‘City of Trees:’

Understanding Shade as an Issue of Environmental Justice through D.C. Tree Canopy

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Introduction

Historically known as the "city of trees," D.C. has earned the nickname for its vast tree canopy. However, there are disparities in coverage across the city that reflect long-standing racial and economic inequalities in the city's urban landscape (Sanders et al., 2015; Maney, J., & Locke, D. H., 2025). Tree coverage is lower in predominantly Black and lower-income neighborhoods, whereas wealthier white neighborhoods, often in the northern part of the city, benefit from denser canopy cover. In 2017, D.C.'s wealthiest neighborhoods had 42 percent more tree cover than the poorest communities (Chuang et al., 2017). These disparities leave neighborhoods without the environmental benefits of a tree canopy, such as improved air and water quality, as well as health benefits such as reduced stress.

As U.S. cities grow hotter, shade from tree canopies is becoming an essential part of urban planning and climate change mitigation strategies. Thus, many U.S. cities are working to increase tree canopy and access to shade to improve residents' quality of life. It is a cost-effective, straightforward method for protecting communities' health and well-being. Unfortunately, many neighborhoods often lack shade on pavement, at transit stops, outside workplaces, and at the playground–gaps that disproportionately impact communities of color and low-income communities. From an environmental justice (EJ) perspective, it is essential to ask where tree canopy cover is increasing and whose quality of life it is improving through ongoing efforts.

In response to historical losses of tree canopy due to disinvestment in the city, Washington, D.C. set a citywide goal in 2013 to increase the tree canopy from 35 percent to 40 percent of city land area by 2032. The District Department of Energy and the Environment created the District of Columbia Urban Tree Canopy Plan as the primary mechanism driving tree-planting initiatives. This positioned urban trees as a key component of the city's heat mitigation strategy and broader sustainability efforts in D.C.

The District Department of Transportation's Urban Forestry Division and the Department of Energy and Environment lead city planting efforts, alongside Casey Trees, the city's largest nonprofit tree planting organization (DC Department of Energy and the Environment, n.d.). Despite these substantial initiatives to increase tree canopy as part of their goal, the city added only .2 percent of canopy between 2011 and 2020, with losses during 2015 and 2020 offset earlier gains. These changes varied by neighborhood, with some neighborhoods gaining canopy and others losing it (PlanIt Geo, 2022).

A few studies examine changes in urban tree canopy from an environmental justice perspective in Washington, D.C. To add to the research, I aim to evaluate the effectiveness of D.C.'s tree strategy in addressing current issues through an environmental justice lens, asking: How effective have D.C.'s efforts to expand its tree canopy been in reducing environmental justice disparities? Using the pillars of EJ, I assess distributional justice in tree canopy growth or loss in D.C. 's predominantly Black and Hispanic neighborhoods from 2011 to 2020.

Using Urban Tree Canopy (UTC) data by census block from Open Data DC (2022)[1] and the American Survey (ACS) 5-year estimates for 2013[2] and 2022 from Social Explorer[3], I examine changes in tree canopy and neighborhood composition from 2011 to 2020 by race/ethnicity. I then use OLS bivariate analysis to determine whether there is a significant

[1] Open Data DC. (2022). *Urban Tree Canopy by Census Block in 2020* [Vector digital data]. https://opendata.dc.gov/datasets/cd2da0109c1b46c3a2ec9890e44623d3_1/explore
[2] American Community Survey. (2009–2013). *Total population (5-year estimates)*. In *Social Explorer*. Retrieved December 10, 2025, from https://www.socialexplorer.com/data/ACS2013_5yr/metadata?ds=SE&table=A00001
[3] American Community Survey (ACS) 2018–2022 5-Year Estimates. (2025). *Social Explorer*. Retrieved December 10, 2025, from https://www.socialexplorer.com/data/ACS2022_5yr/metadata;

relationship between tree canopy change and income and race/ethnicity. There was no significant relationship between tree canopy coverage in 2011; however, there was a negative and significant relationship between tree canopy change and majority-POC neighborhoods in 2020.

Given that the relationship between tree canopy change and race/ethnicity was statistically significant in 2020, I conducted a multivariate analysis to examine canopy change over time and assess whether differences existed between majority-people-of-color (POC) tracts and majority-white tracts, controlling for other factors. My OLS regression shows that, even as tree canopy cover has grown over the last decade, communities of color experienced statistically significant slower growth, indicating that environmental justice gaps remain.

Research shows this was a period of significant demographic change, as D.C. transitioned from a predominantly Black city, so I also examine whether a tract's change (Given the small number of tracts that changed, only tracts that remained majority-white or majority-POC showed significant results: white tracts gained more canopy, whereas predominantly POC tracts lost canopy, further indicating that EJ disparities increased.

The socio-spatial patterns associated with increased tree canopy suggest the presence of environmental injustice, particularly along racial and ethnic lines. Specifically, census tracts with predominantly POC populations saw less tree canopy growth than predominantly white neighborhoods. Overall, neighborhoods with higher proportions of racialized minorities had fewer trees in 2020 and were less likely to gain tree canopy between 2011 and 2020. I therefore conclude this report by making policy recommendations that push the City to address the racialized disparities as a central part of the efforts to green and shade the city.

Background

Tree Canopy History in the District

Trees are a significant part of D. C's landscape, dating back to Pierre L'Enfant's design, which envisioned a city lined with boulevards and public spaces filled with trees. While trees were lost over time to development or to farmland before the Civil War, in the 1870s, D.C. 's governor, Alexander Shepard, directed the systematic planting of 60,000 street trees to improve the quality of life in the nation's capital. The city then gained its reputation as the "City of Trees" (District Department of the Environment, 2013). The expansive canopy persisted into the mid-20th century, with approximately 50 percent of D.C. covered by tree canopy in the 1950s. Due to years of disinvestment and population decline, the city failed to invest in and maintain its trees, leading to significant canopy loss and a lack of new growth. Specifically, between 1973 and 1997, the city's tree cover decreased by 64 percent (Washington Post, 1999). This loss was disproportionately felt among low-income communities of color. Wealthier residents have more disposable income to invest in landscaping and can afford to maintain trees in their yards and neighborhoods.

By the early 2000s, during a period of immense citywide growth, a Back-to-the-City Movement began. Mayor Anthony Williams advocated for an economic development strategy to attract middle-class residents to the city to increase tax revenue. Reports urged city officials to "complement and extend Washington's tourist and city beautiful amenities" to shed its image as a home to "bureaucrats and poor people." (Asch & Musgrove, 2017). This movement led to the most significant period of gentrification in Washington, D.C., and to a push to increase the tree canopy by creating the first tree-protection ordinance (District Department of the Environment, 2013). From 2007 to 2011, under Mayor Adrian Fenty, the Urban Forestry Administration (UFA), under the Department of Transportation (DOT), planted over 4,150 trees and invested heavily in maintaining existing street trees (District Department of the Environment, 2013).

Tree Canopy goal

In response to canopy decline, in 2011, the district first announced its ambitious goal to increase tree canopy cover from 35 percent to 40 percent of the land area by 2032. In 2013, the city formalized this goal in its Urban Tree Canopy Plan, produced by the District Department of the Environment and approved by the Office of the City Administrator. The report found that parks, recreation areas, open spaces, low- and medium-density residential areas, and federal lands have the most significant potential to support additional tree canopy. The 3-pronged approach aims to maintain existing canopy, focus on new planting in priority areas, and strengthen District tree policies and regulations. To achieve the goal, the district projected a need to plant more than 10,850 trees a year. This plan acknowledges but does not explicitly address racial and economic injustices in the city's canopy distribution. While the city recommends focusing on tree planting in areas with the lowest canopy and the highest potential for canopy growth, it does not state which communities disproportionately have less coverage (District Department of the Environment, 2013).

Key Players

These recent efforts, under this plan, are collective efforts involving public agencies, businesses, nonprofits, and individuals. This tree-planting effort is anchored within the city's Urban Forestry Department, which serves as the primary steward of public trees in the district. The D.C. Department of Energy and Environment (DOEE) focuses on outreach, education, and incentives to support the planting and maintenance of trees. Casey Trees is the largest nonprofit focused on the tree canopy in Washington, D.C., with a mission to restore, enhance, and protect the city's tree canopy. Together with partners, it offers programs such as RiverSmart Homes and Tree Rebate programs. RiverSmart Homes is an incentive program that provides free audits to residents to help them plant more trees or reduce stormwater runoff. After completing the suit, homeowners are eligible to pay $50 to the Nonprofit Casey Trees to plant a tree in their yard and receive up to $1,200 in landscaping enhancements, including tree planting.

Current State of Tree Canopy in the District

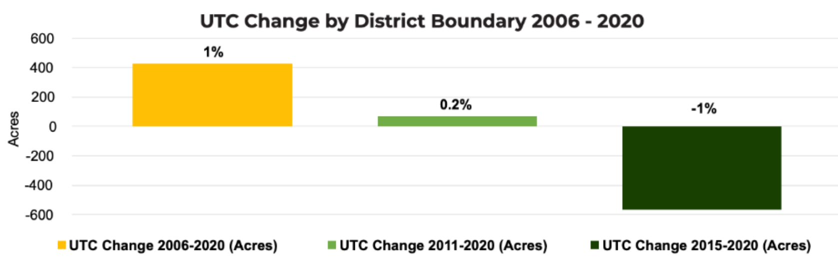

Figure 1. ***UTC Change by District Boundary (2006-2020).*** **Note. Adapted from *Geospatial Urban Tree Canopy Assessment: Washington, DC (2020)*, PlanItGeo, January 2022, https://marketing.planitgeo.com/hubfs/Reports%20%5BGATED%5D/%5BREPORT%5D%20geospatial-urban%20tree%20canopy%20assessment-washington%20DC-united%20states-2020.pdf.**

To track progress towards the city's Urban Tree Canopy (UTC) goal, the Urban Forestry Division conducts a land cover assessment every five years to assess tree canopy coverage and maintain an inventory of tree species. Shown in Figure 1, in 2011, D.C. had 14,601 acres of tree canopy. By 2015, coverage increased to 15,236 acres. As the population grew, housing demand and development increased. More land was covered with concrete and asphalt, often leaving less space for new trees or harming existing ones. As a result, the tree canopy declined back down to 14,670 acres. Overall, there was only a minimal increase in tree canopy coverage between 2011 and 2020, with a 0.2 percent increase (~70 acres) citywide (PlanIt Geo, 2022).

Tree Canopy Disparities

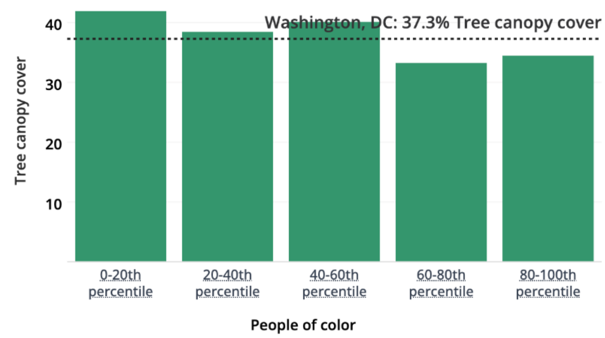

Figure 2. ***Tree Canopy Cover by neighborhood percentile of POC population*** **Note. Adapted from *Tree Equity Score Report: Washington D.C. (2021), Tree Equity Score,*** https://www.treeequityscore.org/insights/place/washington-dc

Despite the city's canopy goals, shade remains unevenly distributed across D.C., with lower-income neighborhoods and communities of color consistently having fewer street trees, green spaces, and shaded public spaces than white and more affluent communities. The Tree Equity score shown in Figure 2 indicates that D.C. neighborhoods with fewer people of color (0-20^{th} percentile), or a higher proportion of white residents, have on average, 1.2 times more tree canopy than neighborhoods with the highest percentage of people of color (Tree Equity Score, 2021).

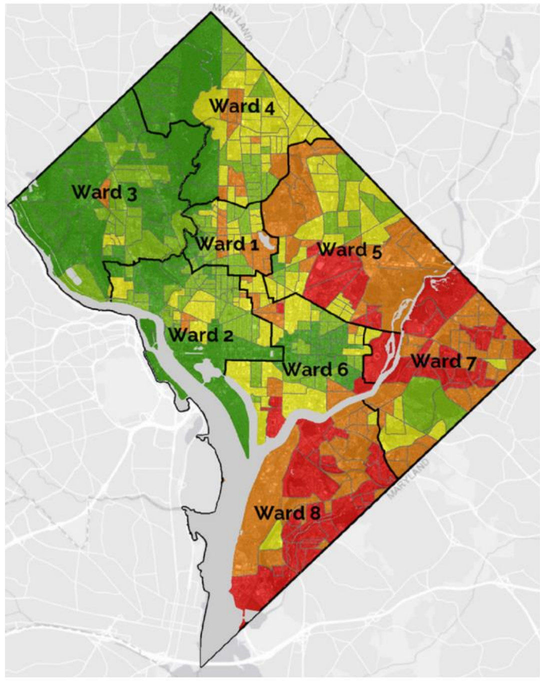

Figure 3. ***Combined planting prioritization by census block group.*** **Note. Adapted from *Geospatial Urban Tree Canopy Assessment: Washington, DC (2020)*, PlanItGeo, January 2022, https://marketing.planitgeo.com/hubfs/Reports%20%5BGATED%5D/%5BREPORT%5D%20geospatial-urban%20tree%20canopy%20assessment-washington%20DC-united%20states-2020.pdf.**

These disparities directly translate into temperature differences across the city. Figure 3 shows a combined planting priority ranking, including environmental factors (e.g., urban heat island), sociodemographic (poverty, homeownership), and public health (obesity, asthma, etc.), showing that Ward 5, 7, and 8 with lower canopy are among the highest priority (PlanItGeo, 2020). These neighborhoods experience the highest heat exposure during summer months and have higher rates of minorities, lower income, elderly residents, and chronic health conditions, making them even more vulnerable. On the other hand, Ward 3 has the largest proportion of white, wealthier residents, high vegetation cover, and low vulnerability to extreme heat, and consistently records some of the coolest temperatures in the city during the summer (Thriving

Earth Exchange, 2018). The lack of equitable tree canopy, therefore, compounds longstanding racial and economic inequities.

Before the tree canopy goal and plan, in D.C. from 2006 to 2011, low-income areas lost more tree canopy area as a percentage of land area than higher-income areas, even though they began with far less (Sanders et al., 2015). These areas that remained relatively wealthy had more tree canopy than those that remained relatively impoverished, and the relatively impoverished areas lost more canopy than the others (Chuang et al., 2017).

Implications for This Case Study

Increasing tree canopy cover alone does not constitute an effective urban tree canopy (UTC) plan. The effectiveness of this goal depends on whether planting and maintenance are targeted to and reach communities most burdened by heat exposure, environmental stress, and historical disinvestment. The following literature review and data analysis examine whether tree-planting efforts between 2011 and 2020 have reduced the identified environmental justice disparities and increased the well-being of all communities in D.C.

Literature Review

Environmental Racism and Justice

Environmental Racism is a longstanding issue in America, referring to any ecological policy, practice, or directive that differentially affects or disadvantages individuals, groups, or communities (whether intended or unintended) based on race or color (Bullard, R.D., Johnson, 2000). Decades of research have established that economically impoverished communities and communities of color face greater environmental risks and health hazards in their homes and neighborhoods than their more affluent counterparts (Mohai & Bryant, 1992; Morello-Frosch et al., 2001; Pastor et al., 2005; Pulido, 2000). This persistent disparity illustrates inequality between white communities and communities of color in ecological outcomes and the policies that shape them (Pulido, 2016).

The Environmental Justice (EJ) movement emerged as a grassroots response to longstanding racial inequities in relation to environmental quality. Foundations of this movement came from many other movements and actors, including the Civil Rights Movement, labor and farming organizing, the antitoxins movement of the 1970s, Native American struggles, and many communities led fights against polluting industries (Cole & Foster, 2000). The movement gained national attention after protests in Warren County, North Carolina, against a polychlorinated biphenyls (PCBs) landfill led to 500 arrests of predominantly Black protesters. The protests a (Bullard, 2001). Historically, environmental justice theory and movement have been concerned with reducing the disproportionate burden of exposure to environmental hazards (e.g., refineries and incinerators). The protests led the Commission for Racial Justice (1987) to produce *Toxic Wastes and Race in the United States,* the first national study to find that race was the most potent variable in predicting where facility sites were located, more powerful than poverty, land, and homeownership (Bullard, 2001; Pastor et al., 2005; Morello-Frosch et al., 2001). The scope of social and ecological equity has since broadened the distribution of environmental goods and amenities, including Urban Tree Canopy (Schwarz et al, 2015). This is often through the lens of environmental privilege, which provides access to coveted amenities such as forests, green spaces, and elite neighborhoods. These benefits result from the exercise of different economic, political, and cultural powers, protecting certain people from harms that other groups face (Pellow & Nyseth-Brehm, 2013). It is therefore important, when understanding environmental injustice, to focus on both the negative (unequal exposure to hazards and risks) and the positive (unequal access to amenities) that environmental inequalities entail (Park & Pellow, 2011; Murphy, 2016).

Urban Tree Canopy Benefits

Urban tree canopy (UTC) is increasingly recognized as an urban amenity. Trees are an essential source of shade, offering multiple benefits, including cooler temperatures, aesthetic value, and improved air quality (Locke et al., 2022). In the built environment, urban shade trees offer significant benefits by reducing air-conditioning demand and CO_2 emissions, with savings of up to $200 per tree (Akbari, 2002). Shade significantly reduces the heat load on the human body and decreases thermal stress on hot, sunny days (Middel et al., 2021). This is especially important in urban areas, where development and infrastructure are highly concentrated and green space can be limited. Heat from sunlight is reflected from and absorbed by these buildings and roads, making these spaces "islands" of higher temperatures relative to outlying areas. These pockets of heat are commonly referred to as urban heat islands (UHI).

In contrast, natural landscapes, such as trees, cool the air by providing shade, transpiring water from plant leaves, and evaporating surface water (US EPA, 2014). Hot weather events and frequent high heat exposure can lead to several adverse physical health effects and contribute to heat-related deaths and related illnesses. It can lead to cardiovascular strain, heat stroke, adverse pregnancy outcomes, and mental health problems (Taylor et al, 2024). By cooling the neighborhoods they are in, urban trees reduce near-surface air temperatures and heat exposure, therefore reducing UHIs and UHI-related mortalities. A study on social vulnerability to heat and the cooling capacity of trees in 38 of the United States' largest cities found that trees have a larger cooling effect in socially vulnerable neighborhoods (Zhou et al., 2021).

Research also suggests that trees offer a wide variety of socioeconomic values. Benefits include increased property values with the strong visual appeal of the canopy. It is also associated with an increased sense of place and social cohesion as outdoor encounters foster social networks and relationships (Locke et al., 2017; Tyrväinen et al., 2005; Sullivan & Kuo, 1996). Research also finds that tree canopies and similar public green spaces can reduce crime by attracting people to spend time outdoors. More people outdoors put more eyes on the streets and in public spaces, making it harder for criminals to go unnoticed. On the other hand, paved areas with little to no vegetation are often seen as "no-man's lands," which discourage residential interaction and reduce "eyes on the street," thereby making it easier for criminals to go unnoticed (Kuo, 2003). Since urban trees provide essential social and physical benefits to urban residents, inequitable access to these benefits creates an environmental justice condition (Heynen, 2003).

Distribution of Urban Trees as an EJ Issue

Given the many benefits that urban trees provide, "uneven distribution of trees contributes to an uneven quality of life" (Perkins et al., 2004, as cited in Foster & Dunham, 2019). How urban trees are managed has important implications not only for conservation but also for distributional and procedural environmental injustice. Distributional injustice is the physical manifestation of recognitional and procedural injustices, where groups lack access to an environmental good and/or live in proximity to environmental harm (Schlosberg, 2007). While EJ encompasses three pillars — distributive, procedural, and recognitional justice — my case study focuses predominantly on distributive justice.

The benefits of tree canopy and lack of access in some communities have driven well-documented EJ implications of UTC. Many scholars note that urban tree canopy and green spaces are inequitably distributed across the U.S. due to physical and socioeconomic factors. EJ-focused research documents that higher-income areas and predominantly white communities have greater tree canopy cover than their lower-income, communities-of-color counterparts (Gerrish & Watkins, 2018; Schwarz et al., 2015; Landry & Chakraborty, 2009). Urban heat is not experienced equally, as heat exposure and associated health risks are spatially distributed across socioeconomic and racial lines, shaping the distribution of tree canopy cover (McDonald et al., 2021). Residents of lower-UTC neighborhoods in these communities are more susceptible to heatstroke and to heat-related exacerbations of myriad other chronic illnesses, with these impacts accelerating in step with climate change (Aguilera, 2021).

While there are nuances, many studies on UTC distribution demonstrate significant relationships between race/ethnicity, wealth, and income. These studies often show that higher-income and predominantly white areas have more trees, while minority and low-income neighborhoods have fewer (Schwarz et al., 2015). Looking at income, a study across 5,723 municipalities and other Census-designated places in the U.S. found that 92 percent of the urbanized areas surveyed have low-income blocks with less tree cover than high-income blocks.

On average, controlling for population density, low-income blocks had 15.2 percent less tree cover and were subsequently 1.5˚C hotter than high-income blocks. This difference was most pronounced in urbanized areas of the Northeast United States, where low-income blocks have 30 percent less tree cover and are 4.0˚C hotter than other areas (McDonald et al., 2021). Schwarz et.al (2015) looked at tree canopy in Baltimore, MD, Los Angeles, CA, New York, NY, Philadelphia, PA, Raleigh, NC, Sacramento, CA, and Washington, D.C. using high spatial resolution land cover data and census data and found a strong positive correlation between median household income and UTC cover. Results on the environmental equity implications of street trees in Tampa, Florida, with respect to race and ethnicity, income, and housing tenure, support the inequity hypothesis by indicating a significantly lower proportion of tree cover on public rights-of-way in neighborhoods containing a higher proportion of African Americans, low-income residents, and renters (Landry & Chakraborty, 2009).

Race-based inequity has also been observed on a national scale. A meta-regression across 40 studies found significant race-based inequity in urban forest cover, including tree canopy. However, the relationship varies across racial groups and study methodology (Watkins & Gerrish, 2018). Schwarz et al. (2015) found that the relationship between UTC cover and the percentage of Black residents is negative and significant for Los Angeles, Raleigh, Sacramento, and Washington, D.C. Similarly, the relationship between UTC cover and the percentage of Hispanic residents is negative and significant for Los Angeles, New York City, Philadelphia, and Sacramento.

While many studies focus on coverage at a single point in time, others examine where tree canopy has increased and whose quality of life has improved. A survey conducted on tree canopy change over time and its EJ implications in Philadelphia indicated that neighborhoods with higher proportions of racialized minorities had lower levels of tree canopy coverage in 2018 and were less likely to gain tree canopy between 2008 and 2018 (Foster et al., 2022). Danford et al. (2014) also found that inequities in Boston persisted despite citywide planting initiatives over time. Difficulties arose regarding expected funding, policy considerations, and the physical availability of tree-planting sites in environmental justice communities that would close these gaps.

These findings underscore that increasing total canopy cover does not necessarily close EJ gaps. This research also informs my use of race/ethnicity and income as main variables for analysis, while also controlling other demographic and spatial variables, to understand differences in urban tree canopy in Washington, D.C., over time.

Distributive inequity in D.C.

Washington, D.C. aims to increase tree canopy coverage from 35 percent to 40 percent by 2032. Consistent with EJ perspectives, the D.C. Urban Tree Plan recommended focusing on tree planting in areas with the lowest tree canopy and the highest potential for canopy growth (Department of Energy and Environment, 2013). Several studies have analyzed the EJ implications of tree canopy distribution in D.C. to understand the historical drivers of this goal and its success today.

A historical view reveals the legacies of institutional racism through the policy of redlining in the present-day distribution of urban tree canopy. In 1933, the federally created Homeowners' Loan Corporation (HOLC), which provided loans to individuals, produced maps for D.C. and across the U.S. that coded areas as creditworthy based on the predominant racial makeup of the neighborhood, a practice known as redlining (Chandler & Phillips, n.d.). The HOLC assigned grades to delimited residential neighborhoods, reflecting "mortgage security," based on various neighborhood characteristics, including the racial composition of inhabitants, using the letters A through H. Areas A-E were associated with white residents. From 1934 to 1962, nearly all (98 percent) of the FHA-insured loans went to white borrowers. Higher-ranked, predominantly white neighborhoods in areas historically ranked A-E had significantly greater tree canopy cover and less impervious surface cover in the present day than lower-ranked neighborhoods. Because tree canopy cools urban areas through shading, while impervious surfaces like asphalt and buildings retain and re-emit heat, formerly HOLC A-graded areas are also more likely to be cooler than formerly HOLC D-graded areas (Maney, J., & Locke, D. H., 2025). This connection between tree canopy and race/ethnicity persists today; indeed, Schwarz et al. (2015) found that the relationship between UTC coverage and the percentage Black is negative and significant in D.C.

Income is another significant factor in areas with greater urban tree canopy. A recent comparative analysis of Washington, D.C. and Baltimore found that stable-wealthy neighborhoods were more likely to maintain consistent tree canopy cover over time than other neighborhood types (Chuang et al., 2017). Another study found that from 2006 to 2011, low-income areas in D.C. lost more tree canopy as a percentage of land area than higher-income areas, even though they had less in 2006 (Sanders et al., 2015). These higher-income areas also tend to have less of their current canopy under stress, indicating their greater capacity to maintain tree health and resources to prevent tree loss and decline (Fang et al., 2023). Research also finds that population density is a statistically significant negative predictor of SFR tree canopy in the district (Frey, 2017).

The literature also highlights the importance of governance and equitable community participation in shaping EJ outcomes. A review on Urban Forest Management Plans (UFMPs) found that studying the impact of different authoring stakeholders on environmental justice goals in UFMPs is a crucial research area. Specifically, it involves analyzing how planning documents, management practices, and decision-making processes address or perpetuate environmental injustices (Myers et al., 2023). This manifests in D.C., focusing on how tree-planting initiatives are carried out and their equally important EJ implications. Locke et al. (2014) found that current free or reduced-cost tree-planting programs on private land were most effective in Washington, D.C.'s most affluent neighborhoods, suggesting that these programs are not always reaching D.C.'s most vulnerable communities and residents. A case study in D.C. focused on promoting tree growth in Ward 8, which has an 88 percent African American population, high poverty rates, and the lowest number of trees over the last 5 years. Using interviews and community outreach to analyze these injustices led 660 Ward 8 residents to commit to planting trees. It was found that residents want to understand the benefits and concrete challenges of increasing canopy while also being involved in the process (Leets, L., 2022). This highlights the community's involvement in improving tree equity in the city.

The research shows that tree canopy and increased urban shade are essential to keeping D.C. livable and healthy amid rising heat. While D.C. has a necessary goal of expanding coverage overall, reducing inequities in access requires planning. This case study builds on previous bodies of work by looking at changes in the canopy over time. Using changes in canopy distribution from 2011, before the official tree canopy plan, and from 2020 across census tracts, I will assess whether the city is closing environmental justice gaps.

Data & Methods

Demographic Data

I derived demographic data for Washington, D.C., from the 2013 5-year American Community Survey (ACS) estimates and 2022 ACS 5-year estimates (downloaded from Social Explorer), to temporally align the place-based demographic data in 2011 and 2020 (as 2011 is the midpoint in the 2013 5-year ACS estimates and 2020 is the midpoint in the 2022 5-year estimates). The main EJ variables of interest in this study are race and income. I converted all racial groups (percent Black, percent Hispanic, percent Asian, percent American Indian and Alaska Native, percent Hawaiian and Pacific Islander, percent other, percent two or more) to percentages and summed to calculate the percent nonwhite population in each census tract. I then created a binary variable, labeled majority-people of color (POC), to classify each tract as majority-white or predominantly minority. I also constructed a racial transition variable that categorizes tracts as remaining majority white, shifting from majority POC to majority white, or shifting from majority white to majority POC.

I included standard demographic variables as controls used in urban forest environmental justice research: population density, median home value, percent renter-occupied, and the percentage of adults 25 and older with less than a high school degree and with a bachelor's degree or higher (Foster et al., 2022; Watkins & Gerrish, 2018; Schwarz et al.,2015). I conducted correlation analyses to avoid overly strong or perfect correlations among the independent variables. Based on these tests, poverty levels were highly correlated with race/ethnicity and, therefore, excluded from my regression.

Although the original analytical plan was to include race/ethnicity and income in a single regression model, the strong correlation between these variables necessitated separate models to evaluate whether canopy gains differed between majority POC tracts and majority white tracts, and between lower-income and higher-income tracts.

Tree Canopy Data

I derived the Urban Tree Canopy (UTC) data from the district's 2020 GIS-based tree canopy assessment, broken down by Census Block. The 2020 assessment utilized high-resolution (1-meter) multispectral imagery from the Pleiades satellite constellation, collected in 2020, and LiDAR data from the District of Columbia. Satellite imagery was used to classify all land-cover types. In contrast, LiDAR data was primarily used to determine vegetation height and distinguish tree canopies from other vegetation (City of Washington, DC, 2022). The dependent variable in my analysis is the change in tree canopy area (acres) between 2011 and 2020. Area coverage in 2011 and 2020 provides a strong understanding of the overall canopy totals for each year and of the baseline disparity in coverage. Physical controls include the 2011 baseline canopy level and the area unsuitable for planting, to account for planting limitations in the built environment. All these estimates were aggregated from the block level to the census tract level for this analysis.

For my time-series analysis, I merged the 2020 tree canopy data and census data files for the 2011 and 2020 estimates. Census tract boundaries change over time as populations shift, so there were 170 census tracts in 2011 and 205 in 2020. I used the U.S. Census Bureau's "Census Tract Relationship File" to reallocate 2020 Census tract-level data to 2010 Census tract shapes, yielding a complete and comparable dataset.

Methods

To evaluate whether tree-plating efforts reduced or perpetuated environmental justice disparities, my analysis examines tree canopy disparity in D.C. as an environmental justice issue through three components: (1) overall canopy change in D.C. from 2011-2020, (2) demographic changes in race/ethnicity across census tracts, and (3) the relationship between canopy change and race/ethnicity.

Following standard EJ methodology for tree canopy analysis, I first estimated bivariate regressions to determine whether there was a baseline disparity along racial lines (Schwarz et al., 2015). I then used multivariate OLS regression to assess whether race/ethnicity or income predicted canopy change after controlling other structural and socioeconomic factors.

Limitations

Unfortunately, due to the complexity of the analysis and time constraints, I could not interpolate median household income from 2010 Census tract shapes to 2010 shapes; therefore, it is omitted from my final regression analysis. Before accounting for boundary changes, I found that income and race were highly correlated and therefore required two separate models for analysis. In an initial bivariate analysis, I found no association between income and tree canopy change from 2011 to 2020. Further research and analysis are needed to elucidate this relationship. Additionally, due to timing constraints, I do not use a Simultaneous Autoregressive (SAR) model, which analyzes spatial relationships by considering how neighboring units influence one another.

Descriptive Statistics

Racial and Economic Change

A defining part of D.C.'s recent history is its transition away from being a majority-Black city. Between 2000 and 2020, the share of the Black population in D.C. declined from 60 percent to 40.9 percent. On the other hand, the white population rose from 30.8 to 38 percent, Hispanic from 7.3% to 11.3% and Asian from 2.7 percent 4.3 of the total population (Chandler & Phillips, 2020). There was also immense population growth from 2011-2020 from 559,892 people to 670,587. According to a study from the National Community Reinvestment Coalition, D.C. had the highest percentage of gentrifying neighborhoods in the country between 2000 and 2013, resulting in the displacement of an estimated 20,000 Black residents. Of 154 neighborhoods "eligible to gentrify"—those with median home values and household incomes below the 40th percentile—62 did so based on increased property values and college degree attainment. Neighborhoods in the city's Ward 6, which includes Capitol Hill, Navy Yard, and Southwest Waterfront, have seen the highest rates of displacement, with some experiencing losses of over 50% of primarily low-income and African American residents (Richardson et al., 2019).

Despite these shifts, most census tracts remained majority-POC in 2011 and 2020. For the 2011 population in 2020 census tracts, there were 103 majority-white census tracts and 102 majority-POC census tracts. In 2020, these numbers changed to 82 majority-white tracts and 123 majority-POC tracts. As summarized in Table 1, these data indicate that although some tracts have experienced shifts in racial composition, most neighborhoods remained demographically similar. Only one tract transitioned from majority-POC, while 22 tracts transitioned from majority-white to majority POC. Some apparent transitions may reflect population relocation across new tract shapes rather than actual demographic changes. Over the same period, median income in 2013 adjusted for 2022 inflation increased significantly from $88,700 to $114,541 in 2022, reflecting broader patterns of economic growth and gentrification in the city.

Table 1. Changes in the Racial Composition of Census Tracts 2011-2020

	Number of Tracts	pct
Stayed Majority POC	101	49.27
Stayed Majority White	81	39.51
Transitioned from Majority POC to Majority White	1	0.49
Transitioned from Majority White to Majority POC	22	10.73
Total	205	100.00

Tree Canopy Change by Racial Demographics

These descriptive statistics provide important context for the subsequent regression analysis. I first examined differences in canopy and changes across census tracts stratified by race/ethnicity. Table 2 examines Urban Tree Canopy UTC) coverage in 2011 across majority-POC and majority-white census tracts. On average, majority-white tracts had 65.16 acres of tree canopy coverage, while majority-POC neighborhoods had 72.09 acres. While majority-POC tracts show slightly higher mean canopy coverage in acres, factors such as tract size, land use, and the presence of a large green space may limit the ability to capture equitable access to canopy. Examining percent coverage and density in future analyses may provide greater insight into this difference.

Table 2. Tree Canopy Coverage 2011 by Majority-White and POC Tracts

Majority-Demographic	mean	sd	min	max	count
Majority White (2011)	65.16	120.76	2.52	857.35	103
Majority POC (2011)	72.09	85.68	3.98	566.28	102
Total	68.61	104.58	2.52	857.35	205

To understand the 2020 tree canopy landscape, I compared canopy cover between majority-POC and majority-white tracts. Here, I found greater disparity by race/ethnicity, summarized in Table 3: majority-white census tracts had higher average canopy coverage than majority-POC tracts. Racial disparities are clearly more pronounced in this period. This finding could be attributed to the broader demographic shifts in the city and the period of gentrification. As new influxes of predominantly white, wealthier residents entered the town, rising property values may have supported increased urban greening in these areas to enhance neighborhood aesthetics and marketing appeal (Asch & Musgrove, 2017). This is often harmful to current residents, many of whom are POC or lower income, who may not see the benefits of new canopy coverage and may increase inequity.

Table 3. Tree Canopy Coverage 2020 by Majority-White and POC-Tracts

Majority-Demographic	mean	sd	min	max	count
Majority White (2020)	76.91	136.25	1.33	890.13	82
Majority POC (2020)	63.97	81.89	3.83	554.57	123
Total	69.14	106.87	1.33	890.13	205

To assess temporal changes, Table 4 presents canopy gain and loss from 2011 to 2020 for majority-POC and majority-white tracts. The white tracts, on average, gained canopy between 2011 and 2020, while the POC tracts, on average, experienced net canopy loss. This suggests that plating and maintenance efforts over the last decades did not close gaps in canopy coverage and may have reinforced existing inequities. The white tracts, on average, gained canopy between 2011 and 2020, while the POC tracts, on average, experienced net canopy loss. This indicates that plating and maintenance efforts over the last decades did not close differences in canopy coverage and may have reinforced existing inequities.

Table 4. Tree Canopy Change from 2011 to 2020 by Majority-White and POC-Tracts

Majority-Demographic	mean	sd	min	max	count
Majority White (2020)	5.24	13.08	-12.22	65.54	82
Majority POC (2020)	-2.60	9.18	-65.65	9.36	123
Total	0.54	11.54	-65.65	65.54	205

To further examine shifts in racial demographics, Table 5 presents tree canopy change by demographic characteristics within census tracts. Tracts that remained majority white experienced the most significant average canopy gains, while tracts that remained majority POC saw average canopy losses. These patterns are consistent with broader environmental justice concerns in D.C. However, tracts that transitioned from majority-POC to White experienced an average loss, whereas tracts that transitioned from White to POC experienced an average gain. These groups have very small sample sizes, which means their estimates are highly influenced by individual tract-level changes and thus are unreliable indicators of broader trends in the city.

Table 5. Tree Canopy Coverage Change 2011-2020 by Racial Composition Change

	mean	sd	min	max	count
Stayed Majority-POC	-3.19	9.85	-65.65	9.36	101
Stayed Majority-White	5.33	13.14	-12.22	65.54	81
POC to White	-1.66	.	-1.66	-1.66	1
White to POC	0.09	4.30	-9.44	8.29	22
Total	0.54	11.54	-65.65	65.54	205

Results

Bivariate Regression Results

My bivariate regression examines the direct relationship between a census tracts 2011 and 2020 majority-POC status and its change in urban tree canopy (UTC) from 2011 to 2020. By including only two variables, the model shows the direct association between racial composition and canopy change without adjusting for other factors. Summarized in Table 6, in 2011, although majority-POC tracts had 6.921 more acres of tree canopy, there was no statistically significant racial disparity in POC and white majority neighborhoods. At this time, race/ethnicity was not the primary driver of inequalities in tree canopy cover, and further analysis should explore other variables, such as income or median home values, that may explain differences across tracts. From 2011 to 2020, however, race/ethnicity became an important factor in understanding tree canopy change. Also shown in Table 6, the results reveal a statistically significant relationship between race/ethnicity and tree canopy change. The majority-POC tracts lost 7.85 acres of canopy compared to the majority-white tracts. The intercept, representing the change in canopy for majority-white tracts, shows that majority-white neighborhoods gained 5.244 acres of canopy. Overall, the patterns of canopy gains in majority-white neighborhoods and losses in majority-POC neighborhoods point to widening environmental justice disparities in tree canopy coverage during this period.

Table 5. Tree Canopy Coverage 2011 and Canopy Change 2011-2020 by Majority Race/Ethnicity

	UTC coverage 2011	UTC change 2011-2020
Majority-POC 2011	6.921	
	(.637)	
Majority-White 2011	65.165**	
	(0.000)	
Majority-POC 2020		-7.848**
		(0.000)
Majority-White 2020		5.244**
		(0.000)
Number of observations	205	205

** p<.01, * p<.05

Next, I wanted to examine he relationship between changes in a census tract's racial/ethnic composition and changes in tree canopy coverage. My second bivariate regression, therefore, examines whether changes in tree canopy are associated with whether a tract remained majority white or changed relative to tracts that remained majority POC. My results, shown in Table 6, indicate a statistically significant difference in tree canopy between tracts that remained majority white and those that remained majority POC. Tracts that stayed majority white are associated with a substantial increase in tree canopy, 8.5 acres, relative to tracts that remained POC. In comparison, tracts that remained POC lost -3.191 acres. This represents a substantial difference, suggesting that stable white neighborhoods experienced significantly greater canopy gains. Racially transitioning tracts did not show statistically significant differences relative to stable majority-POC tracts.

Table 6: Tree Canopy Change by Demographic Change

Stayed Majority White 2011-2020	8.520	**
	(1.627)	
POC to White 2011-2020	1.531	
	(10.960)	
White to POC 2011-2020	3.280	
	(2.566)	
Intercept	-3.191	**
	(1.085)	
Number of observations	205	

** $p<.01$, * $p<.05$

Multivariate Regression Results

Table 7 presents the results of my multivariate regression analyzing how tree canopy changed by the racial composition of census tracts from 2011 to 2020. The analysis suggests that tree-planting efforts have occurred during this period. While race was not a significant predictor of canopy levels in 2011, it was an important predictor of changes in canopy over the subsequent decade. After controlling for other neighborhood factors, majority-POC neighborhoods lost about 5.8 more acres of tree canopy than majority-white neighborhoods. This loss could result from removals for development as the city expanded, from lack of maintenance, or from fewer planting efforts to replace lost cover. These results show that communities of color did not experience increased canopy cover or access to shade, and environmental justice disparities in tree coverage widened over time.

Table 7: Regression Model Results: Tree Canopy Change (2011-2020) as a function of Majority POC Census Tract (as compared to Majority White Census Tract) and other relevant independent variables

Majority POC Tract (2020)	-5.787*
	(0.015)
Population Density (2020)	-0.0000125
	(0.860)
% Renters (2020)	-0.0320
	(0.429)
Median Home Value (2020)	0.0000166***
	(0.000)
% < High School (2020)	9.550
	(0.595)
% BA+ (2020)	-7.074
	(0.260)
Tree Canopy Area (2011)	0.0115
	(0.199)
Area unsuitable for planting (acres)	-0.0611**
	(0.004)
Constant	1.183
	(0.839)
Observations	196

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The results also show that higher median home values are positively associated with canopy change. For example, for every $100,000 increase in median home value in a tract, there was a 1.6-acre increase in canopy cover. Neighborhoods with higher home values gained more canopy, indicating that financial resources that enable greater involvement in planting and maintenance likely helped these communities retain and attract new canopy growth. Additionally, neighborhoods with larger unsuitable areas for planting experienced greater canopy losses, reflecting the physical constraints of adding new trees in built-up urban areas. Gains between 2011 and 2020 in tree canopy were concentrated in wealthier and majority-white neighborhoods, while majority-POC neighborhoods experienced canopy losses. This pattern aligns with previous research indicating that tree canopy cover is often disproportionately lower in communities of color, and that unequal investment can perpetuate these disparities.

To further understand these disparities, I investigated whether neighborhoods that experienced changes in racial composition exhibited different levels of change in tree canopy cover. My results, presented in Table 8, indicate that census tracts that remained majority-white gained more trees than those that remained majority-POC. Specifically, tracts that remained majority white gained 6.211 more acres of canopy than tracts that stayed majority POC. regressed whether tracts with changing composition on change in tree canopy. Census tracts that changed from white to POC did not experience significantly more growth relative to tracts that were majority-POC in both periods. As in my previous regression, tracts with higher home values tended to gain more tree canopy, whereas tracts with more land unsuitable for planting experienced greater losses.

These results further highlight that even as overall tree canopy increased across D.C., majority-white neighborhoods that already had greater canopy coverage benefited more from new planting efforts. Therefore, environmental justice disparities in tree cover persisted as access to trees and shade is divided across racial/ethnic lines.

Table 8: Regression Model Results: Tree Canopy Change (2011-2020_ as a function of Majority POC Census Tract (as compared to Majority White Census Tract) and other relevant independent variables

Stayed Majority White 2011-2020	6.211	*
	(.028)	
White to POC 2011-2020	0.859	
	(0.783)	
Population Density (2020)	-0.000	
	(0.815)	
% Renters (2020)	-0.034	
	(0.410)	
Median Home Value (2020)	0.000	**
	(0.000)	
% < High School (2020)	8.568	
	(0.641)	
% BA+ (2020)	-7.843	
	(0.255)	
Tree Canopy Area (2011)	0.011	
	(0.216)	
Area unsuitable for planting (acres)	-0.061	**
	(0.005)	
Intercept	-4.070	
	(0.437)	
Number of observations	196	

** p<.01, * p<.05

Discussion

This case study contributes to efforts to understand environmental justice implications of D.C.'s tree canopy distribution, particularly as it relates to D.C.'s tree-planting initiatives. My analysis revealed the growth, rather than shrinkage, of environmental justice disparities related to tree canopy coverage. Specifically, I find that majority-POC neighborhoods lost more canopy over time than majority-white neighborhoods. Tracts that remained majority white between 2011 and 2020 showed significant gains in tree canopy relative to tracts that stayed majority-POC. Holding other explanatory variables constant, census tract groups with more people of color saw more canopy loss, even over a period of net growth in tree canopy. Given the many benefits of urban tree canopies and the negative impacts that a lack of shade can have on a neighborhood, such an uneven tree canopy is a significant issue of environmental racism. While present-day planters and groups seek to be more intentional about where they grow and whom they engage, it is clear there is still much work to do. My recommendations will seek to remedy these losses by increasing shade and equity.

Recommendations

1. Expand Tree planting programs and initiatives that center communities of color.

Based on my findings, it is essential for the city and nonprofits to target tree planting and maintenance efforts in the majority of POC neighborhoods. Programs should be co-designed with new and long-term residents in these spaces. A significant concern among D.C. residents is the risk of green gentrification; therefore, they should be paired with opportunities such as workforce development programs and other anti-displacement measures. Local, grassroots engagement with affected communities are vital for buy-in and sustained capacity-building (Leets et al., 2022). These programs could take the form of opt-out programs, in which the city informs residents that it is planting a tree rather than requiring them to opt in. While resident involvement is essential, many lower-income residents lack the time or resources to participate in planting, so offering support will make these programs more accessible. The program should also include the opportunity to promote greater protection of heritage trees, the largest and oldest trees in the district that provide the most shade. Newly planted trees should be tolerant of heat and drought to survive the increasingly hot D.C. summers and, one day, provide more shade for residents.

2. Prioritize integrating built shade into the environment.

Because newly planted trees will take time to provide substantial shade, increasing built-in shade is a critical tool for reducing EJ disparities. The American Planning Association strongly emphasizes that trees and built shade structures are essential to equitable city design. If D.C. is losing trees currently due to climate change, residents cannot be left without shade. The most effective types are shade shales and canvas structures, ramadas, and pergolas. These structures are a more immediate heat-mitigation strategy and provide instant shade (Keith, L., &

Meerow, S., 2022). An easy way to increase built shade is through the passage of the *Solar Shade Expansion Amendment Act of 2025,* introduced by Councilmember Charles Allen (Ward 6). The bill would require the district government to identify 20 sites that would benefit from solar canopies, which are solar panels that can also provide shade (Washington, D. C. Council, 2025). This will improve thermal comfort, reduce heat exposure, and provide clean energy, all at once, while prioritizing the spaces and communities that need more shade.

3. Create a D.C. Tree Coalition

With the recent loss of federal funding for urban forestry under the Trump Administration and budget cuts in the city, D.C. may face even greater challenges in reducing EJ disparities. Seen in other cities, further coordination of its planting efforts and the building of a coalition may keep these efforts afloat. For example, the Cleveland Tree Coalition uses a collective impact model, creating a cross-sector organization to work together to increase tree canopy. This model would rely on nonprofits, city agencies, businesses, and academic institutions to contribute resources such as lobbyists, viewpoints, and greater access to funds, at a time when the city budget is shrinking, making the group adaptive. A coalition can also pursue private funding to offset federal shortfalls and maintain long-term commitments. While D.C. cannot be entirely shielded from the federal government's impact now, more private involvement is needed. It also allows coalitions to use the American Forests Tree Equity Score program to ensure tree equity across racial and income groups. For D.C., the coalition could be composed of the DOEE, DDOT Urban Forestry Division, Casey Trees, and other nonprofits, neighborhood associations, Ward 7/8 community councils, and academic experts. The Tree Equity Score approach can then be used to direct resources, plantings, and protection to tracts that have experienced the greatest loss and have the lowest canopy relative to population vulnerability.

Conclusion

This study examines the effectiveness of D.C.'s tree canopy growth efforts in reducing environmental justice disparities, building on previous analyses (Foster et al., 2022; Danford et al., 2014; Gerrish & Watkins, 2018; Schwarz et al., 2015; Landry & Chakraborty, 2009). It shows that despite ongoing plating initiatives in Washington D.C., environmental justice disparities worsened between 2011 and 2020. Majority-POC census tracts lost more tree canopy than white neighborhoods. These findings suggest a need for a city-wide shift in tree canopy strategy, centering equity in new policies and planting initiatives. Prioritizing EJ in future planning is imperative for heat and climate adaptation, racial equity in D.C., and community stability. To expand on my findings, future long-term studies should document how race and income shape tree canopy and environmental justice outcomes. Ultimately, D.C.'s ability to provide and sustain an equitable tree canopy will require policies and investments that meaningfully center historically marginalized and currently vulnerable residents by planting trees and providing shade for all residents.

References

Akbari, H. (2002). Shade trees reduce building energy use and CO2 emissions from power plants. *Environmental Pollution*, *116*, S119–S126. https://doi.org/10.1016/S0269-7491(01)00264-0

Asch, C. M., & Musgrove, G. D. (2017). Go Home Rich White People: Washington Becomes Wealthier and Whiter, 1995–2010. In *Chocolate City: A History of Race and Democracy in the Nation's Capital* (pp. 425–457). University of North Carolina Press. http://www.jstor.org/stable/10.5149/9781469635873_asch.19

Aguilera, S. M. (2021). Prioritizing tree planting in shade-deprived urban areas as a response to climate change. *Hastings Environmental Law Journal, 27*, 101.

Bullard, R.D. and Johnson, G.S. (2000), Environmentalism and Public Policy: Environmental Justice: Grassroots Activism and Its Impact on Public Policy Decision Making. Journal of Social Issues, 56: 555-578. https://doi.org/10.1111/0022-4537.00184

Chuang, W.-C., Boone, C. G., Locke, D. H., Grove, J. M., Whitmer, A., Buckley, G., &

Zhang, S. (2017). Tree canopy change and neighborhood stability: A comparative analysis of Washington, D.C. and Baltimore, MD. *Urban Forestry & Urban Greening*, *27*, 363–372. https://doi.org/10.1016/j.ufug.2017.03.030

Chandler, J. P., & Phillips, J. (2020). (rep.). *Racial, Education, and Income Segregation in the District of Columbia November 2020*. Retrieved November 24, 2025, from https://planning.dc.gov/sites/default/files/dc/sites/op/page_content/attachments/Segregation%20Report%2011-18-20%20FINAL.pdf.

City of Washington, DC. (2022). *Washington DC's urban tree canopy in 2020* [Data set]. Open Data DC. https://opendata.dc.gov/datasets/DCGIS%3A%3Aurban-tree-canopy-2020

Cole, L. W., & Foster, S. R. (2000). *From the ground up: Environmental racism and the rise of the environmental justice movement*. New York University Press.

Danford, Rachel S.; Cheng, Chingwen; Strohbach, Michael W.; Ryan, Robert; Nicolson, Craig; and Warren, Paige S. (2014) "What Does It Take to Achieve Equitable Urban Tree Canopy Distribution? A Boston Case Study.," Cities and the Environment (CATE): Vol. 7: Iss. 1, Article 2.DOI: 10.15365/1932-7048.1123

District Department of the Environment. (2013). *District of Columbia Urban Tree Canopy Plan* (p. 25). Government of the District of Columbia. https://doee.dc.gov/sites/default/files/dc/sites/ddoe/page_content/attachments/Draft_Urban_Tree_Canopy_Plan_Final.pdf

Fang, F., Greenlee, A. J., He, Y., & Eutsler, E. (2023). Evaluating the quality of street trees in Washington, D.C.: Implications for environmental justice. *Urban Forestry & Urban Greening*, *85*, 127947. https://doi.org/10.1016/j.ufug.2023.127947

Foster, A., Dunham, I. M., & Bukowska, A. (2022). An environmental justice analysis of urban tree canopy distribution and change. *Journal of Urban Affairs*, *46*(3), 493–508. https://doi.org/10.1080/07352166.2022.2083514

Heynen, N. C. (2003). The scalar production of injustice within the urban forest. *Antipode, 35*(5), 980-998. https://doi.org/10.1111/j.1467-8330.2003.00367.x

Keith, L., & Meerow, S. (2022). *Planning for urban heat resilience*. American Planning Association. https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/PAS-Report-600-r1.pdf#page=38

Leets, L., Sprenger, A., Hartman, R. O., Jackson, J. H., Britt, M., Gulley, A., Thomas, J. S., & Wijesinghe, S. (2022). Promoting tree equity in Washington, D.C. *Trees, Forests and People*, *7*, 100209. https://doi.org/10.1016/j.tfp.2022.100209

Locke, D. H., Grove, J. M., & Pickett, S. T. A. (2023). The Role of Urban Tree Canopies in Environmental Justice and Conserving Biodiversity. In M. Lambert & C. Schell (Eds.), *Urban Biodiversity and Equity* (1st ed., pp. 97–114). Oxford University PressOxford. https://doi.org/10.1093/oso/9780198877271.003.0006

Maney, J., & Locke, D. H. (2025). The relationships between an historic neighborhood classification grade and tree canopy and impervious surface in Washington, DC, USA. *Urban Forestry & Urban Greening*, *108*, 128836. https://doi.org/10.1016/j.ufug.2025.128836

McDonald, R. I., Biswas, T., Sachar, C., Housman, I., Boucher, T. M., Balk, D., Nowak, D., Spotswood, E., Stanley, C. K., & Leyk, S. (2021). *The tree cover and temperature disparity in US urbanized areas: Quantifying the association with income across 5,723 communities. PLOS ONE, 16*(4), e0249715. https://doi.org/10.1371/journal.pone.024971

Middel, A., AlKhaled, S., Schneider, F. A., Hagen, B., & Coseo, P. (2021). 50 Grades of Shade. *Bulletin of the American Meteorological Society*, *102*(9), E1805-E1820. https://doi.org/10.1175/BAMS-D-20-0193.1

Murphy, M. W. (2016). Mapping environmental privilege in Rhode Island. *Environmental Justice, 9*(5), 145–153. https://doi.org/10.1089/env.2016.0010

Mohai, P., & Bryant, B. (1992). Environmental Racism: Reviewing the Evidence. In *Race and The Incidence of Environmental Hazards*. Routledge.

Morello-Frosch, R., Pastor, M., & Sadd, J. (2001). Environmental Justice and Southern California's "Riskscape": The Distribution of Air Toxics Exposures and Health Risks among Diverse Communities. *Urban Affairs Review*, *36*(4), 551–578. https://doi.org/10.1177/10780870122184993

Myers, G., Mullenbach, L. E., Jolley, J. A., Cutts, B. B., & Larson, L. R. (2023). Advancing social equity in urban tree planting: Lessons learned from an integrative review of the literature. *Urban Forestry & Urban Greening*, *89*, 128116. https://doi.org/10.1016/j.ufug.2023.128116

Park, L. S.-H., & Pellow, D. N. (2011). *The slums of Aspen: Immigrants vs. the environment in America's Eden.* In *Nation of newcomers: Immigrant history as American history*. New York University Press. https://static1.squarespace.com/static/61747354593c762f6c3c9a64/t/61748ac2ca9fa24400a393b6/1635027651211/Murphy+2016.pdf

Pastor, M., Morello-Frosch, R., & Sadd, J. L. (2005). The Air Is Always Cleaner on the Other Side: Race, Space, and Ambient Air Toxics Exposures in California. *Journal of Urban Affairs*, *27*(2), 127–148. https://doi.org/10.1111/j.0735-2166.2005.00228.x

Pellow, D., & Nyseth-Brehm, H. (2013). An environmental sociology for the twenty-first century. *Annual Review of Sociology, 39*, 229–250. https://doi.org/10.1146/annurev-soc-071312-145544

PlanItGeo. (2022, January). *Geospatial urban tree canopy assessment: Washington, DC (2020).* https://marketing.planitgeo.com/hubfs/Reports%20%5BGATED%5D/%5BREPORT%5D%20geospatial-urban%20tree%20canopy%20assessment-washington%20DC-united%20states-2020.pdf

Pulido, L. (2000). Rethinking Environmental Racism: White Privilege and Urban Development in Southern California. *Annals of the Association of American Geographers*, *90*(1), 12–40.

Pulido, L. (2016). Geographies of race and ethnicity II: Environmental racism, racial capitalism and state-sanctioned violence. *Progress in Human Geography*, *41*(4), 524-533. https://doi.org/10.1177/0309132516646495 (Original work published 2017)

Sanders, J. R., Locke, D. H., O'Neil-Dunne, J. P. M., MacFaden, S. W., Royar, A., Pelletier, K. C., & Gomez, R. (2015). *Tree-canopy change in the nation's capital, 2006–2011* (Casey Trees White Paper No. 1). Casey Trees.

Schlosberg, D. (2007). *Defining environmental justice: Theories, movements, and nature.* Oxford University Press.

Schwarz, K., Fragkias, M., Boone, C. G., Zhou, W., McHale, M., Grove, J. M., O'Neil-Dunne, J., McFadden, J. P., Buckley, G. L., Childers, D., Ogden, L., Pincetl, S., Pataki, D., Whitmer, A., & Cadenasso, M. L. (2015). Trees Grow on Money: Urban Tree Canopy Cover and Environmental Justice. *PLOS ONE*, *10*(4), e0122051. https://doi.org/10.1371/journal.pone.0122051

Taylor, J., Simpson, C., Brousse, O., Viitanen, A. K., & Heaviside, C. (2024). *The potential of urban trees to reduce heat-related mortality in London. Environmental Research Letters, 19*(5), 054004. https://doi.org/10.1088/1748-9326/ad3a7e

Thriving Earth Exchange. (2018, January 31). *Mapping extreme heat vulnerability in support of the District of Columbia's Climate Adaptation Plan: Policy brief.* https://thrivingearthexchange.org/wp-content/uploads/2016/03/TEX-DC-Policy-Brief-2018-01-31.pdf

Tyrväinen, L., Pauleit, S., Seeland, K., de Vries, S. (2005). Benefits and Uses of Urban Forests and Trees. In: Konijnendijk, C., Nilsson, K., Randrup, T., Schipperijn, J. (eds) Urban Forests and Trees. Springer, Berlin, Heidelberg. https://doi-org.oxy.idm.oclc.org/10.1007/3-540-27684-X_5

Tree Equity Score. (2021). *Tree equity score report: Washington, D.C.* https://www.treeequityscore.org/insights/place/washington-dc

US EPA, O. (2014, June 17). *What Are Heat Islands?* [Overviews and Factsheets]. https://www.epa.gov/heatislands/what-are-heat-islands

Washington, D. C. Council. (2025, March 31). *Solar Shade Expansion Amendment Act of 2025* (Bill No. 26-65). https://legiscan.com/DC/text/B26-0065/id/3073244

Watkins, S. L., & Gerrish, E. (2018). The relationship between urban forests and race: A meta-analysis. *Journal of environmental management*, *209*, 152–168. https://doi.org/10.1016/j.jenvman.2017.12.021

Zhou, W., Huang, G., Pickett, S. T. A., Wang, J., Cadenasso, M. L., McPhearson, T., Grove, J. M., & Wang, J. (2021). Urban tree canopy has greater cooling effects in socially vulnerable communities in the US. *One Earth*, *4*(12), 1764–1775. https://doi.org/10.1016/j.oneear.2021.11.010

Washington Post. (1999, February 1). *Mayor working to keep it green*. [Original article]. https://caseytrees.org/wp-content/uploads/2017/04/02.01.1999-original-article-washingtonpost.pdf