

# Cool Neighborhoods NYC

A Comprehensive Approach to Keep  
Communities Safe in Extreme Heat



The City of New York  
Mayor Bill de Blasio

Anthony Shorris  
First Deputy Mayor

#ONENYC

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# Letter from the Mayor



Friends,

Climate change is a growing threat to humanity and our city. New Yorkers understand this. Rising temperatures continue to threaten the health of all New Yorkers, but particularly older adults, those without access to air conditioning, and those with a variety of health conditions. *Cool Neighborhoods NYC* is an innovative citywide effort to tackle extreme heat, which contributes to more deaths than all other natural disasters combined.

When it comes to climate change, it is crucial to have partners at all levels of government and New Yorkers were shocked when the President pulled out of the Paris Accord. But we are not discouraged. New York City will continue to do all it can to preserve a livable planet and a resilient city. Nothing that happens in Washington will change that.

In June, I signed an Executive Order committing New York City to the Paris Agreement and we will continue to follow *OneNYC*, our comprehensive roadmap to a resilient, sustainable and equitable New York. This report outlines an important part of this work.

Our research on New York's neighborhoods shows that heat-related health risks are greatest in certain communities, including those without adequate shade protection from trees and foliage and those with higher rates of poverty. With *Cool Neighborhoods NYC* we are addressing rising temperatures by planting trees, coating roofs with reflective paint, and working with residents to ensure they take proper steps to stay cool and check on each other.

This approach also complements our efforts to reduce greenhouse gas emissions 80 percent by 2050. Over the next several years, we will continue to do our part for our people and our planet and serve as a model to other cities around the world. Anything less would be unacceptable.

A handwritten signature in black ink that reads "Bill de Blasio". The signature is fluid and cursive, with "Bill" on the top line and "de Blasio" on the bottom line.

Mayor Bill de Blasio

# Introduction

More Americans die from heat waves every year than from all other extreme weather events combined.<sup>1</sup> Further, according to the National Oceanographic and Atmospheric Administration and the National Aeronautics and Space Administration's Goddard Institute for Space Studies, 2016 was the hottest year on record globally, making 2016 the third consecutive year of record-high global average surface temperatures. These higher average temperatures, growing urban areas—especially their increasing elderly populations—and projections of more intense, frequent, and longer heat waves make heat an urgent environmental and health challenge.<sup>2</sup> The New York City Panel on Climate Change (NPCC) projects up to a 5.7°F increase in New York City (NYC) average temperatures and a doubling of the number of days above 90°F by the 2050s.<sup>3</sup>

Periods of extreme heat have a profound effect on human health, including dehydration, heat exhaustion, heat-stroke, and mortality. In New York City, specifically, extreme heat is the number one cause of mortality from extreme weather.<sup>4</sup> Every year, NYC experiences an average of 450 heat-related emergency department visits, 150 heat-related hospital admissions, and 13 heat-stroke deaths. The City also averages about 115 excess deaths from natural causes exacerbated by extreme heat annually.<sup>5</sup> Heat and rising temperatures threaten NYC's livability -- a threat that will continue to increase in the absence of strategies to make our city more heat resilient as our climate changes.<sup>6</sup>

New York City, like other urban areas, is more vulnerable to heat than rural and suburban areas. Due to the relative amount of dark, impervious surfaces, limited vegetation, and dense human activity, cities can be up to 22°F hotter than rural and suburban areas as part of a phenomenon known as the Urban Heat Island Effect (UHIE). The UHI effect leads to higher summertime peak energy demand, air conditioning costs, air pollution, and greenhouse gas (GHG) emissions.<sup>7</sup> Aside from rising average temperatures and heat waves, the UHI effect also threatens NYC's livability and quality of life.

#### NYC Thermal Imagery

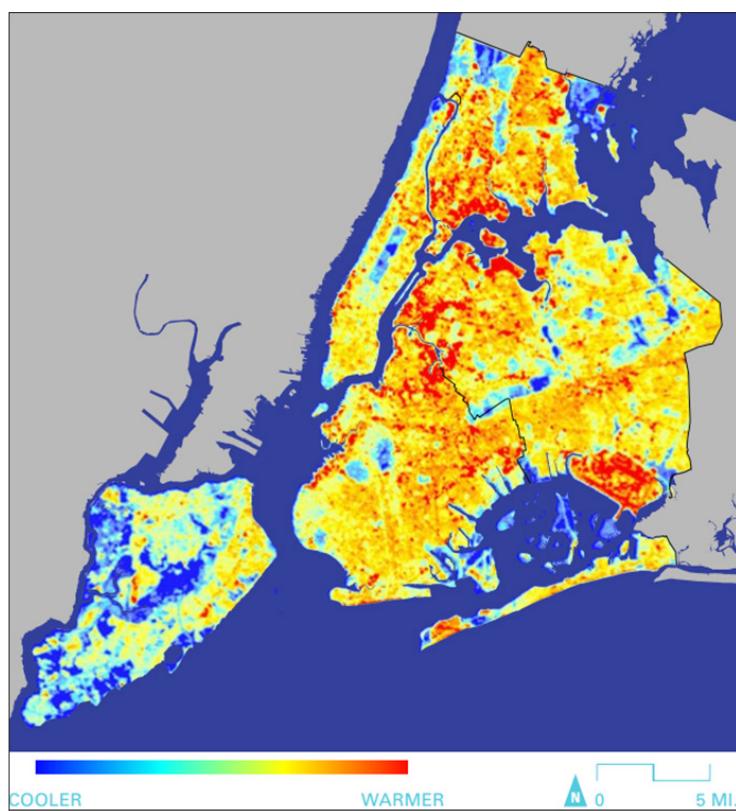


Figure 1: Some NYC communities experience higher temperatures than others. Variation in NYC's densely built environment results in disparate neighborhood-level risks. Source: LANDSAT Thermal Data, 2009.

Further, within NYC, some areas and communities may be more at risk than others. Variation in NYC's densely built environment—including the distribution of our sparse vegetation, building typologies, and surface materials—results in disparate neighborhood-level heat risks. These physical risks overlap with social and health risk factors, resulting in disproportionate effects borne by the most vulnerable residents of high-poverty neighborhoods: older adults, those in poor health, and those who do not have access to air conditioning. To help identify NYC's most heat-vulnerable neighborhoods, Columbia University and the NYC Department of Health and Mental Hygiene (DOHMH) developed a Heat Vulnerability Index (HVI) that combines metrics proven to be strong indicators of heat risk through validation with health data and that describes both social and physical characteristics.<sup>8</sup> (See Figure 3: DOHMH HVI map).

The development of the HVI informed the mayoral charge in the City's OneNYC plan to mitigate heat citywide, with a targeted response for the most at-

### U.S. Fatalities by Hazard, 2006-2015

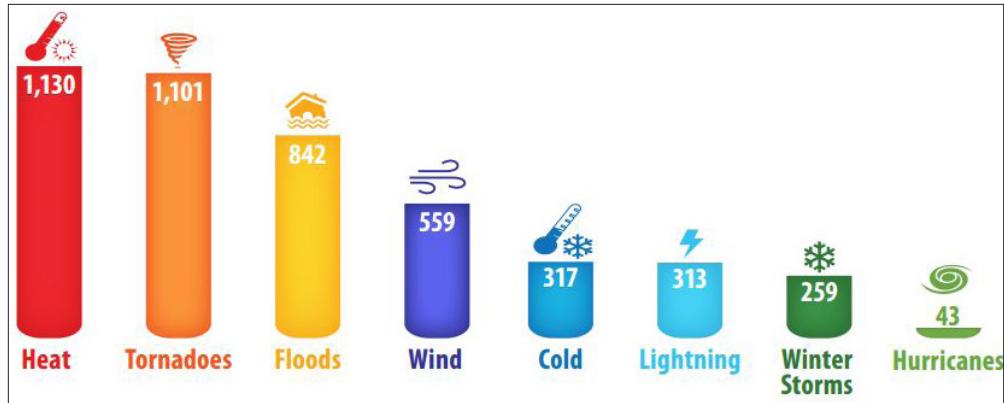


Figure 2: More Americans die from heat waves every year than from all other extreme weather events combined. Source: NOAA National Weather Service, 2016.

risk neighborhoods. As a result, the NYC Mayor's Office of Recovery and Resiliency (ORR) developed *Cool Neighborhoods NYC*: a new \$106 million program designed to help keep New Yorkers safe during hot weather, mitigate UHI effect drivers and protect against the worst impacts of rising temperatures from climate change. This comprehensive approach expands the Administration's aggressive climate resiliency agenda.

The first set of strategies outlined in this report highlights the role that the physical environment plays in driving local temperatures and describes the City's investments to increase shade, greenery, and canopy cover and increase high albedo surfaces in public and private sites to help lower surface and indoor temperatures in NYC neighborhoods with high vulnerability to heat-related illnesses and mortality. High temperatures also threaten New Yorkers inside their homes today and will continue to do so in the future due to climate change. For this reason the *Cool Neighborhoods NYC* comprehensive approach also includes adaptation strategies to keep New Yorkers safe during periods of extreme heat.

The second set of strategies outlined in this report underscores the critical role that our most trusted messengers can play in helping us adapt to climate change. The final strategy outlined in this report describes key efforts to better understand the scope of the challenge via data collection and monitoring.

The City is committed to delivering health-protective messages and encourage all New Yorkers—but especially older adults, the homebound, and those with chronic health conditions—to take action in caring for themselves and one another during extreme heat days.

### **Heat Vulnerability Index (HVI) for New York City Community Districts**

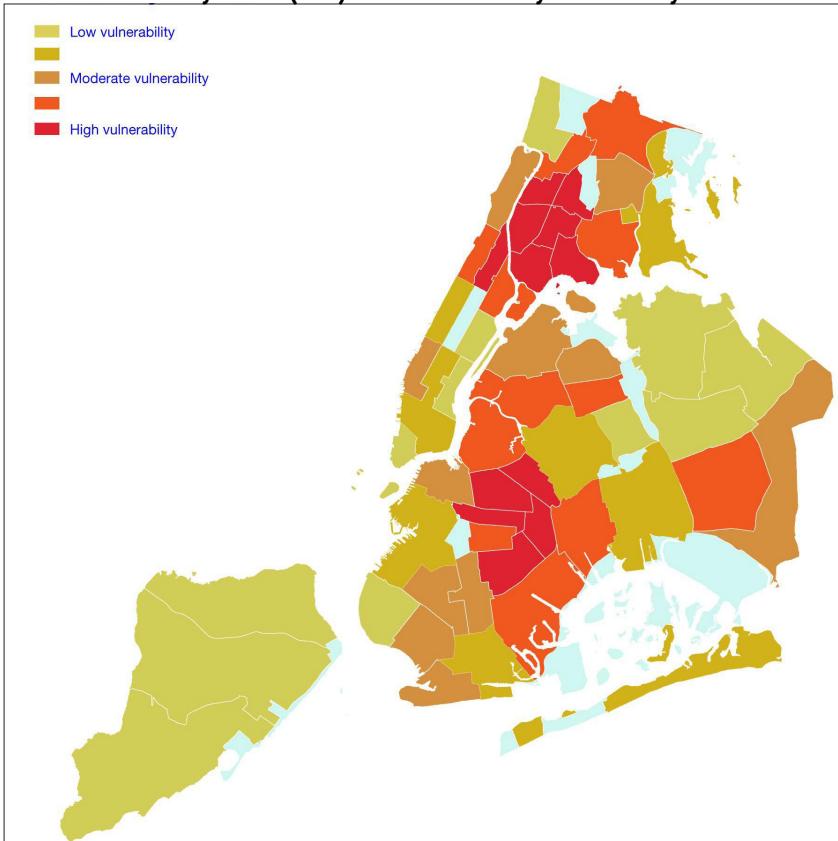


Figure 3: Source: DOHMH, 2015.

The HVI is adapted from a study by researchers at the NYC Department of Health and Mental Hygiene and Columbia University who analyzed mortality data from 2000 to 2011. The analysis identified factors that were associated with an increased risk of deaths during a heat wave. The map shows NYC Community Districts ranked from least to most vulnerable. Each Community District HVI is the average of all census tracts in the Community District.

Through climate change mitigation and adaptation strategies, the City will reduce its contributions to rising temperatures, combat the UHI effect, and protect its residents from extreme heat events. Each program initiative is fully funded or budget neutral and will launch in 2017, with implementation over the next three years through fiscal year 2021.

# Cool Neighborhoods NYC Heat Mitigation Strategies

# Conducting Targeted Street Tree Plantings for Cool Neighborhoods

Trees and forest vegetation cool directly through shading and indirectly through evapotranspiration: a process through which water is moved from a plant's roots to its leaves where it then evaporates through the small pores on the underside of a leaf. The liquid water turns to vapor, losing the water molecules' heat and cooling the plant and surrounding air.<sup>9</sup> Shaded surfaces may be 20°F to 45°F cooler than unshaded surfaces; evapotranspiration, either alone or in conjunction with shading, can reduce peak temperatures by 2°F to 9°F.<sup>10</sup> In addition to outdoor and indoor temperature reduction via shading and evaporative cooling; street trees and vegetation provide a number of social and environmental benefits. These include reduced energy use and related greenhouse gas emissions, improved air quality, increased biodiversity, enhanced stormwater management, as well as improved quality of life through aesthetics, improved mental wellbeing, and noise reduction.<sup>11,12,13</sup>

Improving NYC's resiliency to climate-mediated increases in urban heat will require significant and ongoing investments in green and natural infrastructure strategies. In 2007, the City launched its *Million TreesNYC* program, which planted its millionth new tree in 2015, two years ahead of schedule, and became a renowned greening model for cities across the world. To harness the cooling and ancillary benefits of urban vegetation, the City has committed an additional \$82 million dollars to fund street tree plantings that will prioritize areas that are disproportionately vulnerable to heat risks, as shown in the City's Heat Vulnerability Index: neighborhoods in the South Bronx, Northern Manhattan, and Central Brooklyn (see Figure 3). Tree plantings will also be targeted in other areas of the city with low levels of tree canopy cover and open space; limited shade; and building and landscape characteristics that contribute to heat stress. This targeted tree planting is possible based on the City's highly accurate street tree census completed in 2016 and also based on the work of our academic partners at The New School and the State University of New York (SUNY) at Buffalo.



Figure 4: In addition to temperature reduction via shading and evaporative cooling; street trees and vegetation provide many social and environmental benefits. Source: OneNYC.

**Targeted tree planting strategy and implementation conducted by:**

NYC Department of Parks and Recreation

NYC Mayor's Office of Recovery and Resiliency

NYC Department of Health and Mental Hygiene

Natural Areas Conservancy

Urban Systems Lab at The New School

The State University of New York at Buffalo



2008



2009



2016

Figure 5: Street trees provide shade, support biodiversity, and enhance the quality of life of New Yorkers. Corner of Post Ave. and Academy St. in Manhattan. Source: NYC DPR.

where the city's densest stands exist and are tireless factories of clean air production. Our tree planting efforts will begin in the fall of 2017 and take place through 2021.

This work would not be possible without the tireless efforts of the staff at the NYC Department of Parks and Recreation (DPR), who manage and maintain our natural resources. For this reason, additional staff has been funded to help the City and its partners implement this vision of a resilient and diverse tree canopy and natural habitats in New York City. This comprehensive and proactive approach is possible thanks to our partnership with the Natural Areas Conservancy (NAC)--a champion of New York City's more than 20,000 acres of forests and wetlands for the benefit and enjoyment of all.

Green space is not equitably distributed across the city and some of the most vulnerable populations may not have adequate access to cool or green spaces where they can escape high and extreme heat.<sup>14</sup> Linking vulnerable and high-risk populations to strategies for green infrastructure and other nature-based solutions is critical for increasing equity and addressing environmental justice in the city. Increasing the city's street tree canopy will reduce the UHIE, relieve heat stress in residential neighborhoods, help to improve air quality, and support the city's biodiversity by creating additional corridors of greenery that help connect between larger patches of vegetation, giving local species access to a greater amount of habitat.<sup>15</sup> Finally, moving forward, the City will continue to partner with local organizations and communities to support and foster tree stewardship initiatives and to engage and empower volunteers in our neighborhoods.

Planting trees will help us meet the City's commitments in *OneNYC* to "mitigate the impacts of the urban heat island effect" and green the city's streets, parks, and open spaces, while exemplifying how to incorporate a health-based and environmental justice framework into environmental and natural resource planning and strategy development.

# Strategically Implementing NYC °CoolRoofs

Impervious surfaces, such as asphalt roads and roofs, contribute to the UHI effect by absorbing and reradiating heat, especially at night.<sup>16</sup> Green roofs or vegetation-covered roof surfaces—benefit property owners in numerous ways. They can improve quality of life through noise reduction; increase property values; and beautify a property for owners and neighbors. While their up-front installation costs are high, green roofs reduce energy and maintenance costs by protecting rooftops and building equipment from excessive sun exposure during warmer seasons and increase heat retention during cooler seasons.

Given these benefits, the City sought to incentivize the implementation of green roofs as replacements for dark roofs in the city. In 2008, the City of New York and New York State passed legislation to provide a one-year tax abatement, or tax relief, of \$4.50 per square foot (up to \$100,000 or the building's tax liability, whichever is less). Amended in 2013, the tax abatement is now available through March 15, 2018.<sup>17</sup> In addition to action on green roofs, the City has also funded and implemented “cool roofs,” which are lighter in color and reflect heat. Cool roofs transfer less heat into buildings and in turn help reduce building energy consumption and waste-heat from air conditioning use.<sup>18</sup> Additionally, due to their high reflectivity, clusters of light-colored surfaces reduce ambient air temperatures, thereby mitigating the UHI effect.<sup>19</sup>

Based on this evidence, in 2009, the City launched *NYC °CoolRoofs*, a program that set a goal to coat one million square feet of rooftops each calendar year with white paint. The City of New York has since invested over \$4 million dollars in the *NYC CoolRoofs* program and has coated more than 6.7 million square feet of rooftop space to-date, contributing to lower cooling costs and reducing an estimated 2,680 metric tons of carbon dioxide equivalent (tCO<sub>2</sub>e) emissions in the city (See Figure 7).

The program supports the City’s goal to reduce carbon emissions 80% before 2050 (80x50), as outlined in Mayor de Blasio’s *One New York: The Plan for a Strong and Just City*. Through this program, the City also provides local job-seekers with ten weeks of

**\*Cool Roof targeted outreach, workforce training and implementation conducted by:**

NYC Department of Small Business Services

Sustainable South Bronx (a division of the HOPE Program).

NYC Mayor’s Office of Recovery and Resiliency

Fordham University



**Figure 6:** The *NYC Cool Roofs* program helps thousands of New Yorkers reduce their energy use and will help address the city’s urban heat island effect by coating millions of square feet of roof area. By 2025, this is expected to reduce citywide GHG emissions by 3,500 metric tons of carbon dioxide equivalent, generate \$1 million in annual energy cost savings, and train 500 New Yorkers who will be prepared for jobs promoting energy efficiency in buildings. Source: Dana Ullman for UNHP.

training and work experience installing the energy-saving reflective rooftops. The City hires 70 workforce participants per year and connects them to permanent employment opportunities upon completion of their training. This initiative is a partnership between the NYC Department of Small Business Services (SBS), the NYC Mayor's Office of Sustainability (MOS), the NYC Mayor's Office of Recovery and Resiliency, and Sustainable South Bronx, a division of the HOPE Program.<sup>20,21</sup>

Cool roof installations are provided at no-cost to non-profits, affordable and supportive housing organizations, select cooperatively-owned housing, and select organizations providing public, cultural, and/or community services. Technical assistance and low-cost installation options are also available for other privately owned buildings. By installing a cool roof, a building can lower air conditioning costs by 10% to 30%; achieve up to 30% reduction in internal building temperatures during the summer with negligible impact to heating costs in the winter; increase the longevity of roof and building cooling equipment; and improve the comfort of building residents and tenants.

While the program has had incredible success, we can better target roof coatings to the neighborhoods that need it the most. In response, the City, together with Columbia University, developed a two-year strategic plan to understand how this program could best contribute to urban heat island mitigation in neighborhoods with high heat vulnerability. Using the City's Heat Vulnerability Index (HVI), the study determined geographic areas of focus, assessed the potential to cluster the implementation of roofs, identified and prioritized potential program participants, developed outreach and communication strategies to secure the participation of target building owners, and developed tools to assist owners in understanding the benefits of the program for their own buildings. As a result, the study identified a priority list of 2.7 million square feet of potential private and public buildings to conduct strategic outreach to owners in the heat-vulnerable areas of the Bronx, Central Brooklyn, and Northern Manhattan (See Figure 8). The NYC °CoolRoofs Strategic Implementation Plan will launch in 2017 to improve the impact of this existing City program by concentrating \$2.6 million dollars' worth of new projects to mitigating the UHI effect in heat-vulnerable neighborhoods through fiscal year 2020.

However, we know we cannot achieve our goals without the help of partners from the private sector. To put this plan into action, in 2017 Fordham University will partner with the City on UHI effect mitigation by becoming a participant in the NYC °CoolRoofs program. Fordham is located in Bronx neighborhoods with high heat vulnerability and is also a participant in the *NYC Carbon Challenge*, pledging to voluntarily reduce their building-based emissions by 30% or more over the course of ten years. Together, we will coat 6 buildings, resulting in 81,000 square feet of new cool roofs in the Bronx. In addition, the plan focuses on strategic partnerships and enhanced outreach to a mix of buildings (publicly and privately owned, and those serving a non-profit, affordable housing or social service function) to improve public awareness and increase the program's visibility—key tactics as the City seeks to deliver inclusive climate action.

Pavement choices can have a significant impact on pedestrian thermal comfort in urban areas. Dark-colored asphalt pavements in streets, which can encompass up to 40% of the

### Existing NYC °CoolRoofs

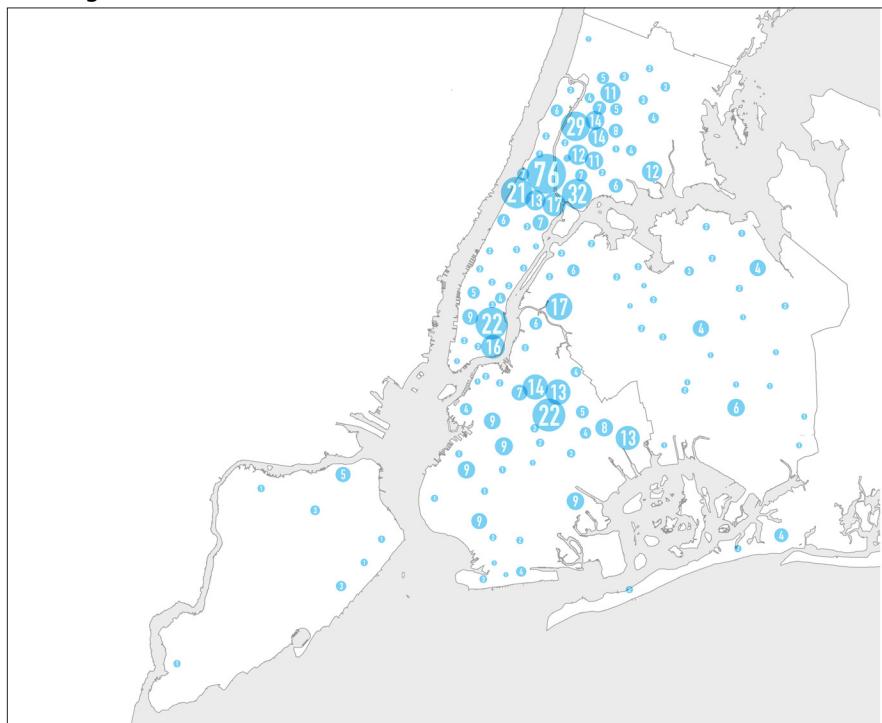


Figure 7: The City has coated more than 6.7 million sq. ft. of rooftop space to-date. Source: Columbia University Master of Science in Sustainability Management Capstone Project, 2016.

### Recommended NYC °CoolRoofs

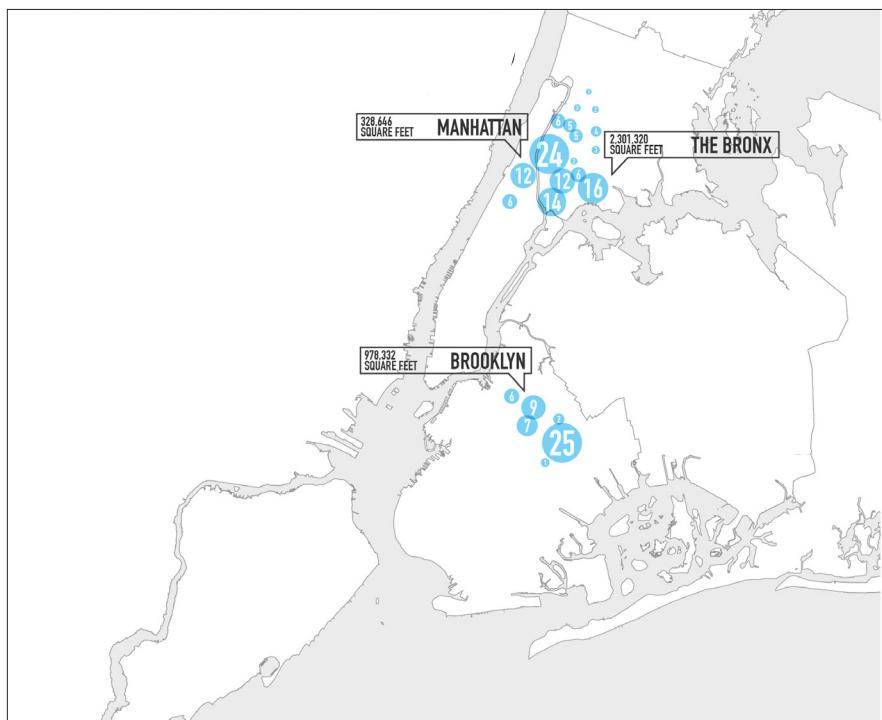


Figure 8: The Cool Roofs study identified a priority list of 2.7 million square feet of potential private and public buildings to conduct strategic outreach to owners in the heat-vulnerable areas of the Bronx, Central Brooklyn, and Northern Manhattan. Source: Columbia University Master of Science in Sustainability Management Capstone Project, 2016.

# Understanding the Role that Cool Pavements Play in Addressing the Urban Heat Island Effect

surface area in cities, contribute to the UHI effect. Similar to dark roofs, asphalt pavements re-radiate absorbed heat into the atmosphere, especially at night. In contrast, “cool pavements” are generally light-colored pavements with a high albedo (over 0.29) that reflect more of the sun’s radiation than a dark-colored pavement with low albedo.<sup>22</sup> Newly installed concrete pavement has an albedo of around 0.35 while fresh asphalt is typically

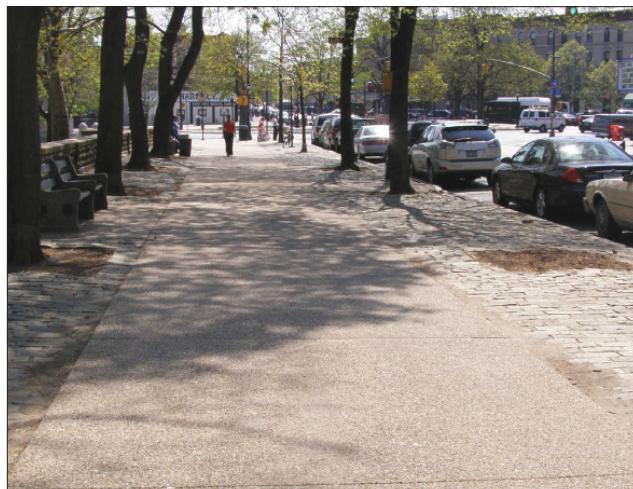


Figure 9: Cool pavements reflect more of the sun’s radiation than a dark-colored pavement. Sand-colored concrete sidewalk on Prospect Park West, Brooklyn. Source: NYC DOT.

closer to an albedo of 0.05-0.10.

City simulations, using weather data from several U.S. cities, have found that reflective pavements, when used in conjunction with cool roofs and shade tree planting, can lower ambient air temperatures, on average by 4°F to 9°F.<sup>23,24</sup> Furthermore, it has been posited that cool pavements with high albedo surfaces can have longer durability because of their lowered temperatures, and can decrease stress on street trees, increasing their vitality, and thus increasing the benefits they afford.<sup>25</sup>

While many NYC streets are paved with asphalt due to

other environmental and engineering considerations, fortunately, over 90% of the city’s sidewalks are light colored. Some NYC sidewalks include permeable interlocking concrete pavers (PICP) and precast porous concrete panels which may reduce the UHI effect through evaporative cooling.<sup>26</sup> Adding trees and ecological features to sidewalks and streets also contribute to improved health, as they provide safe and green corridors where people want to be, walk and exercise.

Finally, vibrant sidewalks can encourage people to support local businesses with active storefronts and streetscapes and can promote opportunities for neighborhood cohesion and interactions and community building. NYC Greenstreets, green infrastructure projects, planted public spaces, medians, and traffic islands help with these environmental and social benefits and also help reduce the UHI effect by promoting evapotranspiration and increasing reflectivity.

Between 2007 and 2016, the NYC Department of Transportation (DOT) Traffic and Planning team has converted a substantial portion of the dark asphalt



Figure 10: Adding trees, lighter surfaces and ecological features to sidewalks and streets also contribute to improved health, as they provide safe and green corridors where people want to be, walk and exercise. Prospect Park Bike Lane, Brooklyn. Source: NYC DOT.



**Figure 11:** The City will continue to convert more and more dark asphalt roadway to lighter concrete and planted spaces. Junior High School 185, Flushing, Queens. Source: NYC DEP.

roadbed (over 3 million square feet) to lighter-colored and/or planted spaces.

In addition, DOT works with the New York City Department of Environmental Protection (DEP) on permeable or porous pavements to facilitate stormwater management where appropriate. Permeable, or porous pavements cool via evapotranspiration from water and air passing through the pavement. DOT is updating their Street Design Manual that will encourage the continued use of permeable pavements, where appropriate, by private entities.

The Public Design Commission has also approved the use of permeable pavers in the furnishing zone of sidewalks citywide by private entities. The furnishing zone is the area of the sidewalk that is immediately adjacent to the

curb where street trees, signs, above-ground utilities, and street furniture are typically located. Through the DOT Vision Zero Great Streets projects, the City is also adding close to 360,000 square feet of new planted space across Brooklyn, Queens and the Bronx.

This increases the permeable area within projects and reduces the overall coverage of heat-absorbing asphalt and/or concrete. As the DOT Capital program's Pedestrian Safety and School Safety projects, Vision Zero Great Streets projects, greenway projects, and similar efforts grow, the City will continue to convert more and more dark asphalt roadway to lighter concrete and planted spaces.

Aside from light-colored concrete sidewalks and pilot programs of other reflective and permeable pavements, real-world, empirically-backed studies specific to UHI effect mitigation are lacking and the large-scale application of cool pavements has no urban precedent. Because of this, the safety, durability, longevity, and upkeep maintenance costs for implementation are relatively unknown and will be a challenge as the City leads this innovative effort.<sup>27</sup>

Increasing the reflectivity, porosity, and planted groundcover of the city's pavement surfaces have the potential to be important tools that the City can use to mitigate the UHI effect. Going forward, the City will assess the feasibility of increasing cool and permeable surfaces in heat-vulnerable neighborhoods and will continue to determine interventions that make sense for certain typologies (plazas, playgrounds, parking lots, low-traffic roads, etc.).

***Assessment of UHI effect mitigation opportunities in heat-vulnerable neighborhoods will be conducted by:***

NYC Mayor's Office of Recovery and Resiliency  
NYC Department of Transportation  
NYC Department of City Planning  
NYC Department of Environmental Protection

# Implementing Green Infrastructure and Understanding its Co-Benefits

## *Green Infrastructure implementation led by NYC DEP in partnership with:*

NYC Department of Parks and Recreation

NYC Department of Transportation

NYC Department of Education

NYC Department of Design and Construction

NYC Economic Development Corporation

NYC Department of Design and Construction

NYC Housing Authority

School Construction Authority

The Trust for Public Land

Since 2011, the NYC Department of Environmental Protection (DEP) has been implementing green infrastructure (GI) practices in combined sewer areas citywide in an effort to manage stormwater. To-date, NYC DEP has installed thousands of green infrastructure practices in the public right-of-way (ROW), replacing sections of sidewalk with rain gardens that include a mix of trees, flowers, shrubs and grasses. NYC DEP also works with partner agencies and non-profit organizations to retrofit public properties with larger green infrastructure practices. NYC DEP is also incentivizing green infrastructure retrofits on private property through the *Green Infrastructure Grant Program*.

NYC DEP continues to progress in development of its Green Infrastructure Program as part of a \$1.5 billion by 2030 commitment. As of March 2017, the Program had encumbered over \$410 million with another \$1 billion budgeted over the next 10 years for thousands more GI practices including rain gardens, permeable pavement, and subsurface storage.<sup>28,29</sup>

Many of the combined sewer areas that have received or will receive green infrastructure are also in HVI neighborhoods, including central Brooklyn, areas of the south Bronx, and areas of northwest and southeast Queens (See Figure 13). Although the primary goal of the GI Program is to capture stormwater, GI has co-benefits beyond stormwater capture. These co-benefits include how rain gardens and green roofs mitigate the UHI effect through added shade and evapotranspiration. NYC DEP has been working on research and development efforts to understand co-benefits of green infrastructure. NYC DEP will continue data collection efforts to investigate the co-benefits of widespread green infrastructure implementation.



**Figure 12:** Green Infrastructure has co-benefits beyond stormwater capture, including creating urban habitat and mitigating the UHI effect through added shade and evapotranspiration. Bioswales, Brooklyn. Source: NYC DEP.

## Green Infrastructure Program Area-Wide Contracts

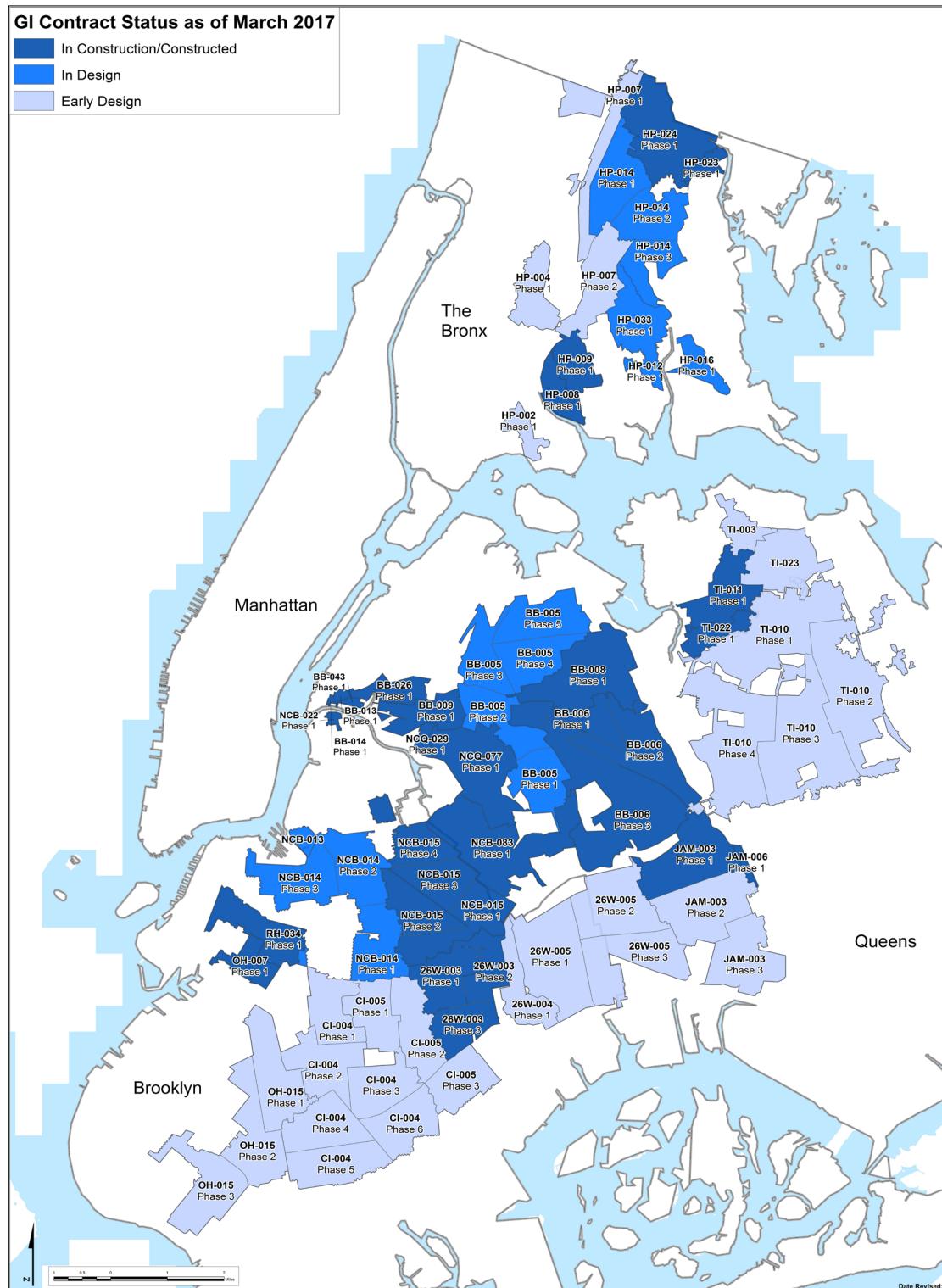


Figure 13: NYC DEP has installed thousands of green infrastructure practices in the public right-of-way replacing sections of sidewalk with rain gardens. Many of the combined sewer areas that have received or will receive green infrastructure are also in HVI neighborhoods. Source: NYC DEP, 2017.

Cool  
Neighborhoods  
NYC

Heat Adaptation  
Strategies

# Launching Climate Risk Training for Home Health Aides

Hot and humid summer weather can cause heat illness and even death. In New York City, DOHMH examined death records from 2008-2011 and found that about 85% of NYC heat-stroke deaths happened after exposure to heat inside the home. Many victims were exposed to heat inside homes that lacked access to or did not use air conditioning.<sup>30,31</sup> Older adults, those who are obese, those with chronic medical conditions or mental health conditions, those who abuse drugs or alcohol, and certain other groups are most vulnerable. Those who are socially isolated or homebound are also at risk. There are place-based risk factors such as poor access to public transportation or cooling centers.<sup>32,33,34</sup>

Cooling centers are open across the city during serious heat waves. However, published studies and City data suggest that many New Yorkers, including those most vulnerable to heat illness, prefer to stay at home during hot weather even if they cannot stay cool there, instead of visiting a cool place like a library, a friend's home with air conditioning, or a city cooling center.<sup>35</sup> Remaining in their homes is dangerous for their health.

Due to current and future risks in light of our changing climate, the City needs strategies to reach heat-vulnerable populations inside their homes. Studies show that indoor home temperatures can be 20°F higher than outdoor temperatures in the absence of air conditioning, and that indoor exposures to heat exceed the comfort range among elderly occupants.<sup>36</sup>

As outlined in *OneNYC*, the City assessed the feasibility of establishing a citywide maximum allowable indoor temperature in residential facilities and supportive housing for vulnerable populations.<sup>37</sup> Interviews with providers, survey feedback from community members, and brainstorming with sister cities facing similar climate risks revealed that the establishment of a maximum indoor temperature would pose significant challenges and requires further examination.

Nevertheless, Home Health Aides (HHAs) play a critical role in protecting our city's most vulnerable residents by providing critical health services inside their homes and are important partners in the City's efforts to protect at-risk New Yorkers.

***Planning and development of Home Health Aide climate and heat risk training conducted by:***

New York Alliance for Careers in Healthcare at NYC Department of Small Business Services

NYC Department of Health and Mental Hygiene

NYC Mayor's Office of Recovery and Resiliency

NYC Emergency Management

Sunnyside Community Services

Allen Health Care Services

Best Choice Home Health Care, A Member of the Centerlight Health System



Figure 14: Home Health Aides can communicate climate-related health risks and promote protective measures inside the home. Source: Stock Photo.

Due to established relationships between aides and clients, HHAs can be trusted messengers in communicating health risks and promoting protective measures inside the home.

Starting in 2017, the City will partner with homecare agencies to promote heat-health messages to New Yorkers and engage HHAs as key players in building climate resiliency. To this end, the City developed a heat-health module for continuing education trainers that will be offered as part of the standard curriculum by three key homecare employers. Through these employers, our continuing education curriculum aims to reach nearly 8,000 HHAs, who will be trained to identify clients that are at highest risk, understand that medicines can affect the body's ability to respond to heat, and understand ways to prevent heat-related illness and death. Most importantly, HHAs will learn to identify barriers that prevent their clients from staying cool and can connect the most vulnerable New Yorkers to the array of services offered by City government.

Offering this training on an ongoing basis will also build a much-needed knowledge base in our communities as HHAs will have a better understanding of climate risks and can act on that knowledge to protect their own families, friends and neighbors during periods of very hot weather.



Figure 15: During the heat-health module, HHAs will learn to identify barriers that prevent their clients from staying cool and can connect them to the array of services offered by City government. Source: NYC SBS.

# Encouraging New Yorkers to Check on At-Risk Neighbors through Be a Buddy NYC

A key challenge in preparing for extreme weather emergencies is their relative unpredictability. To protect New Yorkers in the future, lessons can be learned from strategies tested and evaluated from more common climate emergencies such as heat waves. A heat emergency is not the time to identify vulnerable residents. Rather, it is important to build social networks that can help share life-saving information prior to such an emergency, and can reach out to at-risk neighbors during an extreme heat event. Studies have shown that enhanced social cohesion better prepares communities to withstand natural disasters and their health impacts.<sup>38</sup>

The City is investing \$930,000 to launch Be a Buddy NYC to create a community-led preparedness model that promotes social cohesion. This health-based initiative is a two-year pilot that will promote community resiliency to extreme heat and other weather emergencies in key heat-vulnerable communities (See Figure 16). South Bronx neighborhoods, including Highbridge-Morrisania, Crotonia-Tremont, and Hunts Point-Mott Haven, have among the highest rates of heat illness and death in NYC. Central Brooklyn and Central and East Harlem are also highly vulnerable to heat impacts. The City's Neighborhood Health Action Centers will serve as incubators for community preparedness.

***Development and implementation of Be a Buddy NYC is a partnership between:***

NYC Department of Health and Mental Hygiene

NYC Mayor's Office of Recovery and Resiliency

NYC Emergency Management

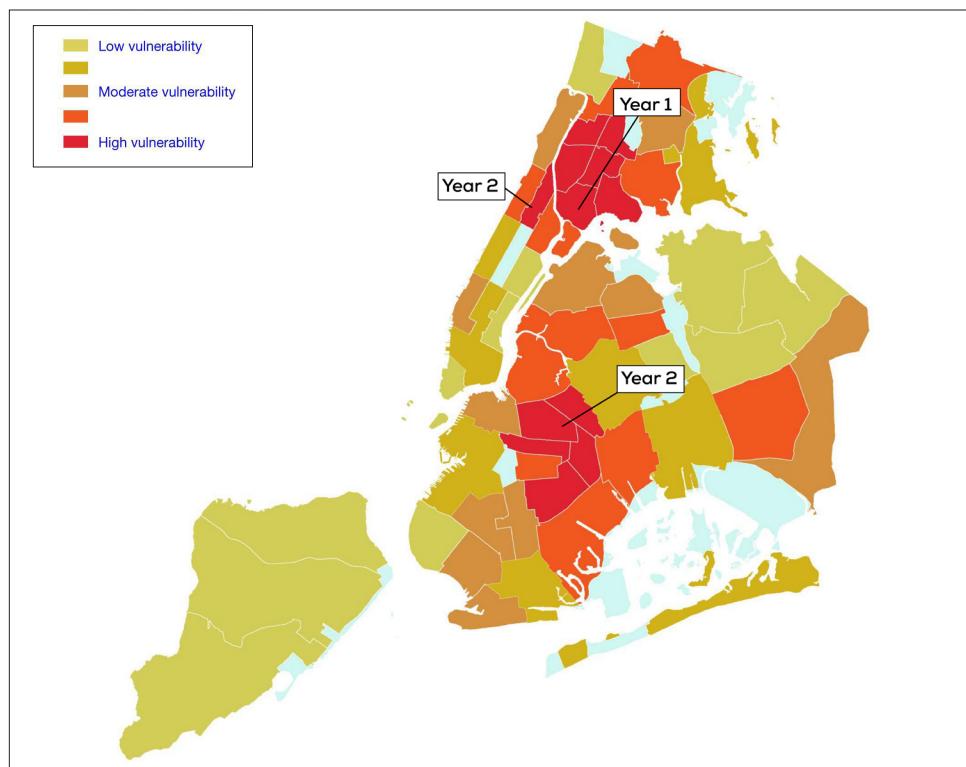


Figure 16: *Be a Buddy NYC* is a two-year pilot that will promote community resiliency to extreme heat and other weather emergencies in key heat-vulnerable communities. Source: NYC DOHMH, 2015.



Figure 17: Resident door knocking at Queensbridge Houses. The City will work with neighborhoods to foster buddy systems between community organizations, and vulnerable New Yorkers. Source: Edwin J. Torres/Mayoral Photography Office.

Be a Buddy NYC is an interagency partnership to address heat-related health impacts by enhancing the response capacity, climate preparedness and communication tools of local community-based organizations, while increasing neighborhood volunteerism through the creation of buddy systems. The City will work with each neighborhood to foster buddy systems between social service and community organizations, volunteers, and vulnerable New Yorkers, to be deployed during emergencies to conduct telephone and, if necessary, door-to-door and building level checks on vulnerable individuals.

Over the next two years Be a Buddy NYC will implement protective measures against heat-related illnesses by: (1) training community organizations and volunteers on emergency protective measures and ways to assist vulnerable adults; and (2) engaging communities to identify alternative neighborhood resources for staying cool and to communicate protective health messages to hard-to-reach populations via trusted messengers. Be a Buddy NYC leverages and models other citywide initiatives including Age-Friendly NYC, Community Emergency Response Teams, NYC Service, and the Neighborhood Health Action Centers.

# Building Partnerships with Health and Weather Reporters for Preventative Messaging

Studies show that residents of the United States may not always perceive climate change as a health threat, despite the fact that several risks, including an increased likelihood of heat stroke due to rising temperatures and higher frequency and intensity of heatwaves, are well understood and documented.<sup>39</sup> For this reason, articulating the health impacts of extreme weather events accurately and effectively to the communities that are most affected is crucial. In New York City, most heat-related fatalities occur from exposure to heat in homes without working air conditioning, and the victims are often older adults and people with

chronic health conditions or other health or place-based risk factors. A citywide survey conducted in 2011 found that among older adults, and adults aged 18-64 who reported being in poor or fair health and who did not own or rarely used air conditioning, almost 50% stayed home during hot weather and 30% were unaware of heat warnings. Focus groups conducted in 2012 found that older adults who participated did not perceive themselves to be at risk during very hot weather, and did not consider air conditioning use as an important preventive measure.

After learning this key health message, they noted that the importance of air conditioning use was missing from local news clips shown to the group about extreme heat. Rather than portraying older adults and potentially dangerous indoor environments, T.V. images and voiceovers broadcasted during extreme heat days tended to portray children and younger adults in outdoor locations.<sup>40</sup> In short, current media coverage of extreme heat may not effectively convey heat risk to the city's most vulnerable residents or focus on indoor exposure. Focus group participants also said that meteorologists and health reporters are trusted sources of heat-health information. Hence, reporters are in a powerful position to communicate accurate and life-saving heat-related information to New Yorkers. Both traditional and social media can play a strong role in promoting health and safety during heat emergencies. Collaboration between the City and broadcast media can increase awareness, clarify populations most at risk, and amplify the reach of public health messages.



Figure 18: Images of outdoor environments, such as beaches, are typically used by the media during extreme heat events. Most heat-related fatalities, however, occur indoors. Source: Orchard Beach in the Bronx. Michael Appleton/Mayoral Photography Office.

***Planning and implementation of heat-health outreach conducted by:***

NYC Mayor's Office of Recovery and Resiliency

NYC Emergency Management

NYC Department of Health and Mental Hygiene

To ensure that New Yorkers receive information about extreme heat and the protective actions they need to take, the City will engage health and medical reporters and meteorologists over the next year to provide information on the health impacts of heat and tips on what individuals, particularly those most vulnerable and their caregivers and social contacts, need to know to stay safe. DOHMH will also post information about heat disparities in NYC's neighborhoods, including a Heat Vulnerability Index and information about air conditioning prevalence by neighborhood, on its website.



Figure 19: TV images and voiceovers broadcasted during extreme heat days tend to portray children and younger adults in outdoor locations rather than portraying older adults and potentially dangerous indoor environments. Source: NYC DEP.

# Advocating for Reforms to the Low-Income Home Energy Assistance Program (LIHEAP)

Air conditioning is the most effective and important way to protect at-risk individuals on hot days and to keep them from experiencing heat-related illnesses. In NYC, a critical climate adaptation strategy is to ensure that vulnerable populations have access to air conditioning during extreme heat days. However, cost is a barrier for low-income populations, making access to air conditioning a serious health-equity issue.

New Yorkers can obtain some financial relief through the Low-Income Home Energy Assistance Program (LIHEAP), which is administered by the U.S. Department of Health and Human Services and provides subsidies to low-income households to assist in paying for heating and cooling needs. In 2016 alone, the LIHEAP program distributed over 700,000 heating and cooling grants (\$37.5 million) in NYC. LIHEAP's cooling assistance, however, is extremely limited in New York State because the majority of the funding is allocated in the winter months to help meet the heating needs of low-income New Yorkers.

In New York State, 65% of LIHEAP funding is allocated to heating assistance, while only 1% is allocated for cooling assistance (with the remainder going to fund crisis assistance, weatherization, and administration costs).<sup>41</sup> When LIHEAP is available for cooling, the assistance applies solely for the purchase and installation of an air conditioning unit for low-income residents with a documented medical need, but the assistance grant cannot be used to offset prohibitive utility costs.

Low-income individuals, particularly those unable to purchase or pay to run air conditioning during very hot weather, are at increased risk for heat illness. In 2014, 94% of NYC households in low-poverty neighborhoods had access to home air conditioning, compared with only 82% in high-poverty neighborhoods. Only 70% of households in Brownsville, one of the city's poorest neighborhoods, had air conditioning coverage compared to 99% of households in South Shore, one of the city's wealthiest neighborhoods.<sup>42</sup>

*Support of changes in  
LIHEAP distribution and  
increased funding will be  
conducted by:*

NYC Mayor's Office of  
Recovery and Resiliency

NYC Department of  
Health and Mental  
Hygiene

NYC Human Resources  
Administration

Two surveys of NYC residents found that the primary reason New Yorkers cite for not owning an air conditioner is cost.<sup>43,44</sup> Even when people own air conditioning, they may not run it during hot weather because of utility cost concerns.<sup>45</sup> Many New Yorkers do not realize that setting their air conditioner at 78°F or “low cool” on a hot summer day is the best way to stay safe and comfortable, while saving money on their energy bill. Fans alone do not keep at-risk people cool during extremely hot days. In fact, improper use of fans, such as using them when all the windows are closed, can be dangerous to health.



Figure 20: Air conditioning is the most effective and important way to protect at-risk individuals on hot days and prevent heat-related illnesses. Source: NYCEM.

By providing air conditioners and offsetting utility costs, LIHEAP has the potential to reduce heat-related risks for a large number of vulnerable New Yorkers. In its current state, the program is greatly underfunded when it comes to cooling funds and is ineffective at meeting the needs of the most heat-vulnerable communities.

In response, the City will work with health departments and other stakeholders across New York State to support an expansion of LIHEAP to assist qualified households in paying utility bills related to the operation of air conditioners. The City will also continue its advocacy for adequate LIHEAP funding at the federal level. As our climate continues to warm, expansion of the LIHEAP cooling assistance component is vitally needed to protect vulnerable New Yorkers from both current and future health risks.

# Working to Improve Ventilation and Ensure Operable Windows in Residential Buildings

Beyond individual vulnerability, the condition of urban microclimates, influenced by the built environment, affects health risk.<sup>46, 47, 48</sup> Multifamily buildings in urban areas are particularly vulnerable due to their building age, construction materials, insulation, roof and wall colors, window orientation, apartment configuration, and lack of operable windows.<sup>49</sup> Studies have found that these and other building characteristics, including a lack of central air conditioning systems, low building height, and those made with exterior building construction consisting of asphalt and wood siding have high heat sensitivity to outdoor temperatures and solar radiation.<sup>50</sup>

The City continues to explore potential building-level interventions to alleviate hot weather conditions in New Yorkers' homes. While air conditioning is the optimal solution for alleviating risks for vulnerable populations, particularly during a heat wave, some city buildings may not be able to accommodate the electrical loads required to provide cooling to all units that need it, depending on the age and condition of a building's wiring.

Operable windows that enable natural ventilation and passive cooling without electricity, can provide relief when outdoor temperatures are moderate and are especially important for ventilation during power outages.<sup>51</sup> Operable windows can be an efficient way to provide fresh air and can substantially reduce energy use, especially during spring and fall when local temperature and humidity are lower. In homes where air conditioning is not used or not available, operable windows can be a New Yorker's main source of temperature control.<sup>52</sup>

Historically, windows have provided passive ventilation around the world. NYC passed crucial legislation in 1901 to ensure that all apartments had access to fresh air and natural light. With this increased ventilation came risk of children falling from windows,



Figure 21: Operable windows can be an efficient way to provide fresh air and can substantially reduce energy use. Source: DTFA.

***Strategy development and outreach to maximize safe natural ventilation through windows will be conducted by:***

NYC Mayor's Office of Recovery and Resiliency

NYC Department of Health and Mental Hygiene

NYC Department of Buildings

4.5 inches.<sup>53</sup> Although tenants or owners of apartments without children younger than 11 may request the removal of guards or stops, some may not due to landlord concerns about legal liability or lack of awareness about the law's requirements.

In response, the City will engage relevant stakeholders to educate on the policy that protects young children from falls, while pursuing strategies for better compliance with the code to maximize safe window usage for passive ventilation in homes. Possible approaches may include discussions with architects and contractors about new and renovation window designs that meet requirements without being overly restrictive and posting information that educates tenants and landlords on the rules to promote the removal of window guards or stops when safe to do so.

# Supporting Improvements to Signage and Programming at Cooling Centers

During heat emergencies, NYC Emergency Management (NYCEM) deploys a multi-agency response to protect public health, including communication strategies around staying safe during heat waves and publicizing the opening of hundreds of cooling centers in order to provide respite from the summer heat. Cooling centers are air-conditioned spaces that are open to the public for free and become activated during heat emergencies in NYC. Typically, the facilities designated as cooling centers already serve as community spaces and include senior centers, community rooms in public housing buildings, and public libraries. Cooling centers serve New Yorkers that do not have access to an air conditioner to help prevent heat-related illness or death. Many of them operate with extended hours to protect at-risk individuals on very hot days. However, the majority of these spaces are not owned, maintained, or operated by City government. While cooling centers are publicized through media, public messaging and 311, the City is drastically limited in its ability to implement any potential capital improvements of these spaces. The facilities volunteer to serve as cooling centers, and physical inspections and upgrades to the buildings in which the facilities operate are outside of the City's purview during each heat emergency.

*Implementing improved signage and coordination with cooling centers will be conducted by:*

NYC Emergency Management

NYC Department for the Aging

The City makes efforts to ensure that enough cooling centers are open citywide to meet demand. Nevertheless, published research shows that many New Yorkers do not want to leave their homes to attend cooling centers even when it is dangerously hot inside their own apartments. This is why we are using a multi-pronged strategy to tackle the issue, using Home Health Aides training and Be a Buddy NYC to target New Yorkers that choose to stay in their homes, as well as increasing the visibility of cooling centers so that they can continue to be a resource for New Yorkers who need them.

To this end, NYCEM will invest in improved signage so that the location of cooling centers will be more accessible to vulnerable New Yorkers. Signage improvements will launch in summer of 2017. Each cooling center will display a 24" x 36" vinyl sign at their main entrance to notify the community that the facility is being used as a cooling center during heat emergencies. The cooling center finder on the NYCEM website will also be updated to be responsive to screen size on mobile devices.

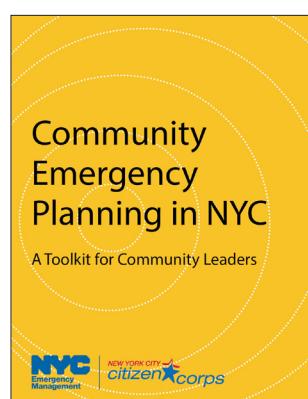


Figure 22: The Community Emergency Planning Toolkit is a New York City-specific guide for emergency planning. Source: NYCEM

Through its Age-Friendly NYC initiative, the City is working to foster opportunities for older New Yorkers to live healthier and more socially connected lives. In 2017, NYCEM launched the Community Emergency Planning Toolkit, which included outreach to aging service providers throughout New York City. Starting in summer 2017, the Department for the Aging (DFTA) in partnership with NYCEM and DOHMH will launch an extreme heat awareness campaign.

The campaign will center on local outreach and print ads that feature older adults and will highlight heat safety tips. In addition, DFTA, in their 2017 Age Friendly NYC report, included recommendations to ensure that senior center participants have information on services available during extreme heat events, access to the Low Income Home Energy Assistance Program, and ways to protect themselves during the summer season.

# Cool Neighborhoods NYC Monitoring Strategies

# Collecting Innovative Data to Deliver Inclusive and Health-focused Climate Policy

The spatial variation within New York City's densely built environment—including the distribution of its vegetation, varied building and other land cover typologies, and surface materials—results in differentiated heat risk at the local level. Studies have shown that certain landscape classes are key drivers of surface temperature in cities.<sup>54</sup> When certain landscape classes are compared with geographic patterns of social risk, they often overlap with disadvantaged neighborhoods. As a result, the effects of extreme heat are disproportionately borne by many of the most vulnerable New Yorkers. Temperature monitoring is a crucial component of effectively targeting heat mitigation and adaptation strategies around the city.

To better understand the geography of NYC's microclimates and differentiated vulnerability, the City is investing \$300,000 to collect baseline neighborhood-level temperature information. This will be used to assess current risk, more effectively target new initiatives in the most heat-vulnerable neighborhoods, and in the long-term, provide baseline data to accurately measure the impact of interventions. Over the next two years, this data collection and analysis will empower the City to inform and target future capital investments in natural infrastructure; to identify operational and policy strategies that address and adapt NYC to the increasing impacts of UHI effect and extreme heat. Finally, this work will allow us to identify the need for additional monitoring and research initiatives that can improve our knowledge of temperature variation and model the effectiveness of needed interventions.

The City is also engaged in the five-year, ten-city, National Science Foundation funded Urban Resilience to Weather-related Extreme Events Sustainability Research Network (URExSRN). The UREx Project integrates social, ecological and technical systems to support urban decision-making in the face of climate change.<sup>55</sup> This research includes scenario modeling projections for spatial variability in heat and heat risk and vulnerability as well as examining how green infrastructure and other interventions may impact exposure to heat in NYC. Scenario modeling includes linking downscaled US Census data with the City's tax lot assessment, land cover, and other land use data to examine heat and heat impacts at lot level resolution for NYC. The City's new high resolution temperature monitoring described above can serve to ground-truth these model scenarios and suggest refinements.

The City has also invested \$1.72M to collect updated LiDAR data for NYC. LiDAR is mapping technology that determines distance to an object or surface using laser pulses to measure elevation, allowing the creation of three-dimensional topographic maps and highly accurate surveys of surface terrain, vegetation and manmade structures. The City is developing several data sets including land cover, tree canopy and other vegetation, elevation data to map coastal flood hazards, and all types of impervious surfaces.

These data sets, which will be made publicly available in 2018, will help identify areas

***Data collection, research and monitoring conducted or overseen by:***

NYC Mayor's Office of Recovery and Resiliency

NYC Department of Health and Mental Hygiene

NYC Department of Parks and Recreation

City College of New York

Urban Systems Lab at The New School

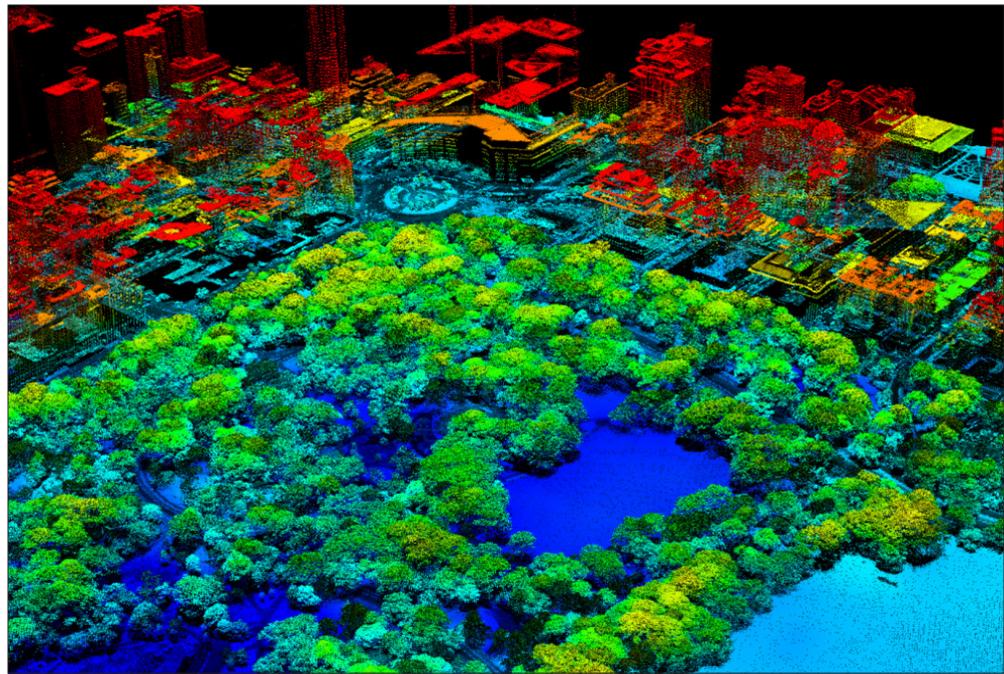


Figure 23: The LiDAR data being captured will be among the most accurate ever collected for a municipality since our 2010 capture, providing numerous government agencies with critical information. LiDAR point cloud data of Central Park. Source: OneNYC

of the city that can benefit from prioritized tree plantings and additional greening and impervious surface removal in order to protect from climate change threats such as the UHI effect and extreme heat. LiDAR data will also help the City to assess ecosystem conditions and opportunities for forest restoration and green infrastructure planning. In all, the landscape of the city has changed since we last collected LiDAR data in 2010 due to many natural events and human interventions, and the new data will help to inform our understanding and investment in the city's resiliency and sustainability.

The City is also collaborating with researchers at the City College of New York (CUNY) to install a high-density hydro-meteorological weather network around the city. This one of the kind network will monitor basic meteorological and hydrological variables to assess the variability in NYC's microclimates and their response to extreme events. The network will deliver real time observations of temperature, humidity and rainfall, which can be used to create an early warning system during heatwaves and flooding. The network will also be used to improve city-scale climate modeling that can be used to study how future climate scenarios will impact different neighborhoods within the city. The framework will be an effective platform to assess the impact of various climate moderation and extreme heat mitigation strategies.

The CUNY Center for Remote Sensing and Technology Institute is developing state-of-the-art citywide high-resolution weather research and a forecasting tool. The tool will use the high resolution LiDAR data that the City will make available to represent the complex morphology of NYC and will ingest data from the weather networks around the city to create neighborhood scale weather forecast. In contrast to the current forecast

produced by the National Weather Service, the improved tool will have representation for various urban processes. For example, the tool can quantify the impact of heat released from buildings' air-conditioning systems. The forecasting platform will aid several weather and climate-related critical operational activities. The tool is currently used to dynamically downscale future climate scenarios projected by the Intergovernmental Panel on Climate Change (IPCC) for New York City.

Innovative data collection is essential in climate adaptation planning. At its core, the City's research and modeling efforts with academic partners can be used to communicate more effectively with affected communities so that the linkages between increased vegetation, lighter surfaces and social adaptation strategies are understood by all New Yorkers, leading to temperature reduction and positive social outcomes including: community preparedness and stewardship, energy savings, increased economic activity, increased productivity, improved health and safety and enhanced quality of life.

# Looking Forward

For years, the City has confronted the issue of heat-vulnerability head-on by developing and implementing multi-agency programs. These include heat emergency response plans, conducting enhanced surveillance after the 2006 heat waves, working with the National Weather Service to update heat product public warning language for NYC, coordinating the opening of cooling centers, issuing safety alerts and advance warnings for special needs populations and their service providers, and launching programs such as the Fire Department's spray cap program, which allows New Yorkers to safely use fire hydrants to stay cool during hot weather.

Still, there is work to be done and through *OneNYC*, the Mayor's Office of Recovery and Resiliency is leading this effort. Moving forward, the City will assess the feasibility of incorporating a heat vulnerability assessment in the New York City Environmental Quality Review (CEQR) Technical Manual, which is the city's guidance document for environmental review. In addition, it is crucial to continue to increase tree canopy cover in the city and to that end we will continue to fulfill our commitments for tree planting and stewardship funding, and will explore the feasibility of lowering the minimum distance required between trees along sidewalks in order to maximize shading. Finally, we will assess opportunities to maximize vegetation within open parking and other areas. Our central strategy has been to leverage key NYC assets: our robust public health, emergency response and parks infrastructure, local climate risk projections, existing cross-sector agency programs, and the research and support of our local academic institutions and community-based organizations. We have worked with practitioners, academics, and colleagues in other cities and states across the U.S. and abroad to identify adaptation strategies and health-based interventions, to get up-to-date information on the implementation status of their own climate initiatives and to solicit feedback on our approaches.

As much as possible, our strategies to adapt to climate change have built upon existing programs and have integrated our City staff and partners to advance program goals. We have worked to strengthen collaboration with agencies and organizations that provide and promote access to essential services; including those involved in the prevention of environmental exposures, the planning and monitoring of community health, and the planning of emergency preparedness and response plans. *Cool Neighborhoods NYC* moves us towards a finer-grained neighborhoods-based analysis that will lead to improved quality of life for all New Yorkers and deliver inclusive climate action that protects public health and addresses environmental justice. By greening neighborhoods and increasing access to air conditioning and cool spaces, we aim to reduce heat-related health impacts, and reduce disparities in vulnerability to climate change.

Our *Cool Neighborhoods NYC* heat mitigation and adaptation program is a multi-pronged, comprehensive strategy that will deliver sustainability and resiliency benefits to all New Yorkers, but especially to those who are most vulnerable to heat-related health risks. Together, we are building community resiliency by continuously expanding interventions known to prevent illness and death from climate-related hazards and by continuously enhancing risk communication strategies for vulnerable New Yorkers.

# Acknowledgements

*Cool Neighborhoods NYC* was created with the shared vision of delivering inclusive climate action and sustainability and resiliency benefits to all New Yorkers, but especially to those who are most vulnerable to heat-related health risks. This multi-pronged, comprehensive strategy will help to reduce heat-related health impacts and deaths, mitigate high temperatures in heat-vulnerable neighborhoods, strengthen social networks, and improve quality of life for all New Yorkers. This program is a result of an incredibly collaborative process that was made possible by the hard work and dedication of numerous individuals who believed in this vision and shared their experience, analysis, ideas, insight, energy, time, and passion.

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Volunteers on the roof of Noll Street Apartments. The Ridgewood Bushwick Senior Citizen's Council, Brooklyn. September 2016. Source: Alex Schneider, SSBx a division of the HOPE Program.

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# Glossary

**Albedo:** reflective power. A ratio of reflected to incident sunlight. It is measured on a scale of 0 to 1: the higher the number, the higher the albedo (solar reflectance).

**Ambient Air Temperature:** the overall temperature of the outdoor air. It does not take into account the relative humidity of air (as apparent temperature does) or wind conditions.

**Cool Pavements:** paving materials that reflect more solar energy, enhance water evaporation, or have been otherwise modified to remain cooler than conventional or asphalt pavements. They include high albedo pavements and coatings, vegetative surfaces (grass pavers), and porous pavements that allow water infiltration.

**Evapotranspiration:** loss of water from the soil both by evaporation and by transpiration from plants. The process through which water is moved from a plant's roots to its leaves where it then evaporates through stomata (small pores on the underside of a leaf). The liquid water turns to vapor, losing the water molecules' heat and cooling the plant and surrounding air.

**Green Infrastructure:** the array of man-made practices that use or mimic natural systems to manage and control urban stormwater runoff such as bioswales, rain gardens, and green roofs. Water is either directed to engineered systems for infiltration or detained at a slower rate before it enters the combined sewer system. In addition to water quality benefits, green infrastructure also produces a host of co-benefits including beautification and heat mitigation.

**The Intergovernmental Panel on Climate Change (IPCC):** The international body for assessing the science related to climate change. The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.

**Microclimate:** the essentially uniform local climate of a usually small site or habitat.

**The NASA Goddard Institute for Space Studies (GISS):** a laboratory in the Earth Sciences Division (ESD) of National Aeronautics and Space Administration's Goddard Space Flight Center (GSFC). The institute was established in 1961 to do basic research in space sciences in support of GSFC programs. A key objective of GISS research is prediction of atmospheric and climate changes in the 21st century.

**Natural Infrastructure:** refers to nature-based solutions that can provide many of the same storm water management, heat mitigation, and resiliency benefits of traditional man-made infrastructure at a lower investment and maintenance cost. Natural infrastructure approaches include forest, floodplain and wetland protection and management, watershed restoration, wetland restoration, etc.

**The New York City Panel on Climate Change (NPCC):** an independent body charged with providing up-to-date scientific information, projections, and analyses on climate risks to the City of New York that can inform climate mitigation and adaptation policy. The NPCC is required by law to meet at least twice each calendar year to review recent scientific data on climate change and its potential impacts, and to make recommendations on climate projections for the coming decades to the end of the century.

**Permeable Pavements:** pervious and porous pavements that contribute to stormwater management and cool via evapo-

transpiration from water and air passing through the pavement. Both asphalt and concrete can be permeable. Permeable pavements have been linked to lowered surface and ambient air temperatures in the scientific literature.

**Reflective Pavements:** light-colored pavements with a high albedo that reflects more of the sun's radiation than a dark-colored pavement with low albedo. To be considered reflective, the albedo of a pavement must be over 0.29.

**Tax Abatement:** a deduction from the full amount of a tax.

**Urban Heat Island Effect:** a regional elevation in air temperature that represents the difference between air temperatures in urban and built up areas and nearby rural areas.

