The Effect of Urban Tree Planting on Residential Property Values and Gentrification

Liqing Li

Department of Agricultural and Consumer Economics

University of Illinois at Urbana-Champaign

September, 2019

Contents

1 Introduction

Poor and minority people in the U.S. face disproportionately high exposure to pollution and low public goods provision. Environmental Justice (EJ) policies seek to address these inequalities through programs such as Superfund clean-ups, brownfields re-developments, and urban tree plantings. However, it is essential to consider the consequences of EJ policies since exogenously providing public goods to reduce inequality may increase segregation and lead to gentrification (Banzhaf and Walsh, 2013). This paper explores whether low-income and minority residents of NYC benefit from an increased supply of urban tree canopy.

Trees provide a variety of environmental benefits to urban neighborhoods, such as improved air and water quality, heat-stress mitigation, and storm-water reduction. However, low-income communities tend to have fewer trees (Garrison, 2017). The distribution of urban tree canopy often disproportionately benefits high-income neighborhoods. Access to urban forests is therefore increasingly recognized as an EJ issue (Wolch et al., 2014). Many US cities have implemented programs to increase the supply of urban tree canopy, especially in neighborhoods with fewer green spaces. New York City (NYC) attempted to expand its urban forest and correct the unbalanced distribution of urban tree canopy through a citywide program, MillionTreeNYC (MTNYC). The program planted one million trees between 2007-2015 and was continued to plant more trees after 2015, including both street trees and park trees. The MTNYC program was committed to EJ and specifically prioritized neighborhoods with fewer green spaces and street trees. However, whether people living in low-income neighborhoods benefit from this program is unclear. While the creation of new urban tree canopy to address EJ problems can make neighborhoods more attractive, it can also increase demand for local housing, and in return, increase housing prices. Communities with more urban trees may be overrun by wealthier households due to higher rents and housing prices. Thus, an increase in an environmental amenity can alter the neighborhood's composition and increase average income (Banzhaf and Walsh, 2008). Identifying the consequence of EJ polices can illustrate if such policies may help the households who were originally exposed to fewer urban green spaces. This paper studies the effect of street tree plantings on housing values in NYC and examines whether gentrification happens in neighborhoods with improved environmental amenities.

A large group of hedonic studies shows that environmental amenities are capitalized in property values. For instance, housing prices are negatively correlated with pollution level (Kim et al., 2003; Banzhaf and McCormick, 2012). When considering the relationship between urban tree canopy and property values, several studies show a positive impact of urban forests on property values in different cities and countries (Pandit et al., 2013; Donovan and Butry, 2010; Sander et al., 2010), while some papers find a nonlinear relationship between urban trees and housing sales prices (Netusil et al., 2010). However, existing studies usually employ a traditional cross-sectional hedonic model when examining the effect of urban trees on property values due to data limitations. Omitted variables can severely bias the estimates in cross-sectional hedonic methods. Voicu and Been (2008) apply a difference-in-difference specification of a hedonic model to examine the effect of community gardens on neighboring property values. A similar approach is applied in this paper to study the impact of urban tree canopy on housing values in NYC.

Environmental quality can indirectly affect demographics through real estate prices (Banzhaf and McCormick, 2012). The hedonic models imply that housing values in an area rise with improved environmental quality. Some people argue that it is possible to make neighborhoods "just green enough" without triggering environmental gentrification (Curran and Hamilton, 2012; Eckerd, 2011), while others indicate that the provision of environmental amenities may induce the neighborhoods to gentrify because richer people can afford higher housing prices. Tiebout (1956) suggested that households "vote with their feet" regarding changes in the environmental amenity. Several empirical tests have been conducted to examine actual migratory responses to exogenously changed public goods provision. The environmental gentrification literature yields mixed findings on the relationship between changes in pollution levels and shifts in demographic characteristics. Kahn (2000) shows that air pollution reductions promote population growth in Los Angeles in a county-level analysis. More recent studies are based on smaller neighborhood definitions, such as census blocks or self-defined community ranges. Some papers support

Tiebout's theory and indicate that community composition changes in response to pollution clean-ups (Banzhaf and Walsh, 2008; Gamper-Rabindran and Timmins, 2011). Other studies show mixed findings of the impact of Superfund clean-ups on neighborhood compositions across different Superfund site locations (Cameron et al., 2012) or even insignificant impacts of pollution reductions, such as the clean-up of hazardous waste sites, on neighborhood gentrification (Greenstone and Gallagher, 2008; Cameron and McConnaha, 2006). In general, these studies focus on the effects of a reduction in environmental quality on neighborhood gentrification. More empirical evidence is needed to examine the impact of improved environmental amenity, especially increasing urban green space, on changes in neighborhood compositions.

This paper examines whether low-income neighborhoods in NYC can benefit from an increased urban tree canopy. Data on NYC tree planting records between 2007 and 2018 provided by the MTNYC program, property sales data from NYC Department of Finance, Zillow data on median housing values, and census data on neighborhood demographics and economic characteristics are applied in the empirical analysis. First, a difference-in-difference (DID) hedonic regression model is used to examine the impact of urban tree canopy on housing prices in NYC at the property-level. This impact is estimated as the difference between property values near the urban tree canopy before and after trees are planted relative to price changes of comparable properties further away but still in the same neighborhood. Second, a panel fixed effects model is applied to study the effect of urban tree planting on housing prices at the zip-code level in NYC. Third, this paper use a DID model to examine whether increased tree canopy triggers gentrification changing in the median household income, racial composition, and housing occupation status. A DID model with a continuous treatment method is applied to study the impact of an increased urban tree canopy on changes in community composition.

Results from the DID hedonic model and the zip-code level panel data model indicate that street tree planting has a positive and significant impact on housing prices. The evidence on the effects of street tree planting on changes in neighborhood composition shows the potential consequence of environmental gentrification for environmental justice policies. The paper proceeds as follows. The next section describes the MTNYC program. The empirical models that applied in this paper are discussed in Section 3. Section 4 provides information on variables explanation and data summary statistics. In Section 5, I present and discuss the regression results. Conclusion and discussion are presented in the last section

2 The MillionTreeNYC Program

The MTNYC program is one of the largest and well-funded tree planting programs in the United States (MTNYC, 2014). The MTNYC program spent $400 million to plant one million trees between 2007-2015, including both street trees and park trees, which increased the NYC forest canopy by approximately 20%. This program is continued to plant trees after it achieved its initial goal in 2015 (planting one million trees in NYC).

The MTNYC program prioritized neighborhoods with no trees or few trees, with a specific focus on street trees. Areas where the program could provide the most visual and physical impact by planting more street trees were prioritized. The program planner identified street tree planting locations based on two criteria: (1) high incidence of asthma among young people, and (2) low street tree stocking levels (MTNYC, 2014). The program's ultimate goal is to plant street trees in every possible location in NYC.

Street trees planted by the MTNYC program are considered as a form of public infrastructure and are located within the city-owned public right-of-way. Hence, nearby homeowners cannot reject the tree planting at any such location. Concerns that some locations may not get street trees planted because of residents objecting to the tree planting program can be avoided.

The MTNYC program is responsible for the care and maintenance of street trees. Planting contractors provide necessary tree care services after trees have been planted. Also, no significant levels of tree vandalism have been reported (Garrison, 2017). Therefore, though trees that may have died cannot be excluded in the regression analysis due to a lack of records about tree survival, it is reasonable to assume that most new trees survived during the study period.

Previous research has evaluated the distributional equity of MTNYC's tree planting and the program's impact on infant health outcomes. Jones and Goodkind (2019) find that an approximately 20% increase in urban forest cover lead to a significant decrease in low birth wright among mothers in NYC. More research is needed, however, to study the effect of the urban tree planing program on housing values and gentrification.

3 Empirical Model

This section discusses the identification strategy and empirical models applied in this paper to examine the effects of the MTNYC program on housing prices and gentrification. The definitions and data source of variables used in the models are presented below in the Data and Summary Statistics section.

A. Estimating the Impacts of Street Tree Planting on Housing Values

I take two appraoches to estimating how housing values respond to new trees. First, I apply a hedonic DID model using individual property transaction data in NYC to identify the impact of street tree planting on housing prices. Second, I apply a panel fixed effects model to examine the effects of the MTNYC program on median housing prices at the aggregated level[1].

Though the MTNYC program planted both street trees and park trees, this paper focuses on the impact of street tree planting on housing values and gentrification for two reasons. It is hard to identify the marginal effects of park tree planting. As an urban park is a bundle of different amenities, the value of additional park trees may be affected by other recreational amenities in each park. Furthermore, the park trees planted by the MTNYC program do not prioritize low-income neighborhoods to a measurable degree due to inequitably distributed parks in NYC (Garrison, 2017). As this paper intends to study whether poor neighborhoods can benefit from improved environmental amenities, the effect of street tree planting is the main focus of the paper. I do control for park tree

[1]The empirical analysis is based on zip-code level data from Zillow.

planting in the regression, however, to avoid omitted variable bias.

I seek to estimate the effect of street tree planting on housing prices by showing whether the values of the properties near tree planting locations increase. Properties within a certain distance d of a street segment that has street trees planted are considered treated properties, while comparable properties within a distance d of a street segment that does not have street trees planted but still in the same neighborhood are used as control properties. The estimated impact of street tree planting is the difference between values of the treated properties before and after trees planted relative to a price change of control properties. Different distances d are applied in the empirical analysis for robustness checks. Using a method similar to Voicu and Been (2008), the reduced-form econometric model is:

$$ln(P_{jkbq}) = \alpha + \beta_1 Treat_j + \beta_2 PostTreat_{jq} + \beta_3 Tpost_{jq} + \gamma_1 X_{jq} + \gamma_2 Controls_{jq} + \lambda_{bq} + \mu_k + \epsilon_{jq} \quad (1)$$

where subscripts j, k, b , and q represent property j, block k, borough b, and year-month q respectively. P represents the per-unit sales price of a property. The key variables of interest are $Treat$, $PostTreat$, and $Tpost$. A street segment is defined as treated if it has or will have street trees planted by the program during the study period. Specifically, the $Treat$ variable is a dummy variable that equals one if the property is located within d meters of a street segment that is ever treated. Intuitively, the coefficient β_1 associated with the $Treat$ variable captures the baseline difference in sales prices between properties located within a d meters buffer of a treated street segment and those located within a d meters buffer of an untreated street segment, but still in the same neighborhood (block). The $PostTreat$ dummy variable indicates whether a property is within a d meters buffer of a street segment on which street trees have been already planted in time q. Its coefficient, β_2, captures the causal impact of street tree planting on housing prices. A post-completion trend variable, $Tpost$, is included in the regression to control for the time elapsed since the street trees were planted [2]. $Tpost_{jq}$ equals the number of months

[2]Results are robust to the choice of the power terms (squared or cube terms)

between the date of the street tree planting and the date of the sale[3]. After controlling for $Tpost$, the coefficient β_2 associated with $PostTreat$ shows the effect of street tree planting immediately after the trees were planted. As sales prices are measured in logarithm form, β_2 can be interpreted approximately as the percentage difference in prices between the treated and control properties before and after trees planted.

This model also controls for property-related characteristics, X_{jq}, such as building age, size, and other structural features. Block-level fixed effects, μ_k, are included in the regression to control for unobserved time-invariant features of different blocks. I also include a vector of dummies, λ_{bq}, that indicate the year-month and borough of the housing transaction. Street characteristics that may affect the housing prices of the properties are controlled in the model as well, including controls include street type, street widths, and variation in pre-existing street trees before the program started. Lastly, ϵ_{jq} is the error term.

In addition to the baseline model showed above in Equation 1, other factors that happened in the same location where street trees were planted and may affect housing prices are controlled as well. Such confounding factors include the park trees planted by the program during the study period, hurricane Sandy that severely affected parts of NYC, and the presence of affordable housing in NYC. More detailed explanations of each factor are available in Section 4.

While the estimates from the DID hedonic model can show whether tree planting increases values of the properties nearby, estimates from a panel fixed effects model can elucidate the marginal impact of an increased supply of urban tree canopy on the median housing price within a region. I apply a zip-code level panel fixed effects model to estimate the effect of street tree planting on median housing values. In this reduced form econometric model, the explanatory variable is the total street trees planted by the program within a zip-code, which is measured as the cumulative sum of the length of the street segments that have trees planted. A reduced-form econometric model shows as follows:

[3]For instance, $Tpost$ equals 6 if a property was sold six months after the trees were planted on the street segment.

$$ln(H_{bitm}) = \beta_1 + \beta_2 ln(X_{bitm}) + \beta_3 Parktree_{bitm} + \beta_4 BuildingAge_{bit} + \lambda_i t + \mu_i + \alpha_{btm} + \epsilon_{bitm} \quad (2)$$

where subscripts b, i, t, and m represent borough b, zip-code i, year t, and month m respectively. H represents the median housing value per square foot for all home types and X represents the stock of street trees. The coefficient, β_2, measures the elasticity of an increase in the street tree planting on the median housing value at zip-code level conditional on the control variables and fixed effects. μ_i and α_{btm} are zip-code fixed effects and borough by month by year fixed effects, respectively; and lastly, ϵ_{bitm} is the error term. The model includes the stock of park trees planted by the MTNYC program and the average building age as controls in the regression to avoid omitted variable bias. New building construction may affect housing prices in that region as well. The average building age decreases as more new buildings are built in that area. The average building age is expected to be negatively correlated with median housing values. The model also includes zip-code specific year linear time trend terms, $\lambda_i t$, to capture other factors that change over time in each zip-code that may affect median housing prices.

B. Identify the Impacts of Street Tree Planting on Gentrification

I use a DID model to estimate the impact of street tree planting on median household income, racial composition, and housing tenure status. The model has the following structure:

$$Y_{jt} = \mu_j + \gamma * d_{post} + \beta_t X_{jt} + \varphi * d_{post} * p_j + \epsilon_{jt} \quad (3)$$

where subscripts j and t represent census tract j and year t respectively. Y is a measure of a neighborhood attribute, including median household income, percentage of the total population in each race category, age group, education-level group, and the housing tenant status, for census tract j in a year t. A set of census tract fixed effects is μ_j, which controls for time-invariant unobserved factors that are both correlated with the intensity of street tree planting and the outcome Y. d_{post} is a time dummy which equals 0 in a pre-treatment year and equals 1 in a post-treatment year, and X_{jt} denotes park tree planting in census tract j in year t. The coefficient of interest is φ, which corresponds to the interaction term between the time dummy d_{post} and the street tree planting intensity, p_j. The interaction term is simply referred to as the "intensity of street trees" to reduce terminology. φ measures whether census tracts with higher intensity of street tree planting have more changes in neighborhood characteristics.

4 Data and Summary Statistics

I use housing price data, tree planting data, and data on neighborhoods' demographic and economic characteristics in regressions to identify the effects of urban tree plantings. This section discusses data sources and the definitions of variables used in the regressions.

Tree planting

The Department of Parks and Recreation (DPR) targets blocks with few or no trees, planting on both sides of the street [4].The street tree block planting data, MillionTreesNYC Block Planting Locations, tracks the streets that have been planted with trees under the MTNYC program in the five NYC boroughs from 2007 to 2018. It provides information related to street locations, length of street segments in feet, and year and season[5] the street trees were planted. When the street tree planting is shown as completed for a specific street segment, it indicates that all available and appropriate locations for street tree installation have been planted with trees on that street segment.

Figure 1 shows the total length of street segments that have trees planted in each year in each borough. There are very few new street trees that were planted at the beginning of the program, and the highest number of street segments were planted with trees in 2008 and 2014. The number of new street trees planted by the MTNYC were not equally distributed across boroughs in NYC. Bronx, Queens, and Brooklyn had more new street trees planted every year than Manhattan and Staten Island.

For examining the impact of street tree plantings on housing prices at the property-level, treated street segments (locations) are defined as street segments (locations) that

[4] This program can also plant street trees through 311 service requests. Individuals may request trees to be planted in front of their homes or within their blocks. 15820 properties requested street trees during the study period. However, none of the properties was transacted during the study period.

[5] This is indicated as either Fall or Spring. According to the data description, spring plantings occur between January 1 and June 30, while fall plantings occur between July 1 and December 31 of any year.

have street trees planted by the program either through the block planting plan or individual requests during the study period. All houses within a certain distance d of a treated street segment (location) are considered as treated properties.

For analyzing the impact of tree plantings on housing values at the zip-code level, I aggregate the street-level tree planting data to the zip-code level. Within each zip-code, I assume that each month the program plants an equal amount of street trees within a season, thus the amount of street trees planted per month is one-sixth of the total length of the streets that have trees planted in one season in a year. Since housing value would be a function of the stock of the street trees in a neighborhood, I calculate the cumulative sum of street tree plantings for each month. More specifically, the stock of street trees planted by the MTNYC program in month i is the sum of all street trees planted until month i. The distribution of street trees planted by the program at the zip-code level is shown in Figure 2. The density of the trees increases as the color gets darker on the map.

To study the impact of tree planting on neighborhood composition, I aggregate the street-level tree planting data to the census tract level. The intensity of the street tree planting is the total length of streets that have trees planted within a census tract. The distribution of street trees planted by the program at the census tract level is shown in Figure 3. The density of planted trees increases as the color gets darker on the map.

One concern with the street tree planting data is that this data only measures the segment length of streets with new trees planted; variations in the street tree planting density and conditions of pre-existing street trees may bias the estimated effects. I assume that trees are planted with the same density on each street within a fixed effect group. I control for variation in pre-existing tree density with a measure of the number of street trees on each streets in 2005 that I calculate from the street tree census.

Property Transaction Data

This paper uses data provided by the NYC Department of Finance on real estate sales in NYC from 2003 to 2018[6] to measure housing prices at the property level. Property addresses were geo-coded using the Geocoding Services of the New York State GIS

[6]Data are available at https://www1.nyc.gov/site/finance/taxes/property-rolling-sales-data.page

Program Office[7]. First, I restrict my sample to NYC's Tax Class 1 properties, which are one- to three-unit residential properties[8]. Second, I restrict the sample to properties that are within a 10 meters [9] buffer of a street segment. Properties within a 10 meters buffer of the street segments that have street trees planted by the program are considered treated properties, while comparable properties within 10 meters buffer of the street segments that do not have street trees planted but still in the same neighborhood are used as control properties. Third, I exclude transactions less than $100,000 since they may be transactions among family members. Property transactions with prices greater than $2.6 million, which is above the 99th percentile among Tax Class 1 sales, are also excluded from my sample to limit the impact of outliers on regression results. After this minimal trimming, there are 423,969 property sales in the full sample.

However, there might be other programs planted trees during the study period as well. Including streets with trees that were planted by other programs or individuals in NYC may bias the results. To identify locations that have trees planted by other programs or individuals, I compare the street tree census data in 2005 and 2015. Streets that have an increasing number of street trees but do not have street trees planted by the program are identified as streets that were treated by other programs. Properties within a 10 meters buffer of these street segments are removed from the control group to reduce potential biases.

Finally, there are 297,412 property sales in the main sample, spread across 1907 census tracts. Regression analysis based on the DID hedonic model in Equation 1 mainly focuses on the main sample[10]. Figure 4 shows the number of property transactions in my main sample by borough from 2003 to 2018. The total number of transactions in each year dropped significantly after the 2008 Financial Crisis. Moreover, there are more housing

[7]https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1278

[8]Tax class 1 properties include most residential property of up to three units (family homes and small stores or office with one or two apartment attached), and most condominiums that are not more than three stories.I will include Tax Class 2 properties for robustness check.

[9]Different buffer widths are applied for robustness check

[10]The full sample is also applied in the regression analysis for robustness check. Results based on the full sample show that street tree planting has a positive but insignificant impact on property values. One possible explanation would be that the control group is contaminated as some properties in the control group are treated by other programs or individuals.

transactions in Brooklyn and Queens and fewer transactions in Manhattan during the study period. Table A.1 and Table **??** in Appendix show summary statistics for the main and full property sales sample.

2018 tax assessment data (the RPAD file) and the Primary Land Use Tax Lot Output (PLUTO) data are obtained from the Department of Finance, and the Department of Buildings permits, respectively. Information on building characteristics provided by these data, such as building age, property size in square feet, are used to estimate the structure value for each property transaction. Previous research shows that building characteristics from these data are rich enough to explain variations in prices (Ellen et al., 2002).

Zillow Median Housing Value Data

This paper applies monthly home value data provided by Zillow at the zip-code level from 2005-2018 [11] to examine the impact of street tree planting on housing prices at the zip-code level. The home value is measured by the Zillow Home Value Index (ZHVI). ZHVI is one of the most accurate and timely measures of residential real estate prices in the United States. It is a smoothed, seasonally adjusted measure of the median estimated home value across a given region and housing type. Two types of ZHVI measurements I used in the regression analyses are the ZHVI for all homes and the median ZHVI per sq.ft. Zillow defines all homes as either single-family, condominium or co-operative homes with county records. The ZHVI for all homes represents the median estimated home value for all homes of these types within a zip code. The median ZHVI per sq.ft. represents the median value of all homes per square foot, and it is calculated by dividing the estimated home value for each home by the home's square footage in a zip code.

The monthly home value data are available for 149 zip-codes in NYC between 2004-2018. Figure 5 show the per square foot median housing value trend for all home types by borough from 2004 to 2018[12]. Housing values in NYC dropped in 2008 due to the financial crisis of 2007–2008 and started increasing in 2010. Moreover, the median housing value in Manhattan is much higher than the other four boroughs. Changes in median housing

[11]Data acquired from Zillow.com/data. Aggregated data on this page is made freely available by Zillow for non-commercial use.

[12]Figure A.1 in Appendix shows the median housing value trend for all home types.

value trends vary among boroughs during the study period as well. Summary statistics in Table 1 show that both the ZHVI for all homes and the median ZHVI per sq.ft vary a lot across zip-codes.

Other Controls

The park tree planting is controlled in Equation 1, 2, and 3. The park tree planting data, MillionTreesNYC Forest Restoration Planting Sites, depicts areas in NYC parks where native trees were planted under the MTNYC program from 2007-2015. It includes information on the location of parks that have forest restoration, the size of forest restoration planting in acres, and the planting year and season [13].

When examining the impact of tree plantings on housing values at the property level in Equation 1, I control for properties sold within 1km of parks that have new tree planted during the study period [14]. When studying the impact of tree plantings on housing values at the zip-code level based on Equation 2, I control for the total acres of new park trees planted during the study period. The total acres of new park trees planted in each month is one-sixth of the total acres of park trees that were planted within each season per year. The stock of the park trees in each month is the cumulative sum of the park tree planting in each month. Figure A.2 in Appendix shows the distribution of park tree planting at the zip-code level. The density of the trees increases as the color gets darker on the map. The park tree planting is included as a control in Equation 3 to identify the effects of tree planting on changes in neighborhood compositions. The park tree planting is aggregated to the census tract level. The intensity of the park tree planting is the total acres of park trees planted within a census tract by the program. The distribution of park trees planted by the program at the census tract level is shown in Figure A.3 in Appendix. The density of the trees increases as the color gets darker on the map.

Other than controlling for the number of pre-existing trees on each street segment and the park tree planting in Equation 1, factors that are controlled in the model include street types and street widths, the areas that are affected by Hurricane Sandy, and the

[13] The definition of the planting season is same as how I explained for the street tree planting.

[14] Approximately 11%(30%) of the total property transactions are within 1km of parks that have new tree planted during the study period.

affordable housing zones.

Property values may be affected by the types and widths of the streets the properties are located on. I obtain the Centerline data from the Department of City Planning to control for street types and street widths of the street segments in NYC. The Centerline data is a single line representation of NYC streets that contains roads related information such as road location and status. There are five types of roads in my main sample, including street, path, driveway, ramp, and Alley. The mean street width in the main sample is 32.56 feet hand the max street width is 90 feet.

Another concern is that other activities may have happened in neighborhoods during the time the street tree was planted; thus the estimated change in property value generated from the property level DID hedonic model may be partly to due to these other activities. To further minimize the probability that other changes in the neighborhoods where street trees were planted may also affect housing prices, two potential factors are addressed as follows.

First, NYC was severely affected by Hurricane Sandy in 2012. Ortega and Taspinar (2018) show that Hurricane Sandy negatively affects the prices of the houses that are damaged by the hurricane. To control for the effect of Hurricane Sandy on housing prices during the study period, I obtain data from the Department of Small Business Services (SBS) on the Sandy Inundation Zone. This data shows the areas of NYC that were flooded as a result of Hurricane Sandy. The variable Sandy is a binary variable that equals one if a sold property is within the Sandy Inundation Zone after Hurricane Sandy happened in 2012 [15].

Second, the NYC government tries to promote and preserve affordable homes through programs such as the Voluntary Inclusionary Housing (VIH) program and the Mandatory Inclusionary Housing (MIH) program. The VIH program started in 1987, is designed to preserve and promote affordable housing by offering bonus developers who construct or preserve of permanently affordable housing. The MIH program, which was adopted in 2016, sets mandatory affordable housing requirement for new constructions in the MIH

[15] Figure A.5 in Appendix presents the Sandy Inundation Zone.

zoning area. Previous research shows that affordable housing may affect the local housing market and housing prices (Nguyen, 2005).To control for the impact of affordable housings on housing prices, I obtain the VIH and MIH data from the NYC Department of City Planning. These data show the areas where the VIH and MIH programs are applicable, respectively[16]. The variable VIH and MIH controlled in the regression model are binary variables which equal one if a sold property is within the programs' designated areas.

To examine the impact of street tree planting on housing prices at the zip-code level using the model in Equation 2, I also control for the average building age in each zip-code. The Primary Land Use Tax Lot Output (PLUTO) data provides building-specific information on the geocoded location of buildings in NYC, and the year the construction of each building was completed. This information provided in PLUTO comes from the Department of Buildings permits. The building age is the difference between 2019 and the year the construction of a building was completed. The zip-code level average building age is calculated as the mean of all buildings' ages within a zip-code. The average building age in a zip-code decrease if new buildings were constructed in that area. Figure A.4 shows the changes in the average building age from 2004 to 2018 by borough. Compared to other boroughs in NYC, there are more new buildings constructed in Manhattan.

Census Data and American Community Survey

I collect census tract level demographic and economic data on the total population of each racial group (e.g., percentage white and percentage black), the median household income, and housing tenant status (e.g., percentage of housing that is owner-occupied). As the MTNYC program was implemented between 2007 to 2015, demographic and economic data used in the regression analysis are from the 2000 Census, American Community Survey (ACS) 5-year estimates of 2006-2010 and 2013-2017. Data from ACS 2013-2017 are used to measure the neighborhood composition in the post-treatment period, while data from Census 2000 and ACS 2005-2009 are used to measure the neighborhood composition in the pre-treatment period. ACS 5 year estimates include data collected over 60 months and are available at the census tract level. For instance,

[16]Figure A.6 in Appendix presents the zones for the VIH and MIH programs

data in ACS 2005-2009 estimates were collected from January 1, 2005 to December 31, 2009. One concern of using the neighborhood composition data from ACS is that there are overlaps between the program implementation period and the ACS 5-year estimates periods. Therefore, the regression results are considered as the lower bound of the estimated impacts on changes in neighborhood composition. Variables used in the analysis are checked to ensure that 2000 census Summary File 3 estimates and ACS 5-year estimates are comparable. Summary statistics of neighborhood characteristics are shown in Table 2.

The regression analysis requires a set of census tracts whose boundaries are fixed over the study period. However, the definition of census tract changes between census 2000 and census 2010. The Geolytic's Neighborhood Change Database reconciles changing boundaries in census data from 1970 to 2010 at the census tract level. The census-tract level data provided by Geolytic's Neighborhood Change Database are applied in the regression analysis.

5 Results

This section is divided into three parts. First, I discuss whether values of the properties near tree planting locations increase using a property-level DID hedonic model. Second, I discuss the estimated impacts of street tree planting on the median housing value per sq.ft and the median housing value for all home types using a zip-code level panel fixed effects model. Third, I discuss the results of estimating the impacts of street tree planting on the median household income and neighborhood composition.

A. Impact of Street Tree Planting on Housing Price - Property Level

I estimate the DID hedonic model in Equation 1 based on the identifying assumption, the parallel trend assumption. It assumes that if the treated properties had not been treated, then the difference of the average potential sales prices between those properties and the control units would only be a constant number. This assumption can be evaluated by examining the pre-treatment housing price trends. Figure 6 shows the average housing price trends for the treatment and control groups from 2003 to 2007 for the main sample used in the regressions. The price trends for the two groups are parallel to each other before the program starts.

The estimated impacts of street tree plantings on housing prices at the property level are presented in Table 3. Coefficients for structural variables are consistent with expectations[17] and are shown in Table A.2 in the Appendix. All three specifications in Table 3 control for the number of street trees on each street segment in 2005 before the program started and the types of streets properties are located on. Column (1) employs borough by year-quarter fixed effects and census tract fixed effects; Column (2) and (3) include borough by year-month fixed effects and block fixed effects. Standard errors are clustered at the block level, which allows for within-block correlation while keeping the assumption of zero correlation across blocks as fixed effects. To account for the possibility that other factors may have occurred at the same locations where street trees planted during the study period, thus biasing the estimated impacts of street tree plantings, other controls are included in Table 3 Column (3). The control variable $ParkTrees$ controls for the sold properties that are within 1km of parks that have new trees planted by the program. Another control, $HurricaneSandy$ controls for the properties sold after 2012 that are within the areas that were affected by Hurricane Sandy. The regression in Column (3) also controls the properties that are within the affordable housing zones.

The coefficients for the $PostTreat$ variable (coded "1" if the property was within 10 m buffer of a street segment that has trees planted by the program, and zero otherwise) are positive and significant across three different specifications, and the magnitude of the coefficients changes only slightly with different controls. The result indicates that street tree planting has a positive and significant impact on the property values. As the average housing prices of the properties located on the treated streets is lower compared to properties on untreated streets in the same unit before treatment, the price gap reduces after street trees planted by the program. The coefficients in Column (3) indicates that if properties are located on a street with street trees planted by the program, their sales

[17] For example, the regression results indicate that property prices are higher if a property is larger, located on a corner, has major alteration, or includes a garage or extension.

prices increase by 1.2%. On average, the values of properties located on streets with street tree plantings would be \$6309 more expensive[18]. The result is consistent with findings from previous research (Donovan and Butry, 2010).

The coefficients associated with the *Treat* variable are positive [19] across three different specifications in Table 3, which indicate that even though this program planted street trees in the poorer neighborhoods with few or no street trees, street trees are more likely to be planted in better locations with relatively higher housing prices within fixed effect groups. *Tpost* measures the number of months between the street trees were planted and the property was sold. The coefficient for the *Tpost* variable is negative and significant, which implies that the positive impacts of street trees have on nearby properties decrease over time. Based on the results from Column (3), on the first month after the street trees were planted, the positive impact slightly decreases by 0.03%. It decreases to zero in 40 months after trees were planted. However, the positive impacts of the street tree planting are generally expected to increase over time as trees can provide better views when turning mature. One possible explanation would be some street trees died after a few months of planting, but existing data cannot track the conditions of each planted tree. The control, *Streettrees*2005, is positively correlated with the housing prices as expected, which confirms the unbalanced distribution of the pre-existing street trees in NYC. Other street characteristics are also controlled in all specifications in Table 3.

B. Impact of Street Tree Planting on Housing Price - Zip-code Level

Table 4 Column (1) to (3) present the estimated impact of street tree planting on median housing value per square foot corresponding to Equation 2. All specifications include zip-code fixed effects and borough by month fixed effects. The park tree planting and the average building age is controlled for in columns (2) and (3). The specification used in column (3) also includes a zip-code specific time trend. The estimated effect of street tree planting is positive and significant across all three specifications, and the magnitude of the coefficients slightly changes with different controls. As expected, the median housing value decreases with the average building age in that zip-code. Moreover,

[18]The mean housing prices is \$525,774

[19]The coefficient is positive and significant in Column (1)

the estimates in column (3) show that after controlling for the zip-code linear time trend, the park tree variable is positively and significantly correlated with per square foot median housing value.

The estimates in Table 4 column (3) indicate that after controlling for park tree planting, the average building age, and all fixed effects, street tree planting has a positive and significant impact on per square foot median housing value. A 1% increase in the stock of street trees is associated with a 0.00119% increase in median housing value per square foot. Referring to the summary statistics in Table 1, one standard deviation change in the stock of street trees, there is a 0.0023% increase in median housing value per square foot. On average, if there is a block[20] length of street segments that have street trees planted, the median housing value per square foot for all homes within a zip code increases by \$3.2. If the stock of street trees is increased by 50% within a zip code, the median housing value per square foot for all homes increases by \$33 and the median housing value for all home types roughly increases by \$38530 [21]. Besides, park tree planting is positively correlated with the median housing value square foot as well. Results for the estimated impact of street tree planting on median housing value for all home types are available in Table A.4 in the Appendix.

C. Impact of Street Tree Planting on Changes in Neighborhood Composition

Table 5 presents the correlation between street tree planting intensity and neighborhood characteristics in the baseline year (using data from Census 2000) before the program was implemented. The results show that street trees are more likely to be planted in poor and minority neighborhoods. For instance, street tree planting is negatively correlated with the median household income, the percentage population that is white, the percentage of occupied housing units, and the percentage of the population with a bachelor degree and above. There are more street trees planted in neighborhoods that have a higher percentage population that is black and have more households with fewer than nine years of education.

Table 6 presents the results of the effect of street tree planting on changes in neighborhood

[20] The length of a standard block in Manhattan is 900 feet.

[21] The average housing size is approximately 1168 sq.ft.

compositions from 2000 to 2017 based on Equation 3. Note that the intensity of street tree planting is log-transformed. Census tract fixed effects and the park tree planting are controlled for in all specifications. For discussing the results, I report the mean value of each outcome variable in brackets so that the readers can get a sense of the magnitude of the point estimates described in Table 6.

Panel A in Table 6 reveals that the street tree planting changes neighborhood composition toward more white and fewer minority households. Census tracts with higher intensity of street tree planting experience an increase in the percentage of residents who are white. Moreover, the intensity of street tree planting has a negative and significant impact on the percentage Hispanic and the percentage black.

As seen in Panel B in Table 6, street tree planting results in a reduction in vacancy rates as the percentage of housing units that are occupied increases. However, street tree planting also increases the share of renter-occupied housing units, which contradicts with findings in previous literature (Gamper-Rabindran and Timmins, 2011). One possible explanation would be that sharing economy services in the housing market, such as Airbnb, have an impact on housing occupation as more homeowners start to provide short-term rental services.

Much of the environmental gentrification literature shows that improved environmental quality changes neighborhood composition toward richer households. However, the result in Panel C Column (1) indicates that the impact of street tree planting on median household income is a positive but insignificant impact. One possible explanation would be that neighborhoods with higher intensity of street tree planting attract a younger and more educated population. These households do not necessarily have higher income, but they are able to afford higher housing prices as they are better able to secure loans from banks. To confirm this hypothesis, I examine the impact of street tree planting on the distribution of education level and age within each census tract. Results in Panel C Column (2)-(4) confirm this possibility, as street tree planting has a positive impact on the percentage of households with a bachelor degree and above [22] as well as a negative

[22]This includes households with associate degrees as well.

impact on the percentage of household with a high school degree or fewer than nine years of education. Besides, results in Panel D show that though the percentage of households in the age group 45 -54 slightly increases. Furthermore, street tree planting results in a significant increase in the percentage of households between ages 25-34 and a significant decrease in the percentage of households between ages 55-74. Thus, an increase in the supply of urban street trees changes neighborhood composition toward younger and more educated households.

Results in Table 6 raise some the concern of environmental gentrification as the street tree planting changes neighborhood composition that is more white, more educated, and younger. However, the magnitudes of the point estimates show that the effect sizes are relatively small. For instance, the point estimate of 0.403 in Panel A Column (1) implies that 1 % increase in street tree planting is associated with a 0.00403 percentage point (0.012 %) increase in the percentage white. One standard deviation change in the amount of street tree planting causes the percentage white increase by 0.0057 percentage points (0.017%). On average, if there is a block[23] length of street segments that have street trees planted, the percentage white within a census tract would increase by 0.001 percentage point. If street tree planting increases by 50% within a census tract, the percentage White would increase by 0.2 percentage point (0.06%). Moreover, the point estimate of 0.238 in Panel C Column (2) implies that 1 % increase in street tree planting is associated with a 0.00238 percentage point (0.046 %) increase in the percentage of the population with a bachelor degree and above. One standard deviation change in the amount of street tree planting leads to 0.0034 percentage points (0.065 %) increase in the percentage of the population with a bachelor degree and above.

6 Conclusion and Discussion

EJ policies seek to reduce the inequality of urban green spaces provision through urban tree planting programs. However, the provision of localized public goods can induce

[23]The length of a standard block in Manhattan is 900 feet. On average, there are 18 blocks in a census tract in NYC.

residential sorting (Gamper-Rabindran and Timmins, 2011). Identifying the consequences of EJ polices can show whether such policies may help households who were initially exposed to fewer urban green spaces. Besides, it may provide an alternative explanation to the circumstance that poor and minorities are more likely to be exposed to a degraded quality of environment (Cameron and McConnaha, 2006).

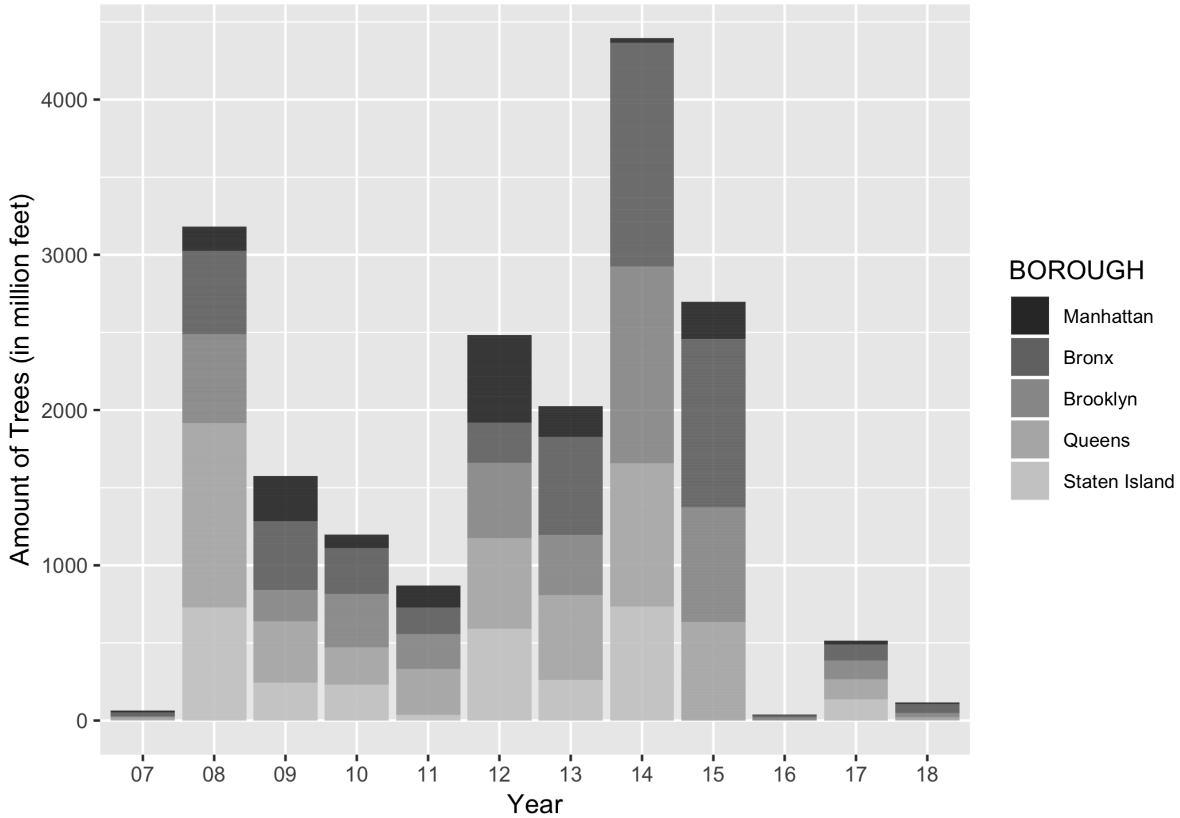
Results from this paper elucidate the impact of street tree planting on housing values and changes in neighborhood composition. According to the results from the zip-code level panel fixed effects model, street tree planting has a positive and significant impact on housing prices. Moreover, results from the DID hedonic regression analysis show that the values of properties near tree planting locations increase by 1.2%. On average, the value of properties located on streets with trees planted by the program would be over $6,000 more expensive. These findings imply that the benefits of MTNYC are large compared to its cost. This program spent around $400 million to plant both street trees and park trees in NYC. As roughly around 160,000 residential properties are located near where trees were planted, a back of the envelope calculation shows the program increased the total housing values by $1 billion and property tax revenue by $7.6 million[24].

The neighborhood effects induced by the provision of localized public goods show that higher intensity of street tree planting attracts more educated and younger households. It also leads to the in-migration of white residents. Residential sorting is induced by this urban tree planting program, yet the magnitudes found in this paper are relatively small (i.e., 1 % increase in street tree planting is associated with a 0.013 % increase in the percentage of the population that is white) compared to the sizable effects found in previous work that focuses on other EJ polices such as Superfund cleanups. This small effect indicates that it is possible for EJ policies to provide public goods without significant gentrification.

[24]The property tax revenue is calculated based the information given by "Annual report of the new york city property tax - fiscal year 2018". For the residential properties (Tax class 1), the assessment ratio is 0.038, and the tax rate is 0.2038 in 2018

7 Tables and Figures

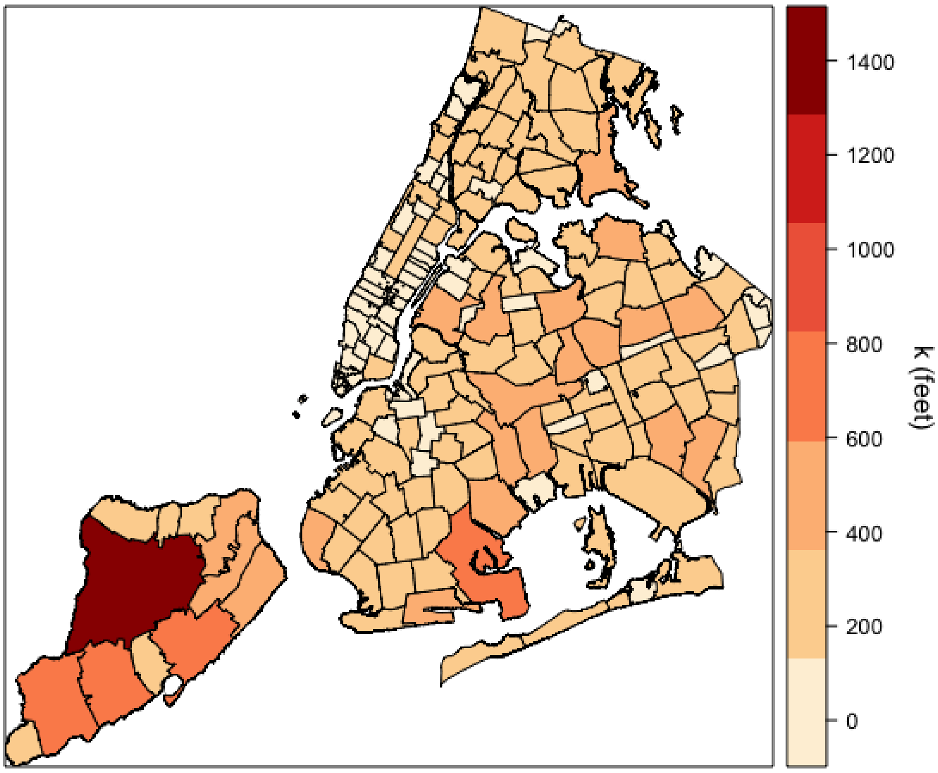
Figure 1: Street Tree Planting by Borough



Data source: The Department of Parks and Recreation

Note: This figure shows the total length of street segments in feet that have trees planted by the MTNYC program in each year in each borough.

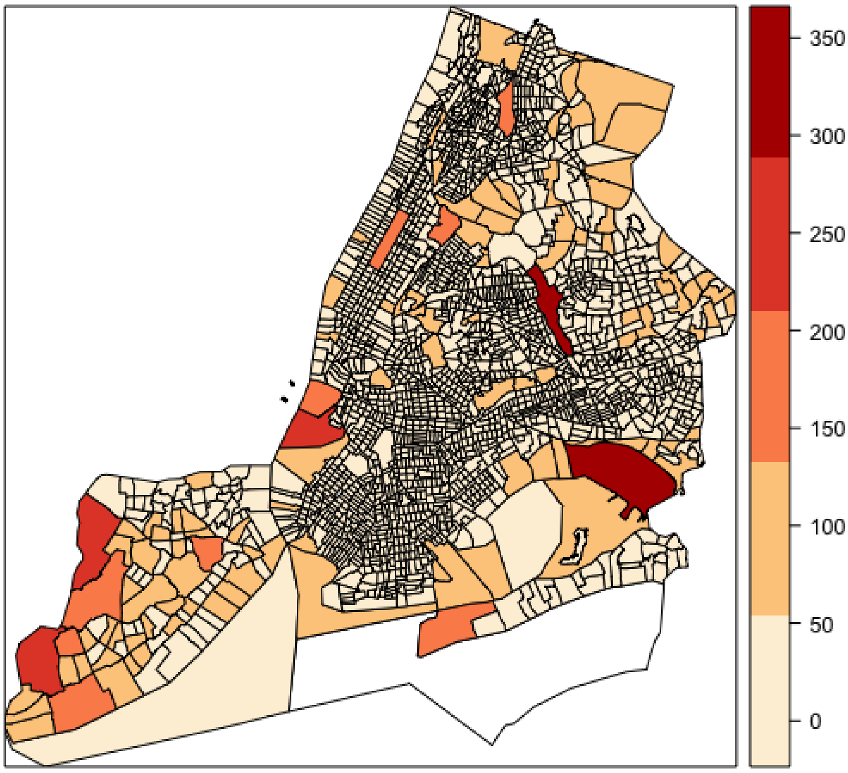
Figure 2: Distribution of Street Tree Planting at Zipcode Level



Data source: The Department of Parks and Recreation

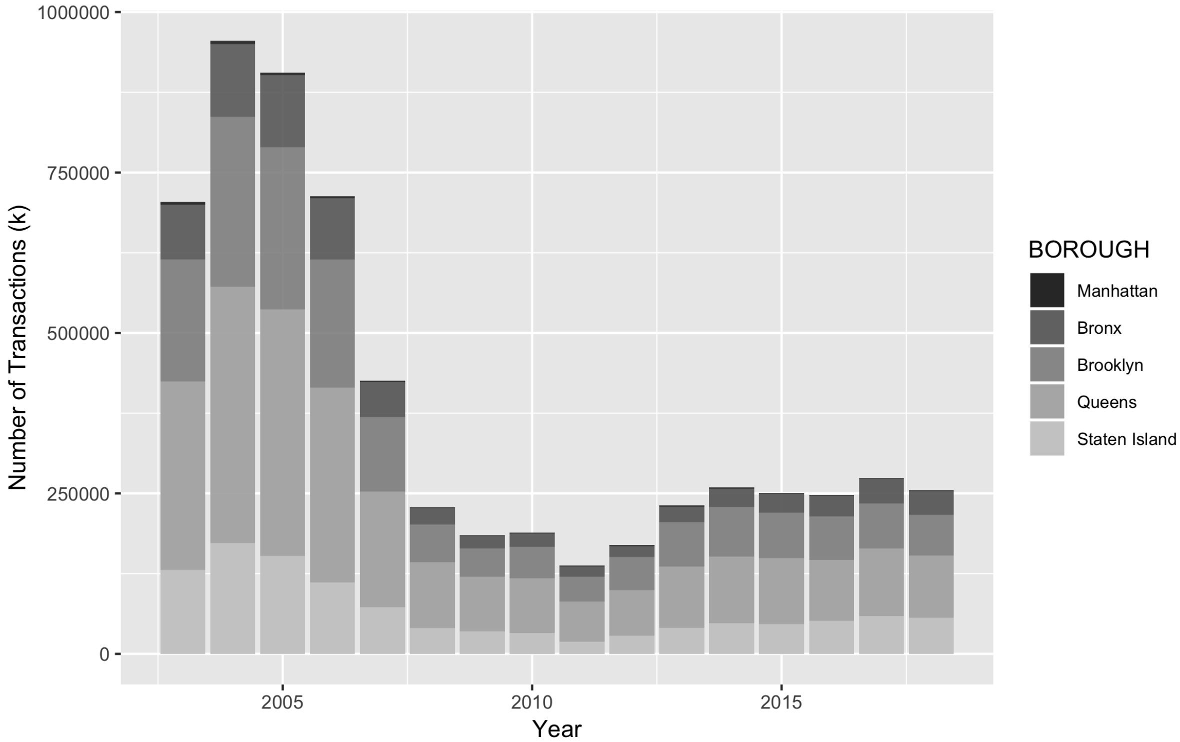
Note: This figure shows the distribution of street trees planting at the zip code level. The density of the trees is measured as the total length of street segments in feet that have trees planted by the MTNYC program within a zip code. The density of the trees increases as the color gets darker on the map.

Figure 3: Intensity of Street Tree Planting at Census Tract Level



Data source: The Department of Parks and Recreation
Note: This figure shows the distribution of street trees planting at the census tract level. The density of the trees is measured as the total length of street segments in feet that have trees planted by the MTNYC program within a census tract. The density of the trees increases as the color gets darker on the map.

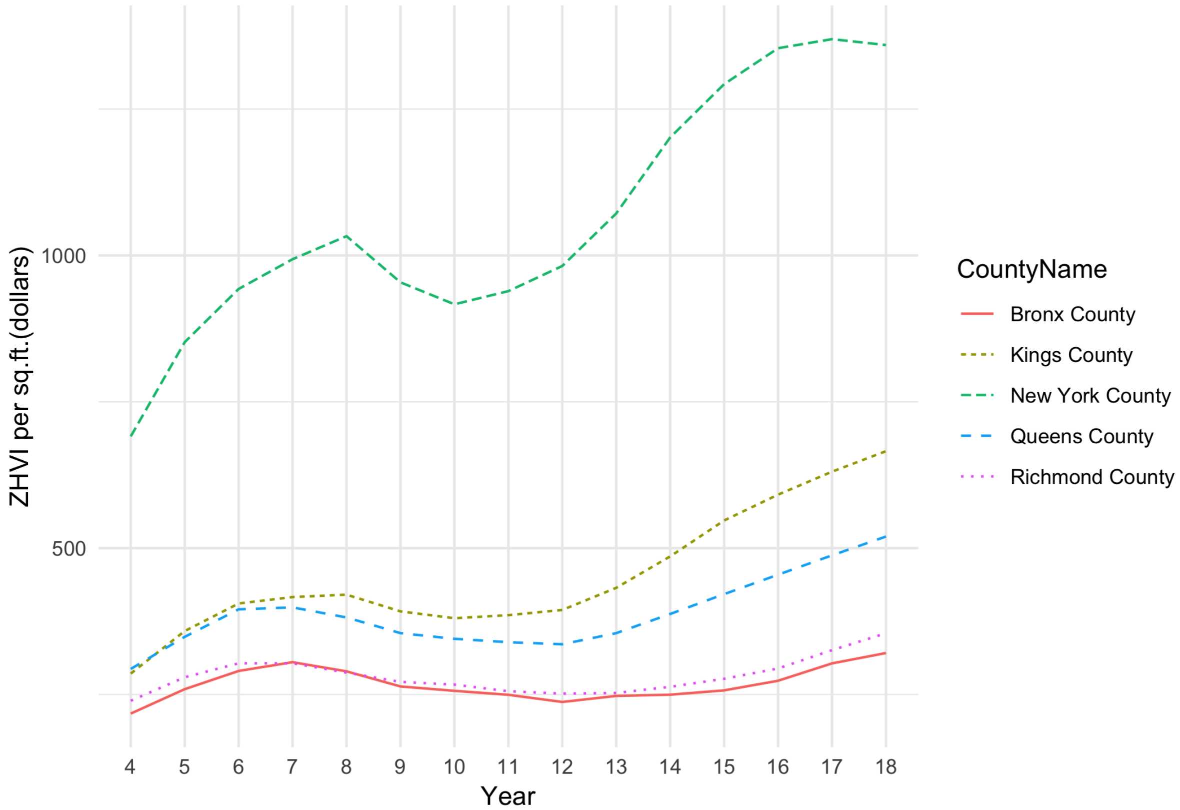
Figure 4: Number of Property Transactions (Tax Class 1) by Borough



Data source: The NYC Department of Finance

This figure shows the number of property transactions in each borough from 2003 to 2018. Only Tax Class 1 properties are included.

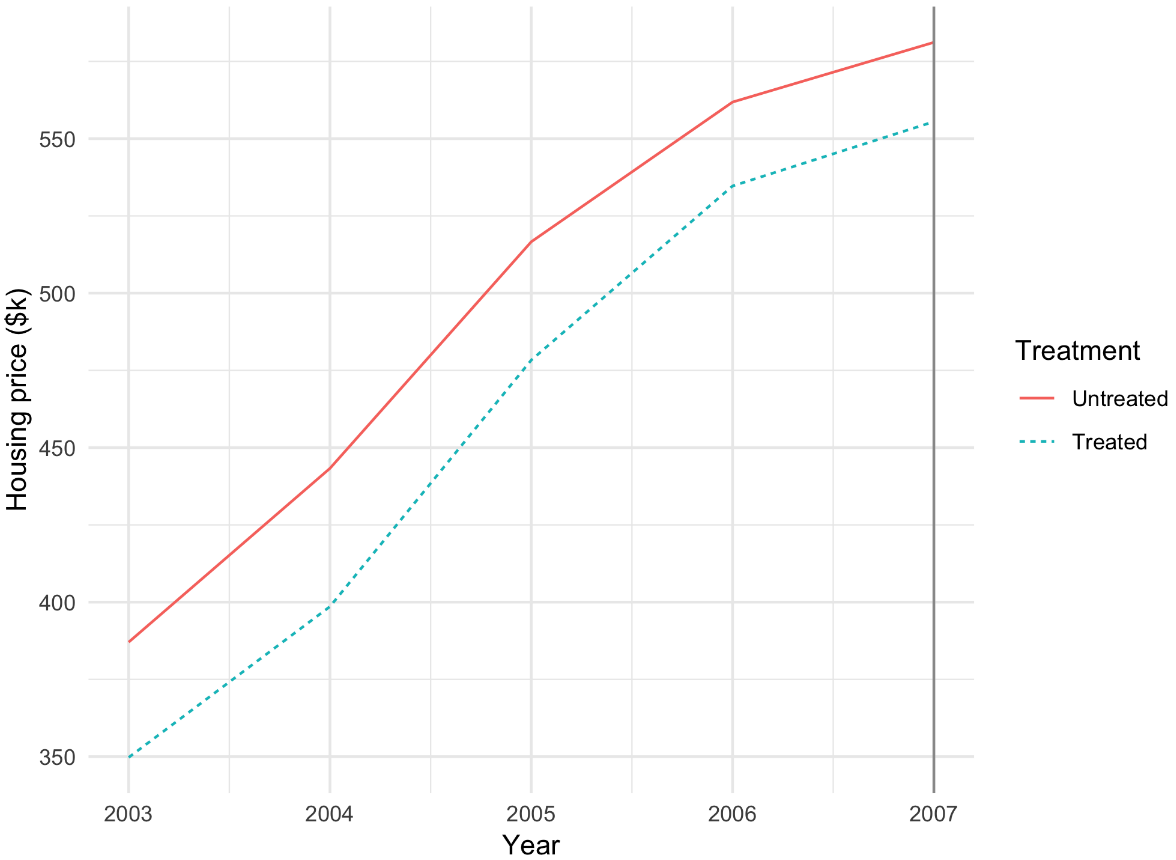
Figure 5: Median Housing Value per square foot for All Home Type by Borough from 2004 to 2018



Data source: Zillow

This figure shows the per square foot median housing value trends for all home types by borough from 2004 to 2018. The home value is measured by the Zillow Home Value Index (ZHVI).

Figure 6: Average Sales Prices Trends from 2003 to 2007 - Main Sample



Data source: NYC Department of Finance
This figure shows the average housing price trends for the treatment and control groups from 2003 to 2007 for the main sample used in the regression analysis. The year 2007 is the year which the MTNYC program started.

Table 1: Summary Statistics: Zip-code Level

Statistic	N	Mean	St. Dev.	Min	Max
ZHVI per sq.ft.	26,359	554.8	367.6	88	2,011
ZHVI	25,656	647,566	382,628	59,100	3,341,500
Newly added street tree	26,671	229.589	1,414.329	0	46,133
Cumulative street tree	26,671	18,622.690	35,258.060	0	344,356
Building Age	26,671	81.699	16.135	16.333	109.
Newly added park tree (acres)	26,671	0.011	0.092	0	4
Cumulative park tree	26,671	1.048	3.843	0	35

Table 2: Summary Statistics: Census Tract Level

Variable	**Year**	**n**	**Min**	**Median**	**Mean**	**Max**
Median household income	Census 2000	2136	4792.00	38146.00	40897.64	188697.00
	ACS 2005-2009	2110	8694.00	51150.00	54839.85	250001.00
	ACS 2013-2017	2104	9053.00	59574.50	64140.15	250001.00
% White	Census 2000	2136	0.00	26.82	35.90	100.00
	ACS 2005-2009	2110	0.00	22.42	34.12	100.00
	ACS 2013-2017	2104	0.00	23.79	32.52	100.00
% Black	Census 2000	2136	0.00	8.53	25.61	100.00
	ACS 2005-2009	2110	0.00	8.29	24.73	100.00
	ACS 2013-2017	2104	0.00	7.70	23.39	97.82
% Asian	Census 2000	2136	0.00	0.05	0.10	0.90
	ACS 2005-2009	2110	0.00	0.06	0.12	1.00
	ACS 2013-2017	2104	0.00	0.07	0.14	0.88
% Renter occupied	Census 2000	2136	0.00	70.41	65.42	100.00
	ACS 2005-2009	2110	0.00	66.80	62.52	100.00
	ACS 2013-2017	2104	0.00	66.84	62.78	100.00
% Owner occupied	Census 2000	2136	0.00	29.49	34.52	100.00
	ACS 2005-2009	2110	0.00	33.20	37.48	100.00
	ACS 2013-2017	2104	0.00	33.16	37.22	100.00
% Occupied	Census 2000	2136	51.61	95.43	94.34	100.00
	ACS 2005-2009	2110	32.53	92.63	91.53	100.00
	ACS 2013-2017	2104	18.36	92.52	91.41	100.00
% Hispanic	Census 2000	2136	0.00	15.93	24.82	96.11
	ACS 2005-2009	2110	0.00	17.48	26.19	100.00
	ACS 2013-2017	2104	0.00	18.73	26.91	96.27
Age 0 -17	Census 2000	2136	0.00	24.58	24.15	60.45
	ACS 2005-2009	2110	0.00	21.87	22.08	60.44
	ACS 2013-2017	2104	0.00	20.61	20.95	64.07
Age 18 - 24	Census 2000	2136	0.00	9.73	9.94	74.55
	ACS 2005-2009	2110	0.00	9.95	10.28	66.26
	ACS 2013-2017	2104	0.00	8.92	9.24	72.28
Age 25 - 34	Census 2000	2136	0.00	15.25	16.41	53.24
	ACS 2005-2009	2110	0.00	15.55	16.55	52.61
	ACS 2013-2017	2104	0.00	16.00	17.45	59.90
Age 35 - 44	Census 2000	2136	0.00	16.02	16.12	100.00
	ACS 2005-2009	2110	0.00	14.26	14.44	34.70
	ACS 2013-2017	2104	0.00	13.32	13.74	67.74
Age 45 - 54	Census 2000	2136	0.00	12.63	12.71	33.96
	ACS 2005-2009	2110	0.00	13.62	13.79	40.00
	ACS 2013-2017	2104	0.00	13.13	13.08	25.96
Age 55 - 74	Census 2000	2136	0.00	14.36	14.68	77.06
	ACS 2005-2009	2110	0.00	16.50	17.07	76.92
	ACS 2013-2017	2104	2.57	18.99	19.35	61.25
Age 75 & above	Census 2000	2136	0.00	4.69	5.60	45.11
	ACS 2005-2009	2110	0.00	4.92	5.82	73.29
	ACS 2013-2017	2104	0.00	5.41	6.19	75.03
Education $<$ 9 years	Census 2000	2136	0.00	10.45	12.06	73.33
	ACS 2005-2009	2110	0.00	8.76	10.63	76.94
	ACS 2013-2017	2104	0.00	8.25	9.77	46.26
High school	Census 2000	2136	0.00	44.63	42.36	100.00
	ACS 2005-2009	2110	0.00	39.79	37.76	85.94
	ACS 2013-2017	2104	0.00	32.04	30.64	70.92
Bachelor & above	Census 2000	2136	0.00	42.93	45.47	100.00
	ACS 2005-2009	2110	0.00	49.77	51.61	100.00
	ACS 2013-2017	2104	16.85	58.64	59.59	100.00

Table 3: Impacts of Street Tree Planting on Housing Value - Property Level

	Dependent variable:Housing Price (log)		
	(1)	(2)	(3)
Treat	0.009**	0.004	0.004
	(0.003)	(0.004)	(0.004)
PostTreat	0.011**	0.012**	0.012**
	(0.005)	(0.005)	(0.005)
Tpost	−0.0003***	−0.0003***	−0.0003***
	(0.0001)	(0.0001)	(0.0001)
Street characteristics:			
Street trees 2005	0.017***	0.011***	0.011***
	(0.002)	(0.002)	(0.002)
Street Type and Width	Yes	Yes	Yes
Borough by Year_Quarter	Yes		
Borough by Year_Month		Yes	Yes
Census Tract	Yes		
Block		Yes	Yes
Other controls:			
Park trees			0.009
			(0.011)
MIH [a]			−0.013
			(0.025)
VIH [b]			0.033
			(0.029)
Hurricane Sandy			−0.006
			(0.011)
Observations	297,384	297,384	297,384
R^2	0.532	0.608	0.608

*p<0.1; **p<0.05; ***p<0.01

[a] Mandatory Inclusionary Housing program. An affordable housing program.

[b] Voluntary Inclusionary Housing program. An affordable housing program.

Table 4: Impact of street tree planting on housing values

	ZHVI per sq.ft.		
	(1)	(2)	(3)
Street tree	0.00262***	0.00263***	0.00119***
	(0.00023)	(0.00022)	(0.00014)
Park tree		−0.0186***	0.008***
		(0.00133)	(0.00162)
Building age		−0.0214***	−0.0038***
		(0.0006)	(0.0009)
Zipcode fixed effect	Yes	Yes	Yes
Borough by Month fixed effect	Yes	Yes	Yes
Zipcode time trend			Yes
Observations	26,359	26,180	26,180
R^2	0.85	0.86	0.95
Adjusted R^2	0.84	0.85	0.95
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 5: Correlations between street tree planting and baseline neighborhood attributes

	Demographic composition			
	% White	% Black	% Hispanic	
	(1)	(2)	(3)	
Street tree	−2.045***	0.891***	1.612***	
	(0.200)	(0.194)	(0.137)	
Observations	2,136	2,136	2,136	
R^2	0.047	0.010	0.061	
	Median household income and Housing characteristics:			
	Income	% Occupied	% Renter occupied	
Street tree	−0.033***	−0.056*	1.447***	
	(0.003)	(0.030)	(0.150)	
Observations	2,136	2,136	2,136	
R^2	0.059	0.002	0.042	
	Education:			
	Education < 9 yrs	High school	Bachelor & above	
	(1)	(2)	(3)	
Street tree	0.555***	0.571***	−1.113***	
	(0.049)	(0.082)	(0.109)	
Observations	2,136	2,136	2,136	
R^2	0.056	0.022	0.046	
	Age:			
	Age18-24	Age25-34	Age35-44	Age45-54
	(1)	(2)	(3)	(4)
Street tree	0.123***	−0.054	−0.007	−0.139***
	(0.028)	(0.035)	(0.023)	(0.017)
Observations	2,136	2,136	2,136	2,136
R^2	0.009	0.001	0.00005	0.030

Note: *p<0.1; **p<0.05; ***p<0.01

Table 6: The effect of street tree planting on changes in neighborhood composition

	A: Racial Composition		
	% White [mean=34%]	% Black [mean=25%]	% Hispanic [mean=26%]
	(1)	(2)	(3)
Street trees*d_{post}	0.403***	−0.150***	−0.137***
	(0.057)	(0.046)	(0.050)
Observations	6,350	6,350	6,350
R^2	0.121	0.056	0.089

	B: Housing Unit Characteristics	
	% Occupied [mean=93%]	% Renter Occupied [mean=63%]
	(1)	(2)
Street trees*d_{post}	0.101***	0.181***
	(0.031)	(0.0005)
Observations	6,350	6,350
R^2	0.150	0.110

	C: Median Household Income & Education			
	Income [mean=53,242]	Bachelor &.above [a] [mean=52.19%]	High school [mean=36.95%]	Education < 9 yrs [mean=10.83%]
	(1)	(2)	(3)	(4)
Street trees*d_{post}	0.002	0.238***	−0.120**	−0.117***
	(0.001)	(0.053)	(0.049)	(0.030)
Observations	6,350	6,350	6,350	6,350
R^2	0.628	0.546	0.494	0.123

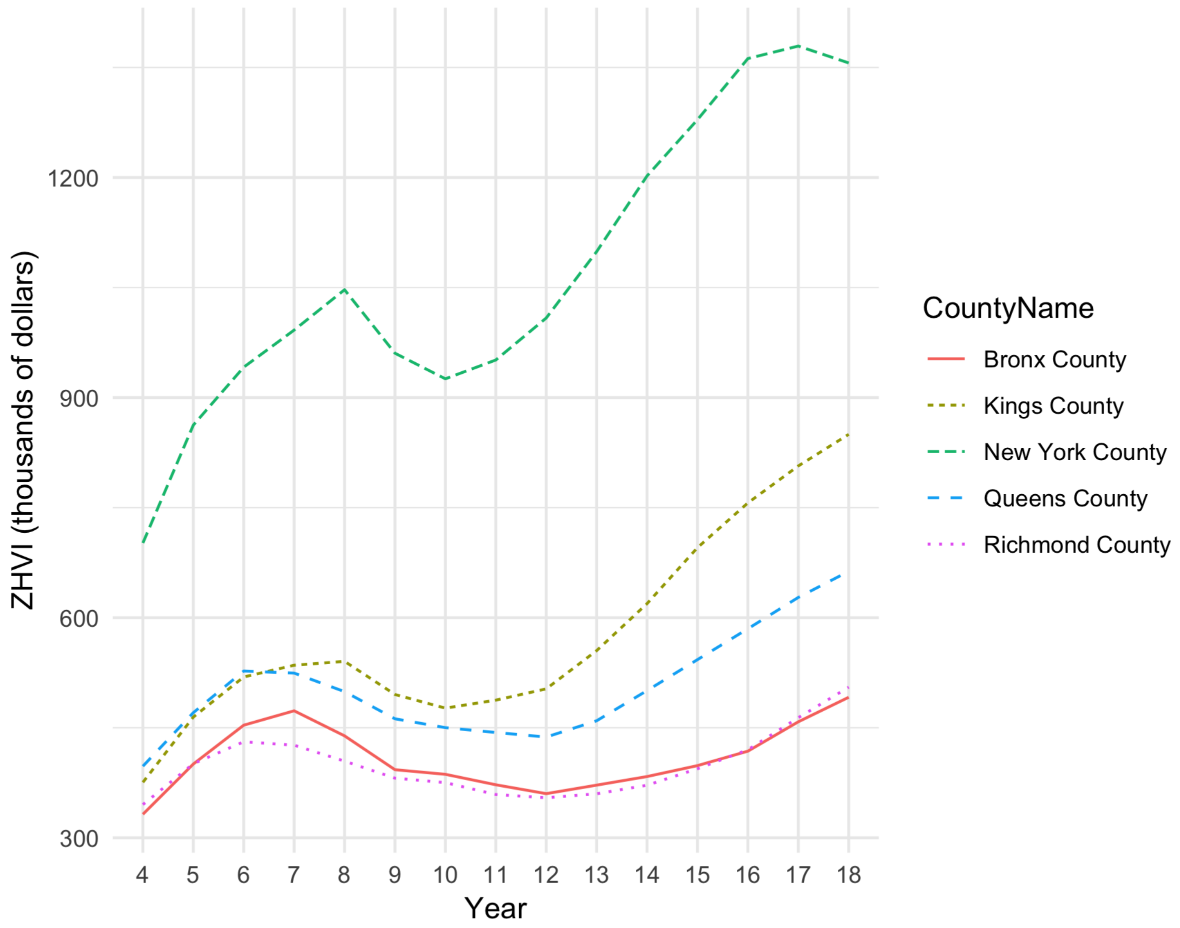
	D: Age			
	Age 25-34 [mean=16.8%]	Age 35-44 [mean=14.77%]	Age 45-54 [mean=13.19%]	Age 55-74 [mean=17.02%]
	(1)	(2)	(3)	(4)
Street trees*d_{post}	0.213***	−0.019	0.084***	−0.107***
	(0.030)	(0.024)	(0.023)	(0.034)
Observations	6,350	6,350	6,350	6,350
R^2	0.052	0.156	0.063	0.248

*p<0.1; **p<0.05; ***p<0.01

[a] Households with associate degrees are included in this category as well.

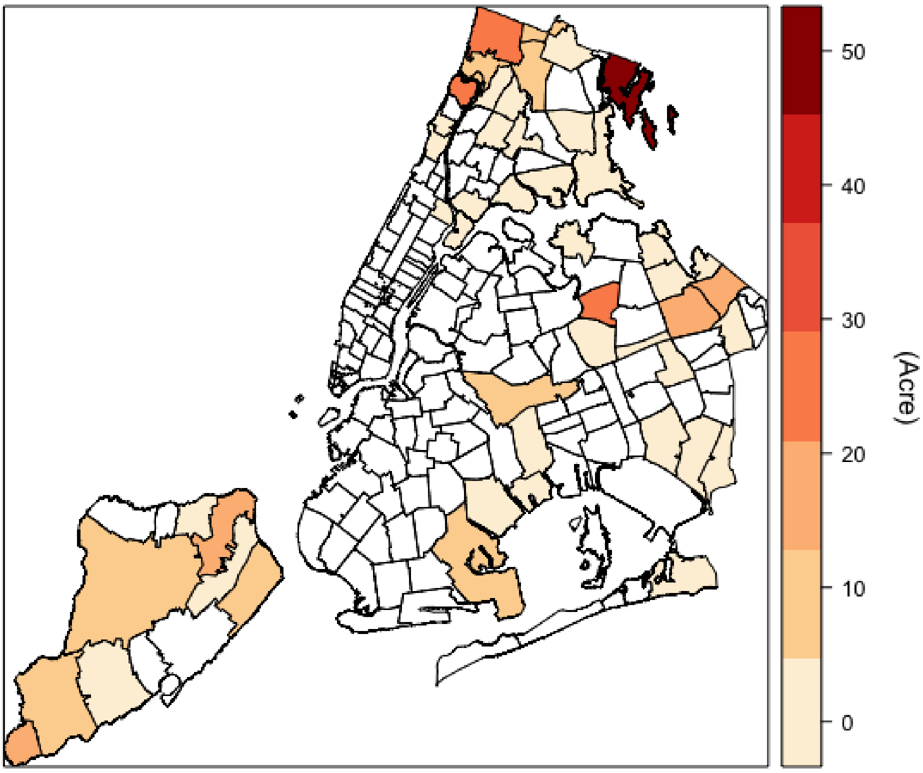
A Appendix

Figure A.1: Median Housing Value trend for All Home Types by Borough from 2004 to 2018



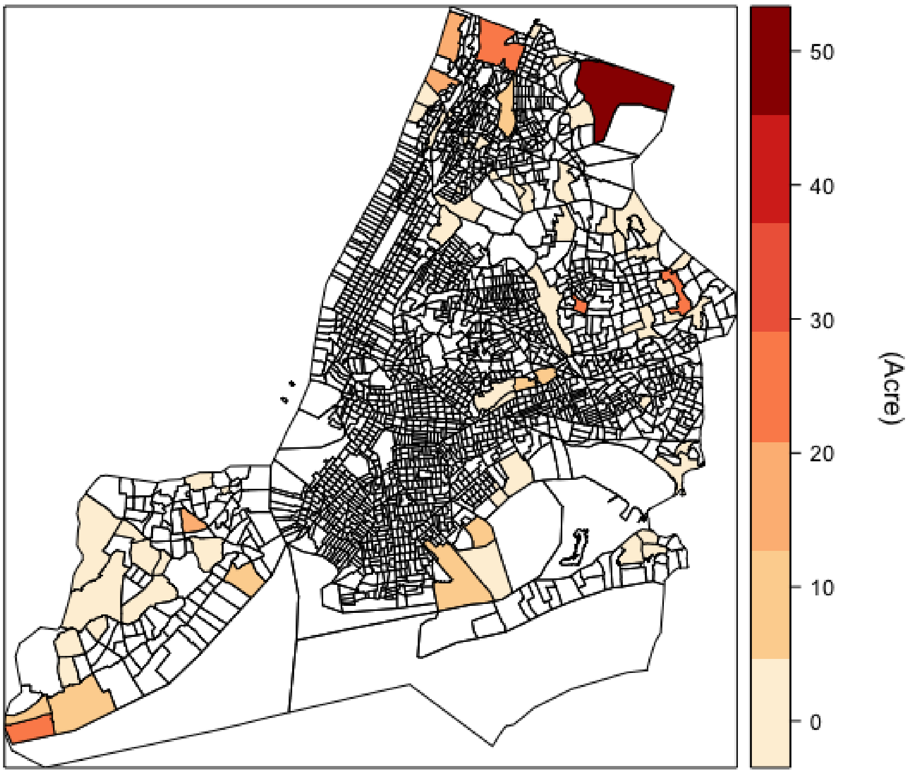
Data source: Zillow
This figure shows median housing value trends for all home types trend for all home types by borough from 2004 to 2018. The home value is measured by the Zillow Home Value Index (ZHVI).

Figure A.2: Distribution of Park Tree Planting at Zipcode Level



Data source: Department of Parks and Recreation
Note: This figure shows the distribution of park tree planting at the zip code level. The density of the trees is measured as the total acres of new park trees planted under the MTNYC program within a zip cpde. The density of the trees increases as the color gets darker on the map.

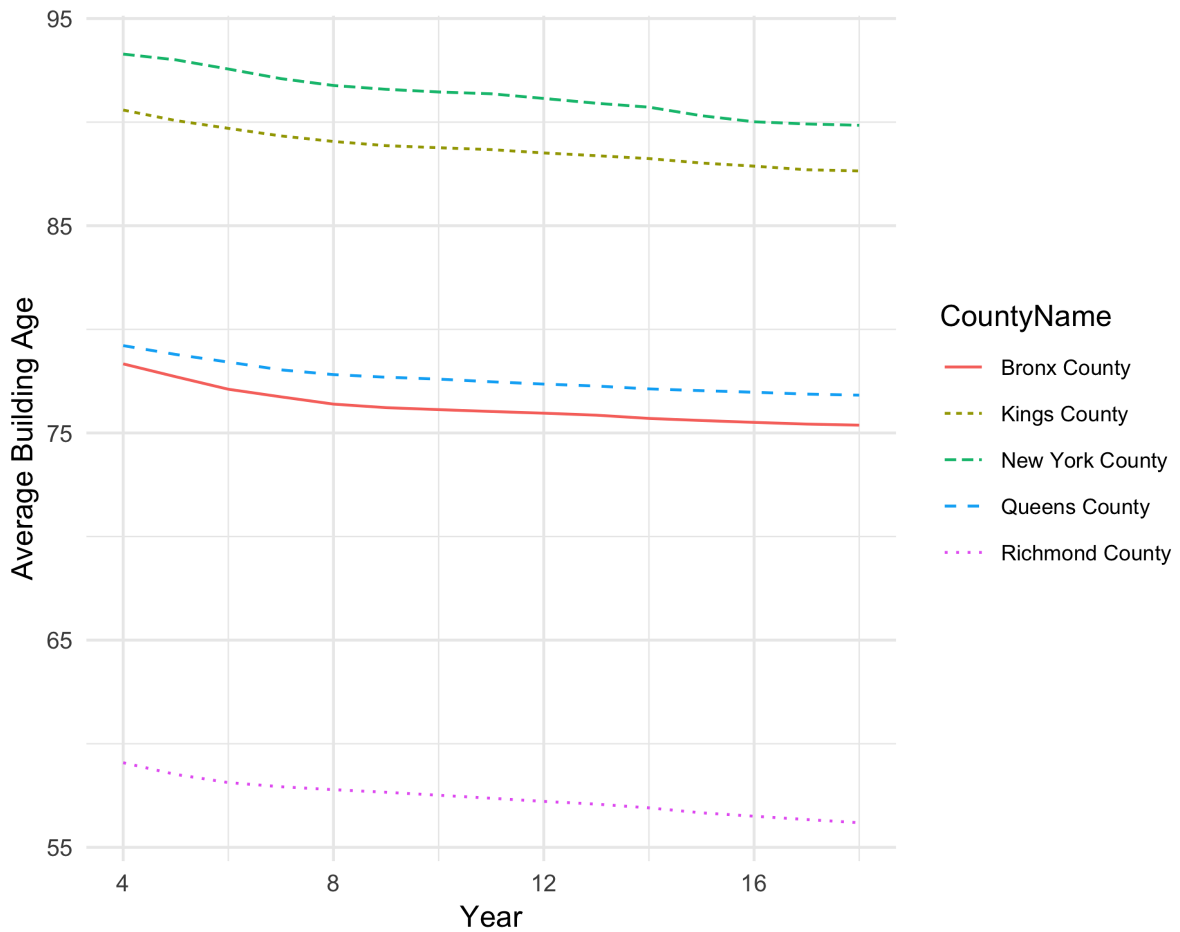
Figure A.3: Intensity of Park Tree Planting at Census Tract Level



Data source: Department of Parks and Recreation

Note: This figure shows the distribution of park tree planting at the census tract level. The density of the trees is measured as the total acres of new park trees planted under the MTNYC program within a census tract. The density of the trees increases as the color gets darker on the map.

Figure A.4: Average Building Age by Borough from 2004-2018

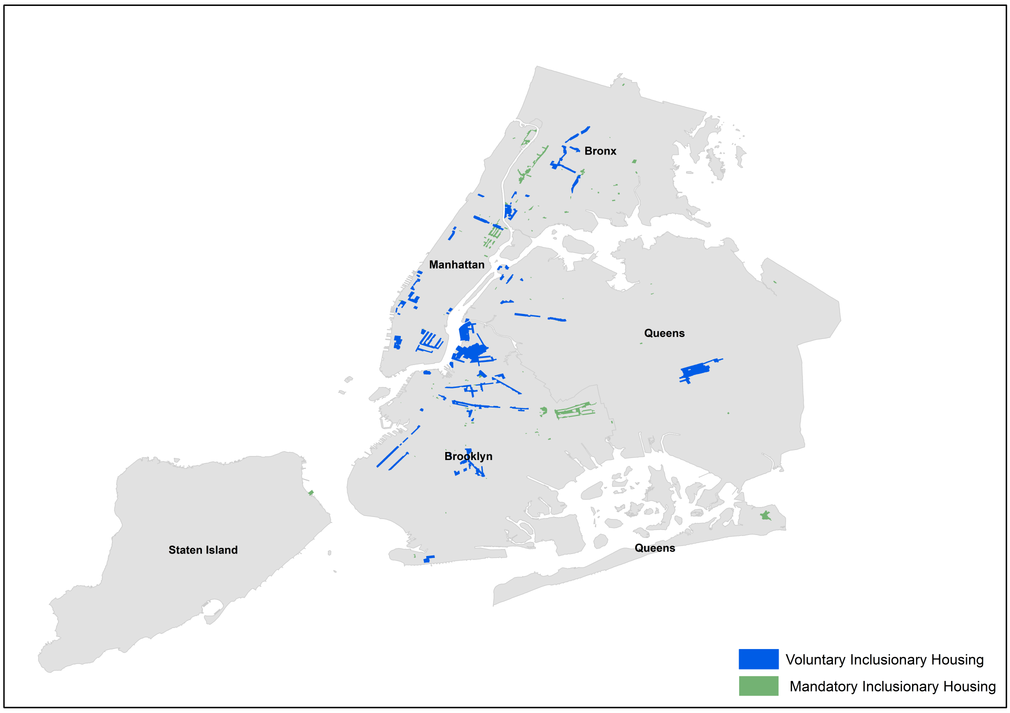


Data source: Primary Land Use Tax Lot Output

Figure A.5: Hurricane Sandy Inundation Zone

Data source: Department of Small Business Services

Figure A.6: Designated Areas for the VIH and MIH Program



Data source: NYC Department of City Planning
Note: This figure shows the desginated areas for two affordable housing programs: Voluntary Inclusionary Housing (VIH) program and the Mandatory Inclusionary Housing (MIH) program.

Table A.1: Characteristics of Property Sold in the Main Sample

	Percent of all sales	Percent of sales in treatment	Percent of sales in control
Borough			
Manhattan	0.419	0.870	0.130
Bronx	12.109	20.781	6.557
Brooklyn	27.411	33.197	23.707
Queens	41.910	29.828	49.644
Staten Island	18.151	15.324	19.961
Building class			
Single-family	45.103	35.360	51.339
Two-family	36.834	42.479	33.220
Three-family	9.858	14.830	6.675
Condo	4.182	2.303	5.385
Mixed-use	4.023	5.027	3.380
Other structural characteristics			
Build pre Word War II	57.031	63.364	52.977
Garage	38.945	31.475	43.727
Corner location	8.772	7.322	9.701
Alteration prior to sale	3.371	3.512	3.280
N	297,384	116,062	181,322

Note: The first column shows the percentage of property sales in each category for the main sample. The second and the third column show the percentages of property sales in each category that are located within 10m buffers of street segments that have street trees planted (Treated group) and that do not have street trees planted (Control group) respectively.

Table A.2: Complete Regression Results for Table 3

	Dependent variable:		
	(1)	(2)	(3)
Treat	0.009**	0.004	0.004
	(0.003)	(0.004)	(0.004)
TreatPost	0.011**	0.012**	0.012**
	(0.005)	(0.005)	(0.005)
Tpost	−0.0003***	−0.0003***	−0.0003***
	(0.0001)	(0.0001)	(0.0001)
Odd shape	0.015***	0.012***	0.012***
	(0.004)	(0.004)	(0.004)
Extension	0.015***	0.010***	0.010***
	(0.003)	(0.003)	(0.003)
Garage	0.039***	0.024***	0.024***
	(0.002)	(0.002)	(0.002)
Vorner	0.046***	0.037***	0.037***
	(0.003)	(0.003)	(0.003)
Age of unit	−0.002***	−0.002***	−0.002***
	(0.0001)	(0.0001)	(0.0001)
$(Age\ of\ unit)^2$	0.00000***	0.00000***	0.00000***
	(0.00000)	(0.00000)	(0.00000)
Age missing	−0.149***	−0.143***	−0.143***
	(0.025)	(0.019)	(0.019)
Major alteration	0.150***	0.143***	0.143***
	(0.005)	(0.006)	(0.006)
Area Missing	0.224***	0.183***	0.183***
	(0.030)	(0.023)	(0.023)
Area Sqft.	0.00004***	0.00003***	0.00003***
	(0.00001)	(0.00000)	(0.00000)
Single family home	0.290***	0.308***	0.308***
	(0.035)	(0.035)	(0.035)
Two-family home	0.441***	0.457***	0.457***
	(0.034)	(0.035)	(0.035)
Three-family home	0.521***	0.536***	0.536***
	(0.034)	(0.035)	(0.035)
Condo	−0.203***	−0.160***	−0.160***
	(0.038)	(0.038)	(0.038)
Street trees 2005	0.017***	0.011***	0.011***
	(0.002)	(0.002)	(0.002)
Street Type and Width	Yes	Yes	Yes
Borough by Year_Quarter	Yes		
Borough by Year_Month		Yes	Yes
Census Tract	Yes		
Block		Yes	Yes
Park trees			0.009
			(0.011)
MIH			−0.013
			(0.025)
VIH			0.033
			(0.029)
Hurricane Sandy			−0.006
			(0.011)
Observations	297,384	297,384	297,384
R^2	0.532	0.608	0.608
Adjusted R^2	0.528	0.577	0.577
Residual Std. Error	0.343 (df = 295134)	0.324 (df = 275961)	0.324 (df = 275957)
Note:			*p<0.1; **p<0.05; ***p<0.01

Table A.3: Impact of street tree planting on housing values per sq.ft.

	Dependent variable:				
	ZHVI per sq.ft.				
	(1)	(2)	(3)	(4)	(5)
Street tree	0.00123***	0.00262***	0.00251***	0.00263***	0.00119***
	(0.00029)	(0.00023)	(0.00022)	(0.00022)	(0.00014)
Park tree			−0.019***	−0.0186***	0.008***
			(0.00135)	(0.00133)	(0.00162)
Building age				−0.0214***	−0.0038***
				(0.0006)	(0.0009)
Month fixed effect	Yes				
Zipcode fixed effect	Yes	Yes	Yes	Yes	Yes
Borough by Month fixed effect		Yes	Yes	Yes	Yes
Zipcode time trend					Yes
Observations	26,359	26,359	26,359	26,180	26,180
R^2	0.0006931236	0.8494824	0.8506399	0.8579424	0.9513051
Adjusted R^2	−0.01186011	0.8433057	0.8445045	0.8520655	0.9490005
Note:					*p<0.1; **p<0.05; ***p<0.01

Table A.4: Impact of street tree planting on housing values for all home types

	Dependent variable:				
	ZHVI				
	(1)	(2)	(3)	(4)	(5)
Street tree	0.00114***	0.0031***	0.003***	0.0032***	0.0021***
	(0.00029)	(0.00023)	(0.00023)	(0.000226)	(0.000154)
Park tree			−0.0165***	−0.0149***	0.01***
			(0.0014)	(0.00137)	(0.0018)
Building age				−0.0218***	0.00191**
				(0.001)	(0.001)
Month fixed effect	Yes				
Zipcode fixed effect	Yes	Yes	Yes	Yes	Yes
Borough by Month fixed effect		Yes	Yes	Yes	Yes
Zipcode time trend					Yes
Observations	25,119	25,119	25,119	25,119	25,119
R^2	0.0006099235	0.8388089	0.839723	0.8472232	0.9399974
Adjusted R^2	−0.01224565	0.8319094	0.8328557	0.8406707	0.9370686
Note:					*p<0.1; **p<0.05; ***p<0.01

Table A.5: The effect of street tree planting on changes in neighborhood composition - Age group

	Dependent variable:						
	Age 0-17	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55 74	Age $\geq$75
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Street trees*d_{post}	-0.153^{***}	-0.016	0.213^{***}	-0.019	0.084^{***}	-0.107^{***}	-0.016
	(0.031)	(0.023)	(0.030)	(0.024)	(0.023)	(0.034)	(0.017)
Observations	6,350	6,350	6,350	6,350	6,350	6,350	6,350
R^2	0.167	0.049	0.052	0.156	0.063	0.248	0.024
Note:							*p<0.1; **p<0.05; ***p<0.01

References

Banzhaf, H. and McCormick, E. (2012). Moving beyond cleanup. *The Political Economy of Environmental Justice*, pages 23–51.

Banzhaf, H. S. and Walsh, R. P. (2008). Do people vote with their feet? an empirical test of tiebout. *American Economic Review*, 98(3):843–63.

Banzhaf, H. S. and Walsh, R. P. (2013). Segregation and tiebout sorting: The link between place-based investments and neighborhood tipping. *Journal of Urban Economics*, 74:83–98.

Cameron, T. A., Crawford, G. D., and McConnaha, I. T. (2012). Superfund taint and neighborhood change:ethnicity, age distributions, and household structure. *The Political Economy of Environmental Justice*, page 137.

Cameron, T. A. and McConnaha, I. T. (2006). Evidence of environmental migration. *Land Economics*, 82(2):273–290.

Chum, A. (2015). The impact of gentrification on residential evictions. *Urban geography*, 36(7):1083–1098.

Curran, W. and Hamilton, T. (2012). Just green enough: Contesting environmental gentrification in greenpoint, brooklyn. *Local Environment*, 17(9):1027–1042.

Donovan, G. H. and Butry, D. T. (2010). Landscape and Urban Planning Trees in the city : Valuing street trees in Portland , Oregon. 94:77–83.

Eckerd, A. (2011). Cleaning up without clearing out? a spatial assessment of environmental gentrification. *Urban Affairs Review*, 47(1):31–59.

Ellen, I. G., Schill, M. H., Susin, S., and Schwartz, A. E. (2002). Building homes, reviving neighborhoods: Spillovers from subsidized construction of owner-occupied housing in new york city. *Low income homeownership: Examining the unexamined goal*, pages 447–77.

Gamper-Rabindran, S. and Timmins, C. (2011). Hazardous waste cleanup, neighborhood gentrification, and environmental justice: Evidence from restricted access census block data. *American Economic Review*, 101(3):620–24.

Garrison, J. D. (2017). Seeing the park for the trees: New York's "Million Trees" campaign vs. the deep roots of environmental inequality. *Environment and Planning B: Urban Analytics and City Science*.

Glaeser, E. L., Kim, H., and Luca, M. (2018). Nowcasting gentrification: Using yelp data to quantify neighborhood change. *AEA Papers and Proceedings*, 108:77–82.

Greenstone, M. and Gallagher, J. (2008). Does hazardous waste matter? evidence from the housing market and the superfund program. *The Quarterly Journal of Economics*, 123(3):951–1003.

Jones, B. A. and Goodkind, A. (2019). Urban afforestation and infant health: Evidence from milliontreesnyc. *Journal of Environmental Economics and Management*.

Kahn, M. E. (2000). Smog reduction's impact on california county growth. *Journal of Regional science*, 40(3):565–582.

Keiser, D. A., Kling, C. L., and Shapiro, J. S. (2019). The low but uncertain measured benefits of us water quality policy. *Proceedings of the National Academy of Sciences*, 116(12):5262–5269.

Kim, C. W., Phipps, T. T., and Anselin, L. (2003). Measuring the benefits of air quality improvement: a spatial hedonic approach. *Journal of environmental economics and management*, 45(1):24–39.

Netusil, N. R., Chattopadhyay, S., and Kovacs, K. F. (2010). Estimating the demand for tree canopy: a second-stage hedonic price analysis in portland, oregon. *Land Economics*, 86(2):281–293.

Nguyen, M. T. (2005). Does affordable housing detrimentally affect property values? a review of the literature. *Journal of Planning Literature*, 20(1):15–26.

Ortega, F. and Taspinar, S. (2018). Rising sea levels and sinking property values: Hurricane sandy and new york's housing market. *Journal of Urban Economics*, 106:81–100.

Pandit, R., Polyakov, M., Tapsuwan, S., and Moran, T. (2013). The effect of street trees on property value in perth, western australia. *Landscape and Urban Planning*, 110:134–142.

Sander, H., Polasky, S., and Haight, R. G. (2010). The value of urban tree cover: A hedonic property price model in ramsey and dakota counties, minnesota, usa. *Ecological Economics*, 69(8):1646–1656.

Tiebout, C. M. (1956). A pure theory of local expenditures. *Journal of political economy*, 64(5):416–424.

Voicu, I. and Been, V. (2008). The effect of community gardens on neighboring property values. *Real Estate Economics*, 36(2):241–283.

Wolch, J. R., Byrne, J., and Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. *Landscape and urban planning*, 125:234–244.