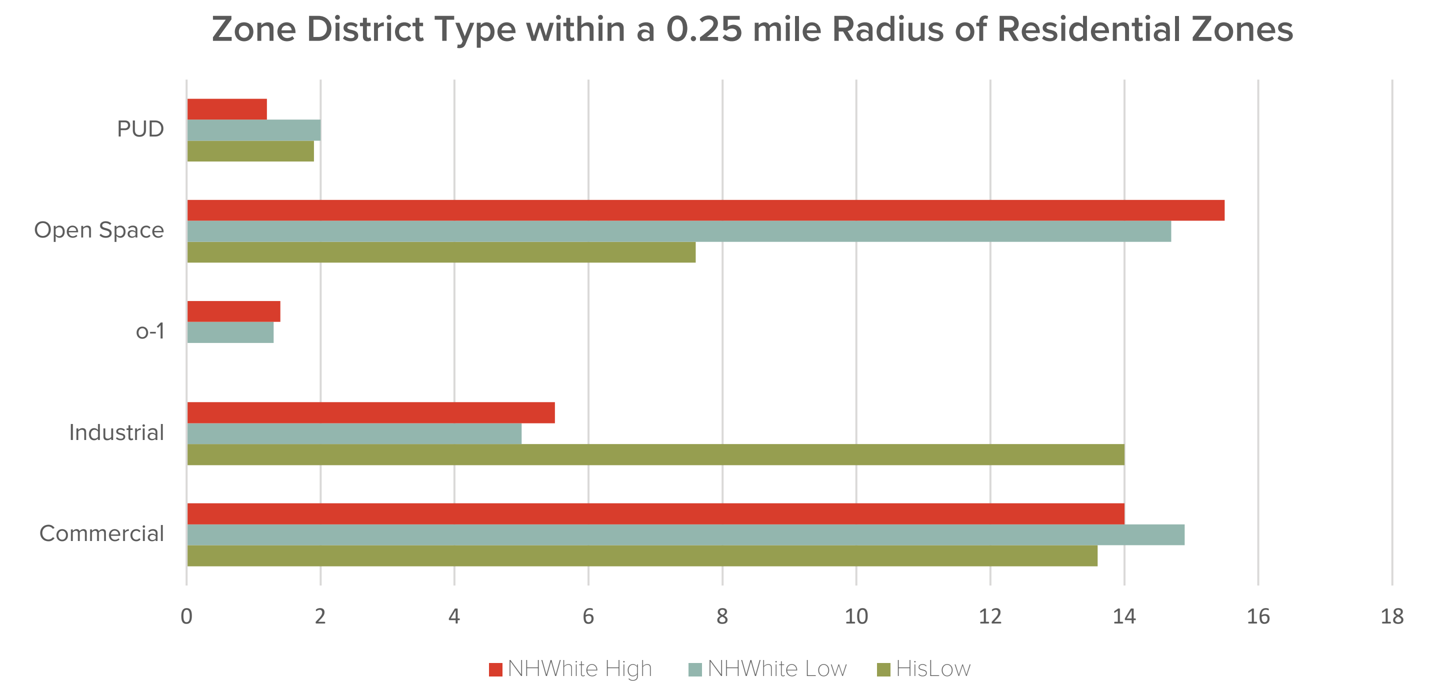


Fig. 4.2 Zone district types within a 0.25 mile buffer of residential zones within each study area.

13.5% (His. Low), 14.9% (NHWhite Low), and 14% (NHWhite High). Residential zone district types are also consistent between study areas, ranging from 62-63%. O-1 percentages are nearly negligible, making up less than 2% of NHWhite High and NHWhite Low, with no presence in the His. Low study area.

Overall Land Cover Findings

Land cover data enriches the analysis of study areas and their relationship to one another by examining how regulation surrounding the built form of zone district types manifests itself. This data is evaluated by study area, as well as by commercial and industrial zones within each study area. In addition, land cover is examined within the same 0.25 mile residential buffer as the previous procedure regarding zone district type.

In terms of study areas as a whole, the His. Low area displays a much higher percentage of impervious surfaces, at 45% when compared to NHWhite High (33%), although a similar proportion to NHWhite Low (43%). Tree canopy is another land cover type in which the His. Low area faces disparity, as its tree canopy percentage overall is only 9.3% in contrast to NHWhite Low's 12% and NHWhite High's near 14% tree canopy makeup. Although prairie/grassland makes up a one of the smallest percentages of land cover in each area, it too differs somewhat significantly in land cover between His. Low and NHWhite High, with NHWhite Low falling somewhere in between (>1%, 3.2%, and 7% respectively). When considering turf/irrigated land, the His. Low area contains the highest percentage of this land cover among the three areas, totaling about 23%. NHWhite Low is comprised of only about 19%, with NHWhite High containing roughly 20%. All areas are comprised of similar percentages of structures as a form of land cover (His. Low 16%, NHWhite Low 19%, and NHWhite High 17%). The remaining land cover types, water and barren land, remain relatively similar between study areas, and account for only a small percentage of total land cover in each (see Fig 4.3)

Land Cover Findings in Commercial Zone District Types

Land cover was also compared between study areas in only commercial or industrial zone district types. This kind of analysis helps to identify how the same zone district types between study areas might have interpreted requirements differently and/or be subject to different ordinances based on their land cover information.

In commercial zones only, impervious surfaces followed the same pattern between study areas as seen in their overall values. The His. Low area contained the most impervious surface at 63%, with NHWhite Low following closely behind at 59%, and NHWhite High containing the least impervious cover at 49%. Tree canopy between commercial zones in study areas was highest in the NHWhite Low area (5%), followed closely by His. Low (3.3%), with NHWhite High containing the least tree canopy (2.5%). Land cover denoted as prairie grassland was much higher in NHWhite commercial zones at 8.6% than NHWhite Low or His. Low commercial zones, at 2.3% and 1.7% respectively. Turf/irrigated land were fairly comparable at the commercial level, as were structures (see Fig. 4.4). Barren land, the final land cover type, was significantly higher in the NHWhite High study area at about 12% when compared the NHWhite Low's 4.2% and His. Low's 4.2%.

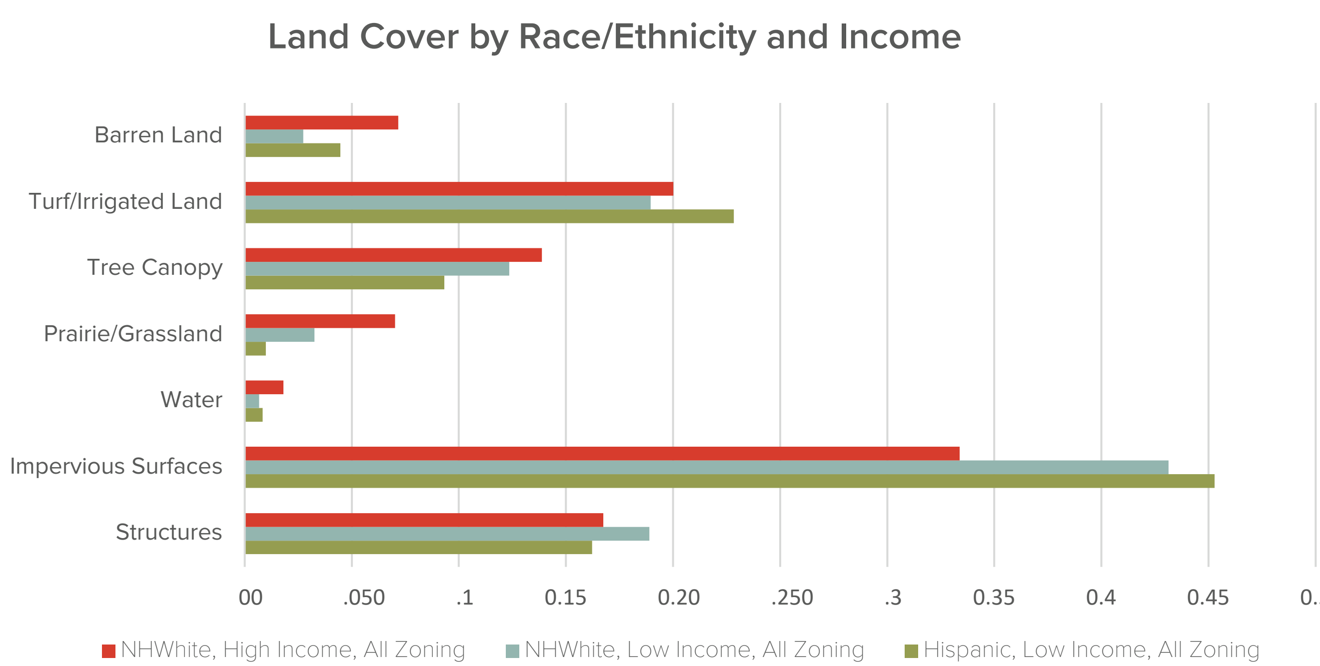
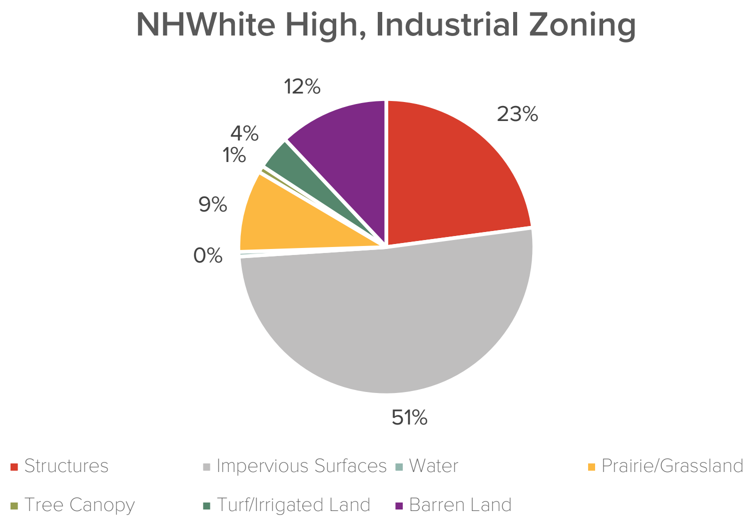
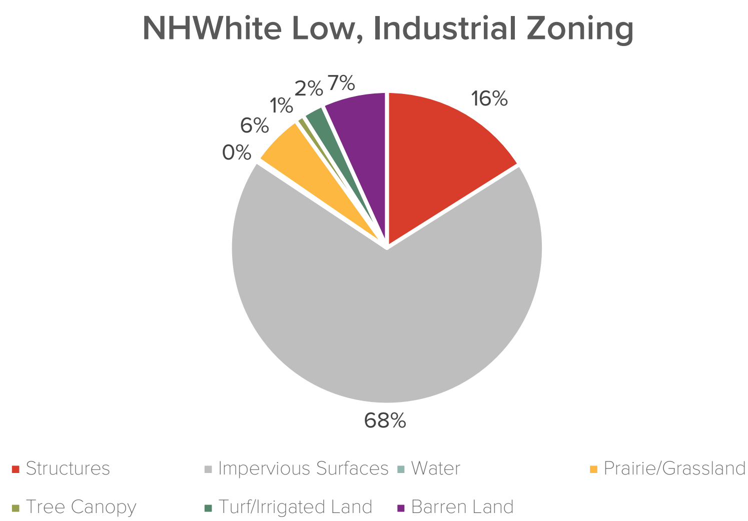


Fig. 4.3 Land cover percentages by study area.

Land Cover Findings in Industrial Zone District Types

In terms of industrial zone types, similar rationale apply as when considering commercial zone types. Impervious surfaces were still highest in the lower income study areas, NHWhite Low containing 68.3% impervious cover, His. Low containing just over 63%, and NHWhite High industrial zones comprised of just over 51% impervious cover. Tree canopy, as might be expected in industrial zones, was quite low, with His. Low being made up of only 1.3% tree canopy, NHWhite Low containing just less than 1%, and NHWhite High containing only 0.7%. One pattern that remained is the proportion of prairie/grassland land cover in industrial zones, with NHWhite High containing the highest percentage (9%), and NHWhite Low (5.5%) and His. Low following (2.8%). Turf/irrigated land was highest in His. Low at 5.4%, NHWhite High followed at 3.7%, and NHWhite Low contained the least at 2.2%. Structural land cover was most plentiful in NHWhite High industrial zone district types, surpassing His. Low (18%) and NHWhite Low (16%). The last form of land cover in the data set, barren land, was matched between His. Low and NHWhite High at 12%, and much less in NHWhite Low at 7% (see Fig. 4.4).





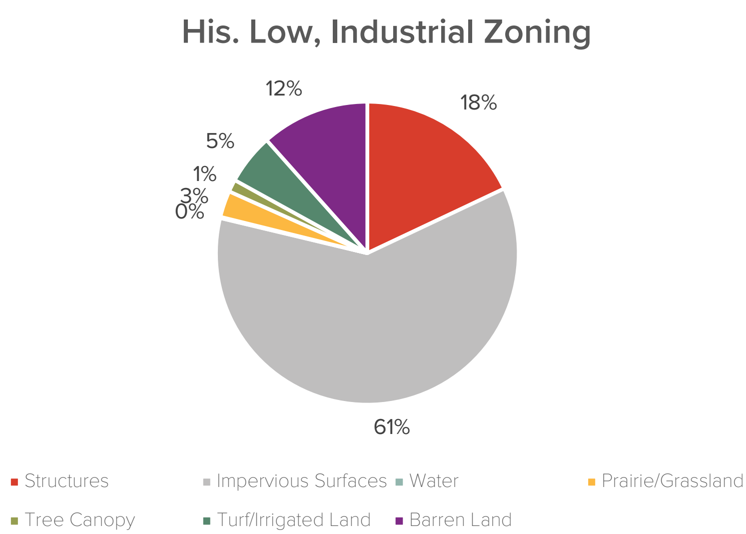


Fig. 4.4 Land cover percentages by study area in all industrial zone district types within study area boundaries

Land Cover Findings within 0.25 Miles of Residential Zones

The last metric analyzed through mapping is the percentage of land cover within 0.25 miles of residential zones within each study area. This, in relation to the zone district type data obtained within the same buffer area, gives the most accurate picture of the application of standards that directly affect residents of each study area.

His. Low once again showed the highest percentage of impervious surfaces, at 43%. NHWhite Low contained the next highest at 38%, followed by NHWhite High at 34%. Tree canopy ranked in the same pattern as previously observed in overall land cover, with NHWhite containing the most tree canopy at 16%, NHWhite Low containing 15%, and His. Low containing 10%. Prairie/grassland appeared relatively equal between study areas, ranging between 3% in His. Low and NHWhite Low to 5% in NHWhite High. Turf/irrigated land data was calculated to be even closer, with all study areas falling within 22-23%. Structural land cover was lowest in His. Low at 16%, but was not very far from the measured amounts in NHWhite Low and High, which were 18% and 17% respectively. Water was nearly negligible, making up 1% or less between all three areas, and the final land cover, barren land, was most plentiful in His. Low and NHWhite High at 4%, and totaled at 2% in NHWhite Low.

Zone District Type Within 0.25 mi of Residential Zones

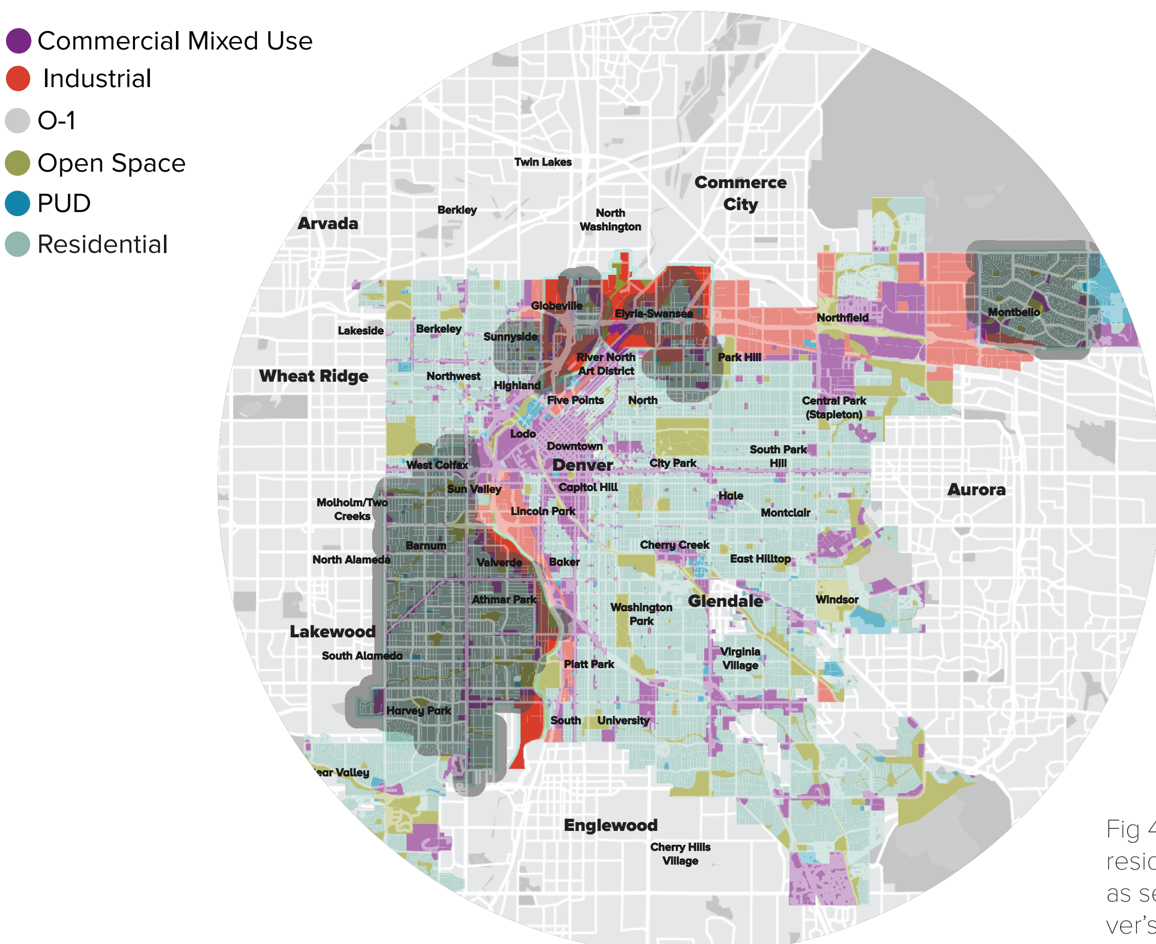


Fig 4.5 His. Low study area residential buffers (dark gray) as seen mapped over Denver's zone district types as a whole.

Zoning Ordinance Findings

Analysis of Article 10. General Design Standards yielded several interesting results relating to the applicability of design standards across zone districts. The divisions of Article 10 selected for this analysis are discussed in this section, while their specifications, being fairly extensive, are referenced as well as provided in Appendix D (see Fig. 4.6 for relevant information regarding the purpose defined for each division, as well as relevant exemptions)

Division 10.3 Multiple Buildings on a Single Zone Lot

This division outlines standards for lots with multiple buildings, and is intended to provide flexible siting, appropriate site conditions, and minimize impact on adjacent sites. The sections within outline requirements for pedestrian pathways through the site and connecting to adjacent sidewalks/streets, provide guidelines for spacing between buildings on the site, and define requirements for emergency vehicle access.

Exemptions within this division that may be relevant to the purpose of this study were found in section 10.3.4. Pedestrian Access and Circulation. It was found that all sites zoned CMP (Campus) are exempt from regulations in 10.3.4 that concern pedestrian access and circulation between buildings on a site, but their plans will still be reviewed for adherence to the intent of the this section on multiple buildings. I-MX and M-IMX (Industrial Mixed Use and Master Plan Industrial Mixed Use) zones are partially exempt from 10.3.4, and are not subject to pedestrian access regulations regarding pedestrian connections between buildings on the site, but still must adhere to regulations regarding pedestrian connections to adjacent public sidewalks and streets (if no sidewalk is available). The code also mentions that it is 'encouraged, but not mandatory' (10.3.4.2) for these zones to adhere to all other standards defined in 10.3.4. I-A and I-B (Light Industrial and General Industrial) zones are completely exempt from 10.3.4's regulations.

Division 10.4 Parking and Loading

Standards regarding vehicle parking size, design, maintenance, loading, and bicycle parking are defined in this division, and the most applicable sections identified are 10.4.3 Bicycle Parking, and 10.4.9 Parking Categories. Within both of these categories, bicycle parking is identified as the most variable standard between zones, and exemptions to requirements for bike parking is focused on. Within 10.4.3. it is established that some zones in the Downtown Neighborhood Context (D-C, D-TD, AND D-CV) are exempt from the standards defined in 10.4.3. Further, within 10.4.9,

Parking Categories - Bicycle Parking

Use Category	Specific Primary Use / Parking Category
Residential	**Low** Community Correctional Facility, Residential Care Use, Small or Large, **Medium** Assisted Living, Nursing Home, Hospice, Residence for Older Adults
Commercial	**Low** Shelter for the Homeless, Utility, Major or Minor Impact, Automobile Industry (Emissions, Gas, Service Station, Wash, Detailing, Repair, Sales, Pawn, Auctioneer, Heavy Vehicle Sales, Rentals), Contractors, Food Preparation/Sales, Laboratory, Research and Development, Industrial Service/Repair Manufacturing, Oil &Gas Drilling, Quarry, Wind Energy, Transportation Facilities, Waste Related Services, Wholesale Storage and Warehouse, Agriculture **Medium** Postal Facility, Adult Business, Recreation and Entertainment Services, Lodging Accomodations, Offices, Retail Sales/Service/Repair
Public Use	**Low** Open Space - Recreation **Medium** Community Recreational Facility, Day Care, Public Safety Facility, Correctional Institution, Library, Museum, Performing Arts Center, Elementary School, University ot College, Vocational or Professional School, Public and Religious Assembly, Sports/Entertainment Stadium, Theater **High** Hospital, Secondary School,
No Requirement	Single unit dwelling, Cemetery, City Park, Open Space - Conservation, Parking (Garage or Surface), Telecommunications Towers/Facilities,

No Requirement

Suburban Neighborhood Context, I-A, and I-B Zones

Residential Low, Residential Medium, Commercial Low, Public Use Low

Urban Edge Neighborhood Context

Commercial Low, Public Use Low

Urban Neighborhood and Master Planned Contexts

Residential Low, Residential Medium, Commercial Low, Public Use Low

General Urban Neighborhood Context and I-MX Districts

Residential Low, Residential Medium, Commercial Low, Public Use Low

Urban Center Neighborhood Context and Campus Zone Districts

Residential Low, Residential Medium, Commercial Low, Public Use Low

Downtown Neighborhood Contexts

Residential Low, Residential Medium, Commercial Low, Public Use Low

Fig. 4.5 Parking categories, and neighborhood contexts where these parking categories identify no requirement for bicycle parking.

the section that lays out specific requirements for parking spaces designated for bicycles, establishes that many zone districts within certain neighborhood contexts are not required to provide any bike parking spaces, either on fixed bike racks or in an enclosed bike parking facility. The categorization system it utilizes is unique, and places specific business/establishment types within categories that are: Residential, Commercial, and Public Use. These are further subdivided into Low, Medium, and High categories, with one additional category termed Multi-unit, with no subcategory. Fig 4.5 explains the system of organization, and focuses on only parking categories defined in the section that have no requirement for minimum bicycle parking spaces. These requirements are organized first by neighborhood context, and notably, in Suburban contexts, I-A, and I-B zones, there is no bicycle parking required for Residential Low, Residential Medium, Commercial Low, and Public Use Low sites. This includes site uses such as some group living homes, utilities buildings, automobile industry buildings, communication, industrial services, manufacturing, transportation, waste-related services, and wholesale storage/distribution, and agriculture, among others.

Division 10.5 Landscaping, Fences, Walls, and Screening

This section identifies general standards, landscaping standards, regulations for fences and walls, as well as retaining wall and screening requirements. Exemptions within this division and its component sections are quite extensive. The first of which states that standards in 10.5.4 Landscaping Standards does not apply to residential development in SU or TU zone districts. While this exemption for residential zones is good to note, standards in this section are much more relevant to the analysis being conducted in this work on commercial and industrial districts, and are described in 10.5.4.2 and 10.5.4.3.

Sections 10.5.4.2 and 10.5.4.3 define two groups that zone districts are placed within. Regulations in 10.5.4.2 apply to all zone districts, identified within the code as 'Group 1', except I-A, I-B, and I-MX, which are identified as 'Group 2'. Group 1 is required to landscape all open areas within a build-to range, as well as all open areas within the required minimum setback. In addition, the minimum landscape standards for Group 1 define that the landscaped areas within the site must consist of at least 50% live planting material, with the remaining 50% consisting of living or non-living landscape material. Group 2's minimum landscaping standards identify the need for a visual barrier wherever the industrial site abutts a residential zone district, even when a street or alley exists between them. In terms of the required landscaped area in Group 2, landscaping is only required for at least 50% of the required setback areas, but this area must consist of live ground cover. Ornamental and shade trees are also mandated, and must total 1 tree for every 40' of linear frontage, although they may be grouped.

Key Exemptions: Article 10. General Design Standards

Division	Specifications	Exemptions
10.3. Multiple Buildings on a Single Zone Lot	Required pedestrian connections and circulation, minimum walkway width, walkways through vehicle areas, spacing between buildings, emergency vehicle access	**10.3.4. Pedestrian Access and Circulation** All CMP (Campus) districts exempt from 10.3.4 re I-A and I-B Zones (Light and General Industrial) z standards requiring pedestrian connections betw but not mandatory.
10.4. Parking and Loading	Vehicle parking size, design, and maintenance, loading, and bicycle parking	**10.4.3. Bicycle Parking** D-C, D-TD, and D-CV zones are exempt from Se **10.4.9 Parking Categories** See Fig X.x
10.5. Landscaping, Fences, Walls, and Screening	General standards, landscaping standards, fences and walls, retaining wall and screening requirements	**10.5.4. Landscaping Standards** 10.5.4 applies to all zone districts except reside I-A, I-B, and I-MX zones adhere to 10.5.4.3, while Perimeter and interior surface parking lot stand **10.5.5. Fences and Walls** I-A, I-B, and I-MX zone districts are permitted ba I-A, I-B, I-MX, CMP-NWC-F zones must adhere to **10.5.6. Retaining Wall Requirements** New developments in I-A and I-B zones are not **10.5.7. Screening Requirements** Developments in zone districts CMP-NWC-F, I-A

Commercial Mixed Use
Industrial
Residential

Fig. 4.6 Notable exemptions within Article 10.General Design Standards by Division and Section

Further, a minimum of 5% of the total zone lot area must be landscaped with live ground cover, but the landscaped area required in setbacks can be counted toward the 5% area total.

In section 10.5.4.4, landscaping standards for perimeter surface parking lots are defined according to neighborhood context and zone district. The section first outlines standards for sites in the Suburban Neighborhood Context, I-A and I-B zones, and I-MX zones with Industrial Building gulations regarding pedestrian access and circulation, but plans will be reviewed for compliance with section intent

ones exempt from 10.3.4 regulations regarding pedestrian access and circulation. I-MX and M-IMX zones (Industrial Mixed Use) must meet
ween entrances and public sidewalks (or streets where no sidewalk exists), compliance with all other standards in 10.3.4. is encouraged,

ection 10.4.3

ntial development in SU or TU Zone districts

e all other zones fall under 10.5.4.2.

ards vary between Neighborhood Contexts, see Fig X.x

rbed or razor wire for fencing if approved by the Fire Department

o their own set of fencing and wall regulations depending on setback area

requried to adhere to 10.5.6

, I-B, SU, and TU are exempt from 10.5.7 regulations regarding screening of rooftop equipment and outdoor trash storage areas.

of the ordinance.

Forms. In these zones, a perimeter planting strip is required, and must be at least 10’ wide. Plantings within this strip must consist of 1 deciduous tree for every 25’ of linear frontage, although the spacing of the trees can vary but should not exceed 40’ between trees. Garden walls are not required, but if one is supplied, the perimeter planting strip minimum width decreases to 5’. Materiality remains the same between all neighborhood contexts, and pedestrian access must be offered among all neighborhood contexts, with some zones in Downtown Neighborhood contexts subject to more specific regulations regarding size and access.

The next category defined consists of Urban Edge, Urban, General Urban, and Campus Master Planned contexts, as well as I-MX zones with General Primary Building Forms. In this category, the perimeter planting strip required is only 5', but 10' for some CMP-NWC (National Western Complex Campus) districts. As far as the planting standards within these perimeter strips, tree standards are only outlined for the CMP-NWC districts identified, and are required at a count of 1 tree for every 35' of linear frontage, with the same 40' maximum spacing as the previous category. The same CMP-NWC district are required to have a garden wall, but all others in this category are not.

The remaining categories have significantly different perimeter surface parking lot standards. In Urban Center Neighborhood Contexts, perimeter planting strips are not required, and as such there are no planting standards defined. Garden walls must be supplied in this category, and it is also subject to the same garden wall material and pedestrian access standards. Downtown Neighborhood Contexts D-AS-12+, D-AS-20+, D-CPV-T, D-CVP-C, and D-CPV-R are mandated to have a perimeter planting strip that is at least 8' wide, although in this context the strip can be located in the street right-of-way. Tree requirements in this context define 1' tree for every 25' of linear frontage, with the same maximum spacing guideline of 40'. Garden walls are also required in this context, and the pedestrian access guidelines here require a minimum of 3' width for all pedestrian access-ways, which must be placed at a maximum of every 80' along public street and parking lot frontages. Other Downtown Neighborhood Context districts including D-C, D-TD, D-LD, D-CV, D-GT, and D-AS are subject to another article determining parking lot standards, Article 8, Section 8.10.3. which will not be explored for the purposes of this study. Parking lot standards are further defined in 10.5.4.5 Interior Surface Parking Lot Landscape Standards, but the only notable exemption that occurs in this section is the lack of applicability to CMP-NWC-G AND CMP-NWC-F zones, likely because of the need for large open parking without medians for livestock trailers and trucks.

Live plant standards are defined in 10.5.4.6, requiring that plants be continuously maintained in live growing condition, and it is encouraged here that sites should use drought-resistant plants and shrubs.

In a later section, 10.5.5 Fences and Walls, some interesting exemptions are made, especially for I-A, I-B, and I-MX zones. Only in these zones is barbed wire or razor wire acceptable upon approval from the Fire Department. These zones, in addition to CMP-NWC-F, must also adhere to their own set of regulations about fence and wall height. In these zones, the maximum height for fences and walls is 7' within the setback or 10' outside of the setback, and must be open walls or fences, chain link, or wire mesh. This is in contrast to the fence and wall height requirements for all other zones, where the maximum height for fences ranges between 4’ and 6’ based upon the location of the fence.

Retaining walls are outlined in 10.5.6, and zones I-A and I-B are fully exempt from the section. The standards define height of retaining walls and terracing by location, and are expanded upon in a separate article of the zoning ordinance.

The final section, 10.5.7, deals with screening requirements, specifically for certain uses, rooftop equipment, and outdoor trash storage areas. This section applies to developments in all zone districts, except CMP-NWC-F, I-A, and I-B, as well as SU and TU.

5. Discussion

Zone District Type and Land Cover

The data discovered through the mapping process and the information found in the analysis of zoning ordinance unveiled several important relationships that, when synthesized, can provide a powerful framework for understanding the current built environment in Denver, as well as areas where improvements might be made in order to address inequities within it.

Results obtained from the overall zone district type mapping displayed a striking difference in the composition of zone districts between study areas. The His. Low study area contained more than twice the percentage of industrial zone districts than the NHWhite High area. This is unsurprising, given the existing literature on the placement of lower income communities of color near industrial areas, especially through historical processes(Conservation Colorado, 2020). The next most significant finding in this data set is the quantity of open space within each area. The NHWhite High study area demonstrated more than twice the percentage of open space than His. Low, with the NHWhite Low study area following shortly behind. However it could be argued that the effects of zoning composition could not be felt to a very high degree, as the population of the His. Low area could be significantly lower, and there just happen to be few neighborhoods meeting this criteria within the tracts and block groups used to delineate the study area. The problems with this line of thinking are that it dismisses the importance of improving conditions for every resident of Denver, however few they may be, and that it is simply not true, as the residential buffer data addresses this counterargument.

The same relationships between industrial zones and open space are represented again in the residential buffer data (Fig 5.1). Within 0.25 miles of residential zones in low income communities of Hispanic/Latino identifying people, there is more than twice the percentage of industrial zones (14%) than either the non-Hispanic white higher income zone (6%) or the non-Hispanic white lower income zone (5%). In terms of open space, both of the non-Hispanic white majority areas have about twice the percentage of open space zones than the Hispanic/Latino majority area. Other zone types are within a few percentage points between each area. Given this information, it can be concluded that even if overall zone district composition is variable, the relationships presented at that level maintain for the areas most directly interacted with by those who live there. The presence of these zone districts has numerous implications for the quality of environment and exposure to hazards for Hispanic/Latino lower income communities. However, not addressed within this data is the manifestation of these zones

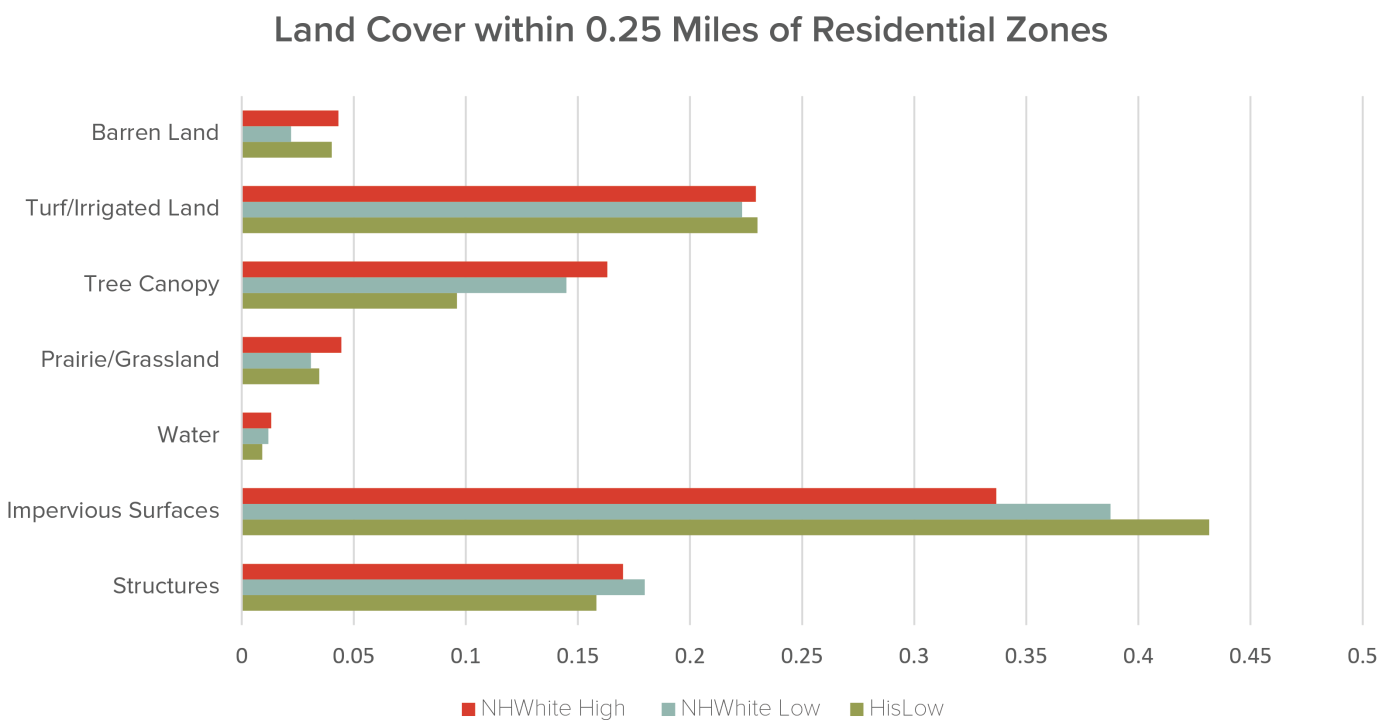


Fig. 5.1 Land cover within 0.25 miles of residential zones in each study area. Patterns in the data here are consistent with most patterns observed at the overall study area level.

in terms of the actual characteristics of the built environment within the area being studied. Land cover data provides information on this relationship.

Overall, land cover data shows that both lower income study areas display much higher percentages of impervious surfaces than the high income study area. Further, both lower income study areas also show less tree canopy, prairie/grassland, and water. The negative environmental, social, and human physical effects of this type of built environment on those who live near it is well-documented in the background section literature. This information suggests that where percentages of industrial zones are higher and open space is lower, there is an observable difference in land cover. The land cover data on turf/irrigated land brings forward an area of interest, as even though this is a living landscaping material, and should, theoretically, be beneficial to the areas in which it is placed, the actual positive effect it has on the environment and community around it is debatable. It can become a potential source of carbon, due to the energy it requires from lawn/landscaping equipment in the form of fossil fuels (Lerman and Contosta, 2019). Lawns can also frequently become a large source of water use, potentially to the economic detriment of the communities maintaining them (Runfola et al., 2013). In addition, alternatives to lawn can be far more beneficial in terms of environmental health, community engagement, and mental and social health. The abundance of lawn in His. Low suggests that parks or open spaces that do exist in this area rely on lawn as a land cover instead of other, potentially more helpful, vegetation or other land cover.

Within commercial and industrial areas in each study area, land cover patterns displayed similar relationships. Prairie/grassland land cover was highest in NHWhite High, and lowest in His. Low, as was tree canopy. Impervious cover, highest overall in His.Low, remained highest in commercial zones, but was overtaken by NHWhite in industrial zones by almost 9%. The significance of these findings is that even in areas where the primary land use is the same, notable differences still exist in composition of land cover.

The final data on land cover analyzed was within the same 0.25 mile residential buffer that was used during measurement of overall zone district type. Findings generally followed the same patterns in the land cover types of interest, especially tree canopy (highest in NHWhite High, lowest in His. Low) and impervious surfaces (highest in His. Low, lowest in NHWhite High). In this metric, prairie/grassland was comparable for all study areas, as were turf/irrigated land and structures.

The findings within this section of the study indicated that the observed relationship in American cities between lower income communities and communities of color and industrial exposure, lack of access to greenspace, and poorer quality of greenspace (Downey and Hawkins, 2008; Pais et al., 2013; Wolch et al., 2017), is true for Denver as well, even when comparing the same zone district types.

Zoning Findings

The second component of research is the analysis of Article 10 of the Denver Zoning Code, General Design Standards. Several exemptions are identified within the various divisions and sections chosen for study. When looking broadly at these, exemptions were numerous in industrial zone districts (I-A, I-B, and I-MX), and districts where a high amount of agricultural and livestock uses occur (CMP-NWC).

Section 10.3.4 outlines the regulations for pedestrian access on a site with multiple buildings, including required pedestrian access to external walkways, parking, gathering spaces, and sidewalks on adjacent properties. Site attributes such as minimum walkway width (10.3.4.4) and walkways through vehicle areas (10.3.4.5) are specified as well. Adherence to this section was somewhat looser for CMP districts, but is likely so in order to account for the high probability that alternative paths need to be made for uses that can occur in this district, especially in the National Western Complex. The exemptions for I-A and I-B could also be attributed to alternative regulations necessary for safety when moving between buildings on a single site, or simply for the high likelihood that a good portion of sites in this industrial context will already be paved or constructed from a surface appropriate for pedestrian use. In addition, rationale for this exemption, specifically the lack of requirement for pedestrian paths on the site to meet adjacent public sidewalks and streets, could be attributed to the lack of need for walkability between multiple industrial sites. Generally, it might be assumed that when individuals working on one site will rely on a personal automobile for transportation, their need for external pedestrian access beyond that which exists between the parking lot and the building will be low. However, the lack of requirement for pedestrian connections between industrial sites and public walkways discounts the potential need that individuals who rely on public transportation may have for safe walkways to and from buildings on the site. I-MX and M-IMX zones must meet the requirement for access to external walkways, but are also exempt from the other standards defined in 10.3.4.

In Division 10.4, Parking and Loading, the most important section noted are 10.4.3 Bicycle Parking and 10.4.9 Parking Categories. These sections identify requirements for on-site parking, but the most significant exemptions occur when dealing with bicycle parking. Many zone districts and primary uses are not required to supply any bicycle parking facilities either through a default requirement based on primary use, or based on use categorization within a neighborhood context (see Fig 4.5). The lack of bicycle parking provided in these sites could be viewed as a reflection only of the size of the establishment and the studied needs of its users, but it could also be viewed as a perpetuation of lack of alternative transportation infrastructure. When few people ride bikes to an establishment, is that the driver behind the lack of bike infrastructure, or does the lack of bike infrastructure discourage potential bike users? In all of the primary use designations that have no requirement for bike parking, it could be beneficial to at least encourage implementation of even bike facilities to demonstrate support for those who may not be able to afford a personal automobile to reach a site. Further, it can be an asset to those who not only cannot drive a car to a site, but to those in areas that are not well-served by public transportation, as is often the case in industrial and lower-income areas (National Association for State Community Service Programs, 2008).

Division 10.5, Landscaping, Fences, Walls, and Screening has by far the most detailed information regarding design standards. The first exemption it makes is for SU and TU zone districts (Single Unit and Two Unit) as landscape standards in residential districts are far less specific, and more difficult to enforce. I-A, I-B, and I-MX zones are then exempted from section 10.5.4.2, and are required to adhere to a different set of landscape standards, 10.5.4.3. This difference in regulations between industrial zones, and all other zone district exists to mitigate the visual impact of industrial sites on adjacent areas, but it also reduces the landscaped area required on sites as a whole when compared to the standards outlined in 10.5.4.2. For industrial areas, only 50% of open areas in a setback must be landscaped with living material, and that area then counts toward the total landscaped area required, which is 5% of the total site area.

The makeup of the other 50% of the setback or landscaped area on the zone lot is not specified, leaving it open to any ground cover determined appropriate by the business owner, developer, landscaper, or other controlling entity. In contrast, the standards in 10.5.4.3 stipulate that all open areas within a setback, build-to range, or other area on the site not occupied by other necessary functions (pedestrian walkway, parking, entrance) shall be landscaped with at least 50% living ground cover and 50% non-living landscape material. Such differences and ambiguity in language in the landscape standards leaves opportunity for very different interpretation of the zoning ordinance, and allows for landscapes in industrial areas that do not serve their environment or communities.

The standards defined in section 10.5.4.4 regarding perimeter surface parking lot landscaping standards further demonstrate differences in specifications for industrial zones. Perimeter planting strips in industrial zones have a minimum width larger than any other context or district, but if a garden wall is provided, then can be halved in size from 10' to 5', thereby becoming the smallest planting strip required in any context (except in Urban Center Neighborhood contexts, where no perimeter planting strip is required). The reasoning for this is unclear in the ordinance, although it could be interpreted as an incentive for visual barriers as opposed to plantings, as well as a way to minimize cost and labor associated with maintaining planting strips. Standards are much more stringent for any zone abutting a residential use, but are consistent across all non-residential zone districts.

Later sections defining retaining wall requirements (10.5.6) and screening (10.5.7) bring the last few exemptions analyzed in this research. The most notable exemption that exists within the first of these sections is the potential for use of barbed or razor wire only in I-A, I-B, and I-MX, upon approval from the Fire Department. In addition, fences in industrial zones can be higher than in any other. This is somewhat understandable, given the value of equipment and facilities within industrial areas, and the need for advanced security on some of these sites. However, the visual impact of these types of fencing can be significant, and the manner in which they affect perceived safety or neighborhood value can be quite negative (de Vor and de Groot, 2009).

All regulations defined in section 10.5.6 regarding retaining walls do not apply to I-A or I-B zone districts, exempting them from maximum height regulations. Lastly, developments in I-A, I-B, and CMP-NWC-F zones are exempt from section 10.5.7 that requires screening of rooftop equipment and outdoor trash storage areas. The visual impacts of this exemption are also significant. This exemption is understandable when one considers that rooftop equipment in industrial sites can be quite large and/or hard to define, and that outdoor trash storage areas in a facility like a recycling center can make up large parts of the site. However, some attempt to mitigate the visual and possible auditory impacts of rooftop equipment and outdoor trash storage areas could be to the detriment of nearby communities and residences.

Limitations

The focus of this study is on the relationship between Hispanic/Latino communities, proximity to industrial and commercial zones, and the landscape standards that regulate these zones. It would be greatly beneficial to investigate the relationship between other communities of color and their proximity to industrial and commercial zones, especially given the presence of communities of African, Asian, American indigenous people, as well as other historically marginalized racial/ethnic groups. Hispanic/Latino communities make up the most populous community of color in Denver, and were chosen for the purposes of this study to investigate the relationship at its most clearly-presented level.

While the data observed give an accurate picture of the relationships between race, ethnicity, income, and various zoning and land cover variables, the use of data from only one threshold of each variable (for example, income only below $55,525) is limited in that it does not capture the correlation between variables at multiple points. For continuous data, such as income, percentage of race/ethnicity in a given area, a more complete statistical analysis of data relationships could be achieved through future research, especially that which incorporates regression analysis of bivariate data. Given more time to develop these findings, it would be hugely informative to conduct further statistical analyses of zone district composition, land cover, and their relationship to code exemptions.

When looking at mapping, there are several limitations to the research. The choice of threshold variables themselves could be improved upon with further research, in order to assign a more accurate and appropriate income threshold that defines 'low' and 'high'. Incorporating data from federal and state poverty guidelines, living wage, property value, cost of living, and other such metrics could help to inform the definition of study areas in future research. In addition, further limitations to the work are the categorization of zone districts into zone district types, as some levels of details are lost in the grouping method. The use of these methods provides a fairly accurate approximation of the relationships occurring between zone districts, race/ethnicity, income, land cover, and zoning regulation, but ultimately every study can be more accurate, and it would be beneficial to utilize more time to further the accuracy of this research.

6. Conclusions

The question initially framed was whether or not industrial landscape standards had the potential to address the environmental inequity that is evident through analysis of the relationship between race/ethnicity, zoning, land cover, and ordinance. Land cover around residential areas Hispanic/Latino communities has significantly less tree cover, more impervious surfaces, and less prairie/grassland. They are also surrounded by significantly more industrial zone districts around residential areas in their communities. Through the research done into Denver zoning ordinance, the exemptions in design and landscape standards found for industrial areas are numerous. The conclusion can then be drawn that revisions to landscape standards that mandate less impervious surface area, more tree cover, and more prairie/grassland could potentially change the landscape around Hispanic/Latino residential areas for the better. Beyond this, in further research, it could even be studied how the addition of certain language regarding individual requirements in code could directly affect the land cover composition of Hispanic/Latino communities.

When building out the body of literature for this research, one cannot help but notice that the systemic problems facing low income communities and communities of color. For too long, Hispanic/Latino communities and low-income communities have seen industry sited around themselves, and themselves pushed around industry. Given the problems that these communities face, and the myriad ways in which they are underserved historically and currently, the implementation of improved industrial landscape standards seems minor and insignificant. What is posited here, however, is that a small, even barely-noticeable change at the outset could have beneficial and measurable impacts in terms of addressing environmental inequities. In the fields of landscape architecture and urban planning, changes like these are within the realm of possibility, and if there is the possibility to change even something small for the better, would that not be worth it? Simply because something doesn't have a large enough impact doesn't necessarily mean that it is not worth doing. Changing zoning ordinance with the help of this kind of research will not change the systemic problems facing communities of color, but it is a way that design professionals can help to make their environments and lives just a little bit better.

References

Abbey, Buck. U.S. Landscape Ordinances: An Annotated Reference Handbook. John Wiley & Sons, Inc, 1998.

Alcock, Ian, Mathew P. White, Benedict W. Wheeler, Lora E. Fleming, and Michael H. Depledge. “Longitudinal Effects on Mental Health of Moving to Greener and Less Green Urban Areas.” Environmental Science & Technology 48, no. 2 (January 2014): 1247–55. https://doi.org/10.1021/es403688w.

Anthun, Kirsti S., Ruca Elisa Katrin Maass, Siren Hope, Geir Arild Espnes, Ruth Bell, Matluba Khan, and Monica Lillefjell. “Addressing Inequity: Evaluation of an Intervention to Improve Accessibility and Quality of a Green Space.” International Journal of Environmental Research and Public Health 16, no. 24 (December 2019): 5015. https://doi.org/10.3390/ijerph16245015.

Aronson, Myla FJ, Christopher A Lepczyk, Karl L Evans, Mark A Goddard, Susannah B Lerman, J Scott MacIvor, Charles H Nilon, and Timothy Vargo. “Biodiversity in the City: Key Challenges for Urban Green Space Management.” Frontiers in Ecology and the Environment 15, no. 4 (May 2017): 189–96. https://doi.org/10.1002/fee.1480.

Astell-Burt, Thomas, Xiaoqi Feng, Suzanne Mavoa, Hannah M Badland, and Billie Giles-Corti. “Do Low-Income Neighbourhoods Have the Least Green Space? A Cross-Sectional Study of Australia’s Most Populous Cities.” BMC Public Health 14, no. 1 (December 2014): 292. https://doi.org/10.1186/1471-2458-14-292.

Banzhaf, Spencer, Lala Ma, and Christopher Timmins. “Environmental Justice: The Economics of Race, Place, and Pollution.” Journal of Economic Perspectives 33, no. 1 (2019): 185–208.

Barbosa, Ana E., Joao N. Fernandes, and Luis M. David. “Key Issues for Sustainable Urban Stormwater Management.” Water Research 46, no. 20 (2012): 6787–98.

Bates, Carolyn R., Amy M. Bohnert, and Dana E. Gerstein. “Green Schoolyards in Low-Income Urban Neighborhoods: Natural Spaces for Positive Youth Development Outcomes.” Frontiers in Psychology 9 (May 2018): 805. https://doi.org/10.3389/fpsyg.2018.00805.

Benedict, Mark A., and Edward T. McMahon. “Green Infrastructure: Smart Conservation for the 21st Century.” Renewable Resources Journal 20, no. 3 (2002): 12–17.

Bird, Karen. “The Political Representation of Visible Minorities in Electoral Democracies: A Comparison of France, Denmark, and Canada.” Nationalism and Ethnic Politics 11, no. 4 (December 2005): 425–65. https://doi.org/10.1080/13537110500379211.

Boone, Christopher G., Geoffrey L. Buckley, J. Morgan Grove, and Chona Sister. “Parks and People: An Environmental Justice Inquiry in Baltimore, Maryland.” Annals of the Association of American Geographers 99, no. 4 (2009): 767–87. https://doi.org/10.1080/00045600903102949.

Burrage, Hilary. “Green Hubs, Social Inclusion and Community Engagement.” Proceedings of the Institution of Civil Engineers - Municipal Engineer 164, no. 3 (September 2011): 167–74. https://doi.org/10.1680/muen.900030.

Byrne, Jason. “When Green Is White: The Cultural Politics of Race, Nature and Social Exclusion in a Los Angeles Urban National Park.” Geoforum 43, no. 3 (May 2012): 595–611. https://doi.org/10.1016/j.geoforum.2011.10.002.

Casey, Joan, Peter James, Lara Cushing, Bill Jesdale, and Rachel Morello-Frosch. “Race, Ethnicity, Income Concentration and 10-Year Change in Urban Greenness in the United States.” International Journal of Environmental Research and Public Health 14, no. 12 (December 2017): 1546. https://doi.org/10.3390/ijerph14121546.

Cohen, Deborah A., Bing Han, Kathryn Pitkin Derose, Stephanie Williamson, Terry Marsh, Jodi Rudick, and Thomas L. McKenzie. “Neighborhood Poverty, Park Use, and Park-Based Physical Activity in a Southern California City.” Social Science & Medicine 75, no. 12 (December 2012): 2317–25. https://doi.org/10.1016/j.socscimed.2012.08.036.

Cohen, Deborah A., Terry Marsh, Stephanie Williamson, Kathryn Pitkin Derose, Homero Martinez, Claude Setodji, and Thomas L. McKenzie. “Parks and Physical Activity: Why Are Some Parks Used More than Others?” Preventive Medicine 50 (January 2010): S9–12. https://doi.org/10.1016/j.ypmed.2009.08.020.

Cohen, Deborah A., Terry Marsh, Stephanie Williamson, Bing Han, Kathryn Pitkin Derose, Daniella Golinelli, and Thomas L. McKenzie. “The Potential for Pocket Parks to Increase Physical Activity.” American Journal of Health Promotion 28, no. 3_suppl (January 2014): S19–26. https://doi.org/10.4278/ajhp.130430-QUAN-213.

Colorado. Department of Local Affairs. Office of Smart Growth. Water-Efficient Landscape Design: A Model Landscape Ordinance for Colorado’s Communities Utilizing a Water Conservation-Oriented Planning Approach. Book, Whole. Denver, Colo: Colorado Department of Local Affairs, Office of Smart Growth, 2004.

Connors, John Patrick, Christopher S. Galletti, and Winston T. L. Chow. “Landscape Configuration and Urban Heat Island Effects: Assessing the Relationship between Landscape Characteristics and Land Surface Temperature in Phoenix, Arizona.” Landscape Ecology 28, no. 2 (February 2013): 271–83. https://doi.org/10.1007/s10980-012-9833-1.

Downey, Liam, and Brian Hawkins. “Race, Income, and Environmental Inequality in the United States.” Sociological Perspectives 51, no. 4 (December 2008): 759–81. https://doi.org/10.1525/sop.2008.51.4.759.

Dwyer, John F, E Gregory McPherson, Herbert W Schroeder, and Rowan A Rowntree. “ASSESSING THE BENEFITS AND COSTS OF THE URBAN FOREST,” 1992, 9.

Elmqvist, T, H Setälä, Sn Handel, S van der Ploeg, J Aronson, Jn Blignaut, E Gómez-Baggethun, Dj Nowak, J Kronenberg, and R de Groot. “Benefits of Restoring Ecosystem Services in Urban Areas.” Current Opinion in Environmental Sustainability 14 (June 2015): 101–8. https://doi.org/10.1016/j.cosust.2015.05.001.

Escobedo, Francisco J., and David J. Nowak. “Spatial Heterogeneity and Air Pollution Removal by an Urban Forest.” Landscape and Urban Planning 90, no. 3–4 (April 2009): 102–10. https://doi.org/10.1016/j.landurbplan.2008.10.021.

Folke, Carl, Steve Carpenter, Brian Walker, Marten Scheffer, Thomas Elmqvist, Lance Gunderson, and C.S. Holling. “Regime Shifts, Resilience, and Biodiversity in Ecosystem Management.” Annual Review of

Ecology, Evolution, and Systematics 35, no. 1 (December 2004): 557–81. https://doi.org/10.1146/annurev.ecolsys.35.021103.105711.

Galster, George, and Erin Godfrey. “By Words and Deeds: Racial Steering by Real Estate Agents in the U.S. in 2000.” Journal of the American Planning Association 71, no. 3 (September 2005): 251–68. https://doi.org/10.1080/01944360508976697.

Gentrification and Disinvestment 2020 » NCRC. Accessed February 25, 2021. https://ncrc.org/gentrification20/.

Gregory McPherson, E. “Accounting for Benefits and Costs of Urban Greenspace.” Landscape and Urban Planning 22, no. 1 (September 1992): 41–51. https://doi.org/10.1016/0169-2046(92)90006-L.

Hayden, Dolores. “Urban Landscape History.” The People, Place, and Space Reader, 2014, 82.

Heynen, Nik, Harold A. Perkins, and Parama Roy. “The Political Ecology of Uneven Urban Green Space: The Impact of Political Economy on Race and Ethnicity in Producing Environmental Inequality in Milwaukee.” Urban Affairs Review 42, no. 1 (September 2006): 3–25. https://doi.org/10.1177/1078087406290729.

Hillier, Amy E. “Redlining and the Home Owners’ Loan Corporation.” Journal of Urban History 29, no. 4 (May 2003): 394–420. https://doi.org/10.1177/0096144203029004002.

Holifield, Ryan. “Defining Environmental Justice and Environmental Racism.” Urban Geography 22, no. 1 (2001): 78–90.

How Racial and Regional Inequality Affect Economic Opportunity. Accessed October 19, 2020. https://www.brookings.edu/blog/up-front/2019/02/15/how-racial-and-regional-inequality-affect-economic-opportunity/.

Irving, Jennifer K., and Margaret Reams. “Community Resilience and Critical Transformations: The Case of St. Gabriel, Louisiana.” Reviews on Environmental Health 34, no. 3 (September 2019): 293–301. https://doi.org/10.1515/reveh-2019-0023.

Isaacs, Charles. “Environmental Justice in Little Village: A Case for Reforming Chicago’s Zoning Law.” Northwestern Journal of Law and Social Policy 15, no. 3 (2020): 357–402.

Jenks, George. “The Data Model Concept in Statistical Mapping.” Internation Yearbook of Cartography 7 (1967): 186–90.

Joe Rubino. Denver No. 2 for Gentrification in Recent Years, National Study Finds. The Denver Post, 2020. https://www.denverpost.com/2020/07/08/denver-gentrification-san-francisco/.

Karas, David. “Highway to Inequity: The Disparate Impact of the Interstate Highway System on Poor and Minority Communities in American Cities.” New Visions for Public Affairs 7, no. April (2015): 9–21.
Kim, Jinki, and Xiaolu Zhou. “Landscape Structure, Zoning Ordinance, and Topography in Hillside Residential Neighborhoods: A Case Study of Morgantown, WV.” Landscape and Urban Planning 108, no. 1 (October 2012): 28–38. https://doi.org/10.1016/j.landurbplan.2012.07.011.

Kimpton, Anthony. “A Spatial Analytic Approach for Classifying Greenspace and Comparing Greenspace Social Equity.” Applied Geography 82 (May 2017): 129–42. https://doi.org/10.1016/j.apgeog.2017.03.016.

Kristin F. Butcher, Diane Whitmore Schanzenbach. “Most Workers in Low-Wage Labor Market Work Substantial Hours, in Volatile Jobs.” Center on Budget and Policy Priorities, July 2018. https://www.cbpp.org/research/poverty-and-inequality/most-workers-in-low-wage-labor-market-work-substantial-hours-in.

Lepczyk, Christopher A., Myla F. J. Aronson, Karl L. Evans, Mark A. Goddard, Susannah B. Lerman, and J. Scott MacIvor. “Biodiversity in the City: Fundamental Questions for Understanding the Ecology of Urban Green Spaces for Biodiversity Conservation.” BioScience 67, no. 9 (September 2017): 799–807. https://doi.org/10.1093/biosci/bix079.

Lerman, Susannah B., and Alexandra R. Contosta. “Lawn Mowing Frequency and Its Effects on Biogenic and Anthropogenic Carbon Dioxide Emissions.” Landscape and Urban Planning 182 (February 2019): 114–23. https://doi.org/10.1016/j.landurbplan.2018.10.016.

Low-Income Working Families: Facts and Figures. The Urban Institute, 2005.

Maas, J, R A Verheij, S de Vries, P Spreeuwenberg, F G Schellevis, and P P Groenewegen. “Morbidity Is Related to a Green Living Environment.” Journal of Epidemiology & Community Health 63, no. 12 (December 2009): 967–73. https://doi.org/10.1136/jech.2008.079038.

McGraw, B. T. “The Housing Act of 1954 and Implications for Minorities.” Phylon (1940-1956) 16, no. 2 (1955): 171. https://doi.org/10.2307/272718.

Mears, Meghann, Paul Brindley, Ravi Maheswaran, and Anna Jorgensen. “Understanding the Socioeconomic Equity of Publicly Accessible Greenspace Distribution: The Example of Sheffield, UK.” Geoforum 103 (July 2019): 126–37. https://doi.org/10.1016/j.geoforum.2019.04.016.

Melles, Stephanie J. “Urban Bird Diversity as an Indicator of Human Social Diversity and Economic Inequality in Vancouver, British Columbia.” Urban Habitats 3, no. 1 (2005): 25–48.

Müller, Norbert, and Mahito Kamada. “URBIO: An Introduction to the International Network in Urban Biodiversity and Design.” Landscape and Ecological Engineering 7, no. 1 (2011): 1–8.

National Western Stock Show - Historic Denver. Accessed March 16, 2021. https://historicdenver.org/national-western-stock-show-site/.

New in WH&G: 1938 “Redlining” Map of Denver. Denver Public Library History, 2015. https://history.denverlibrary.org/news/new-whg-redlining-maps-denver.

Nutsford, D., A.L. Pearson, and S. Kingham. “An Ecological Study Investigating the Association between Access to Urban Green Space and Mental Health.” Public Health 127, no. 11 (November 2013): 1005–11. https://doi.org/10.1016/j.puhe.2013.08.016.

O’Malley, Christopher, Poorang Piroozfar, Eric R.P. Farr, and Francesco Pomponi. “Urban Heat Island (UHI) Mitigating Strategies: A Case-Based Comparative Analysis.” Sustainable Cities and Society 19 (December 2015): 222–35. https://doi.org/10.1016/j.scs.2015.05.009.

Page, Brian, and Eric Ross. “Legacies of a Contested Campus: Urban Renewal, Community Resistance, and the Origins of Gentrification in Denver.” Urban Geography 38, no. 9 (October 2017): 1293–1328. https://doi.org/10.1080/02723638.2016.1228420.

“Legacies of a Contested Campus: Urban Renewal, Community Resistance, and the Origins of Gentrification in Denver.” Urban Geography 38, no. 9 (October 2017): 1293–1328. https://doi.org/10.1080/02723638.2016.1228420.

Pais, J., K. Crowder, and L. Downey. “Unequal Trajectories: Racial and Class Differences in Residential Exposure to Industrial Hazard.” Social Forces 92, no. 3 (March 2014): 1189–1215. https://doi.org/10.1093/sf/sot099.

Pincetl, Stephanie, and Elizabeth Gearin. “The Reinvention of Public Green Space.” Urban Geography 26, no. 5 (August 2005): 365–84. https://doi.org/10.2747/0272-3638.26.5.365.

Racial Disparities Among Extremely Low-Income Renters. National Low Income Housing Coalition. Accessed October 19, 2020. https://nlihc.org/resource/racial-disparities-among-extremely-low-income-renters.

Rao, Meenakshi, Linda A. George, Todd N. Rosenstiel, Vivek Shandas, and Alexis Dinno. “Assessing the Relationship among Urban Trees, Nitrogen Dioxide, and Respiratory Health.” Environmental Pollution 194 (November 2014): 96–104. https://doi.org/10.1016/j.envpol.2014.07.011.

Rigolon, Alessandro. “A Complex Landscape of Inequity in Access to Urban Parks: A Literature Review.” Landscape and Urban Planning 153 (September 2016): 160–69. https://doi.org/10.1016/j.landurbplan.2016.05.017.

Rigolon, Alessandro, and Jeremy Németh. “Green Gentrification or ‘Just Green Enough’: Do Park Location, Size and Function Affect Whether a Place Gentrifies or Not?” Urban Studies 57, no. 2 (February 2020): 402–20. https://doi.org/10.1177/0042098019849380.

Rigolon, Alessandro, and Jeremy Németh. “What Shapes Uneven Access to Urban Amenities? Thick Injustice and the Legacy of Racial Discrimination in Denver’s Parks.” Journal of Planning Education and Research, July 2018, 0739456X1878925. https://doi.org/10.1177/0739456X18789251.

Runfola, Daniel Miller, Colin Polsky, Craig Nicolson, Nicholas M. Giner, Robert Gilmore Pontius, Joseph Krahe, and Albert Decatur. “A Growing Concern? Examining the Influence of Lawn Size on Residential Water Use in Suburban Boston, MA, USA.” Landscape and Urban Planning 119 (November 2013): 113–23. https://doi.org/10.1016/j.landurbplan.2013.07.006.

Sailor, David J. “Simulated Urban Climate Response to Modifications in Surface Albedo and Vegetative Cover.” Journal of Applied Meteorology 34, no. 7 (July 1995): 1694–1704. https://doi.org/10.1175/1520-0450-34.7.1694.

Sandercock, Leonie. Making the Invisible Visible: A Multicultural Planning History. Vol. 2. Univ of California Press, 1998.

Schlosberg, David. “Reconceiving Environmental Justice: Global Movements And Political Theories.” Environmental Politics 13, no. 3 (September 2004): 517–40. https://doi.org/10.1080/0964401042000229025.

Stafford, Walter W., and Joyce Ladner. “Comprehensive Planning and Racism.” Journal of the American Institute of Planners 35, no. 2 (March 1969): 68–74. https://doi.org/10.1080/01944366908977575.

Takano, T. “Urban Residential Environments and Senior Citizens’ Longevity in Megacity Areas: The Importance of Walkable Green Spaces.” Journal of Epidemiology & Community Health 56, no. 12 (December 2002): 913–18. https://doi.org/10.1136/jech.56.12.913.

Ulrich, R. “View through a Window May Influence Recovery from Surgery.” Science 224, no. 4647 (April 1984): 420–21. https://doi.org/10.1126/science.6143402.

Unequal Access to Parks in Denver Has Roots in History. Colorado Trust, 2019. https://www.coloradotrust.org/content/story/unequal-access-parks-denver-has-roots-history.

Vor, Friso de, and Henri L. F. de Groot. “The Impact of Industrial Sites on Residential Property Values: A Hedonic Pricing Analysis for the Netherlands.” SSRN Electronic Journal, 2009. https://doi.org/10.2139/ssrn.1398803.

Ward Thompson, Catharine, Jenny Roe, Peter Aspinall, Richard Mitchell, Angela Clow, and David Miller. “More Green Space Is Linked to Less Stress in Deprived Communities: Evidence from Salivary Cortisol Patterns.” Landscape and Urban Planning 105, no. 3 (April 2012): 221–29. https://doi.org/10.1016/j.landurbplan.2011.12.015.

White, Mathew P., Ian Alcock, Benedict W. Wheeler, and Michael H. Depledge. “Would You Be Happier Living in a Greener Urban Area? A Fixed-Effects Analysis of Panel Data.” Psychological Science 24, no. 6 (June 2013): 920–28. https://doi.org/10.1177/0956797612464659.

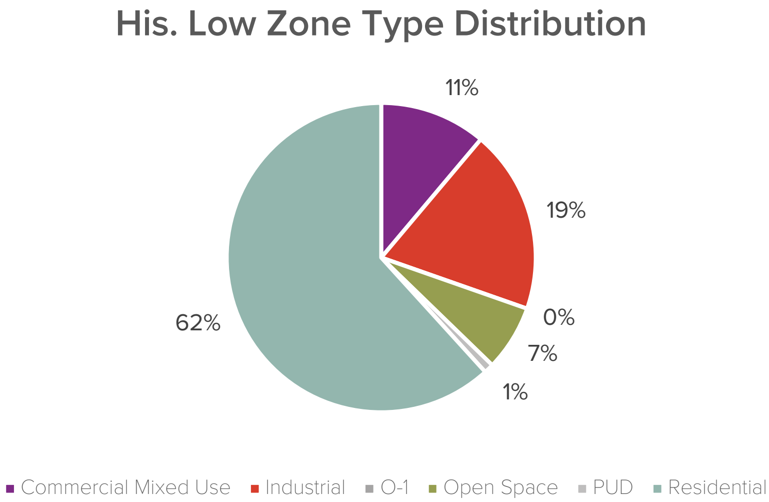
Wilson, Bev. “Urban Heat Management and the Legacy of Redlining.” Journal of the American Planning Association, May 2020, 1–15. https://doi.org/10.1080/01944363.2020.1759127.

Wolch, Jennifer R., Jason Byrne, and Joshua P. Newell. “Urban Green Space, Public Health, and Environmental Justice: The Challenge of Making Cities ‘Just Green Enough.’” Landscape and Urban Planning 125 (May 2014): 234–44. https://doi.org/10.1016/j.landurbplan.2014.01.017.

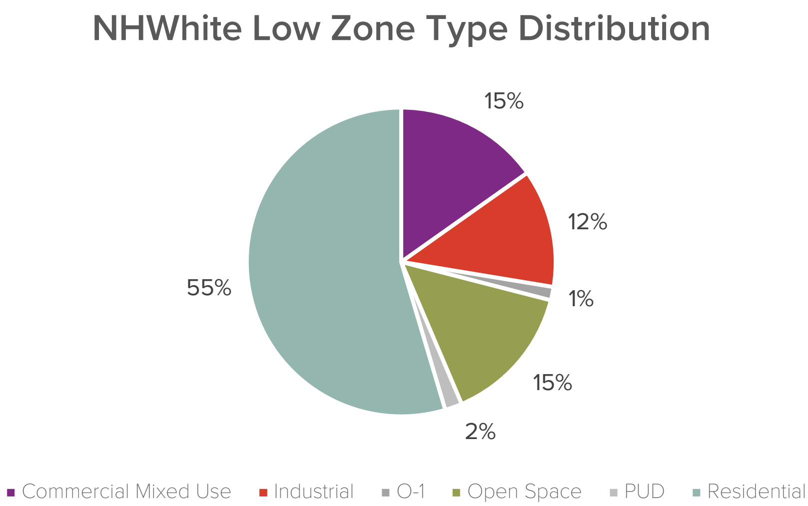
Zenou, Yves, and Nicolas Boccard. “Racial Discrimination and Redlining in Cities.” Journal of Urban Economics 48, no. 2 (September 2000): 260–85. https://doi.org/10.1006/juec.1999.2166.

Zhao, Fang, and Thomas Gustafson. “FTA Report No. 0030 Federal Transit Administration,” n.d., 91.

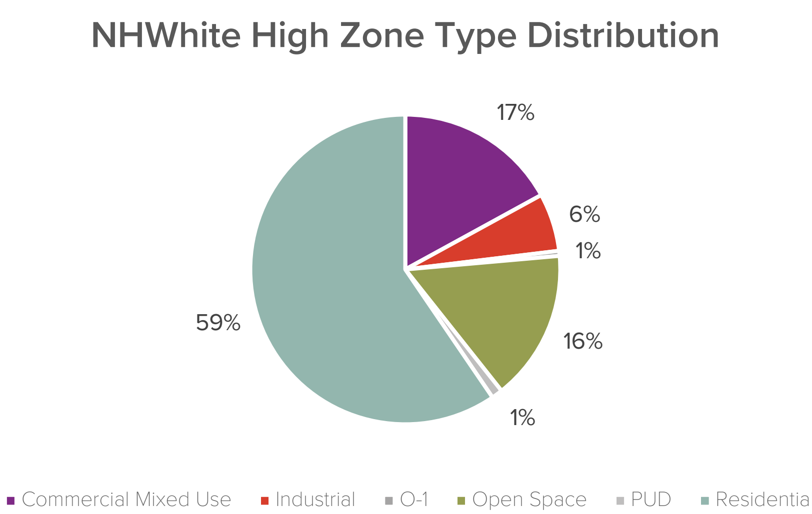
Zone Type Distribution



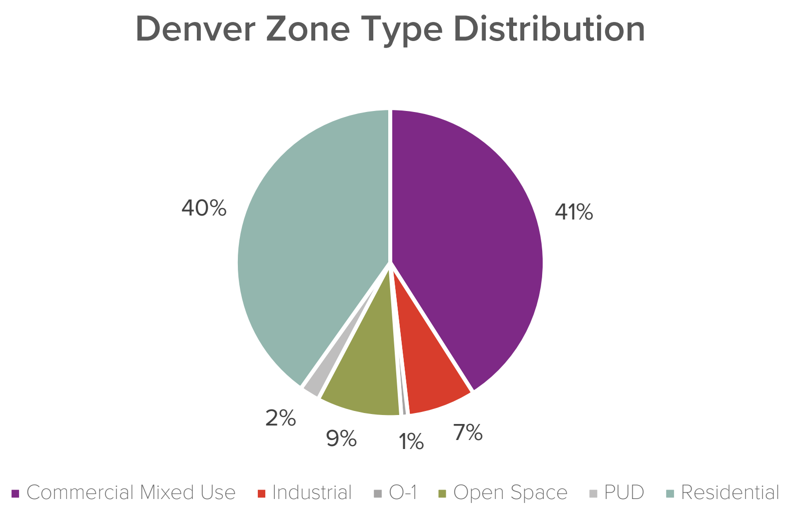
His. Low	
Commercial Mixed Use	0.111496
Industrial	0.192106
O-1	0.000008
Open Space	0.068784
PUD	0.010063
Residential	0.617543



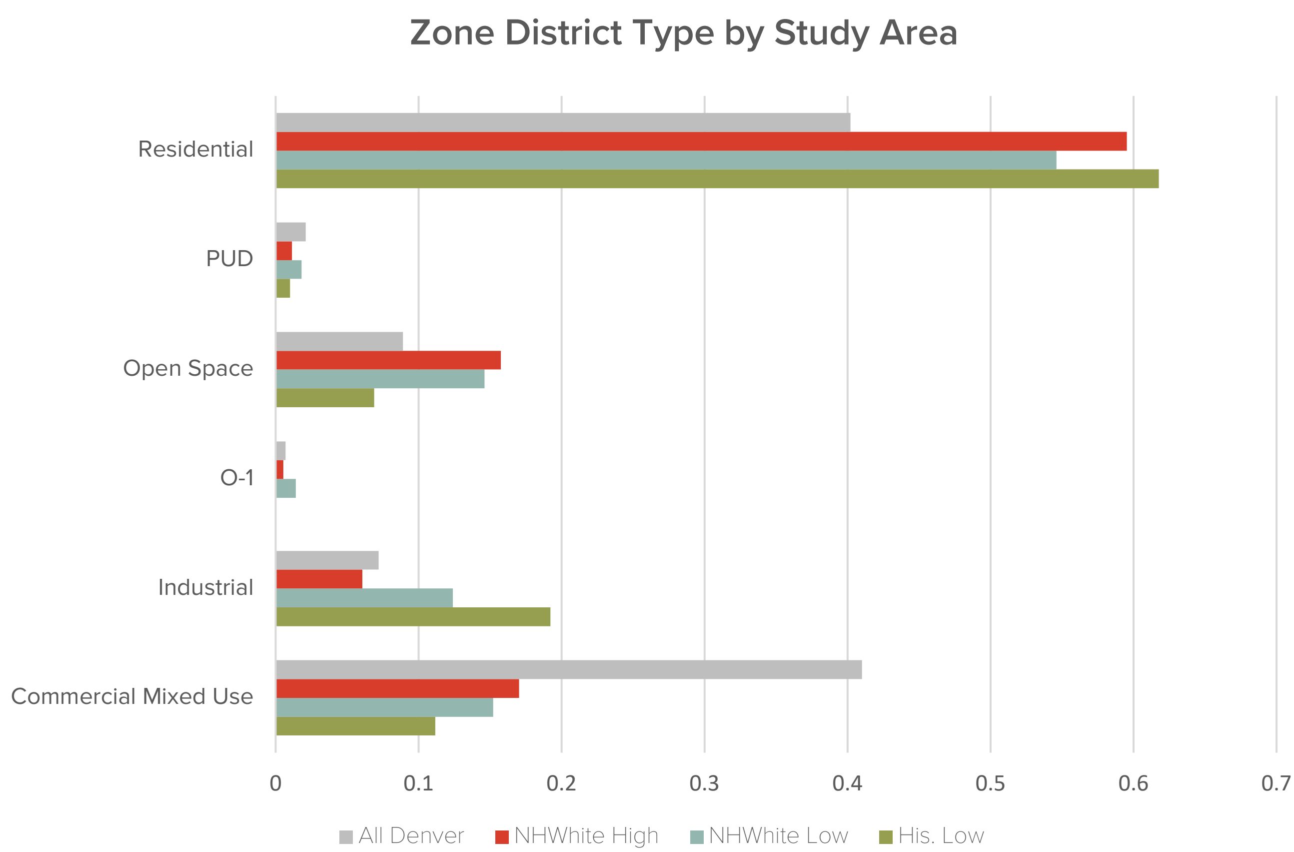
NHWhite Low	
Commercial Mixed Use	0.152
Industrial	0.124
O-1	0.014
Open Space	0.146
PUD	0.018
Residential	0.546



NHWhite High	
Commercial Mixed Use	0.170222
Industrial	0.060547
O-1	0.005245
Open Space	0.157366
PUD	0.011482
Residential	0.595138



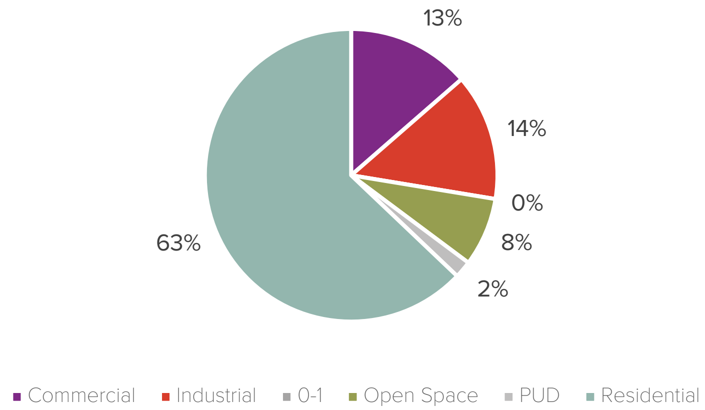
All Denver	
Commercial Mixed Use	0.41
Industrial	0.072
O-1	0.007
Open Space	0.089
PUD	0.021
Residential	0.402



Appendix B

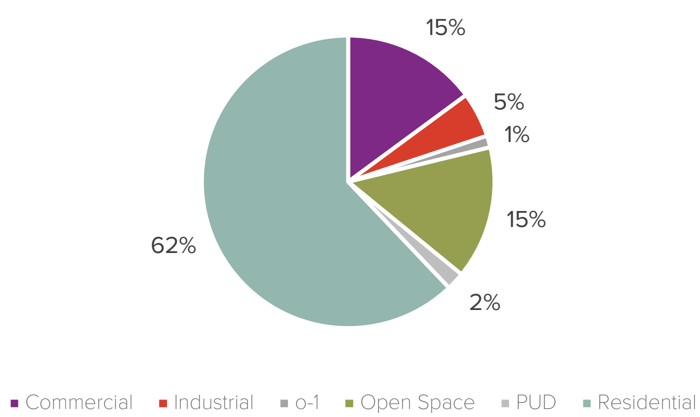
Zone Type Distribution - 0.25 Miles of Residential Zones

His. Low, Zone District Type within 0.25 Miles of Residential Zones



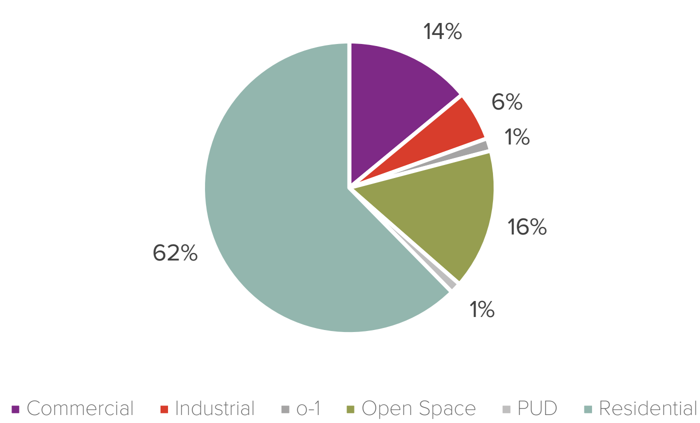
HisLow	Percentage
Commercial	13.6
Industrial	14
0-1	0
Open Space	7.6
PUD	1.9
Residential	62.9

NHWhite Low, Zone District Type within 0.25 Miles of Residential Zones



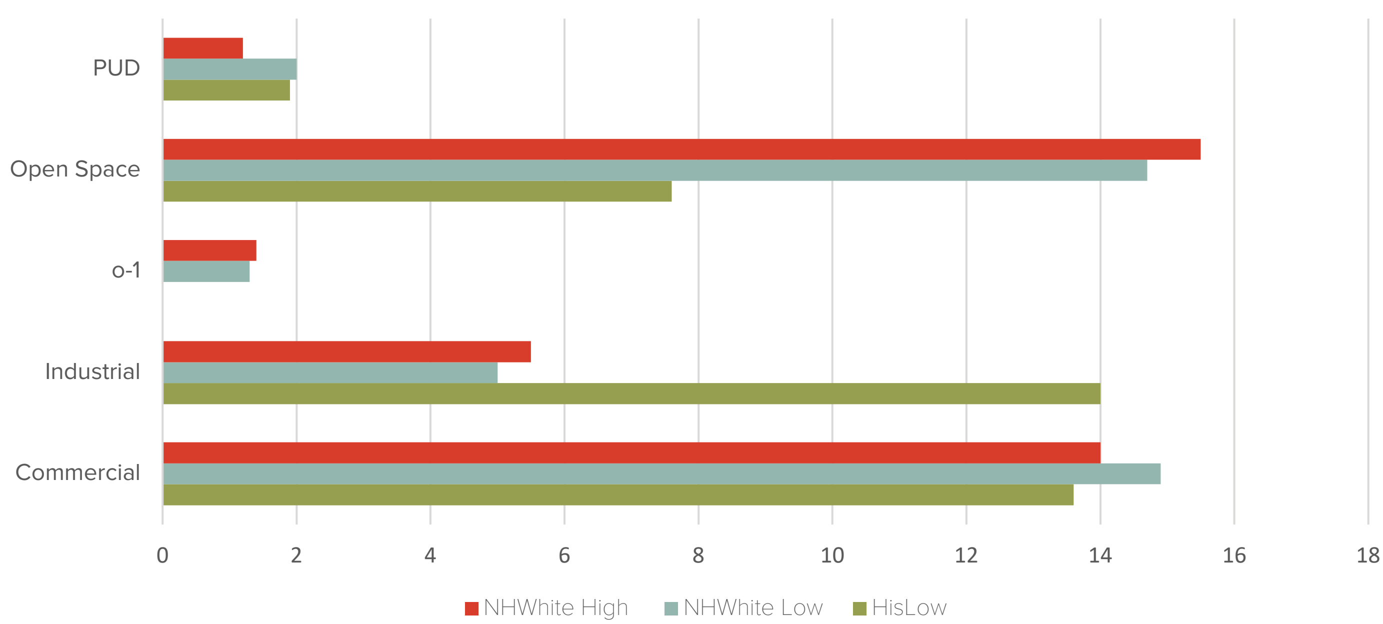
NHWhite Low	Percentage
Commercial	14.9
Industrial	5
o-1	1.3
Open Space	14.7
PUD	2
Residential	62.1

NHWhite High, Zone District Type within 0.25 Miles of Residential Zones



NHWhite High	Percentage
Commercial	14
Industrial	5.5
o-1	1.4
Open Space	15.5
PUD	1.2
Residential	62.3

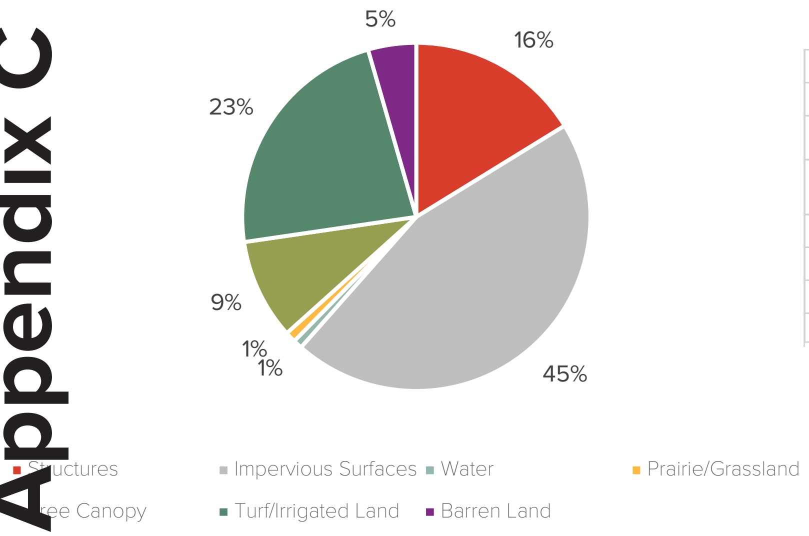
Zone District Type within a 0.25 mile Radius of Residential Zones



Appendix C

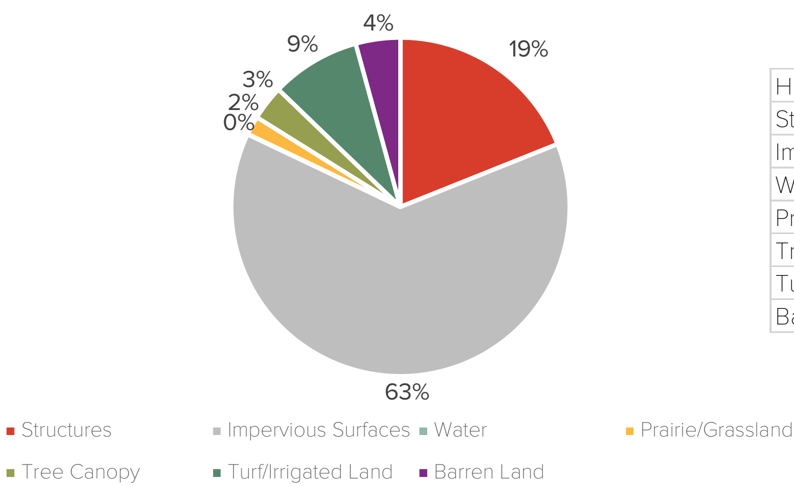
Land Cover by Study Area and Zone District Type

His. Low, All Zoning



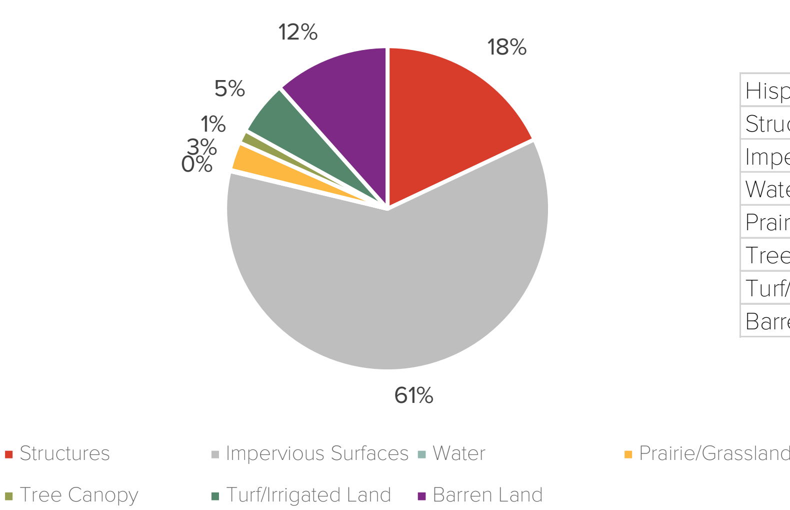
Hispanic, Low Income, All Zoning		Percentage
Structures	9360519	0.162267153
Impervious Surfaces	26127770	0.452932029
Water	486839	0.008439487
Prairie/Grassland	573180	0.009936232
Tree Canopy	5381014	0.093281347
Turf/Irrigated Land	13177088	0.22842842
Barren Land	2579442	0.044715332

His. Low, Commercial Zoning



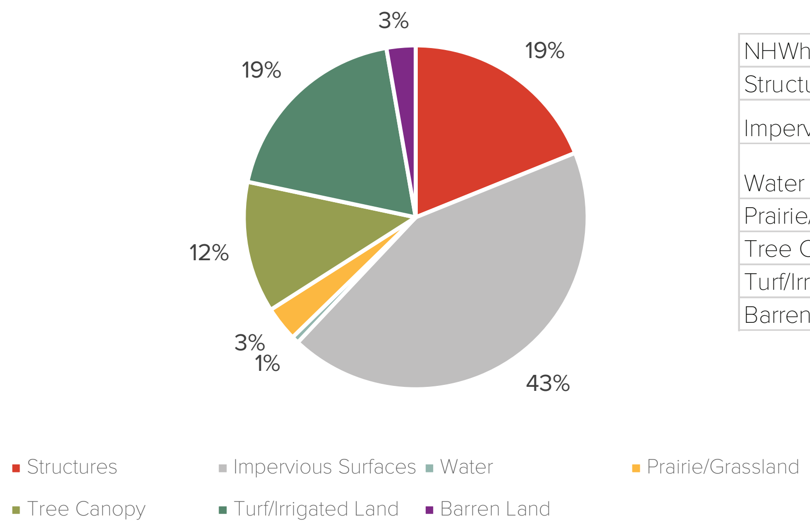
Hispanic, Low Income, Commercial Zoning		Percentage
Structures	1218802	0.189482171
Impervious Surfaces	4058989	0.631034448
Water	2338	0.000363479
Prairie/Grassland	115122	0.017897547
Tree Canopy	213241	0.033151708
Turf/Irrigated Land	549536	0.085434118
Barren Land	274250	0.042636528

His. Low, Industrial Zoning



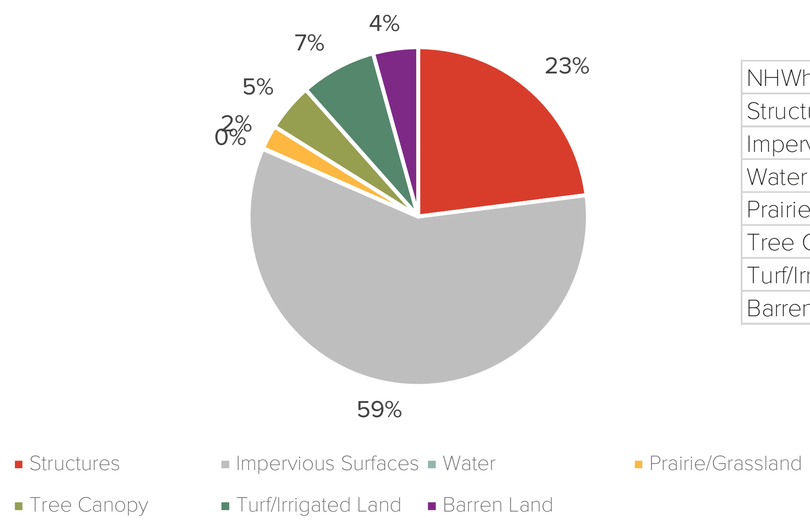
Hispanic, Low Income, Industrial Zoning		Percentage
Structures	1992460	0.179863821
Impervious Surfaces	6729109	0.60745172
Water	13945	0.001258846
Prairie/Grassland	313933	0.028339434
Tree Canopy	146772	0.013249437
Turf/Irrigated Land	597951	0.053978374
Barren Land	1283433	0.115858368

NHWhite Low, All Zoning



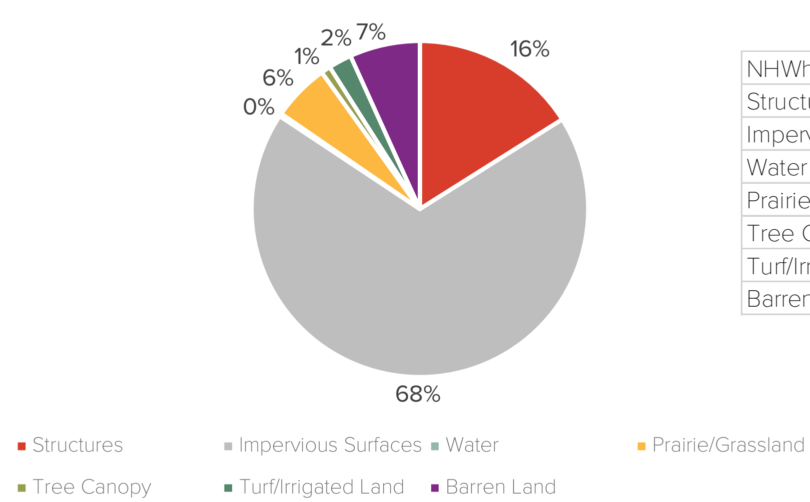
NHWhite, Low Income, All Zoning		Percentage
Structures	7100404	0.188911
Impervious Surfaces	16215046	0.431413
Water	254746	0.006778
Prairie/Grassland	1224994	0.032592
Tree Canopy	4640464	0.123463
Turf/Irrigated Land	7122876	0.189509
Barren Land	1027404	0.027335

NHWhite Low, Commercial Zoning



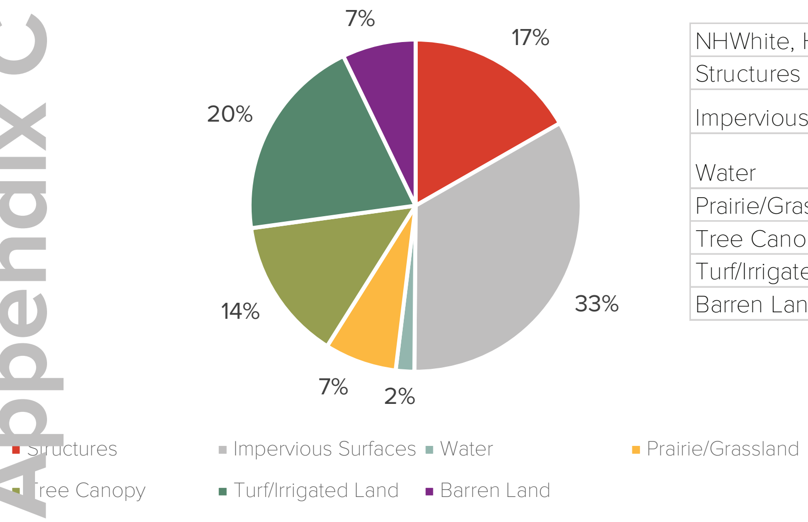
NHWhite, Low Income, Commercial Zoning		Percentage
Structures	2360494	0.229805
Impervious Surfaces	6015832	0.58567
Water	7134	0.000695
Prairie/Grassland	236962	0.023069
Tree Canopy	467542	0.045517
Turf/Irrigated Land	743186	0.072353
Barren Land	440562	0.042891

NHWhite Low, Industrial Zoning



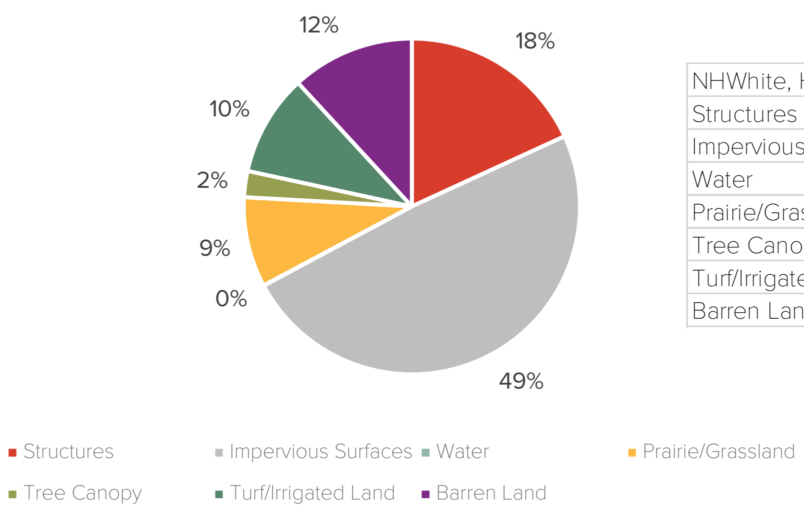
NHWhite, Low Income, Industrial Zoning		Percentage
Structures	259431	0.16047
Impervious Surfaces	1104006	0.682877
Water	4261	0.002636
Prairie/Grassland	88905	0.054992
Tree Canopy	14753	0.009125
Turf/Irrigated Land	36045	0.022295
Barren Land	109296	0.067605

NHWhite High, All Land Cover



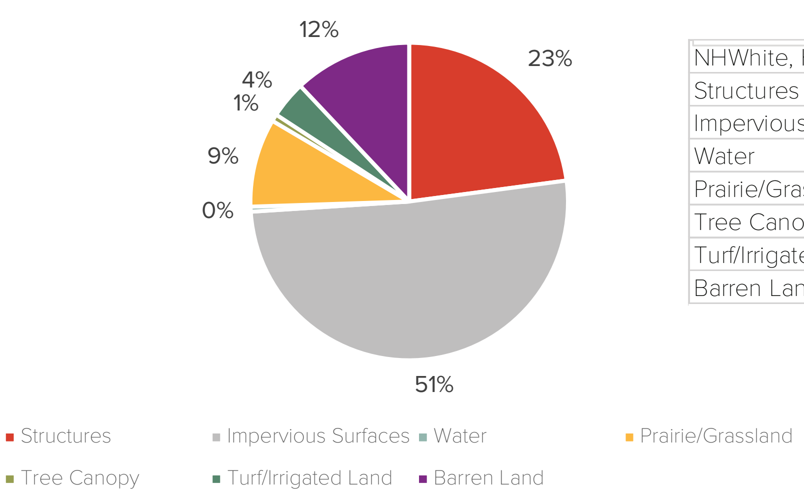
NHWhite, High Income, All Zoning		Percentage
Structures	10578714	0.167395559
Impervious Surfaces	21095003	0.333803316
Water	1139236	0.018027054
Prairie/Grassland	4438599	0.070235547
Tree Canopy	8771800	0.138803295
Turf/Irrigated Land	12644038	0.200076853
Barren Land	4528516	0.071658376

NHWhite High, Commercial Zoning

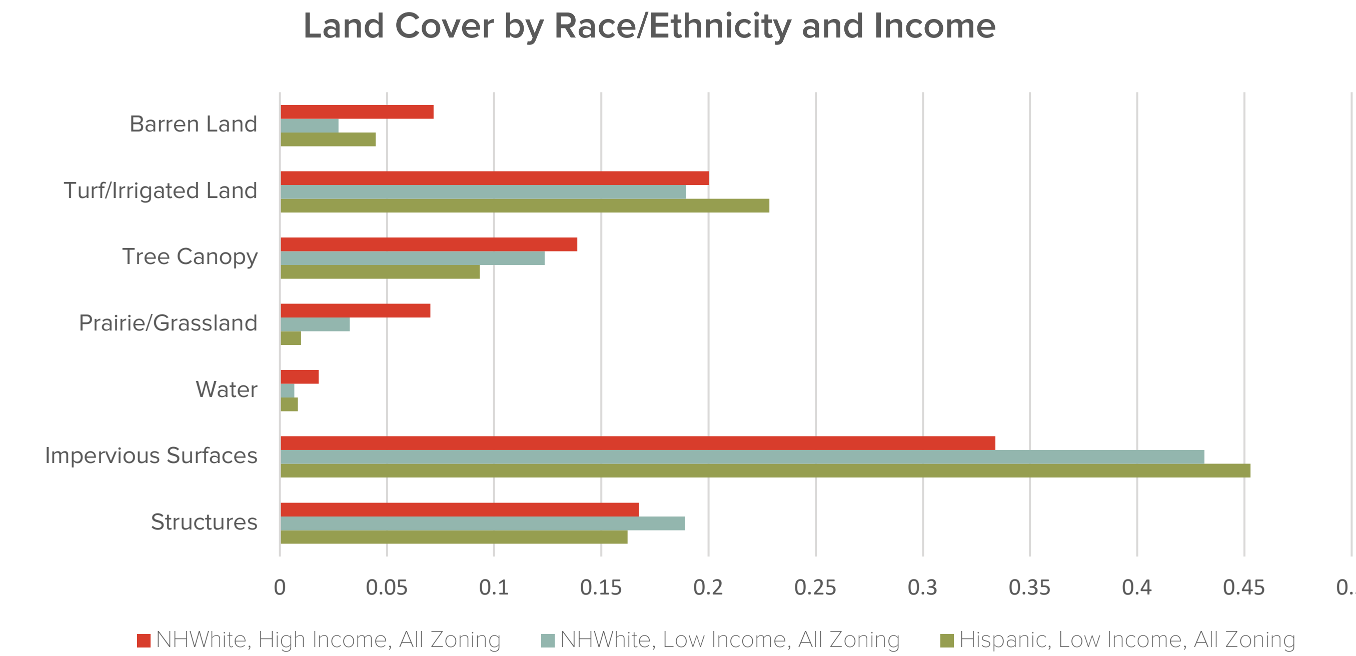


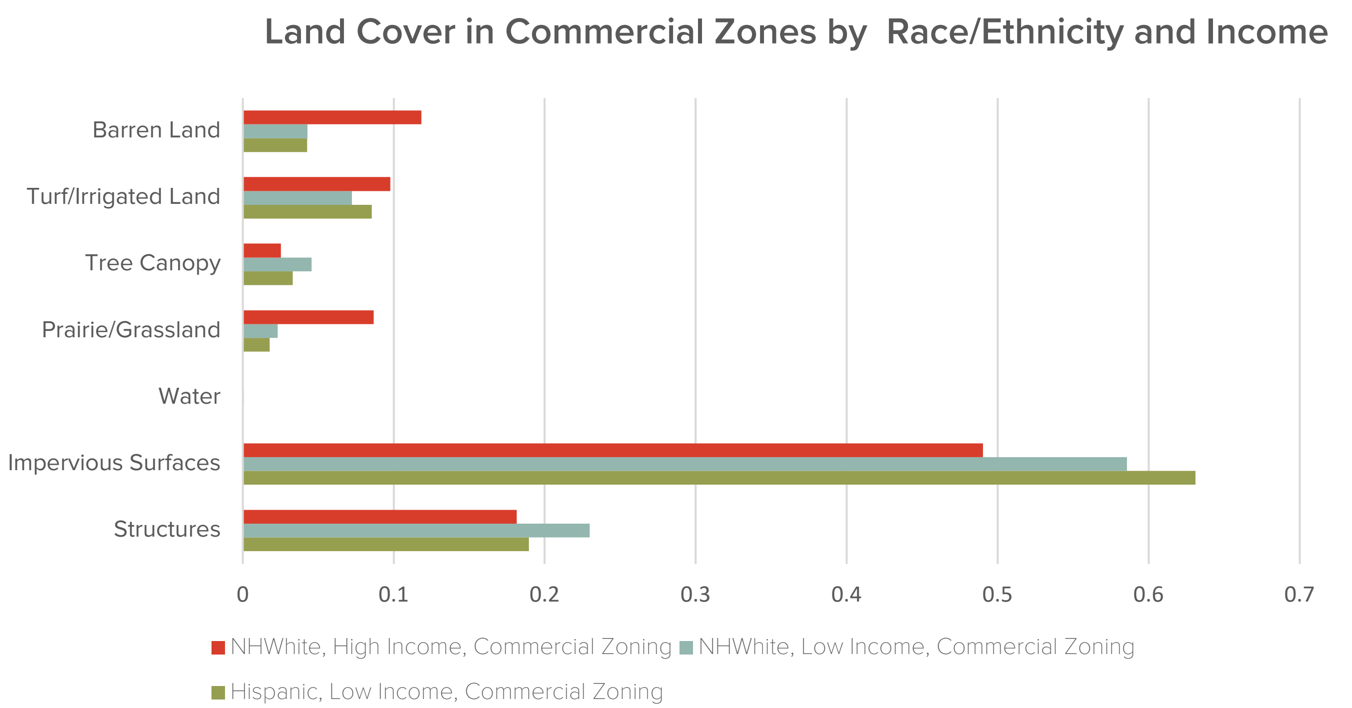
NHWhite, High Income, Commercial Zoning		Percentage
Structures	1951242	0.181395415
Impervious Surfaces	5274480	0.490337174
Water	3231	0.000300367
Prairie/Grassland	933404	0.086773043
Tree Canopy	270620	0.025157939
Turf/Irrigated Land	1050495	0.0976583
Barren Land	1273371	0.118377762

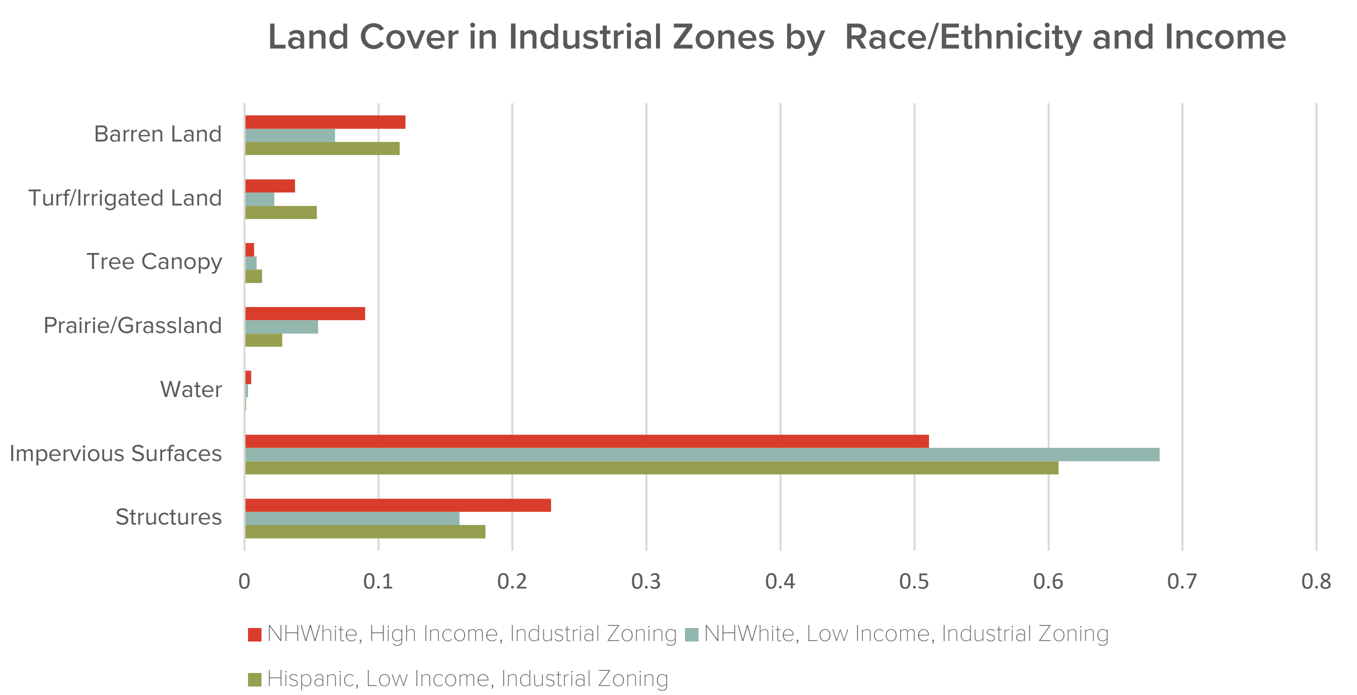
NHWhite High, Industrial Zoning



NHWhite, High Income, Industrial Zoning		Percentage
Structures	875264	0.228905227
Impervious Surfaces	1953374	0.510860173
Water	19377	0.00506761
Prairie/Grassland	344164	0.090008201
Tree Canopy	27755	0.007258684
Turf/Irrigated Land	144117	0.037690496
Barren Land	459645	0.120209609


Land Cover by Race/Ethnicity and Income
Barren Land
Turf/Irrigated Land
Tree Canopy
Prairie/Grassland
Water
Impervious Surfaces
Structures
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
NHWhite, High Income, All Zoning
NHWhite, Low Income, All Zoning
Hispanic, Low Income, All Zoning

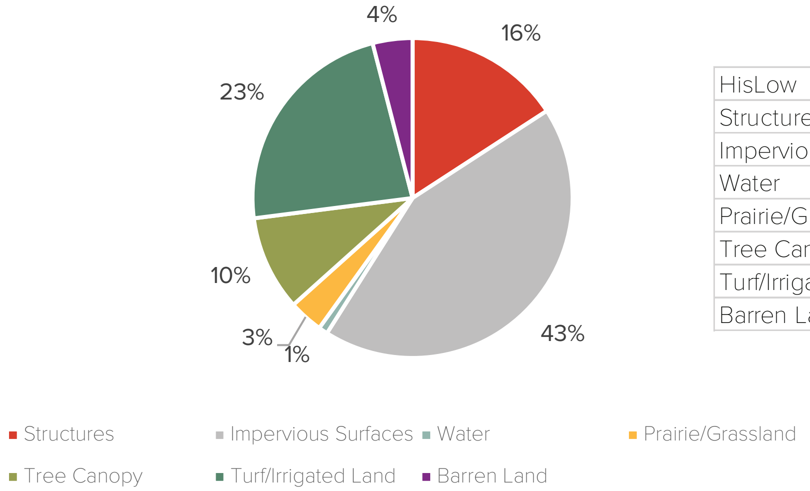

Land Cover in Commercial Zones by Race/Ethnicity and Income
Barren Land
Turf/Irrigated Land
Tree Canopy
Prairie/Grassland
Water
Impervious Surfaces
Structures
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
NHWhite, High Income, Commercial Zoning
NHWhite, Low Income, Commercial Zoning
Hispanic, Low Income, Commercial Zoning


Land Cover in Industrial Zones by Race/Ethnicity and Income
Barren Land
Turf/Irrigated Land
Tree Canopy
Prairie/Grassland
Water
Impervious Surfaces
Structures
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
NHWhite, High Income, Industrial Zoning
NHWhite, Low Income, Industrial Zoning
Hispanic, Low Income, Industrial Zoning

Appendix D

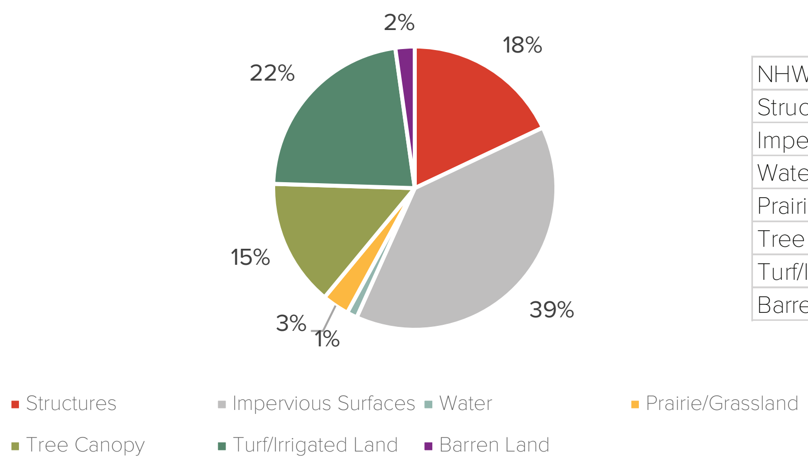
Land Cover Within 0.25 Miles of Residential Zones

His. Low, 0.25 Miles from Residential Zones



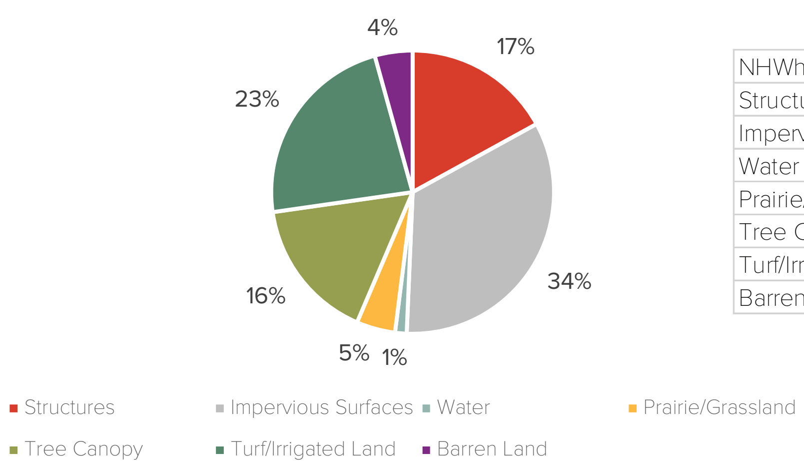
HisLow		Percentage
Structures	10836638	0.158292159
Impervious Surfaces	29541478	0.431516153
Water	633484	0.009253382
Prairie/Grassland	2371982	0.034647845
Tree Canopy	6571883	0.095996337
Turf/Irrigated Land	15752680	0.230101414
Barren Land	2751582	0.040192711

NHWhite Low, 0.25 Miles from Residential Zones



NHWhite Low		Percentage
Structures	16446594	0.17976
Impervious Surfaces	35452564	0.387494
Water	1088325	0.011895
Prairie/Grassland	2819655	0.030819
Tree Canopy	13254519	0.144871
Turf/Irrigated Land	20417512	0.223162
Barren Land	2012688	0.021999

NHWhite High, 0.25 Miles from Residential Zones



NHWhite High		Percentage
Structures	17060634	0.170129
Impervious Surfaces	33751394	0.336569
Water	1325891	0.013222
Prairie/Grassland	4452652	0.044402
Tree Canopy	16356280	0.163105
Turf/Irrigated Land	23004006	0.229396
Barren Land	4329972	0.043178

Land Cover within 0.25 Miles of Residential Zones