Institutionalized Tree Planting in Chicago:

Challenges to Promoting Tree Equity

by

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Abstract
Given the rural exodus to urban centers, increased population density constrains access to green spaces and their benefits. Trees provide a variety services to humans such as lowering asthma rates, mitigating urban heat islands, improving test scores, and lowering recovery times for surgery patients. Given the value of trees and the historical privileging of green spaces for wealthier and whiter populations, lower tree canopy cover in poorer and predominately Black, Indigenous, and People of Color communities (BIPOC) means that these populations have disproportionate access to these benefits, or tree inequity. Different organizations across the public, private, and nonprofit sectors cooperate with communities to plant trees and alleviate tree inequity. As the city of Chicago intends to increase the canopy cover by 4% by 2050, it will be necessary for policy makers and tree planting firms to prioritize tree planting so as to reduce tree inequity and benefit all citizens.

A metadata analysis was completed using data from the Environmental Protection Agency (EPA) (provided by the Chicago Regional Trees Initiative (CRTI)) and the US Census Bureau. Bivariate regressions were analyzed for the impacts of environmental and socioeconomic factors on tree canopy cover, and t-tests were used to test for significance at the 90, 95, and 99% levels. This study demonstrated that trees reduce socioeconomic vulnerability, flood susceptibility, mean air temperatures, and concentrations of air toxins. Given that certain census tracts have lower canopy cover, these neighborhoods have less access to the benefits of trees, indicating that tree inequity exists in Chicago. As population density increases, tree canopy decreases. As household income increases, tree canopy increases, however, there is no statistically significant relationship between poverty and canopy cover (even when controlled for race). As the percentage of black and white residents increases, percent canopy cover increases, however it increases by over a factor of three for white residents compared to black residents. There is no statistically significant relationship between the percentage of Latino residents and tree canopy cover, and as the percentage of Asian residents increases, percent canopy cover decreases. According to interviews with private and non-profit firms associated with tree planting, while these factors are diverse, organizations still work to alleviate tree inequity. Yet they must contend with community misperceptions of trees – communities may be resistant to tree planting, and firms must sensitize community members to tree benefits prior to planting trees. Other challenges to tree planting include proper funding by the community and providing proper maintenance of pre-existing trees.

Therefore, cross-sectoral cooperation among the public, private, and nonprofit spheres is essential to project success. Combatting tree inequity requires more than simply planting trees in places with lower canopy cover, and firms must involve community stakeholders in the project development process. Firms may choose to add nuance to their prioritization schemes in order to demonstrate where communities are lie in the continuum of tree planting progress (between needing trees but not interested, and needing trees and interested). In addition to sensitizing communities, other strategies such as the use of more sophisticated signage to prevent tree vandalism. Additionally, while the analysis may show that there are associations with certain demographics, or a lack thereof in the cast of increases in percent Latino population, that does not mean that more Latino neighborhoods are less deserving of trees than others. A lack of statistical significance may be due to missing data points, and these gaps will need to be filled for further analysis. Further future exploration may include case studies highlighting successes and failures within neighborhoods to provide future program managers with greater context.

Introduction

Humans possess an affinity for the natural world, but increased access to economic opportunities in cities incited rapid urbanization at the expense of widely accessible green spaces and their benefits. In the process of urban development and renewal across the United States, trees have played an increasingly

vital role as citizens and municipalities acknowledge their value for human health, society, and the environment. From a public health perspective, trees support mental and physical well-being, help regulate urban heat islands (UHIs), and improve neighborhood property values (Wade, 2020). From a sociological perspective, planting trees similarly constitutes an opportunity for residents to engage in community activity, which positively reinforces collective values and safety (Hoffman, 2017). From a policy and environmental perspective, city planners recognize that trees help deter crime, regulate flooding, improve air quality, and provide wildlife habitat (Wade, 2020). Since trees benefit humans in many ways, many cross-sectoral institutions in Chicago promote tree planting opportunities.

City municipalities, private contractors, nonprofits, and community-based organizations (CBOs) offer programs to plant and monitor trees in cities in order to increase green spaces. However, despite the wealth of programs and opportunities to plant trees, tree inequity, or the disproportionate planting of trees across racial, socioeconomic, and environmental categories, continues to manifest in cities across the US (Watkins et al., 2012, Lin & Wang, 2021, & Princetl, 2013). Specifically, while trees provide many benefits to some community members, tree inequity denies other communities of these benefits and privileges others.

If households living in areas with a higher canopy cover have lower incidences of heat-related illnesses, then this incentivizes planting trees in areas with lower canopy cover to improve public health. However, it is important to acknowledge that correlation is not causation, and there are myriad factors which influence UHIs. Nonetheless, given their psychological and environmental impacts, planting trees is still favorable to no trees planted at all. Given the positive correlation of community wellness measures with canopy cover (defined as percent area covered by tree foliage), municipalities incentivize tree planting through direct donation and grants (TNC, 2020). Therefore, this research intends to investigate how tree inequity manifests itself in the city of Chicago, how organizations combat tree inequity, and the challenges these organizations face therein.

Unfortunately, over the evolution of urban tree planting, tree inequity has become much more pronounced (TNC, 2020). Despite these local priorities, research has substantiated that institutions have

not historically planted trees equitably in major metropolitan areas such as Detroit, New York City, and Los Angeles (Watkins et al., 2012, Lin & Wang, 2021, & Princetl, 2013). For example, in NYC, Lin & Wang (2021) demonstrated that since 1995, percent canopy cover improved in predominantly Black and Asian neighborhoods but decreased in poorer and Hispanic neighborhoods. This differs from Detroit, where tree planting diminished as canopy cover increased but decreased as the percentage of African Americans and Hispanic residents increased (Watkins et al., 2017). Therefore, reducing these racial inequities provides access to the benefits of trees to underserved communities.

Consequently, the background section will examine the advantages of trees in urban settings, whereby trees provide inherent value for humans beyond their purely aesthetic purposes. This will also include Chicago-specific research, which includes the benefits of trees for air pollution, perceptions of green spaces, and the effects of trees on urban heat islands. Then, the paper will then elaborate on racial and socioeconomic inequities in tree planting in Detroit, NYC, and L.A. Currently, there is an overall lack of Chicago-specific research regarding tree inequity, however, given climate change, providing more access to trees to more people will prove increasingly important.

Thus, following the methodologies in the literature, this research will rely on a non-experimental, observational research design and undertake secondary data analysis by comparing demographic data, percent tree cover, and trees planted by organizations (Johnson, 2015). The use of secondary data analysis makes use of pre-existing datasets in order to draw comparisons without the need for researchers to directly sample populations. In this case, publicly available demographic data provided by the US Census Bureau also offer massive samples sizes to improve accuracy, cover a comprehensive geographical range, and allow researchers to avoid the resource use (money and time among others) required to directly survey community members.

Other secondary data sources, such as the geographical information systems (GIS) data provided by Morton Arboretum, provide percent tree canopy cover, again freeing researchers from fieldwork. Interviews with firms will then support qualitative understanding of challenges to tree equity in Chicago and provide means by which to promote tree planting project success. The research will support

informing where organizations need to prioritize tree planting and outreach in Chicago while exposing the organizational barriers to tree equity. Subsequently, organizations can recognize barriers, overcome them, and promote tree equity to support wider access tree benefits.

Background

Benefits and Impacts of Planting Trees

Trees provide a wealth of benefits to humans which has only recently gathered importance as humans immigrate to cities and adjust to rapid urbanization. Much of the early research regarding urban tree planting focuses on the psychological and public health impact of trees and natural aesthetics in urban environments. In response to increasing urbanization in the 1970's and its negative impacts on mental health, psychologists and sociologists determined that urbanites prefer natural scenes over urban scenes (Wohlwill, 1976). Research in the early 1980's built on this principle to demonstrate that compared to urban scenes, natural scenes reduced fear, stress, and fostered quicker recovery from stress (Ulrich, 1984).

In light of biopsychosocial models, natural environments improve mental well-being, which subsequently impacts physical well-being. In a widely cited paper, Ulrich (1984) used hospital records from 1971-1982 to determine that patients recovering from gall bladder surgery required fewer analgesic narcotics, had generally more positive dispositions, and had shorter recovery times when their recovery room windows had views with trees. Conversely, patients who had views of a brick wall required more analgesic narcotics, needed more emotional support, and had significantly longer recovery times. The paper is still widely cited today for substantiating the benefits of trees for humans using a simple research design.

As planting trees positively correlated with psychological outcomes, research evolved and elaborated on the presence of natural spaces to broader social and community benefits. For example, tree planting provides benefits at the community level by offering an opportunity for residents to cooperate in neighborhood projects and strengthen community ties (Hoffman, 2017). Accordingly, community service work affords participating residents with a multiculturalist opportunity while providing a platform for community education on environmental practices. As another example of community impacts, Wu et al. (2014) revealed how student performance improved with increasing canopy cover of the school's

surrounding neighborhoods. Yet, it is important to note that increased student performance also correlates with socioeconomic status (Farooq et al, 2011). Thus, in the same way that Kardan et al. (2015) demonstrated that canopy cover correlates to socioeconomic status, trees may influence income only by increasing property values. Therefore, planting trees merely to increase income would benefit property owners but not their tenants. Policy then would need to address other underlying factors to improve socioeconomic equity and test scores rather than to merely plant trees.

Regarding other influences on public health, trees' impact on improving air quality may be clearer and more intuitive to the public. Subsequent studies on air quality in urban environments indicate canopy cover positively correlates to improved health outcomes. Kardan et al. (2015) employed a non-experimental research design to compare public health data, canopy cover, and tree health in Toronto, Canada. As Canada offers universal healthcare, the location allowed the researchers to control for access to health care. Researchers used survey data from the Ontario Health study (OHS) which asked nominal questions such as whether respondents had ever had a physical condition such as high blood pressure, diabetes, etc. The survey also asked ordinal questions related to health perception.

The researchers then organized publicly available GIS data on trees and compared information regarding health, health perceptions, demographics, socioeconomic status, and geographical location. They then performed a canonical correlation analysis, and they showed that tree canopy and tree health are positively correlated to health outcomes; though, trees only explain 9% of the variance. The other 91% of variance included lower ages, higher education, and higher affluence. Nevertheless, while 9% might not seem large, the large sample size rendered the results significant. Accordingly, despite a myriad of other factors which affect public health, trees play a role in health outcomes.

Thus, available health statistics and GIS data likewise simplifies secondary analysis, indicating that data sources can be readily plumbed to analyze possible management priorities regarding tree planting in Chicago. Research widely confirms that trees and tree planting correlate with psychological, physical, and collective benefits for humans. As such, better management of tree planting programs would increase the numbers of trees and subsequent benefits to the public.

Tree Inequity

Furthermore, neighborhoods in Chicago may have socioeconomic, racial, and ecological differences which may indicate that trees are privileged for certain groups over others. The general trend in tree inequity confirms that neighborhoods with higher socioeconomic statuses correlate to higher canopy cover. While more trees tend to be planted in higher income areas, the aforementioned correlation/causation argument does not expressly indicate that planting trees in lower income areas will increase income. Trees are associated with more affluent neighborhoods presumably because wealthier individuals have more disposable income to green their areas or move to greener neighborhoods (Locke, 2016).

Nevertheless, planting trees in a neighborhood does increase property values which would indicate increased income for homeowners (Wade, 2020). Furthermore, since trees help to regulate temperatures during heat waves, individuals in poorer neighborhoods who lack access to air conditioning would be less susceptible to heat-related illnesses. Studies indicate that there are higher rates of asthma in neighborhoods of lower socioeconomic status and subsequently lower tree canopy cover. As trees remove pollutants associated with asthma, a higher percent canopy cover would mitigate respiratory diseases (Kardan et al., 2015). Consequently, planting trees in areas with lower socioeconomic statuses will improve tree equity and quality of life in these neighborhoods.

Tree planting programs may experience a number of hurdles as they weave through a complex framework involving city government, infrastructure management, nonprofits, public agencies, and residents. For example, achieving a prescribed canopy cover of 40% has recently been seen as too high for semi-arid cities such as L.A. (American Forests, 2017). Princetl et al. (2013) noted that the city must then decide to pull more water from overtaxed resources (IE the Colorado River) or rely on more water-tolerant species. However, the city was not employing any criteria regarding tree selection, property owners were not incentivized to plant, and the maintenance responsibility of these trees fell to residents or nonprofits. Given L.A.'s opportunistically ad hoc strategy to plant trees, inequity is likely high, although the literature does not address socioeconomic factors.

In spite of these trends, tree planting programs have mostly focused on planting as many trees as possible, but there have been procedural inequities which have exacerbated tree inequity. For example, in New York City, the MillionTreesNYC program planted one million trees from 2007-2015 through requested plantings (by calling 311) and block planting which targeted streets with low levels of trees and high population densities (Lin & Wang, 2021). Despite the equal opportunity to have trees planted in neighborhoods, canopy cover improved in predominantly Black and Asian neighborhoods but decreased in poorer and Hispanic neighborhoods (Lin & Wang, 2021). However, factors such as language barriers may be driving tree inequity in this case as individuals are not aware of programs as advertising and website data appear only in English (Pham et al., 2012).

However, inequity is not uniform across all cities, and consequently, city-specific programs to promote tree equity should not be applied uniformly. Contrary to L.A. and NYC, studies on Detroit, MI confirmed that percent canopy cover increased as socioeconomic status decreased and decreased as the percentage of African Americans and Hispanic residents increased (Watkins et al., 2017). This suggests that trees were planted where trees were less abundant, but they were being less planted in Black, Indigenous, and People of Color communities (BIPOC) neighborhoods. Additionally, it is worth noting too that tree benefits accrue over time, and neighborhoods demographics are subject to change (Watkins et al., 2017). Therefore, while it may be a priority to plant one neighborhood one year, nonprofits may opt to plant trees in a location based on research available at the time, only to discover that other variables affected demographics, and trees should now be planted in another neighborhood.

Considering the benefits of trees and inequitable tree planting in cities, it is relevant to evaluate how trees can be more evenly distributed across urban environments so that equal access to trees yields equal access to their benefits. Currently for the city of Chicago, there is data available from TNC which tracks canopy cover, flood risks, and socioeconomic statuses by neighborhood. However, there has been no evaluation of this data to prioritize neighborhoods or to elucidate whether municipalities, private contractors, and nonprofits are planting trees in areas of the greatest need, nor whether or the trees are

actually surviving in these places. The whole of which would contribute to a better understanding of where trees should be going in order to maximize benefits for the maximum population.

Tree Planting in Chicago

A slew of actors plant trees in Chicago ranging from the City of Chicago's Request a Tree program, privately contracted companies such as Tallgrass Prairie Restoration, and nonprofits such as Chicago Region Trees Initiative (CRTI), Openlands, and The Chicago Gateway Green Initiative. The organizations have multiple partnerships and provide a variety of services to folks in Chicago. In particular, the Morton Arboretum recently published its 2020 Chicago tree census which catalogued the trees across Chicago and made recommendations regarding species selection. These organizations have innovative data systems in place to prioritize where trees need to be planted based on canopy cover, temperature, urban flooding, air quality, and socioeconomic status (CRTI). Nevertheless, there is scant data regarding whether or not the trees are actually planted in these priority zones, nor is there substantial data regarding follow-up, maintenance, or survival of these trees. This may be caused by Chicago's lack of participation in high profile national tree planting programs such as the Million Trees initiative. Nevertheless, despite a proliferation of tree planting, Chicago's canopy cover of 19% lags behind NYC's 21% and LA's 25% (Friends of the Chicago River, 2020).

Research has focused on other environmental and social concerns. A study by Coseo & Larsen (2019) quantified how trees mitigate urban heat islands (UHIs), or areas with locally increased temperatures due to increased solar radiation absorption. As impervious surfaces, such as buildings and roads, indicate likely areas of UHIs, urban areas are therefore highly susceptible to temperature fluctuations. Their study highlighted how decreased canopy cover led to higher temperatures, potentially affecting heat-sensitive groups such as children and the elderly (Coseo & Larsen, 2019). It is worth noting that the researchers only had access to data from eight weather stations. Thus, while the relatively small sampling of neighborhoods may not provide a completely accurate depiction of Chicago, the results hint that increased tree planting would mitigate the effects of urban heat islands and improve the health of Chicago residents.

Other tree research specifically associated with Chicago centers around residents' preferences towards green spaces and benefits of planting trees. For example, Hadavi (2017) confirmed that while green spaces improve mental well-being, other qualities such as the presence of trees increased satisfaction and consequently mental well-being among Chicagoans. Another study by Yang et al. (2008) quantified that 1675 kg of air pollutants were removed from the air by green roofs (trees, shrubs, and other plants planted on roofs). While this research gestures to the importance of trees, if does not capture tree inequity and organizational challenges therein.

Methodology

While there are numerous organizations working to plant trees, research has indicated that tree planting has not been equitable across racial and socioeconomic lines. This research intends to explore several hypotheses related to tree inequity in the context of Chicago. First, trees provide benefits to Chicago residents, and therefore disproportionate access indicates inequity. Secondly, tree inequity exists across racial and socioeconomic contexts. Thirdly, organizations have priorities, challenges, and strategies to plant trees equitably. This research will support organizations to prioritize locations while providing a foundation for subsequent research on barriers to tree equity.

Tree Benefits & Inequity

Previous research has demonstrated that tree inequity increases as the percentage of residents of color increases, however, this varies between cities. However, there is no current research comparing race and income levels with trees in Chicago. Therefore, it is likely that tree inequity exists in Chicago given variation in race, socioeconomic status, and percent canopy cover across neighborhoods (see exhibit four for a list of independent variables). Statistically, Watkins et al. (2017) conducted a bivariate regression with trees planted versus trees not planted between 2009-2011 as a dependent variable and race, ethnicity and income as independent variables. For the purposes of this paper, a bivariate regression sufficed as well.

Data available through the CRTI's Canopy Map were downloaded in the form of shape files so as to assign values for vulnerability, flood susceptibility, surface temperatures, air toxins, and percent canopy cover data to census tracts within Chicago. Socioeconomic (income and poverty) and racial data

were downloaded from the US Census Bureau, assigned to corresponding census tracts, and converted into shape files using R. Shape files were then uploaded to ArcGIS to produce display maps. Data attribute tables from ArcGIS were converted into excel spreadsheets, and the data were scrubbed to remove zero values for percent canopy cover. A series of bivariate regression analyses were undertaken with percent canopy cover as the dependent variable and the Chicago Greenprint and US Census Bureau variables as independent variables. T-tests evaluated for significance at the 90, 95, and 99% level (p-value < 0.10, 0.05, and 0.01).

Organizational Barriers to Tree Equity

The final hypothesis assumes that tree inequity exists, and there are therefore organizational barriers to planting trees in certain neighborhoods (see Exhibit 6, interview questions regarding tree inequity). Nonetheless, organizations are employing strategies to rectify tree inequity, as evidenced by tools such as the Canopy Map and the Chicago Greenprint (TNC, 2020). This hypothesis was exploratory in nature, and themes which emerged from Princetl et al.'s (2013) article such as resource limitations, linguistic barriers, and lack of incentive by owners of private property were applied to questions to elucidate barriers. Interviews with tree planting organizations provided qualitative data, and their concerns and strategies were summarized.

Analysis

Observation 1: The extent of canopy cover in a neighborhood is positively linked to environmental conditions and the health of community residents. Conversely, neighborhoods with lower canopy cover tend to have higher levels of economic and social vulnerability, greater flood susceptibility, more extreme heat, and lower air quality as measured by higher concentrations of toxins.

Analyzing tree canopy while taking environmental factors into account indicate that tree inequity tangibly impacts vulnerability, flood susceptibility, surface temperatures, and air toxins concentration. Data compiled by the Morton Arboretum from the EPA and the US Census Bureau indicate that Chicago's neighborhoods have vastly diverse tree canopy cover, and they therefore do not equally share benefits of trees.

Concentrations of air toxins significantly decrease as tree canopy increases in the city (p-value < 0.05). Similarly, other studies indicate that decreased concentrations air toxins influence respiratory

health as trees absorb harmful chemicals. Therefore, areas with lower percent canopy cover have a lower capacity for air filtration. Lower tree canopy cover results in greater human exposure to harmful chemicals and, ultimately, poorer health outcomes.

The available evidence also indicates that air surface temperatures significantly decrease as tree canopy increases in Chicago (p-value < 0.05). The effect is apparently due to the propensity for higher tree canopy cover to mitigate urban heat islands. Trees capture sunlight and evaporate water through their leaves, lowering temperatures in the same way that sweating lowers body temperatures (evapotranspiration). Therefore, higher tree canopy cover can insulate Chicagoans from temperature spikes which, in turn, may reduce heating and cooling costs or lessen heat-related illnesses or even death. It follows that neighborhoods without fewer trees are more vulnerable.

Furthermore, increasing tree canopy cover may significantly decrease flood susceptibility (p-value < 0.05). Research has demonstrated that having more canopy cover increases the capacity for trees to absorb excess water in flooded areas. Likewise, these areas have higher amounts of organic material in soil which functions like a sponge to support water capture.

Lastly, increasing tree canopy cover significantly reduces a neighborhood's vulnerability (p-value < 0.05). Vulnerability is an aggregate term which encompasses socioeconomic factors such as income and race, and it was defined by CRTI by assigning a score based on these factors. Accordingly, tree canopy cover, median income, and racial variables are statistically related. However, it must be emphasized that correlation is not causation, and it not necessarily productive to advocate for tree cover to increase wealth for its inhabitants. This scheme could exacerbate poverty if, for example, increasing percent canopy cover in an area leads to green gentrification; residents may be "priced out" of their homes due to rising property values, taxes, or rents. Further elaboration of this topic can is explored within observations four and five below.

Summarily, the evidence shows that trees do benefit inhabitants in Chicago, but they do not benefit all inhabitants of Chicago equally. Differing canopy cover further exacerbates long-established

inequities by contributing to health problems (air quality problems), higher temperatures, flood susceptibility, and increasing vulnerability.

Observation 2: Areas with higher canopy cover tend to have lower population densities. There is no significant relationship however between canopy cover and poverty, even when controlling for a geographic area's ethnicity. Nevertheless, as non-family household income increases, so does canopy cover, while canopy cover decreases as family household income increases.

Variation of tree canopy cover in Chicago is influenced by population density; lower population density tends to be associated with higher percent canopy cover. This may be due to the number of parks in a neighborhood, resulting in less space for residential populations. Conversely, residential suburban areas have much more yard space and planted medians, and there is consequently more space for planting, which therefore influence percent canopy cover. Other densely populated areas such as the Loop business district have low percent canopy cover as there is little available lawn space to plant trees; land is also at a premium due to high rise apartment buildings increasing population density. However, while tree canopy cover increases significantly as population density decreases (p-value < 0.05), the R square value is exceedingly low (0.015); thus while we can say there is a significant correlation, we cannot use the model to predict percent canopy cover.

Canopy cover was not significantly impacted by the percentage of community members experiencing poverty. Therefore, there is no indication that increasing numbers of households below the poverty line influences canopy cover (p-value > 0.1). Even when controlled for race and ethnicity, there result is still insignificant (p-value > 0.1). However, canopy is significantly and negatively related to non-family household income (single individuals and roommates for example) and household income is significantly and positively related (p-value < 0.01). The discrepancy of poverty being insignificant but household income being significant may be due to the influence of Section 8 housing and its ubiquitously dispersed nature regardless of a community's median income. Likewise, non-family household income may be negatively related due to the number of single working adults in high rises in less greened areas.

Areas with higher median incomes often have a more suburban orientation. For example, many professionals live in the suburbs but commute to the city. Due to their higher incomes, they can afford

high transportation costs to and from work. Likewise, these households may have more disposable income with which to purchase trees and the tools required to plant them. These neighborhoods may also be under a homeowners association guidelines which require more trees. Furthermore, these neighborhoods may have more disposable time with which they can research programs which provide for tree planting (311 for example), or the inhabitants may have more income and therefore more time to be able to participate in community groups which plant trees.

As household income is positively correlated, and non-family income is negatively correlated, it was expected that family income would be positively correlated. However, the impact of family income on canopy cover is not significant, and the coefficient is miniscule (see exhibit 4). This may be due to more families living in areas with lower housing costs in order to conserve resources. These areas may be cheaper due to their proximity to industrial corridors, and consequently, they may have lower canopy cover. Or canopy cover may be higher in these areas due to the presence of abandoned lots with trees growing on them. Discrepancies here may be accounted for based on certain census tracts having zero values for percent canopy cover, and that the study focuses on Chicago specifically and excludes the seven county collar of Chicagoland. In either case, this shows that there is nuance when considering the relationship with income and tree canopy cover within the city of Chicago.

In short, contrary to general perception, poverty is not a significant factor for determining percent canopy cover. When the data is sorted by percent of ethnicities in poverty, there is still no significant relationship with canopy cover. However, increasing median household incomes influence canopy cover, higher non-family income reduces canopy cover, and family income does not influence canopy cover at all. Arguably, increasing income influences canopy cover, but increasing canopy cover does not necessarily influence income. Increasing percent canopy cover in an area may lead to "green gentrification" and price people out of their homes, which can exacerbate poverty rather than improve it. This analysis indicates that the subtleties between income and tree canopy cover are more nuanced rather than simply stating that lower incomes mean less trees.

Observation 3: Canopy cover tends to increase as the share of residents in a neighborhood who are Black and White increases; however, canopy cover falls as the share of Latino and Asian residents increases. This evidence tends to contradict the discourse which suggests that canopy cover is consistently lower in neighborhoods heavily populated by racial groups that have suffered extensive discrimination (EG BIPOC neighborhoods). For instance, even though neighborhoods with higher percentages of Black residents tend to have higher canopy cover, there is even higher canopy cover in places with more white people.

Tree inequity, reflects a greater distribution of trees in more affluent, white neighborhoods, nevertheless the data analysis presented here paints a much more nuanced picture. There is a significant increase in percent canopy cover for neighborhoods with higher percentages of Black and White residents. According to metadata analysis, for every increase in 1000 Black residents, the percent canopy cover increases by 0.76% (significant where p-value < 0.01), whereas for every increase in 1000 White residents, the percent canopy cover increases by 2.5% (significant, where p-value < 0.1). However, there is no significant increase in canopy cover as the number of Latino residents increases. Conversely, for every increase in 1000 Asian residents, the percent canopy cover *decreases* by 3.2% (significant, where p-value < 0.01). Therefore, this indicates that percent canopy cover does not split evenly along White and non-White neighborhoods, and furthermore, the R-squared value of 0.084 indicates that there are many other factors which influence percent canopy cover.

A few factors may explain why percent canopy cover rises as Black and White (non-Latino) residents in a neighborhood increases. For one, city planners after the Great Fire may have privileged neighborhoods with greater numbers of White people (Graf, 2019). Likewise, parks and access to other greens spaces were historically privileged for White people. However, simultaneously, demographics have shifted, and areas which were originally predominantly White have shifted and are no longer strictly white. Other neighborhoods which have been historically Black such as Bronzeville, Grand boulevard, and Hyde Park have higher amounts of percent canopy cover. Likewise, in areas where there are higher amounts of abandoned homes or vacant properties, there can be more canopy cover due to happenstance.

Nevertheless, as demonstrated by the data, increases in Latino populations has no significant impact on canopy cover. Areas that have been traditionally settled by Latino peoples have been relegated to industrial areas, with less concern for parks and natural spaces. However, other neighborhoods outside

of the main industrial areas have also been settled by Latino people. Conversely, for neighborhoods traditionally settled by Asian peoples tend to be near interstate corridors, which feature lower canopy cover. Given this data, in order to alleviate tree inequity, and provide underserved communities with the benefits of trees, it will be necessary to prioritize planting in neighborhoods with the greatest tree deficits with greater populations of BIPOC inhabitants.

Observation 4: It is more challenging for organizations to plant trees in neighborhoods with lower canopy cover due to a lack of community resources and expertise. Conversely, communities with robust organizations, time, and means tend to be more affluent and thus better situated to take advantage of programs. However, due to their already greater canopy cover, this may exacerbate the inequities.

According to nonprofit administrators working in tree planting projects, communities that would benefit from more trees face a series of challenges. These administrators recognize the benefits of planting trees in disadvantaged neighborhoods, and prioritize them based on a variety of metrics. Nonprofits make concerted efforts to plant trees where there tree deficits, lower median incomes, and higher amounts of historically disadvantaged peoples.

For example The Chicago Regional Tree Initiative (CRTI), a program of the Morton Arboretum, focuses on promoting tree programs in areas of lower income. According to project coordinators, areas with lower income lack the funds to pay for materials, and they have less time to participate in tree-planting or other community-building events. The lower percent canopy cover in Latino neighborhoods, for example, may be due to people not having enough time to familiarize themselves with free tree planting programs. Conversely, those in areas with higher income readily capitalize on opportunities to plant trees in the neighborhoods. Simply, if the community does not have the resources to match the grant funding, it does not receive trees.

Nonprofits serve broad geographical areas, but they prioritize communities in need, IE areas with lower median incomes and areas with higher percentages BIPOC citizens. The nonprofits work to fill gaps: if a community cannot make time to plant trees or are disinterested in planting trees, for example, then activity coordinators offer alternate activities, such as organizing tree walks, workshops, or trips to forest preserves. CRTI also provides opportunities to close funding gaps, including matching programs,

organizing grants, and even organizing safety workshops on chainsaw use. Given that the nonprofits must tailor their programs to a neighborhood's needs and interests, a singular path to tree planting will not suffice. In effect, every community requires an ad hoc strategy, and going at the pace in which its constituents are comfortable contributes to success.

CRTI cites the North Lawndale community group, "Treemendous," as an example of a predominantly black community interested in planting trees. The community members locate places where trees can be planted and CRTI guides them through the process of planting trees. These communities are prioritized over more affluent neighborhoods whereby available trees go to needy places, with "leftover trees" relegated to more affluent ones. They cite projects proliferating due to word of mouth, as communities see first-hand the successes of others.

Other neighborhoods may also simply require support to properly manage the trees that are already planted. Planting trees does not immediately contribute much canopy, but older, more mature trees do. So the maintenance and survival of older trees will have more impact on canopy than saplings. Other organizations such as Openlands evaluate the health of mature trees to contribute to their survival and increase canopy. This allows the organization to make informed recommendations to communities regarding tree maintenance, proper species selection, or removal of exotic invasive species. Other challenges may stem from not knowing who owns certain parcels of land. Other nonprofits get involved and in some cases have to go door to door to figure out to whom vacant lots belong, and whether or not they are viable places to plant tree.

CRTI also provides other services such as providing manuals to describe maintenance and care for trees. They also focus in on "getting their foot in the door" with communities which they believe they can support. Otherwise, the main concern is that chronic inadequacy in funding tree planting projects in spite of grant funding availability. Lydia Scott (personal communication, July 13th, 2022) of CRTI cited that if Chicago is going to achieved its plan to increase canopy by 4% by 2050, then 22 million trees are going to need to be planted. While 75% of trees in the Chicago area are less than 6" in diameter, then firms are going to need to concentrate on maintaining pre-existing canopy and managing the larger trees.

Observation 5: Organizations need to overcome misconceptions of trees and cultivate community buy-in before large numbers of trees can be planted. Organizations may need to overcome misperceptions that trees pose a danger by providing cover for individuals involve in illicit activities, or that tree roots interfere with water, sewer, and other utilities. The general pathway to plant trees in a neighborhood begins by finding interested citizens, holding meetings to increase awareness among the population, and *then* planting trees with the community.

In addition to communities lacking community change agents and community based organizations, tree planting efforts can be actively thwarted by residents. Concerns regarding crime or damage to utility infrastructure can lead those living nearby to vandalize newly planted trees by ripping them out or cutting them down. In order to promote project sustainability, community members need to be sensitized to how trees do not have these negative effects in addition to the benefits of trees.

While it is generally understood how trees are beneficial to communities, there are also misperceptions regarding damage that trees can effect, further limiting their popularity. For example, some residents have cited that they do not want trees in the neighborhood because it provides a haven for those who commit crimes. In their view, the shade provides cover for illicit activities. According to CRTI, recent literature has emerged to suggest that more crime occurs behind shrubs than trees. Therefore, in communities where this is a concern, selecting trees with higher overstory (not shrubs) and explaining the nuanced nexus between trees, shrubs, and crime is imperative to sustainability.

Other concerns stem from a misperception that tree roots can interfere with water, sewer, electrical, and other utility lines. In reality, tree roots tend to follow the path of least resistance and will move around solid objects. Another misconception is that trees can often cause damaging to houses (such as when branches fall during high winds). While this is true in some circumstances, proper tree maintenance can help avoid the problem of branches damaging a house. Anecdotally, in these cases, instead of maintaining the trees, homeowners have opted to cut the entire tree down to prevent any future perceived nuisances.

A more vexing problem is that that planting trees can lead to green gentrification such as what occurred following the construction of the 606 greenway in Chicago. While having higher canopy cover in an area correlates to higher median income, this also indicates that affluent citizens moving into these

areas can drive up property values and taxes, and the higher costs can push out lower income community members. Nevertheless, planting trees in a community is not the same as constructing a greenway, and, as previously noted, poverty is not a significant influence on percent canopy cover.

Hence, planting trees in a neighborhood without community input or support can lead to friction. As previously noted, it will be necessary to sensitize community members regarding the benefits of trees and the minimal risks given proper care and maintenance before any trees can be planted in a neighborhood. Otherwise, convincing communities to apply for grant dollars and plant will be moot if the community chooses not to prioritize tree planting projects. Nonprofits will have to rely on generating grassroots support within the community in order to stimulate neighborhood tree planting projects. Nonprofits moving at the pace appropriate for a neighborhood will conserve resources (less money spent on trees which may ultimately be vandalized), engender trust, and promote more sustainable practices. This, in turn, promotes project longevity and ecological outcomes.

Observation 6: Extensive cross-sectoral collaboration has been a springboard for tree-planting in urban neighborhoods. Non-profits rely on corporate support and federal grant money to fund programs, volunteer supervision, and raw materials. The private sector relies on government grants and access to property, often in the form of imminent domain or roadway beautification. Similarly, the public sector relies on private contractors to help facilitate projects in keeping with the priorities of their constituents (accountability).

Tree planting projects are a cross-sectoral nexus of collaboration, generally reliant on a robust pipeline of federal funding. The funds are made available to the state through grants. Communities, nonprofits, private companies, and the public sector can all apply for these grants. Each entity plays particular roles in administering funding and in project implementation, and each sector interacts with and relies on other sectors to contribute to a project's success.

First and foremost, the public sector sets goals and provides funding. For example, Chicago's mayor, Lori Lightfoot, has set a goal of planting 75,000 trees in 2022 (City of Chicago, 2022). Some of this funding is allocated to the Chicago Parks District or the department of transportation for planting along roadways. The funding goes to private nurseries who provide trees. The public sector also makes funds available to communities in order to plant projects which best serve their particular needs.

Nonprofits and private businesses can facilitate tree planting projects by supporting communities in grant writing. While the public sector provides funding for grantees, nonprofits may take advantage of public funding or solicit corporate sponsorship. For example, CRTI's corporate sustainability partnerships program provides funding on the condition that communities agree to take care of trees for 26 years. Funds are also allocated to nonprofits in the form of grant matching programs whereby the community entity provides a percentage of the necessary project funds, and the nonprofit fills the gap. Currently, many are "50:50" matches, but there are also programs for underserved communities with lower thresholds for matches. Other nonprofits, such as the Arbor Day Foundation, may provide low-cost ($1) trees, although the young saplings face high mortality rates. While organizations such as CRTI advocate for and provide larger trees (diameter of at least 1.5"), most of their budget and operations go towards supporting project facilitation in lieu of tangible provision.

For their part, private entities, such as Olson Ecological Solutions serve a different role, which may involve writing up a plan for communities based on their goals and desires. They charge a fee for the plan and for writing the grant, but then leave it up to the community to administer the project. The community's payment of Olson's fee does not substitute for the grant matching program, and they must also contribute time and labor. OES likewise can counsel community members, such as by pointing to issues what they should consider, but they cannot be prescriptive. This helps overcome community trepidation regarding EPA and federal influence through regulation. OES must then make time to attend the meetings to help communities understand that management is an asset and not an impediment. In this case, the private sector advocates for the public sector's management practices as a means to bolster its credibility and secure contracts.

Thus, tree planting projects cultivate an interdependency between the public, private, and non-profit sectors to liaise with communities and community based organizations. Public agencies provide funding, administration, and knowledge, but also directly plant trees in neighborhoods. Private firms also contribute monetarily (through corporate sponsorships, for example) in addition to administering projects. Nonprofits administer and provide funding, operate planting programs, and provide community support

and advocacy. Each sector relies on the other in order to successfully bring complex tree-planting endeavors to completion.

Conclusion

These results demonstrate the significant benefits of trees and the manifestations of tree inequity. Trees in an urban setting provide a variety of services including improved air quality, lower temperatures, lower flood susceptibility, and lower vulnerability. Therefore, areas with less trees have less access to these services, and tree inequity is rooted in disparate privileging of resources, such as access to parks for minority communities. The public, private, and nonprofit sectors alleviate tree inequity by planting in areas with greater need including BIPOC communities and those of lower socioeconomic status.

Increasing canopy cover to benefit the maximum number of Chicago residents, thus reducing tree inequity, must rely on planting new trees sustainably and maintaining current tree canopies through proper maintenance. Given citizen concerns regarding crime and property damage, care will need to be taken to ensure that trees are not cut down. While nonprofits such as CRTI sensitize targeted communities prior to planting trees and provide informational pamphlets regarding the benefits of trees, other strategies may include signage around newly planted trees. Community members may be reached through tree walks and pamphlets, but other community members may nevertheless vandalize the trees in the name of perceived safety. Bilingual signage would inform community members of the benefits of trees, demystify myths regarding their impact on crime and property damage, and encourage them to contact the alderman's office, city office, or nonprofits for more information. This may deter some vandalism and promote plant survivorship.

Also, given the results of this study, targeting communities where there are tree deficits is evident, and areas for prioritization are . While planting trees in areas of lower socioeconomic status and/or areas with higher percentages of BIPOC are relatively straightforward goals, it is also necessary to evaluate a neighborhood's willingness to accept trees. An area may be a priority due to socioeconomic and ethnic parameters, but if the community members are reticent to participate in tree planting, then this can be reflected in the prioritization maps so that policy makers are aware of where they can best allocate

resources. Areas that are priorities according to CRTI's Canopy Map may be further categorized according to their willingness to participate in tree planting or their status in the sensitization process.

For example, according to Airis Cervantes (personal communication, July 7th, 2022) one neighborhood may be ready to plant trees, but another may be reticent to plant but be interested in tree walks. Another category could indicate that the neighborhood is interested, but requires extra funding assistance, while another yet may indicate no interest in tree planting. The Canopy Map may be enhanced by labeling the census tracts according to their continuum of tree planting progress, neighborhood parameters such as ideal species selection, and contact information for community change agents or CBOs. This would support partner organizations to know which neighborhoods will guarantee success in tree planting projects, and which ones will require more organizing before planting is possible.

However, if organizations merely focus on communities where they can likely plant trees, then other communities may be excluded from the benefits. This would be unacceptable as perceived partiality would undermine community trust in tree planting organizations. Specialization of teams within an organization between communities ready to plant and communities making progress towards planting may further support program implementation. Ultimately, this allows firms to organize their efforts around the realities of their constituents.

It is also worth noting that despite the common perception that firms need to be planting trees in neighborhoods with a greater BIPOC population, the analysis does not fall neatly within these bounds. While it may show that increasing Latino populations in a census tract has no significant impact on canopy cover, that does not mean that firms should not also be focused on planting trees in these neighborhoods. There were many missing values in the canopy cover variable, which were not evaluated in the regressions. Therefore, filling in data points may lend to the accuracy of the assessment and consequently yield more significant results.

Additionally, future studies may benefit from case studies of particular neighborhoods. Firms can benefit by targeting CBOs, but also developing committees as points of contact to help organize tree planting projects in the future. For example, CRTI cites North Lawndale's "Treemendous" group as a

particular success based on community involvement and organizing. It is worth elaborating on these successes and reporting on them as a means by which future program managers and coordinators may reference for greater context. These can be compared to other case studies which elaborate on failures within communities and help to shape best practices.

Furthermore, knowledge regarding ideal trees in specific settings would benefit tree planting success. For example, some trees respond better to pollution, higher water tables, different soils, and other factors. Therefore, it would behoove communities and their partner organizations to know which trees would thrive under specific conditions.

In conclusion, while trees provide benefits to Chicagoans, their uneven distribution creates tree inequity. Organizations work across sectors together to plant trees in neighborhoods which have traditionally been underserved. However, increasing canopy cover and promoting equity may not necessarily involve planting trees; organizing and fostering community buy-in are essential to ensuring survivorship of saplings. This requires organizations to go at the pace of communities and be proactive in response to their need along the continuum of tree planting progress. The goal of which is to reduce tree inequity and provide all citizens with equal access to the benefits of trees.

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Exhibits

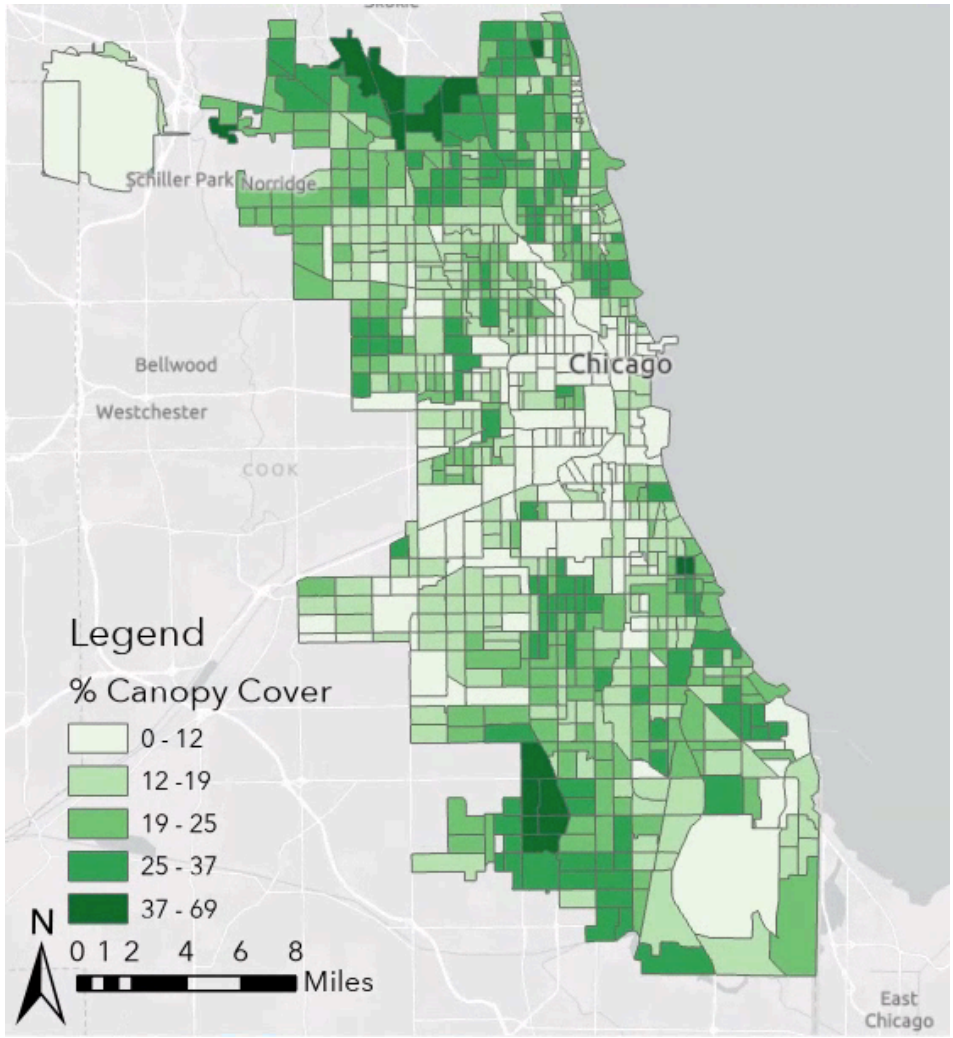

Exhibit 1: Chicago canopy cover (%) by census tract

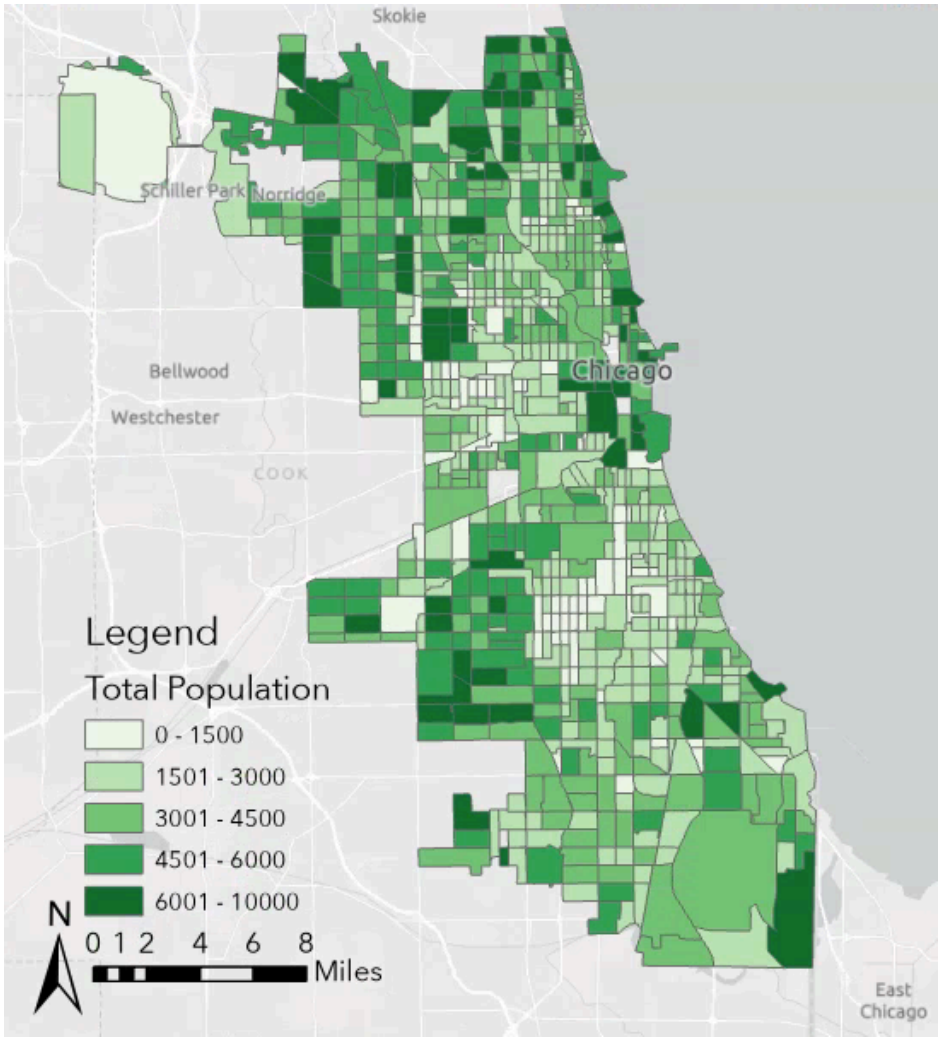

Exhibit 2: Chicago's total population by census tract

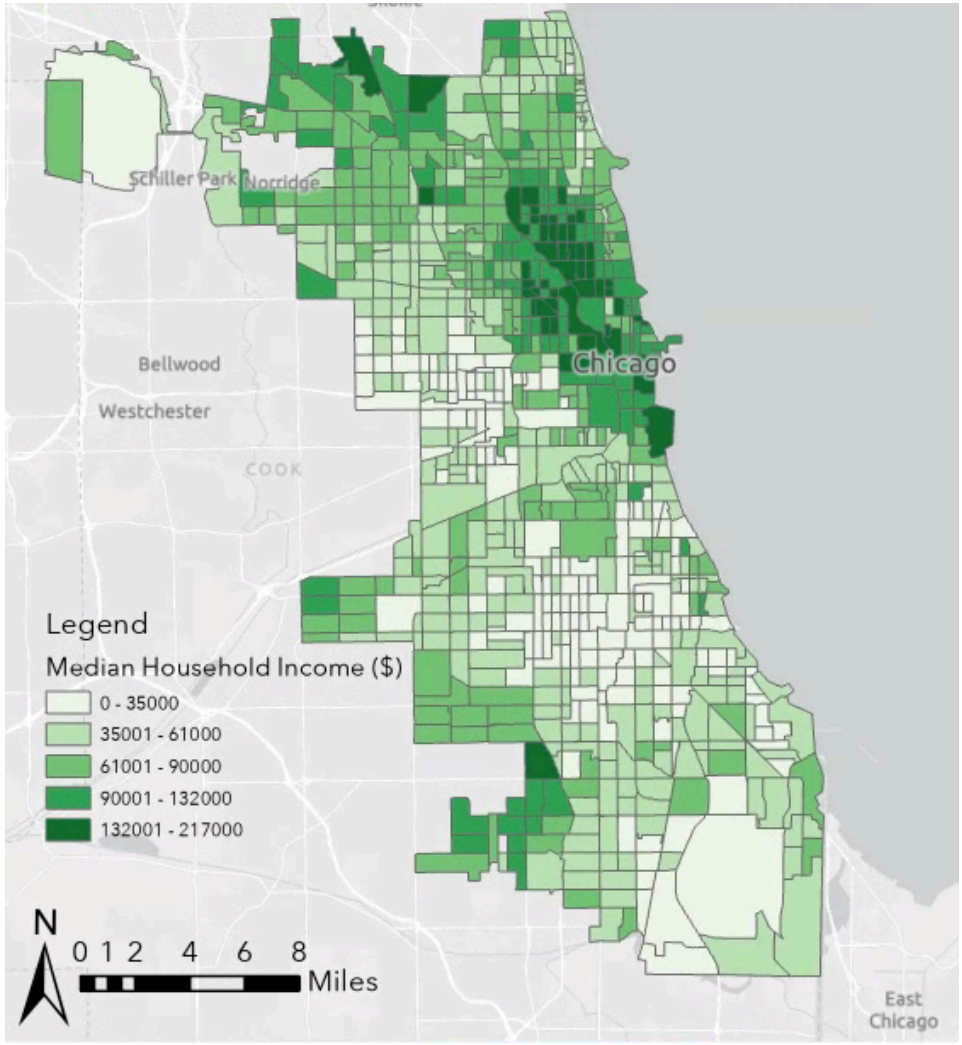

Exhibit 3: Chicago's median household income by census tract

Exhibit 4: Summary of regression analyses

Regression	Variables	Observations	R Square	Coefficient	t-stat
1. Environmental Factors	Vulnerability	796	0.1920	-10.58924	**-5.1639*** **
	Flood Susceptibility			-0.47864	**-2.1710** **
	Surface Temperatures			-0.79460	**-7.4243*** **
	Air Toxins			-2.55241	**-6.8667*** **
2. Population	Population Density	789	0.0147	-0.00006	**-3.4230*** **
3. Income	Median Household Income	707	0.0581	0.00011	**4.4578*** **
	Median Non-Family Income			-0.00014	**-6.4816*** **
	Median Family Income			0.00000	-0.2666
4. Poverty	Population Density	788	0.0071	-0.00004	**-2.3202** **
	% Below Poverty			0.01173	0.5477
5. Poverty by Race	% Below Poverty	788	0.0101	-0.00114	-1.6081
	% Below Poverty Black			-0.01412	-1.0438
	% Below Poverty White			0.00628	0.3130
	% Below Poverty White (including Latino)			0.01669	0.7291
	% Below Poverty Latino			0.01910	1.3022
6. Race	# of Black Residents	791	0.0841	0.00076	**2.9049*** **
	# of White Residents			0.00251	**1.6653** *
	# of White Latino Residents			-0.00117	-0.8037
	# of Latino Residents			-0.00032	-0.4571
	# of Asian Residents			-0.00323	**-4.7372*** **

*, **, *** indicate significance at the 90, 95, and 99% level (respectively)

Exhibit Five – List of Interviewees

Interviewee	**Date**	**Email address**
Airis Cervantes	July 7th, 2022	acervantes@mortonarb.org
Angelia Millsap-Giblin	July 8th, 2022	AMILLSA1@depaul.edu
Lydia Scott	July 13th, 2022	LScott@mortonarb.org
Lyndsay Darling	July 19th, 2022	ledarling@gmail.com
Trinity Pierce	July 19th, 2022	tpierce@mortonarb.org
Melissa Custic	July 19th, 2022	mcustic@mortonarb.org
Rebecca Olsen	July 22nd, 2022	rebecca@olsonecosolutions.com

Exhibit Six – Interview Questions

1. What is your role in your organization, and what actions do you take regarding tree planting?
2. What do you consider when undertaking a tree planting project?
3. What are your tree planting priorities?
4. Is there a geographical range or neighborhoods in Chicago on which your organization focuses?
5. Conversely, are there neighborhoods in Chicago which pose particular challenges for tree planting?
6. What strategies are you implementing to combat tree inequity?
7. How do the tree planting efforts pan out? – Do nonprofits think they can make a reasonable dent in inequity? Or is any effort considered to be a good effort?