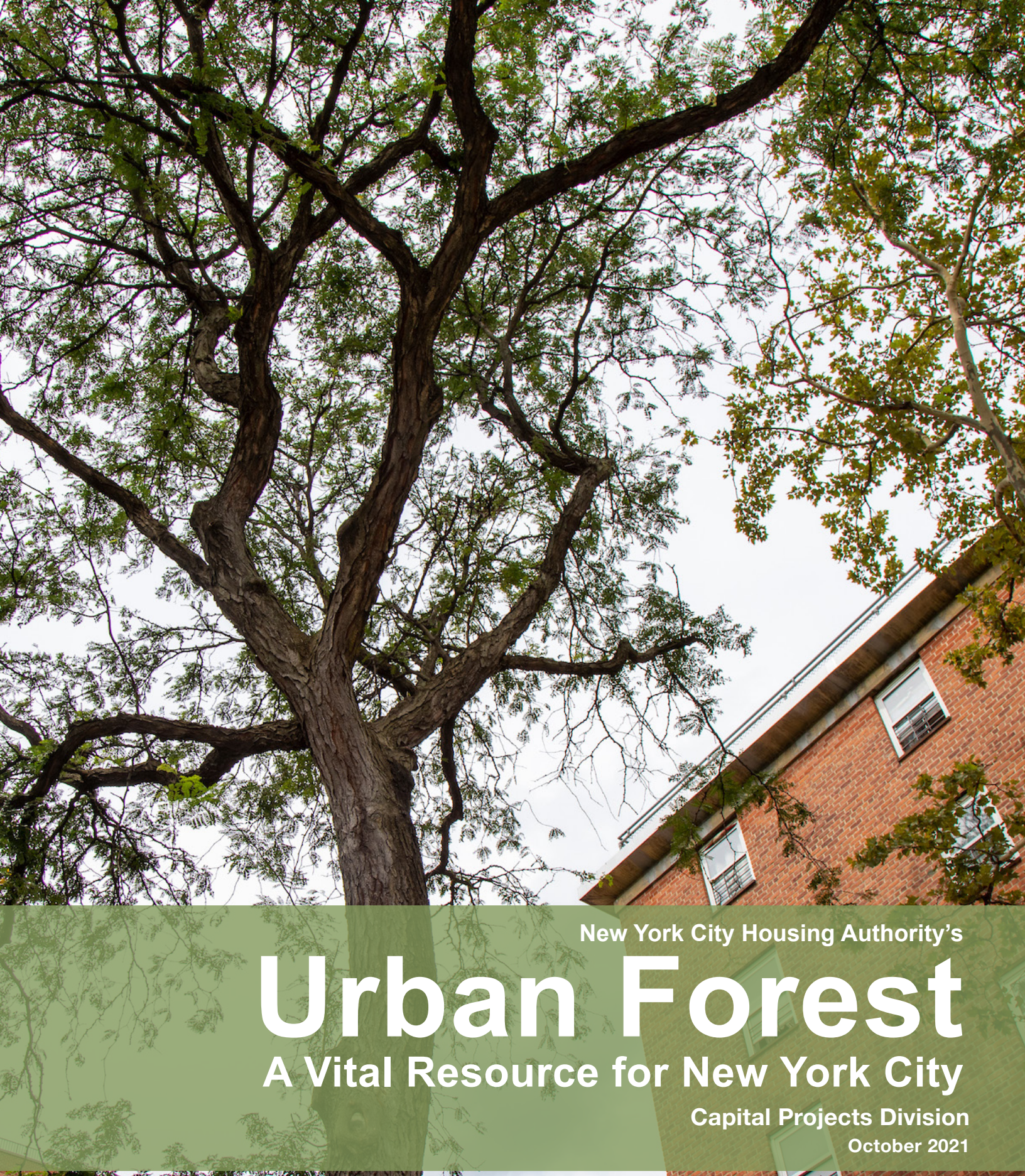


New York City Housing Authority's

Urban Forest

A Vital Resource for New York City

Capital Projects Division

October 2021

NEW YORK CITY HOUSING AUTHORITY

Table of Contents

01. Introduction

The New York City Housing Authority (NYCHA) is the nation's largest landlord, housing 1 in 15 residents of New York City and providing much-needed housing security to low- and moderate-income New Yorkers. NYCHA is also the second-largest owner of open space, over 2,400 acres in New York City, behind only the New York City Parks Department. NYCHA's open spaces are an important resource in their own right, both for NYCHA residents and New York City as a whole. They contain bucolic green space, playgrounds, community gardens, seating areas, barbeque areas, and other uses varying by site. NYCHA's open spaces support about 1,000 acres of tree canopy, providing shade, comfort, and beauty in addition to carbon sequestration, air pollutant removal, reduced heat island impact, and stormwater mitigation benefits. In neighborhoods with clusters of NYCHA developments, NYCHA is often the primary source of tree canopy cover neighborhood-wide, making NYCHA trees particularly important in neighborhoods with less access to large parks and other open spaces. However, as a housing authority focused on upgrading housing quality in the context of decades of deferred maintenance and a $40 billion capital need, the resources NYCHA is able to devote to caring for trees are limited.

This report looks comprehensively at NYCHA's portion of the New York City urban forest: a truly multi-faceted resource that provides essential ecological and social benefits, but one that requires investment and care to continue doing so into the future. Especially in the context of a changing climate, it is essential to find partnerships and funding streams to help maintain, enhance, and expand NYCHA's urban forest resource for the benefit of NYCHA residents and all New Yorkers.

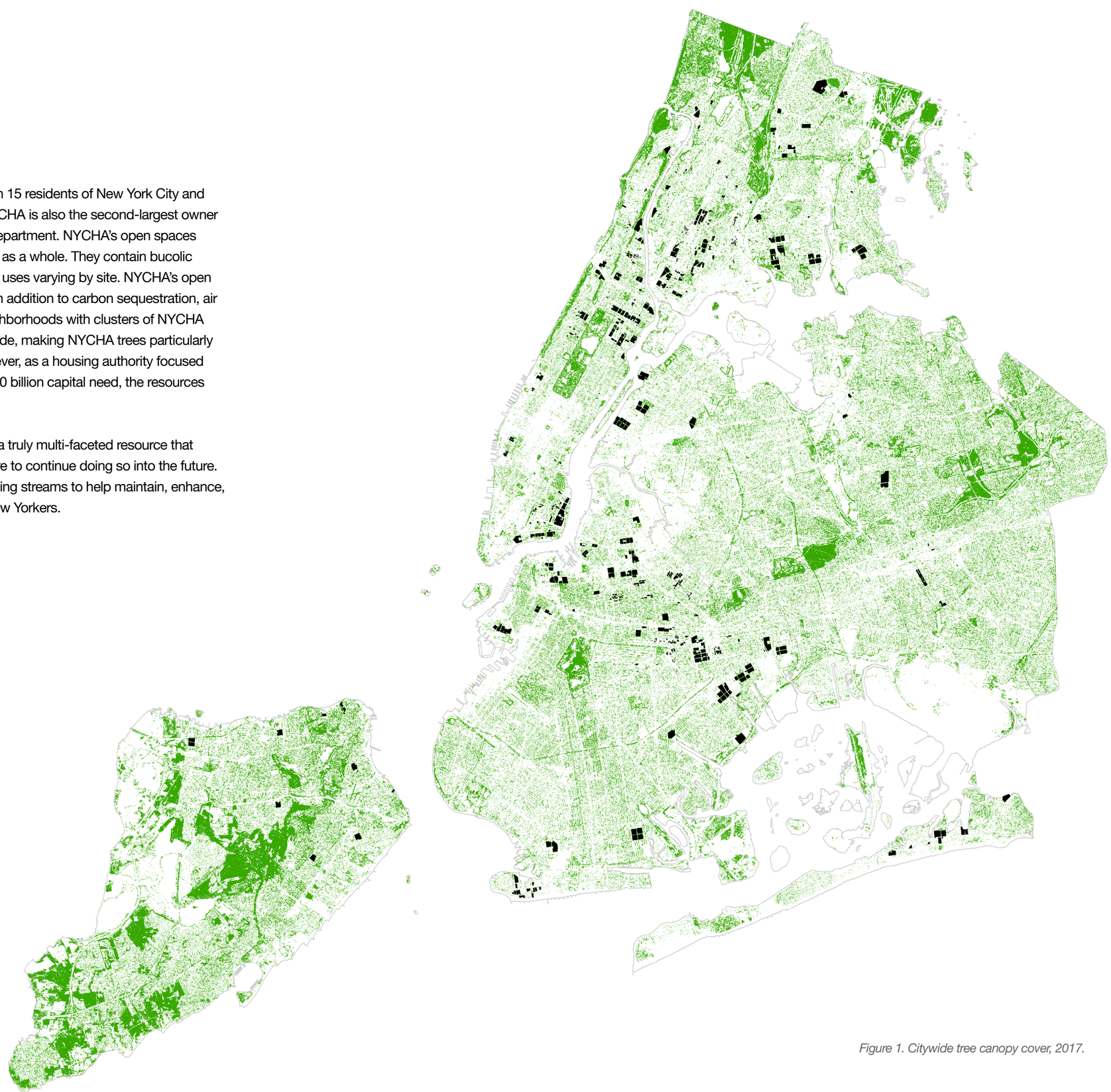


Figure 1. Citywide tree canopy cover, 2017.

Background

Although NYCHA's housing developments vary in their configuration, many conform to a "towers in the park" urban design typology that was intended to provide light and air to each NYCHA apartment while creating open space for residents to use throughout each campus. NYCHA's buildings are primarily mid-century masonry mid- to-high rise buildings and are often arranged on "superblocks" that merged multiple city blocks when they were built, with buildings placed away from the usual street grid within open spaces[1].

Many of the trees still present on NYCHA's campuses were planted when the developments were originally built in the 1950s and 1960s. NYCHA invested heavily in its trees at the time, with planting plans showing that many very large trees, up to 10 inches in caliper, were transplanted to NYCHA's campuses to establish the tree canopy quickly (Figure 2). Large, long-lasting shade trees such as London Planetrees, American Elms, and various Oaks dominated tree selections in open spaces, with smaller trees and shrubs used closer to buildings.

The legacy of NYCHA's early investment in trees is apparent today, with NYCHA's trees providing levels of canopy cover far above what would be found in a typical New York City neighborhood. LiDAR data commissioned by the City of New York in 2017 provides detailed information about how tree canopy cover varies throughout the city and demonstrates the scale of NYCHA's tree resources. Analysis of that data shows that tree canopy cover at NYCHA campuses ranges from 0 (for scattered-site developments without substantial open space) to 71% at sites with the greatest tree density, and an average of 34% cover.

NYCHA developments are clustered in neighborhoods with lower-than-average levels of tree canopy cover overall, making the NYCHA developments' high density of tree canopy within these neighborhoods stand out as a resource. Images showing tree canopy cover in the South Bronx, East Harlem, and Brownsville, three neighborhoods with large clusters of NYCHA developments, show that much of the tree canopy cover in those neighborhoods is inside of NYCHA developments (Figures 3, 4, 5).

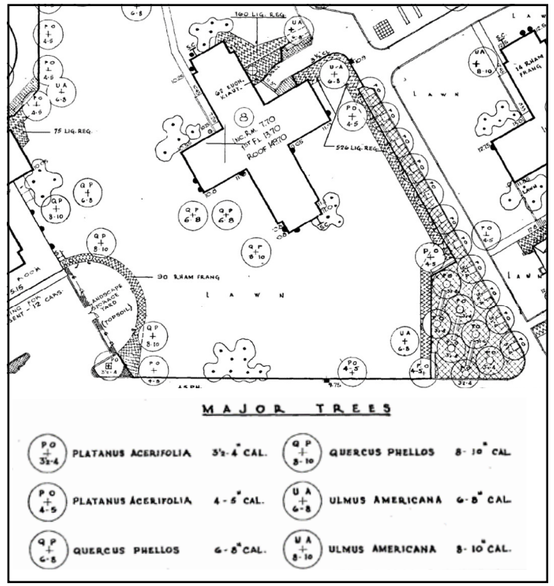


Figure 2. 1956 planting plan excerpts for Wagner Houses shows that NYCHA placed a high importance on trees, installing many very large London Planetrees, American Elms, and Willow Oaks to quickly establish a dense tree canopy.

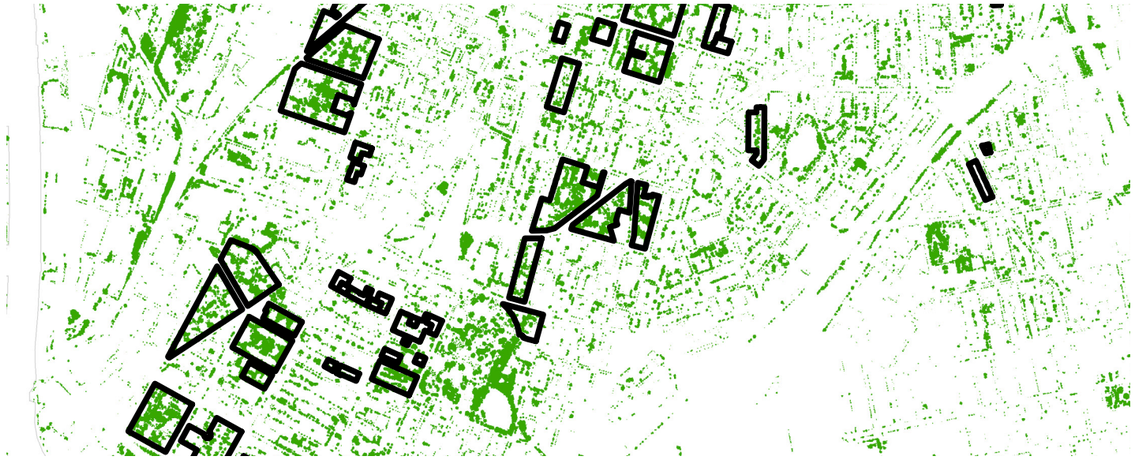


Figure 3. South Bronx trees/NYCHA developments | Data: NYC DoITT, https://maps.nyc.gov/lidar/2017/

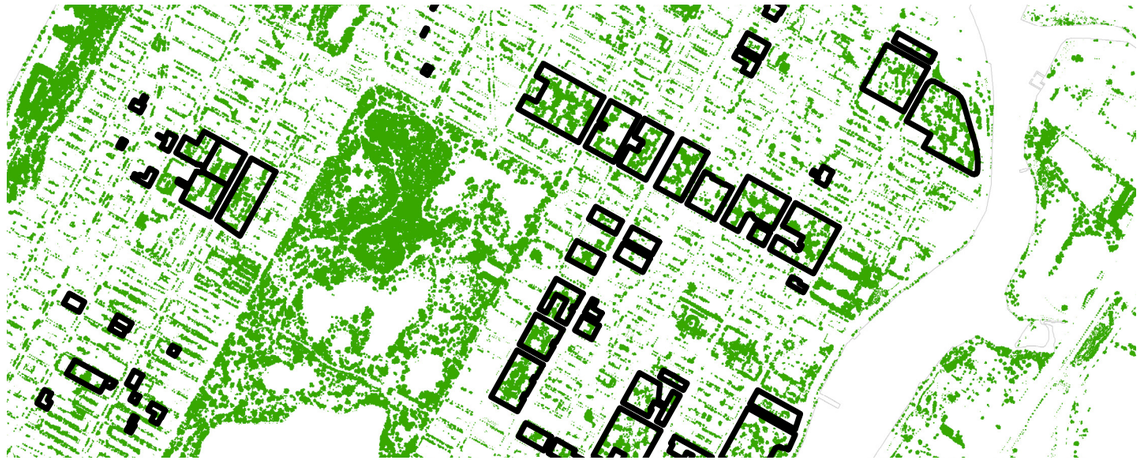


Figure 4. East Harlem trees/NYCHA developments | Data: NYC DoITT, https://maps.nyc.gov/lidar/2017/

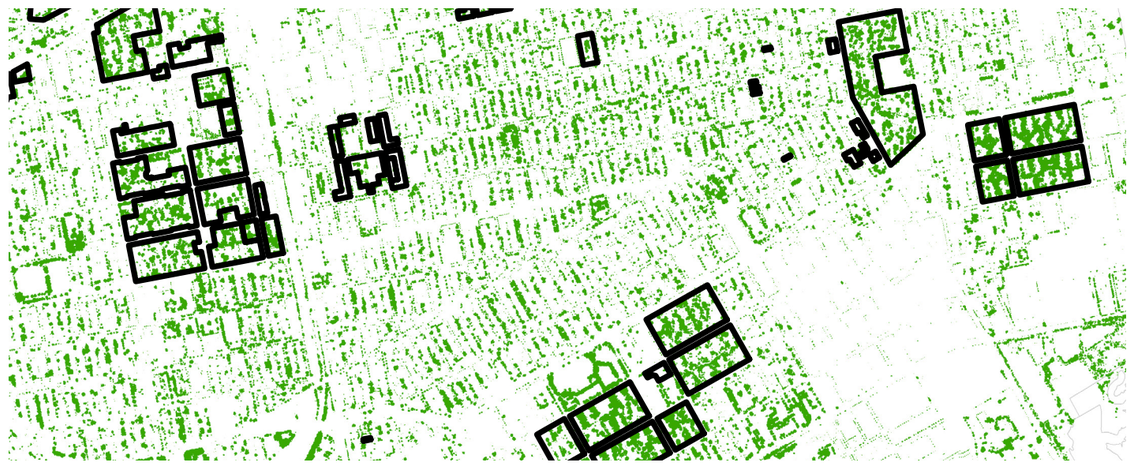


Figure 5. Brownsville trees/NYCHA developments | Data: NYC DoITT, https://maps.nyc.gov/lidar/2017/

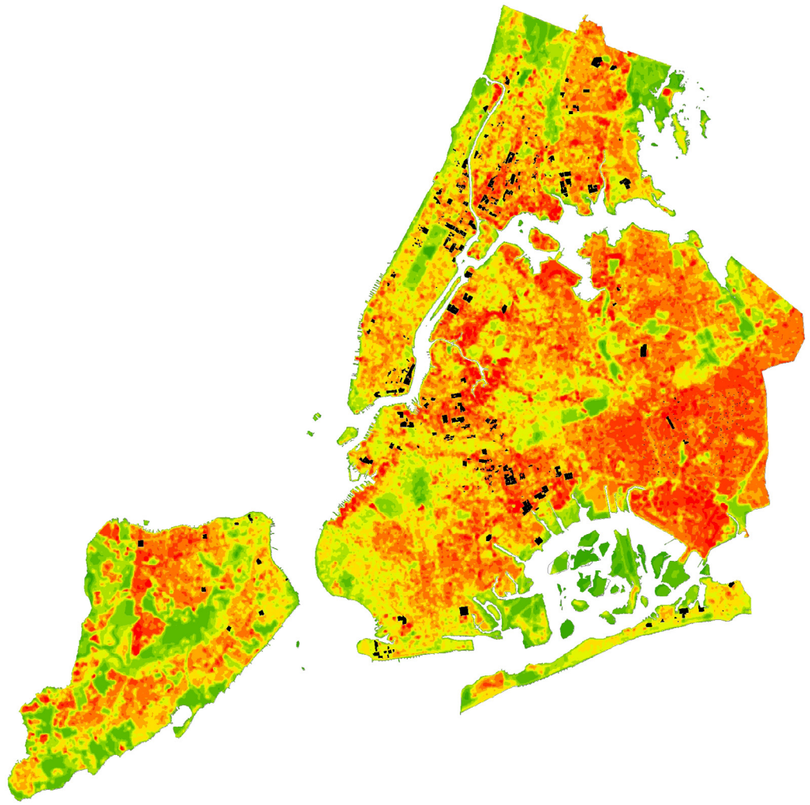


Figure 6. NYCHA developments are clustered in some of the city's neighborhoods that experience the highest temperatures during hot weather. Data: USGS surface temperature during a July 2018 heat wave.

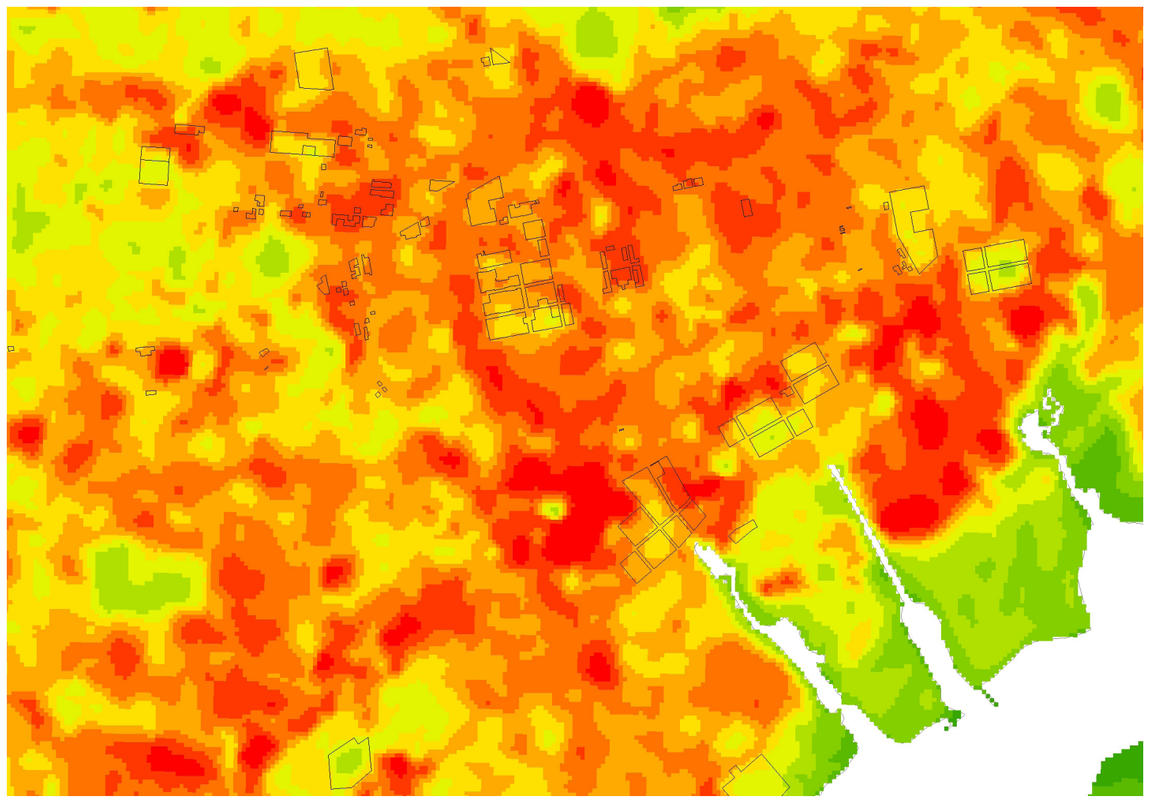


Figure 7. Within hot neighborhoods, NYCHA developments, especially larger developments, tend to show noticeably lower surface temperatures during hot weather. Data: USGS surface temperature during a July 2018 heat wave.

Lower tree canopy cover and a higher level of paved surface lead to higher temperatures during hot weather, so NYCHA developments' concentration in areas where there is lower tree canopy cover also means that they are in some of the city's hottest neighborhoods (Figure 6). Within those hotter neighborhoods, though, NYCHA developments with high levels of tree canopy cover stand out as cooler islands in maps showing surface temperature variations during a heat wave[2] (Figure 7).

Despite NYCHA's substantial tree resources, the authority has never completed a comprehensive tree inventory and has been unable to devote resources in recent years to comprehensive tree maintenance, protection, and enhancement. As NYCHA anticipates a hotter climate with increasing incidence of rain-driven flooding as well as coastal storms, the Authority recognizes the need to monitor and protect its trees and landscapes, which play a key role in mitigating extreme heat and flooding.

In 2019, NYCHA and the Mayor's Office of Resiliency worked together with a summer fellow from the Environmental Defense Fund to inventory trees on two campuses—Tilden Houses and Carver Houses--and to conduct health assessments on a portion of them, with advice and input from the USDA Forest Service Northern Research Station's NYC Urban Field Station. Results from that work underscored the richness of NYCHA's tree resources, revealing an average of 28.36 trees per acre, storing 6.8 tons of carbon per acre, sequestering an additional 0.21 tons per acre per year, and removing 17 pounds of air pollutants per acre per year. The 2019 analysis also revealed troubling trends: NYCHA trees exhibited signs of stress at a higher rate than street trees in New York City as a whole, and species diversity was low, with only a few species dominating the tree types present at the two campuses. A large portion of the trees present were older, indicating that NYCHA is over-reliant on legacy trees and may need to increase the planting of younger trees to ensure the longevity of its tree resources. The two campuses studied in 2019 diverged in their tree density and species diversity: the study team noted that Carver Houses, which had greater tree density, diversity, and health, showed signs of more resident involvement in landscape care, with more community gardens and signs of resident-planted and -maintained trees. The results pointed to the need for a comprehensive inventory and a better understanding of the relationship between tree health, tree maintenance, and resident engagement with landscape stewardship.

NYCHA Trees affected by Hurricane Sandy

An additional motivator for working toward a better understanding of NYCHA's tree resources and vulnerabilities is the substantial tree loss that NYCHA suffered as a result of Hurricane Sandy. The 2017 LiDAR data showed that Sandy-affected NYCHA developments had lost an average of 8% of their tree canopy cover since 2010, with 12 developments losing more than 25% of their tree canopy cover.

Some tree losses were immediate after the storm, whereas others continued for years after as trees that had been inundated with saltwater declined in the aftermath of the storm. Research on New York City trees after Hurricane Sandy showed that London Plane Trees, which predominate at many campuses, are particularly sensitive to saltwater inundation, showing much worse health outcomes a few years after the storm as compared to other species such as Red Maple[3]. At NYCHA developments lying partially within the Sandy inundation zone, such as those on Manhattan's Lower East Side, tree loss patterns over the 2010-2017 period clearly demonstrate the impact of floodwaters on NYCHA's trees (Figure 8).

The tree loss shown on the citywide LiDAR capture, moreover, does not include the further tree removals that were required at many storm-damaged developments for resiliency construction work, since many removals occurred after the LiDAR data was captured. NYCHA's resiliency work will prevent future storms from having the devastating effects that Sandy had on NYCHA's critical infrastructure and therefore on the health and safety of NYCHA residents; however, these upgrades involved substantial trenching and excavation that resulted in tree removals. The removals had a particularly large impact at Red Hook Houses, where a "Lily Pad" design is being built that will provide the site with continuous passive protection from flood events and drastically reduce flood risk and increase habitability of buildings under conditions of sea-level rise and heavy downpours in the future. To enable this work, approximately 450 trees were removed (Figure 9), and residents were understandably frustrated. The campus will be replanted, with some large-caliper trees (about 10" DBH) and many smaller trees, as well as shrubs and native grasses that are part of a resilient landscape design developed for the site.

Nevertheless, the impact of the loss of many mature trees is dramatic. A comprehensive tree inventory will help NYCHA identify where developments are vulnerable to future flood-related tree losses and continue to build resilience by integrating more flood-tolerant species to vulnerable sites.

For further discussion of how NYCHA's trees support resilience at NYCHA, see *Climate Change at NYCHA: A Plan to Adapt*; for further discussion of NYCHA's work recovering from Hurricane Sandy, see NYCHA's report *Flood Resilience at NYCHA: Memorializing Lessons Learned from the Hurricane Sandy Disaster Recovery Program.*

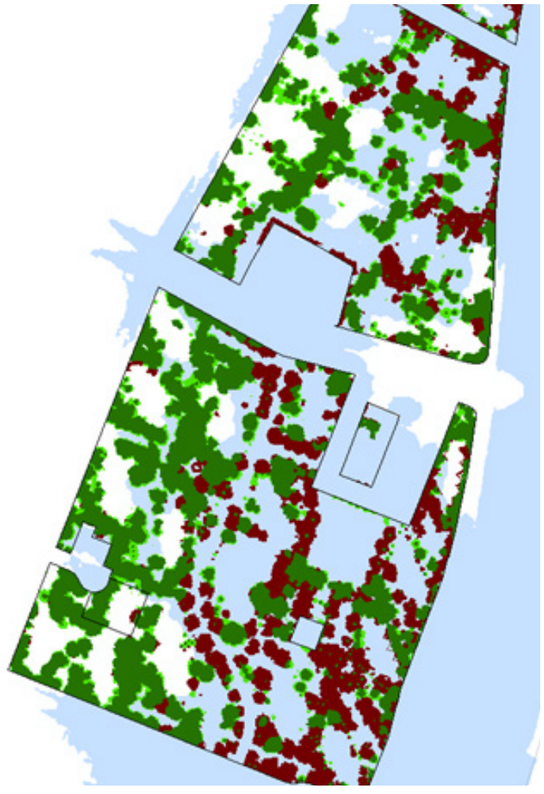


Figure 8. The Sandy inundation zone tracks closely with areas of heavy tree loss at NYCHA from 2010-2017.
Data: NYC DoITT and NYC SBS, https://maps.nyc.gov/lidar/2017/ and https://data.cityofnewyork.us/Environment/Sandy-Inundation-Zone/uyj8-7rv5

2020 Tree Assessment Goals

NYCHA's 2020 tree assessment sought to lay the foundation for data-driven landscape management at NYCHA, identifying potential paths for elevating landscape maintenance while maximizing the social benefits of the urban forest for NYCHA residents.

The assessment was designed as a collaboration with Green City Force (GCF), a non-profit organization that builds paths to green careers for NYCHA residents through an AmeriCorps job training program and an ongoing commitment to alumni skill-building and job placement. NYCHA supported GCF in hiring six alumni of the GCF green job training program to serve as the project's field crew, working with a GCF field supervisor. The USDA Forest Service and The Nature Conservancy supported the project by advising on study design and research methods, assisting in training the field staff in urban forestry and social science skills needed to complete each component of the 2020 assessment, as well as by providing ongoing technical assistance and analytical support. The collaboration with GCF served not only to provide the short-term staffing needed for this project, but it was also a way for GCF and NYCHA to explore the development of longer-term urban forestry programming. The collaboration was an opportunity for NYCHA and GCF to assess interest among GCF alumni in urban forestry career paths and identify potential new models for providing urban forestry job training and employment that would simultaneously elevate NYCHA landscape maintenance.

The tree assessment aimed to move toward a more comprehensive inventory of NYCHA trees while also improving NYCHA's understanding of the ecological and social impacts of NYCHA trees and their maintenance needs. On the biophysical side, the assessment sought to identify variation in tree density and diversity among the developments studied, to identify trends in the signs of tree insects and diseases noted among NYCHA's trees, and to explore the relationship between tree canopy cover and heat on hot summer days. On the social side, the assessment sought to document systematically how residents use and perceive NYCHA's landscapes. Finally, the maintenance assessment sought to understand how property management staff fit tree care into their work on a day-to-day basis within the limits of NYCHA's available staffing and resources. Taken together, the various components of the tree assessment inform a holistic understanding of NYCHA's trees and landscapes.

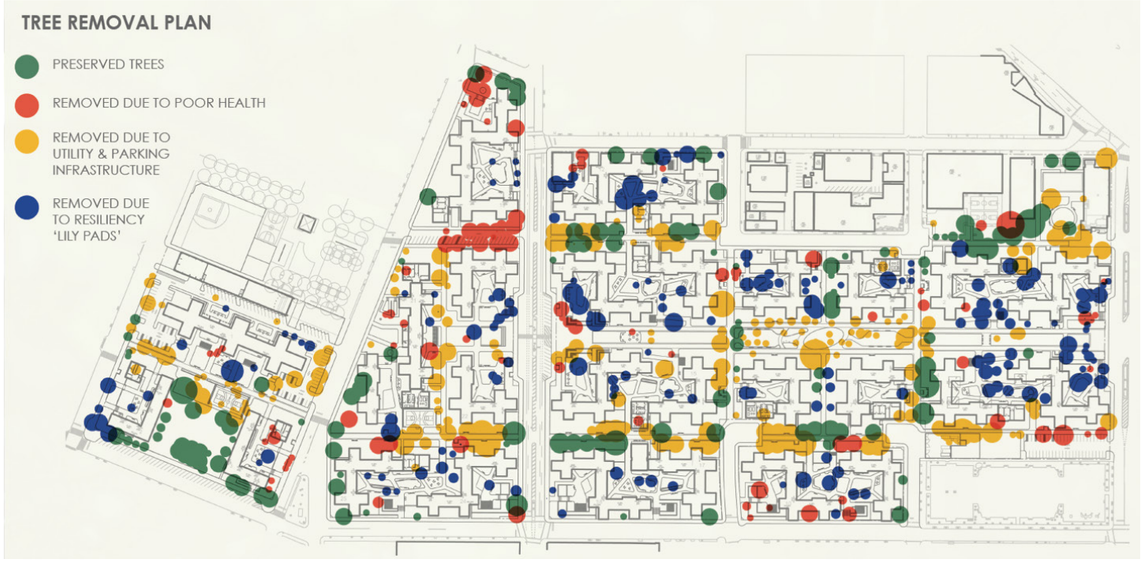


Figure 9. Tree removals at Red Hook enabled the construction of a continuous, passive flood protection system but required extensive tree removals.

02. Methodology

NYCHA conducted its 2020 inventory in three neighborhoods--East Harlem, the South Bronx, and Brownsville—where there are large clusters of NYCHA developments. In each of these neighborhoods, the largest development inventoried was the site of a Green City Force Eco-Hub. Eco-Hubs are the home of Green City Force's flagship Farms at NYCHA program, where GCF members build and manage gardens that provide fresh produce to NYCHA residents. These developments form a natural starting point for alumni of GCF's programs to begin tree inventory work. Because the 2020 inventory took place under restrictions related to COVID-19, NYCHA and GCF made an effort to hire field staff members that could access one of the neighborhoods with ease, preferably by foot, and divided the field staff into crews of two, each assigned primarily to one neighborhood that was convenient for them to reach.

Additional developments near each central Eco-Hub were inventoried, with crews reaching as many nearby campuses as possible during the six-week data collection period in the fall of 2020. Field crews completed inventories for a total of 18 campuses, ranging in size from less than one acre to over 26 acres, with varying layouts in terms of number of buildings and percent of the development covered by tree canopy (Table 1).

Field staff conducted a biophysical tree inventory, a social assessment, and a maintenance interview at every campus studied; NYCHA staff supplemented onsite maintenance interviews with additional interviews of stakeholders with knowledge of NYCHA's past and present landscape maintenance practices. NYCHA and GCF field staff also placed temperature sensors throughout the campuses studied to be able to relate tree inventory variables to temperatures on NYCHA's campuses on hot summer days.

The Nature Conservancy, the USDA Forest Service Northern Research Station's NYC Urban Field Station, and the New York City Parks Department assisted NYCHA with the development of inventory and assessment methods as well as the training of the GCF field staff. All field staff participated in a combination of virtual and in-person training that built skills in urban forestry, including tree species identification, measurement of tree size in terms of Diameter at Breast Height (DBH), and detection of the signs and symptoms of tree insects and diseases. For the social assessment and maintenance assessment components, field staff received training in qualitative social science data collection methods from Research Social Scientists at the USDA Forest Service. This included the systematic recording observations of green spaces, recording of interactions with residents, semi-structured interview techniques, and training in how to conduct team debriefs and write field notes.

	Development *Indicates site of a GCF Eco-Hub	Size (acres)	Year built	Number of Buildings	% Tree Canopy Cover	% Change in Tree Canopy Cover 2010-2017
East Harlem	Wagner*	26.91	1958	22	44%	14.64%
	Wilson	3.06	1961	3	39%	19.67%
	Lehman Village	4.07	1963	4	55%	8.53%
	Clinton	5.60	1965	6	40%	19.16%
	Johnson	11.88	1948	10	42%	0.94%
Brownsville	Howard*	15.26	1955	10	45%	19.80%
	Garvey Group A	3.28	1975	3	31%	15.68%
	Brown	2.28	1985	2	32%	32.10%
	Glenmore Plaza	4.27	1968	4	22%	8.70%
	Low Houses	5.89	1967	4	44%	5.70%
	Woodson	3.21	1970	2	51%	-12.90%
	Hughes Apartments	5.56	1968	3	35%	5.50%
	Van Dyke 2	0.83	1964	1	71%	-2.24%
South Bronx	Forest*	17.72	1956	15	47%	14.40%
	Davidson	1.9	1973	1	27%	29.60%
	Union Avenue-East 166th St	2.27	1988	6	19%	142.90%
	Union Avenue-East 163rd St	2.65	1962	1	31%	62.20%
	McKinley	6.66	1962	5	43%	9.80%

Table 1. Tree Inventory Developments 2020.

Biophysical Tree Inventory

Field crews conducted a comprehensive tree inventory for each campus studied, recording the location, DBH, and species of each tree within the Healthy Trees, Healthy Cities app developed by The Nature Conservancy and the USDA Forest Service on a mobile device. Field crews looked for signs and symptoms of tree insects and diseases using the Healthy Trees, Healthy Cities early tree insect detection module, and recorded additional notes about the condition of the tree as needed in the app (Appendix A).

Heat Sensor Placement

In late July 2020, NYCHA staff and partners from New York City's Department of Health and Mental Hygiene placed small temperature sensors on trees and on light posts throughout the campuses that NYCHA aimed to study as part of its tree inventory. The sensors remained in place throughout the summer, and GCF field staff assisted with their removal in the fall so that the temperatures could be analyzed.

Social Assessment

Field crews collected social data for an assessment that draws on the methodology developed by research ecologists at USDA Forest Service Northern Research Station's NYC Urban Field Station and the New York City Parks Department[4]. Social assessment methodology was tailored to this project, drawing on NYCHA's Connected Communities framework for evaluating how green spaces serve NYCHA residents. Field crews recorded one or more observational surveys for each campus studied (Appendix B), filling out information about what types of amenities were available in the open spaces and how residents were using the space. Larger campuses were divided into zones, with one observational survey completed per zone. Field crews also recorded the interactions with residents as they worked on the inventory, noting when residents approached them and the nature of their comments.

Maintenance Assessment

Field crews conducted a semi-structured interview with grounds staff at each development inventoried, usually the Superintendent of Grounds, documenting how NYCHA property management fits tree and landscape care into its work on a day-to-day basis (Appendix C). NYCHA staff supplemented the analysis of NYCHA maintenance practices with a series of interviews with stakeholders in NYCHA landscapes. This includes current NYCHA central office staff members as well as past NYCHA staff and staff of the NYC Parks Department and private companies who have worked with NYCHA on tree-related questions and projects.

03. Results

The 2020 tree assessment found that NYCHA trees are an essential ecological and social resource at NYCHA. It identified maintenance challenges as well as paths forward to address these challenges. Based on the results of this assessment, NYCHA has integrated four key urban forestry commitments into its forthcoming climate adaptation plan and is actively working to implement those commitments. Results are presented here in four categories: the tree inventory reporting on the biophysical inventory of trees and measurements of summer heat across campuses; social assessment results; maintenance assessment results; and an evaluation of the potential for building urban forestry career paths through NYCHA's tree-related work.

Tree Inventory

At the 18 developments included in the 2020 tree inventory, field crews identified, measured, and assessed 2,636 trees. The data collected through the HTHC application was imported onto the i-Tree Eco v6.0 software. By selecting the variables such as the species, DBH, location, and stratum (individual sites) the software generated a report based on the collected data. Analysis of the data shows that the trees at these 18 developments provide a variety of ecological benefits, including[5]:

- Sequestering 44 tons of carbon per year;
- Storing 1.801 thousand tons of carbon[6];
- Preventing 100,500 cubic feet of stormwater from running off into the sewer system each year; and
- Removing 2,157 pounds of pollution and producing 117.3 tons of oxygen each year.

Analysis of heat sensors placed throughout the developments inventoried showed that NYCHA's large concentrations of trees also provide temperature reductions on hot summer days.

The important ecological benefits that NYCHA's trees provide vary based on the density, diversity, and size of trees. In addition, the prevalence of signs and symptoms of tree insects may indicate where action is needed to keep NYCHA's urban forest in good health. Analysis of how tree characteristics vary across campuses begins to provide NYCHA with a more detailed understanding of its tree resources. This baseline information is crucial for guiding decisions about where and what to plant and how to target limited maintenance resources.

i) Tree Density, Diversity, and Size

NYCHA campuses vary widely in size and configuration, as do the number, diversity, and size of trees on campuses. The largest developments contain enormous tree resources, with hundreds of trees and dozens of different tree species (Table 3). But even the smallest development included in the inventory—Van Dyke II, at 0.8 acres—contained 50 trees and 7 species, showing that even smaller NYCHA developments contain significant tree resources for an urban environment. In fact, many of the smaller developments had greater concentrations of trees per acre than the largest developments. Wilson Houses, for example, at about 3 acres, contained 32 trees per acre, compared to 17 at Wagner Houses, a much larger development nearby.

Many of the benefits of trees correspond more directly to the total leaf area than to the number of trees, since leaves are the site of oxygen production, pollution removal, and shade provision. Leaf area density corresponded closely to tree density for these developments; a development with a high density of trees like Van Dyke II can grow a leaf area multiple times its own size—6 acres of leaf area in a development of less than an acre. In general, the NYCHA campuses in East Harlem had the highest average density of both trees and leaf area (Table 2).

Neighborhood	Average Tree Density	Average Leaf Area Density
East Harlem	26.28	110,795
Brownsville	23.46	101,050
South Bronx	21.64	59,059

Table 2. Average tree density and average leaf area density by neighborhood.

The prevalence of smaller trees at developments is a good indicator of active planting in more recent years and the availability of younger trees to provide shade when larger trees are eventually lost. Trees with a DBH of 6" or less were likely planted within the past decade. Across the 18 developments, the percentage of total trees less than 6 inches (15.2 cm) of DBH is 16.9%, demonstrating that across the board NYCHA relies on older trees for much of its shade. Some developments have very few smaller trees: Van Dyke II, Hughes Apartments, Low Houses, and Clinton are developments where less than 5% of the trees have a DBH below 6 inches (Table 3). This tells us that there have been fewer or no plantings at these developments in the recent past. Union Ave 163rd, Union Ave 166th, Forest, Davidson, and McKinley have the largest number of trees under 6 inches DBH and are all located in the South Bronx. Understanding which campuses have few smaller trees can be an important indicator when NYCHA considers planting new trees to ensure that all developments have some younger trees that are able to provide the next generation with shade as older trees are lost in the future. Planting young trees that are shade tolerant will allow them to grow into gaps in the canopy that are created when a large tree is lost.

Understanding species composition at NYCHA developments helps to show which species are most prevalent within NYCHA's current tree canopy and where NYCHA is heavily reliant on just one or two species. There are a total of 93 different tree species across the 18 inventoried campuses. By far the most common tree across developments is the London Plane; however, the extent to which it dominates varies from development to development (Table 5). At Low Houses, for example, 70% of trees are London Planes; at Howard, although London Planes are also the most prevalent species, they make up only 29% of the campus' total trees (Table 4). London Planes' dominance is even more evident in the percentage of leaf area they are responsible for: while they make up 34.1% of the trees on the 18 campuses inventoried, they are responsible for 54.9% of the leaf area (Table 5). This dominance demonstrates London Planes' success on NYCHA campuses and their utility at providing shade; however, it also indicates that some campuses may be over-reliant on a single species, and new plantings at these campuses should prioritize diversity.

Detailed information about tree species composition also helps NYCHA understand its balance between overstory and understory trees. While all trees can help to offset urban heat island effect and provide stormwater benefits, it is important to make the distinction between overstory trees (also known as shade trees) which can grow up to 30-60+ feet and smaller understory trees, which grow to only 15-30 feet, usually with lower branching, at full maturity. LiDAR analysis measures tree canopy cover but does not make a distinction between overstory and understory trees: the tree inventory provides more detail about the canopy's composition.

Large overstory trees typically provide more shade and sheltering benefits, which can complement seating or passive recreation areas and help create a sense of enclosure. On the other hand, understory trees relate more to the human scale and when selected for habitat value or visual interest (for example, flowering species) they can enhance a sense of place and invitation within NYCHA campuses, particularly when located near seating or play areas, at key intersections or near entrances. Today the dominant species throughout NYCHA are deciduous overstory trees, but residents frequently request smaller flowering trees to be planted during grounds improvements projects. Data on where understory trees are less prevalent helps NYCHA understand where the resident experience of the grounds could be enhanced by using more understory trees.

	Development	# of Trees	# of species	Tree Density (#/acre)	% of trees with DBH less than 6 inches	Leaf Area Density (ft2/ac)	Leaf Area (acres)	Leaf Biomass (tons)	Leaf Biomass (lb/ac)
East Harlem	Wagner*	474	33	17.6	11.4	97,643	60	17.2	1,277
	Wilson	98	15	32	22.5	107,561	8	1.6	1,044
	Lehman Village	136	17	33.4	20.6	139,553	13	2.9	1,402
	Clinton	139	11	24.8	4.3	105,921	14	3.9	1,386
	Johnson	280	27	23.6	13.3	103,297	28	8.1	1,369
Brownsville	Howard*	280	37	18.3	10.4	74,499	26	7.8	1,015
	Garvey Group A	78	9	23.8	9	71,446	5	1.7	1,047
	Brown	52	12	22.8	7.7	49,182	3	0.9	784
	Glenmore Plaza	87	23	20.4	14.9	55,823	5	1.7	780
	Low Houses	110	7	18.7	1.8	93,635	13	3.4	1,169
	Woodson	42	9	13.1	7.2	55,613	4	1.6	1,011
	Hughes Apartments	58	8	10.4	0	72,972	9	3.2	1,143
	Van Dyke 2	50	7	60.2	0	335,226	6	1.8	4,214
South Bronx	Forest*	462	48	26.1	30.5	90,093	37	9.7	1,090
	Davidson	33	13	17.4	30.3	63,322	3	0.8	814
	Union Avenue - East 166th St	50	14	22	36	28,522	1	0.4	390
	Union Avenue - East 163rd St	52	11	19.6	53.8	34,455	2	0.8	586
	McKinley	154	23	23.1	29.2	78,903	12	2.8	846

Table 3. Tree density, diversity, and biomass results by development.

	Development	Most Prevalent Species	#1 Species as Percent of All Trees	Second Most Prevalent Species	#2 Species as Percent of All Trees	Third Most Prevalent Species	#3 Species as Percent of All Trees
East Harlem	Wagner*	London Planetree	37%	Japanese Pagoda Tree	22%	Willow Oak	8%
	Wilson	London Planetree	59%	Japanese Flowering Cherry	8%	Northern White Cedar	5%
	Lehman Village	London Planetree	61%	Apple	9%	Plum/Cherry	7%
	Clinton	London Planetree	45%	Honey Locust	21%	Callery Pear	7%
	Johnson	London Planetree	35%	Pin Oak	13%	Honey Locust	11%
Brownsville	Howard*	London Planetree	29%	Honey Locust	18%	Norway Spruce	6%
	Garvey Group A	Honey Locust	27%	Callery Pear	23%	Black Locust	19%
	Brown	Little Leaf Linden	33%	Red Maple	31%	Kousa Dogwood	6%
	Glenmore Plaza	English Oak	15%	Hophornbeam	9%	Plum/Cherry	8%
	Low Houses	London Planetree	70%	Honey Locust	16%	Willow Oak	10%
	Woodson	Willow Oak	36%	Honey Locust	29%	White Mulberry	10%
	Hughes Apartments	London Planetree	36%	Willow Oak	26%	Honey Locust	19%
	Van Dyke 2	London Planetree	66%	Ginko	10%	Willow Oak	6%
South Bronx	Forest*	London Planetree	29%	Zelkova	7%	Little Leaf Linden	6%
	Davidson	American Elm	12%	Kentucky Coffeetree	9%	Silver Linden	6%
	Union Avenue - East 166th St	Dawn Redwood	36%	London Planetree	14%	Callery Pear	14%
	Union Avenue - East 163rd St	Holly	21%	Kentucky Coffeetree	21%	Northern Red Oak	17%
	McKinley	London Planetree	39%	Catalpa	8%	Flowering Dogwood	6%

Table 4. Top three species at each development.

Most of the benefits trees provide correspond directly to the amount of healthy leaf surface area. London planetree, Willow oak, and Honey Locust contribute the most to NYCHA's total leaf area (Table 5). They compose 46.4% of the total number of trees at the inventoried developments, but contribute 70.9% of the leaf area, dominating NYCHA's urban forest structure and again demonstrating that NYCHA is heavily reliant on a smaller number of large, older trees for its canopy, and that species diversity among these larger shade trees is limited. Development-specific information about tree species prevalence can help guide future decisions about planting, and increasing species diversity should be a priority for all future plantings based on these findings.

Species Name	Percent Population	Percent Leaf Area
London Planetree	34.1%	54.9%
Willow Oak	4.3%	10.2%
Honey Locust	8.0%	5.8%
Pagoda Tree	6.0%	4.6%
Pin Oak	2.7%	3.6%
Littleleaf Linden	3.1%	2.0%
Callery Pear	3.1%	1.5%
Japanese Zelkova	2.8%	1.3%
Northern Red Oak	2.2%	1.3%
American Elm	1.7%	1.5%

Table 5. Most prevalent species at 18 NYCHA developments by number of trees and leaf area.

ii) Tree Insects and Diseases

Signs and symptoms of tree insects and diseases can provide a clue about which developments' trees may need attention and which species may be in poor health[7]. Although these signs, which are not collected by certified arborists, do not represent a complete tree health assessment, collecting this information through the Healthy Trees, Healthy Cities app can be a simple and cost-effective way to detect which areas and/or species should be looked at more closely. The results presented here show which of these campuses may be experiencing more tree pest problems, and they demonstrate a methodology for using data to inform NYCHA's landscape management in a cost-effective way.

For the developments included in the 2020 inventory, a few campuses stood out as having more signs of tree insects and diseases than others. Brown, Garvey, and Howard—three developments in Brownsville—emerged as having the highest numbers of signs per tree (Figure 10). NYCHA may want to look more closely at tree health in these locations and determine if targeted tree care and maintenance are necessary there.

iii) Using Signs of Insects and Diseases for Targeted Tree Interventions

The USDA Forest Service New York City Urban Field Station helped NYCHA develop a methodology for using signs and symptoms of tree insects and diseases, collected by field staff without extensive knowledge of tree health, to target tree analysis and maintenance interventions. As an illustration of how this method could make use of scarce maintenance resources, data on Howard Houses is presented here along with the proposed methodology.

First, HTHC signs and symptoms data can be broken down by development to identify locations where potential problems are being noticed most frequently. Given that Howard is among the top three developments in this inventory in terms of average signs and symptoms per tree, it merits further exploration. Once a specific location has been identified, the next step is to look at which tree species are driving the higher numbers of signs and symptoms at the development (Table 6).

London Plane Trees are the most prevalent tree at Howard; while other species have higher average signs per tree, the elevated number of signs per tree on London Planes is an important driver of the overall high average for the campus because there are so many London Planes. Looking more closely at what signs were observed on London Planes, it is evident that the London Plane trees at Howard showed a higher prevalence of fissures, dead bark and exit holes than

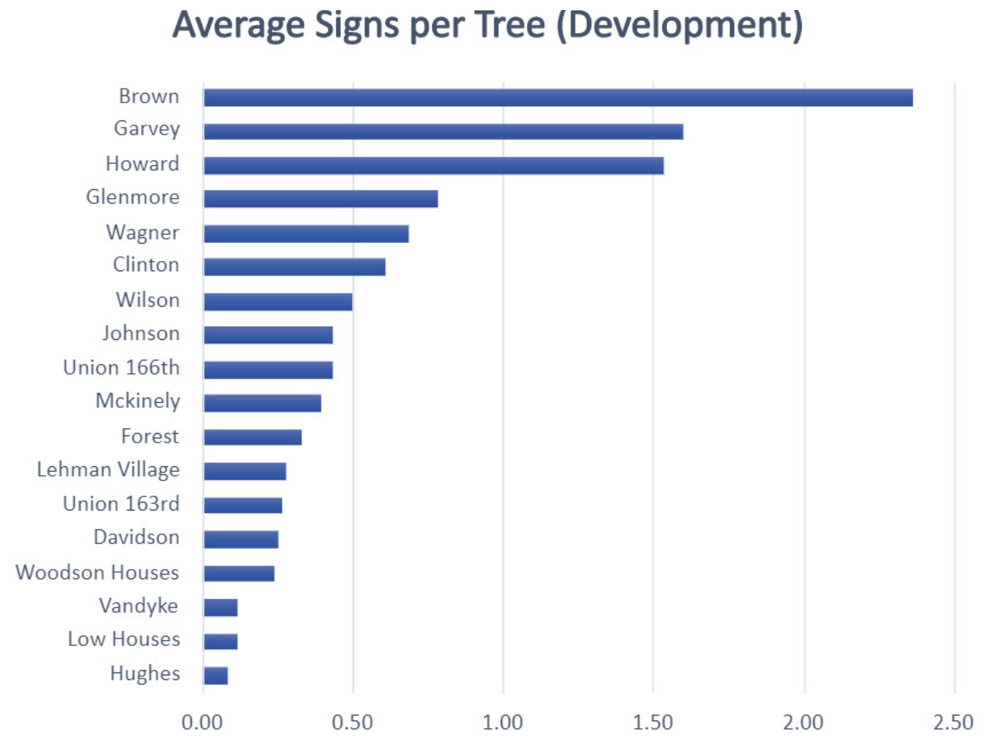


Figure 10. Average signs of tree insects and diseases per tree by development.

Species Name	Total Signs	Number of Trees	Average Signs Per Tree
London Planetree	126	80	1.58
Honey Locust	58	49	1.18
Norway Spruce	39	17	2.29
Hophornbeam	19	16	1.19
Japanese Pagoda Tree	19	13	1.46
Callery Pear	12	11	1.09
Northern White Cedar	8	9	0.89
Ash	11	9	1.22
Katsura Tree	12	9	1.33
Flowering Dogwood	22	8	2.75

Table 6. Signs per tree for top 10 tree species at Howard Houses.

London Planes at other developments[8] (Figure 12). The next step in this analysis would be to have a professional arborist go to the development and verify whether there is an insect or disease affecting London Planes at this development and recommend interventions that would improve the health of those trees. The arborist would start with more information about what is being observed across the development and be able to quickly go to the most heavily affected trees or areas with the georeferenced HTHC data in hand.

By Species

Another use for the tree insects and disease data from Healthy Trees, Healthy Cities is to be able to see which species across NYCHA's portfolio are exhibiting signs and symptoms of tree insects and diseases. Across the 18 developments, species such as River Birch and Hedge Maple show high numbers of signs of insects and disease. Looking more closely at some of the trees of these species that are showing these signs will help NYCHA determine if these species should receive special attention, or whether NYCHA should consider ceasing plantings of these species in the future.

The species with the highest average number of signs of insects and diseases are not necessarily the most common trees. Of the top ten most common trees at NYCHA, Callery Pear shows the highest number of signs of insects and diseases (Figure 11). They tend to have fissures and exudation; Little-Leaf Linden trees were more likely to have epicormic sprouts and dead bark. With a professional arborist able to review specific signs are prevalent in the species at various developments, a few key management recommendations could likely be provided to property management staff that are tailored to the specific conditions at the development, without extensive site-based analysis.

The Spotted Lanternfly is an invasive insect that has the potential to cause detrimental effects to NYCHA's urban forests. There are advantages of having devoted crews look at trees for early action reporting. The Department of Agriculture and Markets has been helping NYCHA work on responding to this threat.

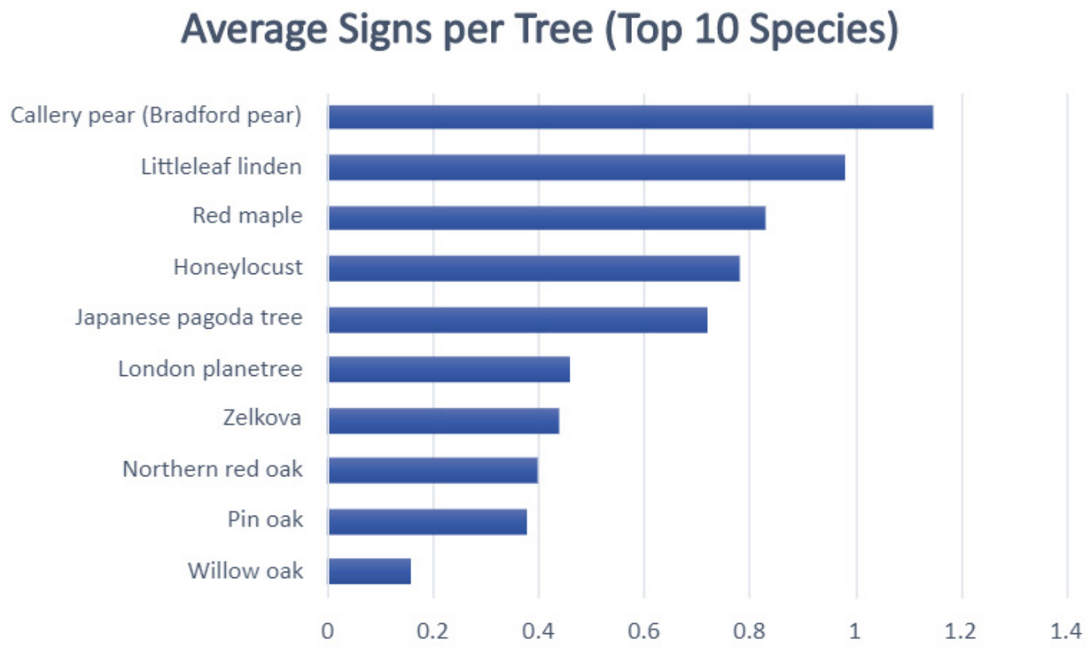


Figure 11. Average signs per tree by species with the largest signs of insects and diseases recorded.

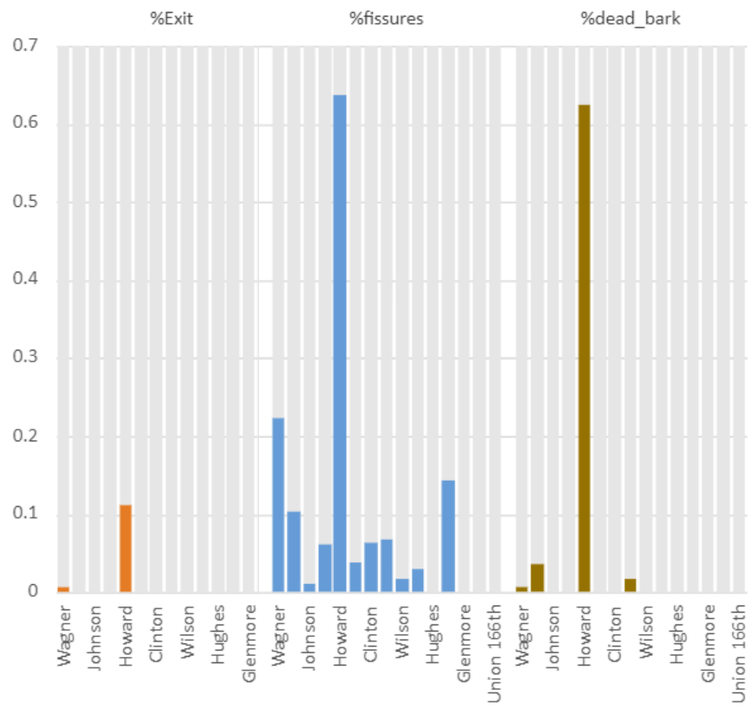


Figure 12. Type of signs observed on London Plane trees across developments

Heat Sensor Analysis

NYCHA's tree canopy provides respite from the summer heat. As heat waves become more frequent and more intense, NYCHA's residents will be increasingly vulnerable to adverse health effects, particularly elderly residents and those with underlying health conditions. Ongoing research on strategies to mitigate extreme heat demonstrates that large clusters of trees are more effective at mitigating summer heat than single trees scattered throughout a neighborhood; NYCHA campuses, with their large concentrations of trees, are therefore a crucial heat mitigation resource, especially in neighborhoods with lower tree canopy cover outside of NYCHA campuses.

New York City's Department of Health and Mental Hygiene (DOHMH) has conducted ongoing monitoring of temperatures in New York City; in 2019, DOHMH and NYCHA installed heat sensors at the two NYCHA developments that were part of the tree inventory that year, as well as in locations just outside of the developments. **Temperatures inside the NYCHA developments were about 2 degrees F lower than the temperatures just outside,** suggesting that the heavily shaded NYCHA campuses are creating a substantial cooling effect.

Building on this work, NYCHA installed approximately 180 heat sensors throughout the eighteen campuses inventoried and an additional 10 campuses in Brownsville, East Harlem, and the South Bronx. Analysis of sensor data (performed with support from Hummingbird Firm) showed that temperatures in parts of NYCHA campuses with dense tree canopy cover were substantially cooler on hot summer days (Figure 16); at the development scale, however, the average temperature of the broader neighborhood seemed to have more influence than the percent tree canopy of the individual development (Figure 17). The results emphasize the importance of trees in reducing peak temperatures, but also demonstrate that mitigation of the Urban Heat Island effect must happen on a larger scale than the individual property, as neighborhood effects are larger than property-level tree canopy measures.

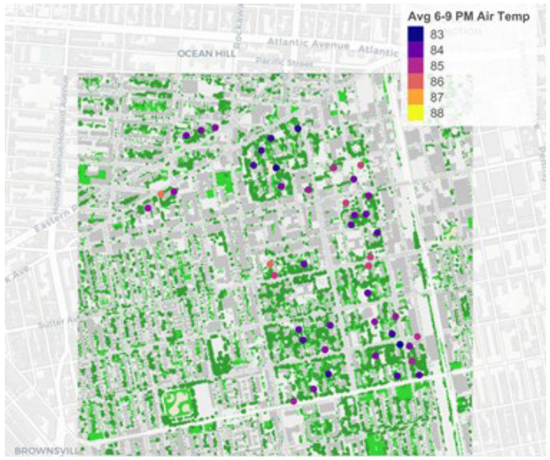


Figure 13. Brownsville heat sensors average air temperature

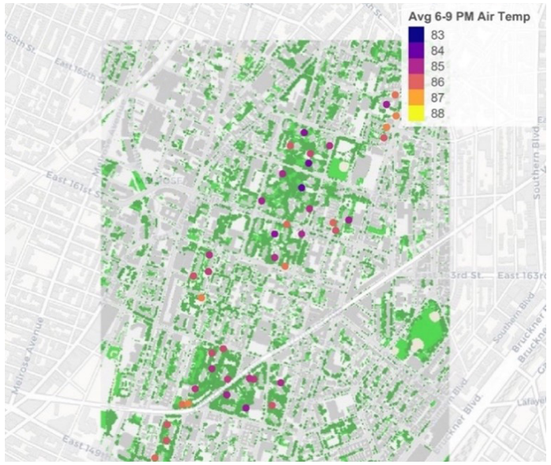


Figure 14. South Bronx heat sensors average air temperature

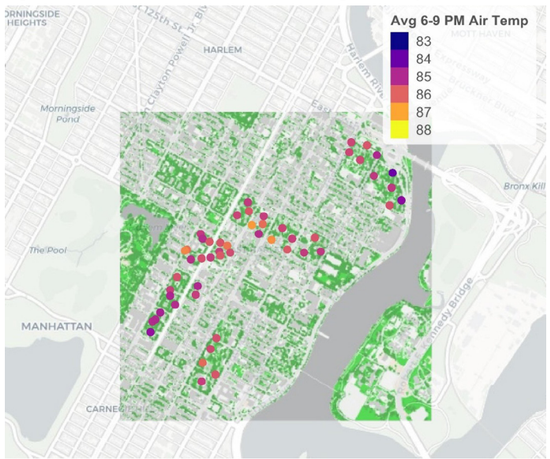


Figure 15. East Harlem heat sensors average air temperature

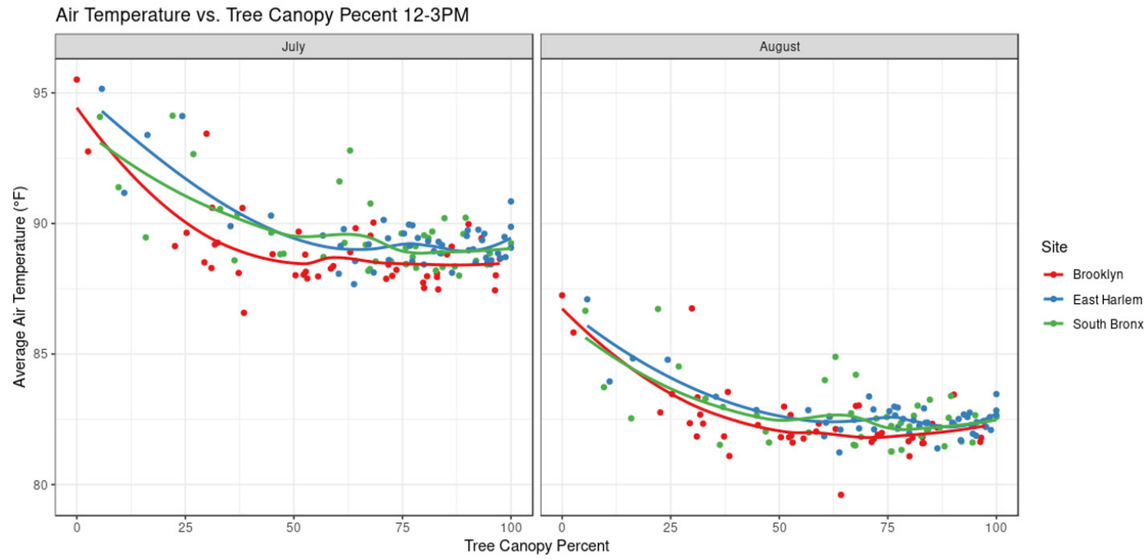


Figure.16 . On hot days, temperature drops precipitously in areas with high levels of tree canopy cover.

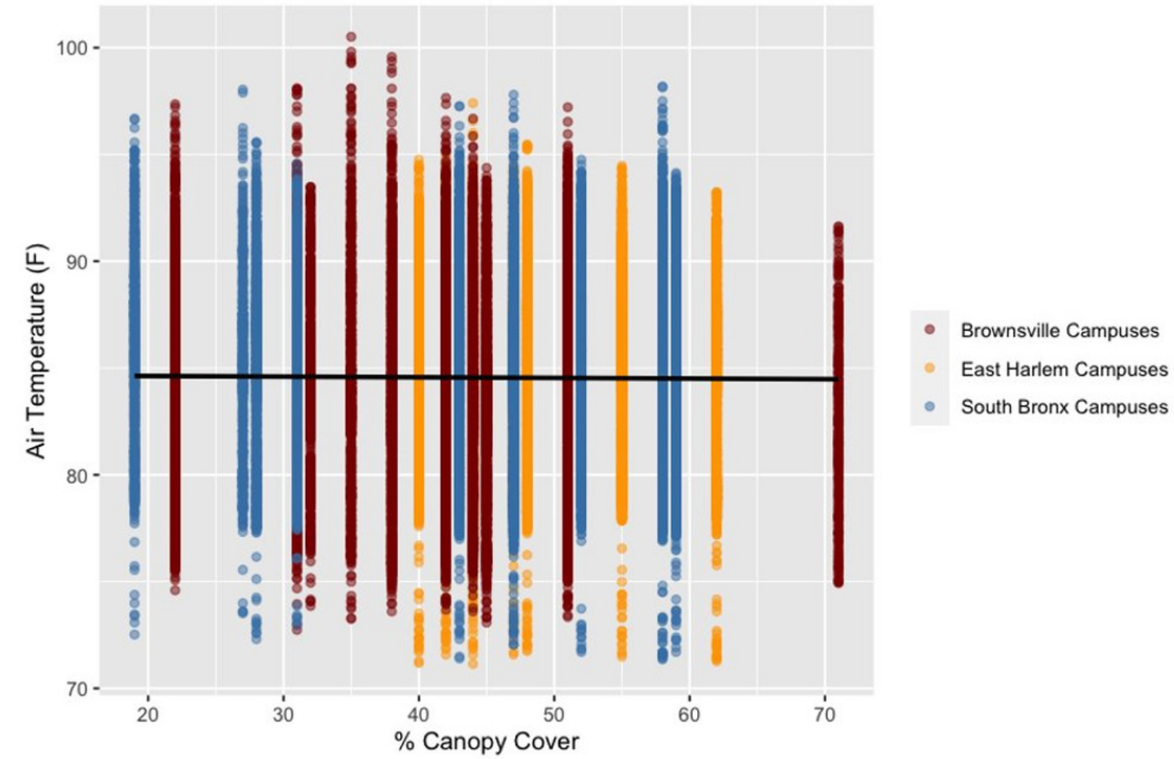


Figure 17. Percent of canopy cover is unrelated to air temperatures at the development scale.

Temperatures varied by neighborhood more than by individual development within the neighborhood. Throughout the three neighborhoods, Brownsville has a lower average air temperature than East Harlem and the South Bronx (Figure 18).

NYCHA developments fall into several distinct categories in terms of urban design: developments with tall buildings set among open green spaces, for example, can be grouped together as “high-rise in the park” type developments. Heat sensor results were analyzed by urban design typology to provide information on whether there are specific campus layouts that may be more vulnerable to high heat than others. With “high-rise in the park” developments as the reference category, each urban design typology’s average temperature was compared. Campuses categorized as “low-rise in the park” were significantly cooler by .97 degrees F on average. “Context towers,” tall buildings that are aligned with New York City’s street grid rather than being set back within open spaces, were nearly significantly warmer than “high-rise in the park” developments (.35 degrees F on average) (Figure 19). Understanding the heat-related implications of different developments’ urban design helps NYCHA design teams prioritize sites for urban heat island mitigation efforts.

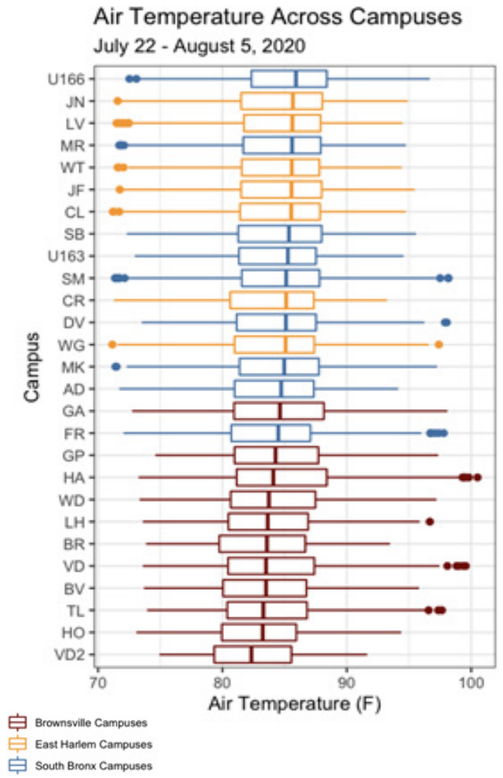


Figure 18. Average air temperatures across the campuses by neighborhood

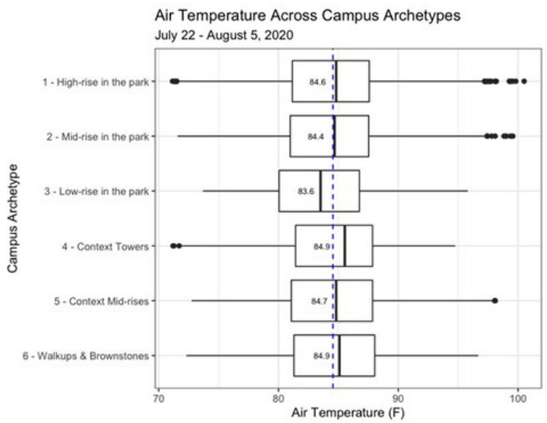


Figure 19. Air temperatures across campus archetypes between July 22nd to August 5, 2020. The blue line indicates the mean air temperatures across all campuses

Social Assessment

The social assessment component of this study found that green spaces are primarily used for socializing and relaxation and identified benefits that resident’s value in trees as well as concerns about how trees may have a negative impact on residents when they are not well-maintained.

i) Green Spaces are Primarily used for Socializing and Relaxation

GCF field staff recorded a total of 50 observational surveys throughout the 6-week tree inventory period, making notes about the activities of 292 people actively using NYCHA’s green spaces. These observations provide important information about what these spaces are used for on a day-to-day basis (Appendix B). By far, the most frequent use observed (42.2%) was informal socializing—talking and spending time with family, friends, and neighbors. Sitting and relaxing was a close second at 26% of observations (Table 7).

Outdoor Activity	Number of Observations	Percent of Observations
Socializing with Family Members/Neighbors	122	42.2%
Sitting/Relaxing	75	26.0%
Playing	35	12.1%
Planting/Gardening	24	8.3%
Dog Walking	16	5.5%
Events/Activities	13	4.5%
Sports/Exercise	4	1.4%
TOTAL	**289**	**100%**

Table 7. The number and percent of outdoor activities recorded.

NYCHA’s Connected Communities initiative has found that the vast majority of outdoor recreational facilities at NYCHA are designed for children engaged in active play, and that more spaces for passive recreation and relaxation are needed[9]. Social scientists have found that both socializing and relaxation are connected to important cultural ecosystem services[10]. The Open Space Master Plan recommends the integration of far more facilities designed for adults and a greater focus on spaces designed for socializing and passive recreation. This study’s observations support the need for that shift in the types of activities outdoor amenities are designed for.

ii) Qualitative Rankings of Green Space

Field staff ranked green spaces on several qualitative measures as part of the observational surveys. When completing observational surveys for each zone of a campus, they answered “Are the open spaces welcoming?” with “No, Mostly No, Somewhat, Mostly Yes, Yes.” Field staff answered whether spaces were accessible to residents using the same scale and gave the visual environment of each zone a ranking with options for answers of “Ugly, Unattractive, Attractive, Beautiful.” Of more interest from these questions than the responses themselves was whether there were relationships between these rankings and the biophysical measures of tree density, diversity, and presence of signs of tree insects and diseases. Qualitative rankings were combined into an average index by development from 1 to 5 for the questions about whether spaces were welcoming and accessible, and to a scale of 1-4 for the overall visual environment ranking. Univariate regressions showed no significant relationship between a campus’ overall index of whether spaces were welcoming and tree density, leaf area density, or average signs of insects. However, campus’ average ranking of overall visual environment was negatively correlated with signs of insects and diseases (Figure 20). With only 18 campuses

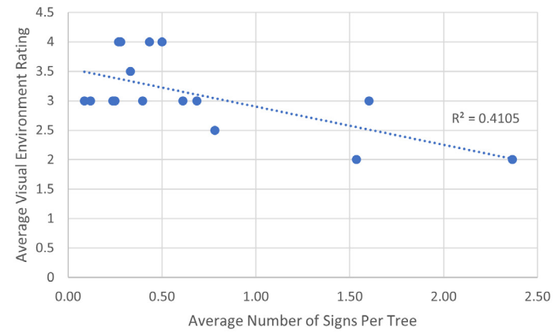


Figure 20. Field staff found higher levels of signs of insects and diseases at campuses that they ranked lower in terms of having a pleasing visual environment (p=0.007, R-square=0.41).

and highly subjective ranking criteria for the visual environment, this relationship is not conclusive, but the strong relationship between field staff impressions of campuses' beauty and the signs they found of insects and disease does provide support for the idea that improved care for trees provides quality of life benefits to NYCHA residents.

iii) Many Residents Value Trees, But Concerns About Negative Impacts Are Common Too

Field crews' notes about resident encounters provided a wealth of information about the kinds of benefits residents enjoy related to NYCHA's trees and the concerns they have about them. Resident comments to field crews fell into several distinct categories, listed in order of frequency with the number of times the type of interaction was documented in parentheses:

1. **Interest in or support for GCF work (14)**
   The most common resident interaction documented by field staff simply revolved around residents' interest in why they were there, what the goals of the project were, and in some cases exactly how crews were going about their work. These interactions were generally of a positive nature, with residents expressing appreciation for GCF field crews. One resident visited the field crew at two different campuses out of continuing interest in how the project was going; another mentioned that this seemed like a job she'd like to see her child get interested in. Other residents shared their interest in trees or horticulture and mentioned work they had done in the field in the past.

2. **Concern about level of maintenance of landscapes (10)**
   Residents expressed concern about trees not receiving adequate maintenance, such as having dead limbs that had not been removed or trash building up in tree branches or around trees. One resident took the time to point out fissures in trees to the field crews, while others pointed to potential safety concerns. One resident said that "When nobody checks on the trees, no one will know what's going on about them."

3. **Concern about negative impacts of trees (8).**
   Some interactions were related to specific negative impacts that trees can have, depending on their location and type. Multiple residents mentioned that trees planted close to the buildings have branches that brush up against their windows, blocking views and/or creating irritating noise within apartments. One resident expressed concern that trees block lines of sight, creating opportunity for crime. Another mentioned that a particular tree produces fruit that attracts insects and animals, leading to a lot of noise near windows and insects getting into apartments.

4. **Pointing out the benefits of trees (3).**
   Some resident encounters were simply about people expressing their love for trees—one resident mentioned that we will need more trees as the climate changes, and another talked about a specific tree with a "spooky Halloween look" that she liked.

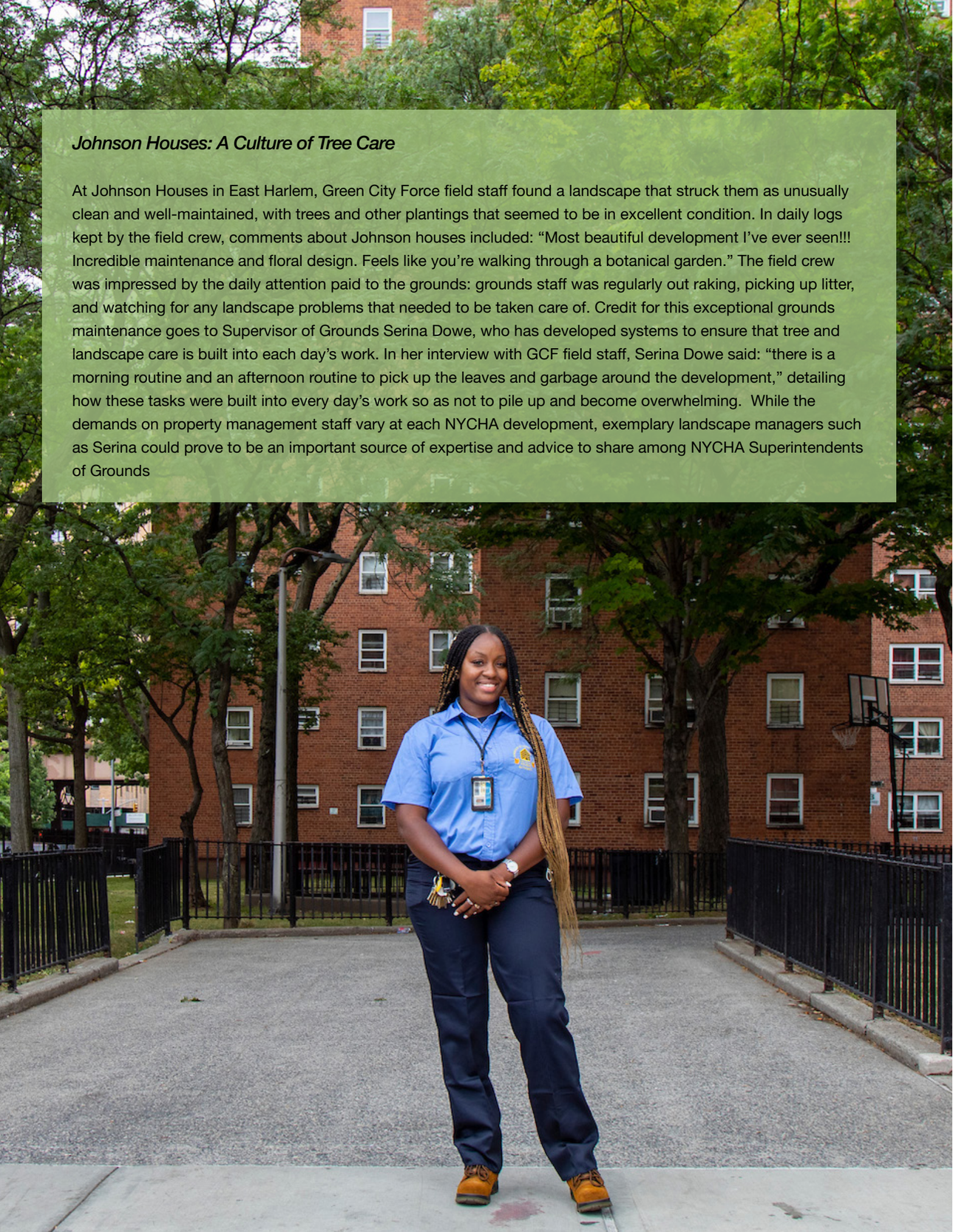
5. **Providing context about the history of trees at NYCHA (3).**
   A few residents spoke with field staff members primarily to bring up their experience with trees at NYCHA. One resident noted that people don't climb trees as much as they used to; another talked about how when one particular tree was smaller, residents would come together and decorate it as a Christmas tree, becoming very nostalgic about that time. Another resident mentioned that the reason some trees had been cut down was to enhance visibility on the campus and ensure that cameras could capture views to assist law enforcement

6. **Concern about GCF presence (3).**
   A reaction that some residents had to GCF presence was an assumption that GCF crews were there to cut down trees, or simply wanted to know exactly what field crews were doing, reflecting a concern that capital work was taking place that residents had not been informed of.

7. **Concern that work on trees distracts from more important priorities for NYCHA (2).**
   Finally, a couple of residents commented that work on trees should not be NYCHA's priority, advocating for staff to focus on the inside of the buildings instead of "wasting time with trees."

Resident reactions to the field crew provide a snapshot of how trees affect the experience of living at NYCHA. The high level of interest in what field crews were doing, questions about how to get involved, and commentary about past experiences with specific trees indicate that the trees and landscapes at NYCHA provide an important source of connection that has the potential to be built upon or enhanced through additional work, volunteer, and engagement programs.

The results of the social assessment make clear that many residents would appreciate tree stewardship programming aimed at engaging residents in tree care at their developments. Such programming would provide an opportunity for community-building, connection with nature, and environmental education that reaches beyond those involved in more intensive urban forestry training, while at the same time enhancing NYCHA trees' health. Trees New York, a non-profit organization, regularly trains New York City residents to prune New York City street trees through its Citizen Pruner program. NYCHA is exploring creating a similar program aimed specifically at NYCHA trees and designed for NYCHA residents.



Johnson Houses: A Culture of Tree Care

At Johnson Houses in East Harlem, Green City Force field staff found a landscape that struck them as unusually clean and well-maintained, with trees and other plantings that seemed to be in excellent condition. In daily logs kept by the field crew, comments about Johnson houses included: “Most beautiful development I’ve ever seen!!! Incredible maintenance and floral design. Feels like you’re walking through a botanical garden.” The field crew was impressed by the daily attention paid to the grounds: grounds staff was regularly out raking, picking up litter, and watching for any landscape problems that needed to be taken care of. Credit for this exceptional grounds maintenance goes to Supervisor of Grounds Serina Dowe, who has developed systems to ensure that tree and landscape care is built into each day’s work. In her interview with GCF field staff, Serina Dowe said: “there is a morning routine and an afternoon routine to pick up the leaves and garbage around the development,” detailing how these tasks were built into every day’s work so as not to pile up and become overwhelming. While the demands on property management staff vary at each NYCHA development, exemplary landscape managers such as Serina could prove to be an important source of expertise and advice to share among NYCHA Superintendents of Grounds

Maintenance Assessment

This assessment sought to understand how NYCHA trees are typically maintained on a day-to-day basis at developments and the challenges involved in tree maintenance at NYCHA. Interviews with Superintendents of Grounds at the NYCHA developments that were part of the assessment, as well as interviews with current and former NYCHA staff who have been involved with tree care, provided a picture of how maintenance protocols vary across developments and the challenges that many developments have in common in caring for trees (Appendix C). Data collection staff found examples of developments where tree care was a priority for the Supervisor of Grounds (SOG) (e.g., Call-out box: Johnson Houses) alongside developments where the development was understaffed or did not have protocols for grounds maintenance that were as well-developed.

NYCHA once had a much stronger horticultural focus than it does today. During the 1980s and 1990s, NYCHA had a landscape unit that included a forester, an arborist, and 22 landscape architects. During this time, NYCHA had a robust maintenance program that included an extensive plant list, a pruning policy, an integrated pest management policy, and a planting policy. Funding cuts in the early 2000s eliminated the landscape unit, and NYCHA now relies on 4 landscape architects within the Capital Projects Division, up from 2 landscape architects that were relied on for many years. Certain staff within the Grounds unit in Operations are now informally relied on by many developments for input into tree care, but there is currently no central operational staff person responsible for developing a tree maintenance plan and overseeing ongoing tree care. Tree care at NYCHA is instead the responsibility of each development and is assigned to the Superintendent of Grounds (SOG). The SOG and supporting development staff are responsible for tree care that can be done at ground level and using personnel with minimal tree care training, but for larger jobs and work on high branches, outside contractors are used. Tree care, however, is just one of an SOG’s many responsibilities. With many pressing concerns to attend to at NYCHA developments, proactive tree care is not often a priority.

Comments from SOGs, central staff, and urban forestry professionals who have worked with NYCHA as former staff members, consultants, and partners converged around several central recommendations that would allow NYCHA to elevate tree care in the future.

i) NYCHA Staff Devoted to Tree Care Are Needed

While some SOGs take on the task of developing the expertise and protocols needed to maintain trees at their developments, others do not have the staff or resources to achieve this. Just one development’s SOG reported having enough time to care for trees on a daily basis. A frequently mentioned feature of the landscape unit that existed prior to the early 2000s was that the unit worked across capital projects and day-to-day operations, creating a continuous connection between design and maintenance that does not exist to the same extent today. Urban forestry professionals interviewed strongly recommended that NYCHA once again employ a full-time arborist to oversee the care of NYCHA’s vast tree resources.

iii) A Maintenance Plan Should Guide Tree Care

Interviewees—both NYCHA development staff and outside forestry experts--expressed a variety of concerns about how NYCHA trees are maintained, with a central theme being that a proactive plan to keep NYCHA’s green spaces healthy is needed. NYCHA development staff who were interviewed were particularly concerned with timely removal of dead trees and branches, and forestry professionals who work or have worked with NYCHA frequently pointed out the need to adequately protect mature trees and plant new trees to ensure that the benefits of NYCHA’s urban forest continue to serve future generations of New Yorkers. The recommendation to create a comprehensive tree maintenance plan goes hand in hand with the recommendation to ensure that NYCHA has staff whose primary responsibility is to oversee the execution of the plan in partnership with development staff. Interviewees recommended several specific items that should be part of a comprehensive maintenance program, including:

- A comprehensive tree inventory is the basis of a good maintenance plan. Many stakeholders emphasized the importance of continuing to work toward a complete tree inventory in order to create an effective maintenance plan.

- Timely removal of dead trees and branches. Former members of NYCHA's landscape unit pointed out that grounds contracts once contained an emergency clause that required a response from the vendor within 48 hours for a hazardous branch or tree, and that it would be useful to reinstate this requirement.

- A goal to diversify NYCHA's tree species. The dominance of London Planes across NYCHA's campuses is clear to any observer of NYCHA's outdoor spaces. Forestry professionals pointed out that when a single species dominates an area, the trees are more vulnerable, and diversifying the species NYCHA relies on is important.

- Tree insects and disease monitoring and management using an Integrated Pest Management (IPM) framework: NYCHA's former landscape unit used an IPM methodology that minimized the use of pesticides but targeted specific species when a particular tree insect or disease was becoming a problem. Invasive insects can destroy specific species or populations of trees in a short period of time. One example of this is the Asian Longhorn Beetle, which was a major threat to NYC trees over the past 25 years but was recently eradicated through careful monitoring and response citywide. A newer insect that is just starting to establish itself is the Spotted Lanternfly; new insect species will continue to arise and addressing them would be part of a comprehensive tree maintenance plan.

iv) Tree Protection During Construction is Essential

NYCHA is working to upgrade housing quality across its portfolio and improve living conditions for residents. These improvements are sorely needed, but one thing that positively affects the quality of life for our residents is trees. Forestry professionals have pointed out that now is the time to shore up NYCHA's policies regarding tree protection and preservation during construction. NYCHA already includes tree protection in all of its construction contracts: staging areas are not allowed to be located in the drip line of any trees; and contractors are not allowed to cut roots over two inches in diameter. If the roots are larger than two inches in diameter, NYCHA has the contractor bridge over the roots. The best scenario is to not build in the drip line of the trees at all. Typically, however, the existing trees are planted very close to these existing paved areas and, unfortunately, contractors are sometimes forced to work within the drip line of the trees because of site constraints.

Forestry professionals pointed out that tree damage takes 3-4 years to appear after construction impacts have occurred; while NYCHA requires a one-year guarantee for the quality of workmanship and materials, tree damage would not be evident during this time frame, meaning that there is no mechanism for enforcing tree loss after the 1-year guarantee period. Forestry professionals recommended that NYCHA invest in expert guidance for tree preservation during the design and construction phase of any capital project, as it is more difficult to make changes for the purpose of tree preservation later in the construction process. They also recommended that for major projects, an outside party monitor the quality of tree protection efforts and identify any trees that may have been affected by construction at the close of a project so that their health can be monitored. In future years, any impacts can be tied back to construction impacts and contractors who do not adequately protect trees can be held responsible.

v) Tree Preservation is more Valuable than Tree Planting

Planting new trees is important, but preserving large, mature trees provides more ecological value than planting new trees. While tree loss is sometimes unavoidable, urban forestry professionals universally recommended that alternatives to removal be pursued whenever possible.

Evaluating the Potential for Urban Forestry Career Pathways

The collaboration with GCF served not only to provide the short-term staffing needed for this project, but it was also a way for GCF and NYCHA to explore the development of longer-term urban forestry programming. While the project lasted a total of six weeks, NYCHA recognizes the importance to create full-time jobs from experiences such as these. The collaboration was an opportunity for NYCHA and GCF to assess interest among GCF alumni in urban forestry career paths and identify potential new models for providing urban forestry job training and employment that would simultaneously elevate NYCHA landscape maintenance.

GCF field staff trained to perform tree inventory work as part of this project expressed a great deal of interest in this line of work. Staff reported developing a new skill set, appreciation, and passion for urban forestry work, and provided reflections on their work at the end of the inventory period.

GCF staff members mentioned that their new knowledge of tree health was valuable in understanding general ecological benefits of trees as well as how trees mitigate climate threats. One GCF staff member mentioned in his reflection that “They are important because as I learned there are a lot of places that are vulnerable to high temperatures which can be dangerous for folks.” Another employee stated: “I learned how to identify trees by the leaves and bark alone. I learned that different species of insects can be harmful to trees while some don’t cause any harm at all. I know in the future I would be able to help others or take care of trees around my community and home.”

Discussing the environmental and social benefits of NYCHA’s trees and open spaces, A GCF staff member said that NYCHA’s urban forest “Allows people to come together and enjoy a breath of fresh air. To not just stare at buildings but the beauty of the different foliage throughout the year. Let kids socialize, have mini-adventures, and explore their habitat. Which could get people comfortable around bugs/insects/small creatures and potentially reverse any fear of the unknown.”

On the experience of completing the inventory and assessment work itself, a field crew member wrote: “My overall experience has been nothing less than exciting and educating. From identifying a tree, to checking for tree insects, to speaking with residents, to just simply doing an observational survey of the area, it has been an experience that I will continue to speak on to my peers and my child. Even if I do not decide to make forestry a part of my future career plan, I am still extremely honored to have done this work and have the skills I now have under my belt. Trees play a huge role in our everyday lives. In fact, without trees, we will not be able to live. It is important for our community to care for our trees as we care for our lives.”

Another staff member mentioned that the skills learned during the assessment would allow him to teach others about tree health: “During this project I learned a lot about tree identification and how I can tell if the tree is healthy or not. I learned many skills throughout the duration of the project, like tree identification, tree insect detection and reasoning behind tree placement in New York City. I would use all these skills in the future to help teach other people about the trees in New York City. Walking through the developments you have different types of experiences such as chatting with the elderly or telling a group of young people why you’re looking at trees and why it benefits them. The most important aspect for people to understand about this project is that all the trees throughout the development are there to benefit the residents and the environment.”

Staff members also provided input into how data collection could be made simpler to improve inventory data collection methods for the next time. Field staff members’ enthusiasm for the work and skill in learning data collection methods and implementing the assessment provided a basis for continuing to seek funding to partner with GCF to build both urban forest health at NYCHA and urban forestry career pathways for NYCHA residents.

04. Next Steps

Understanding the biological and social characteristics of NYCHA's landscapes and the benefits and challenges that go with them is essential to building the health of NYCHA's piece of the New York City Urban Forest. This assessment has furthered understanding and insights about trees at NYCHA and has provided the Authority with the foundation of a data-driven approach to tree management.

NYCHA is already working to implement some of the recommendations received as part of this assessment and is working steadily toward building a comprehensive tree inventory. As a result of this work, NYCHA has included four key commitments in its climate adaptation plan, which will facilitate the continued implementation of the recommendations collected as part of this assessment.

Complete a Comprehensive Inventory of NYCHA Trees

A primary recommendation of urban forestry professionals was to complete a tree inventory to use as the basis of an improved tree maintenance at NYCHA. Urban forestry professionals recommended that NYCHA undertake a complete tree inventory as a way to better understand key aspects of NYCHA's urban forest, including:

- Tree density and diversity: up-to-date information on tree density and diversity should be the basis for deciding where and what types of plantings are pursued at NYCHA developments;
- Tree health: tree health assessments and/or monitoring of the signs and symptoms of tree insect and disease should be integrated into the tree inventory to provide NYCHA with an indication of where targeted tree care and intervention is needed;
- Social benefits: the understanding the tree assessment provided of residents' concerns and how various spaces serve residents is essential to ensure that tree planting and maintenance protocols are developed in accordance with residents' needs. NYCHA and its partners concluded that including social components is beneficial for the continuation of a tree inventory.

Within five years, NYCHA aims to have a complete inventory of its approximately 1,000 acres of tree canopy. NYCHA's collaboration with GCF will continue in 2021 using staff members funded by the New York City Cleanup Corps. By the end of the 2021 growing season, NYCHA will have completed an inventory of at least 25% of its total acreage and will continue to work toward a complete inventory in subsequent years.

Create and Implement Authority-Wide Tree Maintenance Plan

Urban forestry experts agreed that NYCHA needs to develop a comprehensive tree maintenance plan. The maintenance plan should include strategies for implementing several key recommendations, including:

- Increasing tree species diversity, particularly with an eye to planting species resilient to flooding and heat;
- Planting new trees across NYCHA's developments, concentrating on developments with lower levels of tree canopy cover but ensuring that those with large, older trees also have young trees able to grow and replace these large trees when they are lost;
- Increasing the concentration of understory trees to enhance cooling and other ecological benefits and to respond to resident requests for smaller flowering trees;
- Using Integrated Pest Management Protocols (IPM) to protect the health of NYCHA trees; and
- Engaging residents in tree stewardship and education.

NYCHA is already working to respond to the systemic needs identified in this report. For example, NYCHA is pursuing training on tree maintenance, selection, and preservation for capital projects staff to enhance tree-related knowledge and oversight of tree protection during capital construction. Additionally, NYCHA is working to integrate a greater diversity of tree services into its grounds contracts. One example of a necessary service is sidewalk ramping and curving, so that development staff have alternatives to tree removal when tripping hazards exist. Additional items NYCHA will seek to integrate into its contracts are a maximum acceptable response time for vendors called to remove potentially hazardous branches, and a policy requiring vendors to assess the need for tree removal and provide alternatives to removal if possible.

Secure funding for arborist and community foresters devoted to NYCHA tree care

Stakeholders frequently recommended that staff be devoted specifically to tree care at NYCHA, helping to facilitate several specific needs that were brought up as part of this assessment, including:

- Providing development staff with expertise and advice when development staff are evaluating and managing tree-related problems;
- Providing up-to-date information related to maintenance and operational implications to those making planting decisions as part of capital investments;
- Ensuring the timely removal of dead trees and branches;
- Sharing best practices for tree care among NYCHA property management staff;
- Providing guidance for tree protection during construction; and
- Facilitating the development of the Authority's tree maintenance plan.

NYCHA will seek funding to hire a full-time arborist within one year, either as part of NYCHA's staff or through an agreement with another agency or partner organization. An arborist would provide a central resource for development staff as they evaluate and manage tree-related problems and would be able to contribute up-to-date information related to maintenance and operational concerns to those making planting decisions as part of capital investments.

A single arborist, however, is inadequate to oversee the execution of a maintenance plan for all NYCHA developments. To provide development staff with greater support for urban forestry needs, NYCHA will additionally advocate for community foresters assigned to work more closely with developments in each borough. Community foresters would develop a deeper understanding of the needs of a subset of NYCHA landscapes and develop targeted maintenance strategies for providing support to developments, including collaborating with GCF via the Trees at NYCHA program and leading resident tree

stewardship events and programs. If these positions become available, NYCHA will seek to fill community forester positions with NYCHA residents who have gained urban forestry expertise through GCF urban forestry efforts.

Build Partnerships around Urban Forestry

This assessment has highlighted the value of partnerships with organizations with expertise in tree care, green jobs training, and urban forest advocacy. Recommendations emerging from this report that partnerships will help address include:

- Increasing resident engagement in tree care;
- Ensuring that NYCHA is connected to the deep tree expertise that exists in New York City, both in the public sector and within non-profit organizations focused on tree and landscape stewardship;
- Advocating for additional resources to help NYCHA's tree canopy continue serving both NYCHA residents and the city as a whole.

NYCHA already has strong partnerships with several agencies and organizations. Green City Force is a valued partner because of its unique focus on creating green jobs opportunity for NYCHA residents. NYCHA will continue to expand its partnership with Green City Force, with the goal of creating urban forestry career pathways as additional options for participants in Green City Force programs. In parallel to the existing "Farms at NYCHA" program, NYCHA will seek to establish an ongoing "Trees at NYCHA" program that institutionalizes the urban forestry collaboration that NYCHA and GCF have begun together.

Additional partnerships that have been essential to building NYCHA's urban forestry work are those with the New York City Parks Department, The Nature Conservancy, the USDA Forest Service's Urban Field Station, and Trees New York. From 2020-2021, NYCHA participated in the Urban Forest Task Force, a group convened by The Nature Conservancy to develop an Urban Forest Agenda for New York City as a whole. Equity is central to the agenda and NYCHA will continue to participate in the Forest for All coalition that will work to implement the agenda. The USDA Forest Service and The Nature Conservancy have both provided essential technical and training support in completing this assessment and planning for a healthier NYCHA forest. And in 2020, NYCHA was able to re-establish a lapsed license agreement with Trees New York that allows Trees New York to plant trees on NYCHA property as funding becomes available.

05. Partners' Perspectives

Green City Force

Green City Force's (GCF) partnership with NYCHA to conduct a tree inventory project began in late 2020. As an extension to our land improvement work within NYCHA creating community gardens and urban farms, GCF was excited to grow and add urban forestry within our portfolio. GCF values connecting Alumni to opportunities within their communities. Multiple GCF Alumni have worked in their communities during this project, making direct impacts where they live. Having the opportunity to educate their neighbors has been a valuable experience for all parties involved. GCF hopes to continue to help make sustainable impacts towards climate change across many activities. As we embark on our second phase of a tree inventory partnership with NYCHA, our Alumni and community continue to benefit from the project. More importantly, Alumni are actively working towards creating a safe space for trees and further a safer space for the community - mitigating the heat island effect, strengthening relationships between residents and their surrounding environment, and ensuring that we have healthier ecosystems. We look forward to continuing to build this relationship and are hopeful for what's next!

USDA Forest Service Urban Field Station

The New York City Urban Field Station's mission is to improve quality of life in urban areas by conducting and supporting research about social-ecological systems and natural resource management. It began in 2006 as a partnership between the USDA Forest Service Northern Research Station and the NYC Department of Parks & Recreation and has since expanded to include numerous agencies, NGO's, and university collaborators. USDA Forest Service scientists have worked collaboratively with NYCHA residents, staff, and partners on a diverse array of applied social and ecological research and community projects over the history of the field station. This includes collaborating with the NYCHA Gardening and Greening program to feature their work in the Forest Service publication, Restorative Commons (see Bennaton 2009) as well as building on this partnership through the Landscapes of Resilience project at Beach 41st Street Houses in Rockaway to support resident gardening and stewardship following Hurricane Sandy in 2013-2015. Forest Service Civil Rights funding was used to support youth urban forestry training in partnership with Trees New York (2008) and a "green collar mentoring series" with the Horticultural Society of New York (2007). In 2019 we assisted a Mayor's Office of Resiliency Fellow in a pilot project focused on Tilden and Carver Houses to assess trees, their health and ecosystem services they provide. This led to our ongoing work with NYCHA on tree inventory and social assessment which leverages Forest Service expertise in tree health and community stewardship. We look forward to continued collaboration. To learn more visit: https://www.nrs.fs.fed.us/nyc/

The Nature Conservancy & the Forest for All NYC Coalition

The Nature Conservancy in New York launched Future Forest NYC to galvanize a clear, coordinated, committed, and broad-based voice for protecting, maintaining, and expanding the city's urban forest and ensuring that its benefits are shared equitably among all New Yorkers. As part of this effort, The Nature Conservancy, alongside many partners including NYCHA, launched the NYC Urban Forest Task Force starting in an effort to elevate, build on, and link the many initiatives, assets, and efforts related to the NYC urban forest. This coalition of nearly 50 diverse organizations and 70 participants collaboratively developed the NYC Urban Forest Agenda: Toward a Healthy, Resilient, Equitable, and Just New York City. The Agenda is a strategic, concrete, and broadly endorsed roadmap that provides detailed recommendations to meaningfully protect, maintain, expand, research, and promote the New York City urban forest to benefit all New Yorkers in a way that is just and equitable. The NYC Urban Forest Task Force has transitioned into the Forest for All NYC coalition to help carry out the Agenda along with many new supporters.

NYCHA occupies about 1.15% of all land in NYC and is home to about 2.23% of the total tree canopy in NYC. Given this, we estimate that NYCHA is one of the largest holders of canopy in NYC outside of the NYC Department of Parks and Recreation, making NYCHA a meaningful urban forestry leader in NYC whose actions not only impact the urban forest both locally and citywide, but also help lead and set precedent for others.

NYCHA's trees are meaningful not only for NYCHA residents who may access their myriad benefits from connecting with nature locally to cooling, but also for the broader communities in which they sit, where they may represent some of the limited vegetation in our most heat vulnerable communities. This valuable resource contributes to the health and wellbeing of the neighborhoods it serves, and The Nature Conservancy is interested in sustaining and expanding it to provide more benefits into the future and to galvanize action to advance the NYC Urban Forest Agenda.

All of NYCHA's recommendations directly advance the NYC Urban Forest Agenda and, if implemented, will ultimately result in a more sustainable and robust urban forest for all. We are eager to see a full inventory completed that will then inform a management plan. Professional staffing will be required to bring such a plan to life, and thus we support the hiring of an arborist. And collaboration is key to success, long-term stewardship, and sustainability and we encourage NYCHA to continue to invest in partnerships to preserve and advance its portion of the urban forest and to provide local employment and workforce development opportunities. NYCHA is to be commended for its laudable steps toward and commitment to these priorities.

Endnotes

1. NYCHA's Connected Communities Guidebook discusses NYCHA's urban design and how it changed through the history of public housing construction in detail. It can be found at https://www1.nyc.gov/assets/nycha/downloads/pdf/Connected-Communities-Guidebook.pdf

2. The New York City Department of Health and Mental Hygiene has created a "Heat Vulnerability Index," or HVI, that is highest for neighborhoods most vulnerable to heat-related health impacts. Many of the neighborhoods in which NYCHA developments are clustered are also high HVI neighborhoods.

3. Hallett, Richard; Johnson, Michelle L.; Sonti, Nancy F. 2018. Assessing the tree health impacts of salt water flooding in coastal cities: A case study in New York City. Landscape and Urban Planning. 177: 171-177. https://doi.org/10.1016/j.landurbplan.2018.05.004

4. Auyeung, D.S. Novem; Campbell, Lindsay K.; Svendsen, Erika S.; Sonti, Nancy F.; Johnson, Michelle L. 2016. Reading the landscape: citywide social assessment of New York City Parks and natural areas in 2013-2014. Social Assessment White Paper No.2. New York, NY: New York Department of Parks and Recreation. 9-15. https://www.fs.fed.us/nrs/pubs/jrnl/2016/nrs_2016_auyeung_001.pdf

5. i-Tree Eco. i-Tree Software Suite v6.0. (n.d.). Web. Accessed March. 2021. http://www.itreetools.org

6. Carbon sequestration refers to the amount of new carbon removed from the atmosphere each year; carbon storage refers to the total amount of carbon stored in the trees.

7. Note: this report refers only to tree insects and diseases, not pests within NYCHA buildings. Examples of tree insects and diseases that may affect landscape plants are the Spotted Lanternfly, Asian Longhorn Beetle, Emerald Ash Borer, and the Gypsy Moth.

8. London Planes have a characteristic "camouflage" look with older bark naturally sloughing off as trees mature. Field staff were familiar with this and knew to indicate that there was "dead bark" only when there were areas of open wound or injury to the bark. However, it would be important to note tree features that could easily be mistaken for signs of insects and diseases if using data collected by groups with less training.

9. NYCHA's Connected Communities Guidebook, https://www1.nyc.gov/assets/nycha/downloads/pdf/Connected-Communities-Guidebook.pdf

10. Campbell, Lindsay K.; Svendsen, Erika S.; Sonti, Nancy F.; Johnson, Michelle L. 2016. A social assessment of urban parkland: Analyzing park use and meaning to inform management and resilience planning. Environmental Science Policy. 62: 34-44. https://doi.org/10.1016/j.envsci.2016.01.014

Appendix A: Signs and Symptoms of Tree Insects and Diseases

The field crews inspected each tree for the presence of the following signs and symptoms:

Questions	Selection Options
Exit Holes	Tunnels through bark caused by insects exiting the tree.
Exudation	A substance that oozes from a damaged area of a tree. When damaged or diseased, the vascular tissues of a tree can ooze or seep out of holes in the bark.
Egg Sites or Eggs	Pest insects may leave visible egg masses or eggs sites on trees or nearby surfaces.
Appearance of Adult insect or Larvae	Insects have different stages of life. Species may be most visible at different stages of life.
Damaged Fruits/Tree Buds	Diseases that affect fruit can cause them to grow poorly, making them have low or no value to orchard growers.
Holes in Leaves	Holes in leaves can be caused by pests feeding on them. This feeding can be a significant stress on a tree when large amounts of leaf area are missing
Frass	The waste produced by insect larvae tunneling through the wood. It can be pushed out of the tree through exit holes and wounds. It will collect along the ground near the base of the tree, or in between tree branches.
Epicormic Sprouts	New green growth coming from the base of a tree or along the trunk, also called 'suckers'. When the tissues connecting the roots (where energy is stored) to the crown of the tree are damaged, the tree sends signals to other parts of the tree to start growing leaves.
Blonding	A type of damage caused by woodpeckers looking for insect larvae in wood. As woodpeckers search for larvae, they strip away outer layers of bark revealing the lighter colored inner bark hence the term 'blonding'.
S-Shaped Galleries	S-Shaped galleries are the winding tunnels chewed by insect larvae feeding in or underneath the bark of the tree. These tunnels damage the vascular tissues that move nutrients and water through the tree.
Cankers/Dead Bark	Areas of dead plant tissue, varying in size. They are open wounds or injuries to a tree which may change color or texture due to exposure to pathogens (e.g., bacteria, fungus). Many diseases spread by invasive insects cause cankers (e.g., thousand cankers disease).
Galls on Twigs or Leaves	Galls are caused by numerous species of insects or mites. These parasites force the plant to make these structures for the parasite's food or as a safe habitat.
Fine Twig Dieback	Fine twigs are the support structures for the leaves, buds, flowers, and fruit of a tree. Some pests and diseases damage and destroy the tissues that supply nutrients and water to the fine twigs in the outer parts of the crown.
Leaf discoloration	Damaged, dying, or stressed leaves will change color outside the normal seasonal color changes. This can be caused by disease, nutrient imbalance, or drought. Discolored leaves cannot photosynthesize, depriving the tree of energy.
Needle discoloration	Damaged, dying, or stressed needles will change color. This can be caused by disease, nutrient imbalance, or drought. Discolored needles cannot photosynthesize, depriving the tree of energy and starches (food).
Wilted or Brown Leaves	Damaged or dying leaves will wilt, turn yellow to brown, or both. Some diseases cause rapid death to the tree.
Premature Leaf Loss	Disease, stress, or pest damage can cause trees to lose their leaves during the growing season instead of during autumn. Disease or pests that damage vascular tissue can cause this as well as herbicide drift.

Appendix B: Observational Survey Questions

Once the field crews familiarized themselves with the development, they opened the ArcGIS Collectors App on their tablet and selected an observational survey feature in each section throughout the campus where they see multiple people using open/outdoor green spaces. The survey is intended to observe and capture data on how trees and outdoor spaces are used throughout the development.

Questions	Selection Options
1. Outdoor activities: What outdoor activities do you see people doing in this zone?	Sports/Exercise, Playing, Sitting/Relaxing, Events/Activities, Socializing with family members/neighbors, Planting/Gardening, Dog Walking, Biking/Skating, Working, Other
2. Are the open spaces welcoming? Are the open spaces in the zone welcoming?	No, Mostly No, Somewhat, Mostly Yes, Yes
3. Can young & old people use together? Is this a development that people young and old can use at the same time?	No, Mostly No, Somewhat, Mostly Yes, Yes
4. Greenery in the zone is: How much greenery is in the zone, like trees, flowers, plantings, and shrubbery?	Low, Medium, High
5. Is there access to green space? Can people access the green space in this zone?	No, Mostly No, Somewhat, Mostly Yes, Yes
6. Tree usage: Is anyone using the trees in this zone?	For shade, to lean against, Other
7. Safety concerns: Overall, would someone of any age feel safe in this zone?	No, Mostly No, Somewhat, Mostly Yes, Yes
8. Visual environment overall rating: Overall, how would you rate the visual environment?	Ugly, Unattractive, Attractive, Beautiful
9. Recreational use: Does this zone have areas to gather, spend time, rest, or have a conversation comfortably?	No, Mostly No, Somewhat, Mostly Yes, Yes
10. Count people using the space: Count or estimate the number of people you see using the space	
11. Possible changes to the zone: Is there anything you would change about this zone?	
12. Any other comments	

Appendix C: Development Staff Questionnaire

Once the field crews arrived at the development, the GCF team was met by the supervisor of grounds (SOG) at or nearby the development's maintenance office. Once GCF had introduced themselves and the project to the SOG, one person would ask the questions while the other recorded the interview and took the notes. The questionnaire was intended to capture development staff perspectives on current tree management practices, what limitations exist to caring for NYCHA's trees, and what benefits and/or challenges trees bring to NYCHA developments.

Questions
1. What is your title? e.g., Property Manager, Superintendent of Grounds, etc.)
2. In your opinion, what are the biggest benefits that trees at your development bring to residents?
3. Do trees bring any negative impacts to residents at this development? If so, what are they?
4. Do residents get involved with tree care at this development?
5. What are the benefits of trees at your development to the staff?
6. What are the challenges for staff related to trees at this development?
7. How does the staff at your development care for trees? Does staff have enough time to care for trees?
8. Is there anyone in NYCHA's central staff who helps get you support with tree care or make decisions about what needs to be done to care for trees? If so, who? If not, what could NYCHA's central staff do to make this connection possible?
9. How do you decide when to call in additional help from landscape/tree contractors? When you do call in contractors, what kind of work is it usually for?
10. Are you able to plant new trees when needed? If so, how do you decide when to do this?
11. How do you decide when a tree needs to be removed?
12. Is there anything else that we should know about trees at your development? If you remove a tree, do you try to replant a new tree?
13. Is there anyone else we should contact about tree care at this development?

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