

COLUMBIA SCHOOL OF
INTERNATIONAL AND PUBLIC AFFAIRS

CLIMATE CHANGE RELIEF FOR URBAN AREAS ACT OF 2023



FINAL REPORT

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Prepared by

MPA ESP WORKSHOP TEAM

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Bronx River Dam, Jada Johnson, 2024

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8th Av, Manhattan, Kimberly Liu, 2024

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We, the authors of this report, recognize that the land occupied by the government of the United States holds traditional and ancestral significance to a multitude of Indigenous peoples. Columbia University is located on the island known as Manhattan, which is part of the traditional and ancestral homeland of the Leni-Lenape and Wappinger people. We aim to address issues of community exclusion, erasure, and discrimination through our commitment to equity and justice, as well as ongoing education and advocacy efforts.

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EXECUTIVE SUMMARY

Across the United States, extreme weather events are on the rise. As the effects of anthropogenic climate change worsen, more communities become vulnerable to extreme drought, flooding, and overall increased temperatures. Moreover, past and present urbanization and land use changes exacerbate the problem. Urban populations are ever-growing and often planned with little green space in mind. As more people live in urban areas, they become increasingly vulnerable to heat-related injury and mortality, flooding damage, food insecurity, and other environmental problems.

In this report, our team examines H.R. 2786, the Climate Change Relief for Urban Areas Act of 2023 (henceforth referred to as the Act). This federal bill is aimed at reducing the negative impacts of urban heat island effect (UHIE), extreme weather, and air pollution in communities with limited access to tree canopy and gardens and face disparate impacts to environmental hazards. Typically, these communities are low-income communities and majority BIPOC (Black, Indigenous, and People of color) who lack resources to reduce environmental and socio-economic impact on their communities. We also examine some of the potential incongruencies in the science of finding impact in green

infrastructure, as well as examine key socio-economic and political controversies such as political partisanship, availability of resources, and green gentrification.

While the majority of empirical evidence on urban green infrastructure agrees on its ability to address environmental problems and promote community wellbeing, the standards by which impacts are assessed are not universal. Within this report, we have proposed key performance indicators (KPIs) to assess the outcomes the Act aims to achieve, including success metrics for ambient temperature reduction, improvements to public health, and community engagement.

The Act's creation of tree and garden equity scores at the federal level is a critical first step on the path towards enabling environmental justice (EJ) communities to achieve better environmental and socioeconomic outcomes. However, the path to the Act's successful implementation is not without challenges, including project selection, green infrastructure maintenance, and leveraging community support. In the next stage of our analysis, we will explore challenges like these and systemic levers to determine how the federal government can successfully implement the Act's programs.



Section 1

Introduction

Manhattan, Kimberly Liu, 2024



1.1 Defining the Problem

Rising temperatures in cities are a serious problem and exacerbate pre-existing inequalities. Green spaces act as natural cooling and filtration systems, but low-income and BIPOC neighborhoods often lack this green space, causing heat-related and respiratory illnesses. The Climate Change Relief For Urban Areas Act focuses on increasing urban tree canopy cover and creating rooftop gardens, aiming to mitigate the negative outcomes associated with increased heat.

Addressing urban heat inequities is vital now is vital, as the cities will only continue growing. The urban population of the United States increased by 6.4% between 2010 and 2020, and it is estimated to reach 89% by 2050 [1]. In addition, the U.S. urbanized land area grows by about 10% from 2010 to 2020 [2]. Expanding urbanization has led to the destruction of ecosystems and several environmental problems.

The combined effect of lack of tree canopy and heat-absorbing surface in urban areas leads to cities

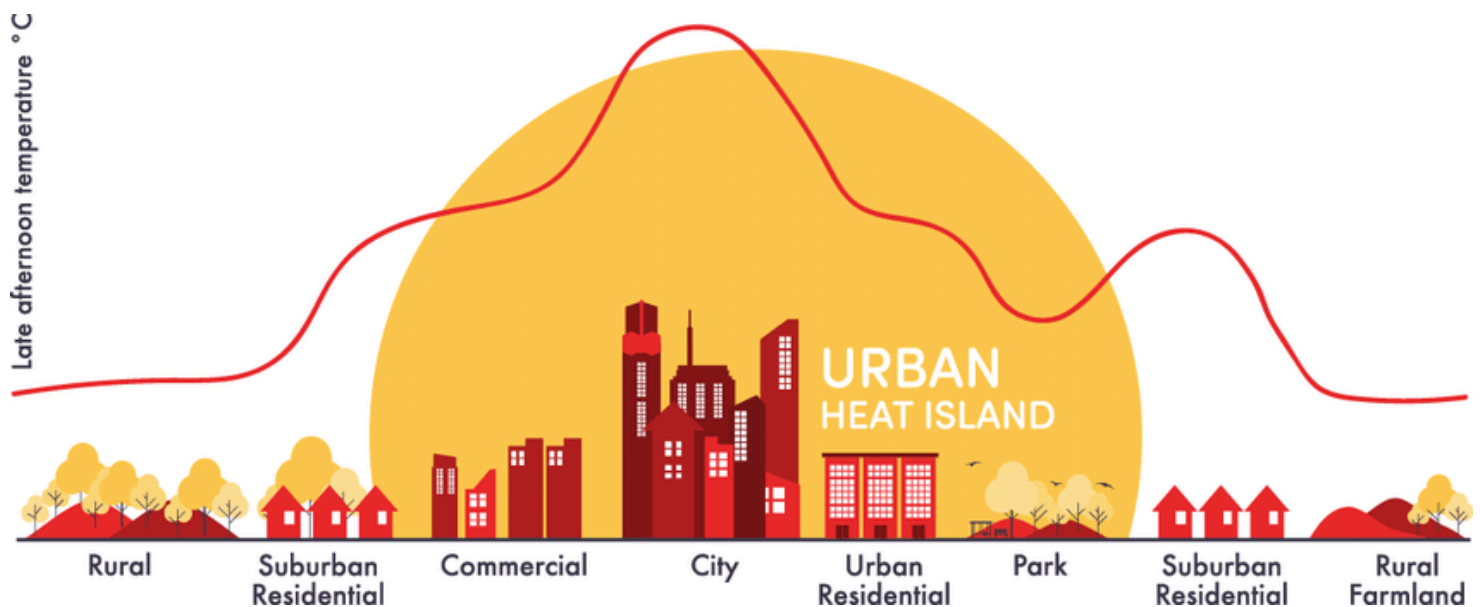


Figure 1.1: The intensity of the heat island across different landscape. In cities, late afternoon temperatures are higher than in their rural and suburban counterparts [3].

facing higher temperatures than rural counterparts, a phenomenon known as the urban heat island effect. The detrimental impacts of urban heat islands consist of increased day-time temperatures, higher energy costs (high energy burden), heat-related illnesses and deaths, impaired water quality, impaired air quality, increased greenhouse gas (GHG) emissions, and exacerbated poverty issues. As climate change intensifies, temperatures will only increase, exacerbating these pre-existing conditions.

Urban stormwater runoff can cause significant degradation of local streams and have a negative impact on rivers' water quality. This contaminated water contains pollutants such as heavy metals, organic waste, and harmful toxins, which are harmful to aquatic systems and human health as well as wildlife [4]. According to the EPA, stormwater runoff contributes approximately 30% of pollutants found in the nation's waters. It is observed that extreme weather events such as floods and severe precipitation are becoming more frequent because of climate change in the US and around the world. Nine of the ten single-day extreme precipitation have happened in the last 30 years [5]. As extreme rain events increase, urban stormwater will become increasingly problematic.

Introducing green spaces into urbanized environments is crucial to addressing these problems. The Climate Change Relief for Urban Areas Act of 2023 (H.R. 2786) is designed to provide federal funding for low tree canopy communities and establish a pilot program to create rooftop gardens at public elementary and middle schools in disadvantaged communities. The Act is sponsored by Rep. Adam Schiff (D-CA) and supported by 18 other Democratic co-sponsors. By amending the Cooperative Forestry Assistance Act of 1978 and issuing a pilot grant program, the act focuses on mitigating the adverse impacts of climate change and promoting environmental justice by creating green space in underserved areas.



Figure 2.1: Chesapeake Bay Stormwater Runoff with sediment, chemicals, and other pollutants. [6] ■



Section 2

Legislative Summary



Manhattan, Kimberly Liu, 2024

2.1 Introduction

The Climate Change Relief for Urban Areas Act of 2023, introduced in the 118th Congress (2023-2024), encompasses two major solutions to environmental injustices in relation to lack of access to green space. The first major solution involves the increased prioritization of disadvantaged communities in receiving federal forestry assistance, while the second solution authorizes new federal funding for the development and maintenance of rooftop gardens in public schools, primarily in disadvantaged communities. Although not explicitly

stated in the Act's language, environmental justice plays a significant role in the ethos behind the bill's provisions. Both solutions are targeted towards reducing injustices established as a result of historic urbanization and redlining practices and exacerbated by disrupted natural systems and climate change.

2.2 Forestry Assistance

Section 2 encompasses the first major solution offered by the Act, which is the prioritization of

disadvantaged communities in receiving federal forestry funding and technical assistance [7]. The section calls for the amendment to Section 9 of the Cooperative Forestry Assistance Act of 1978 (which was codified as Title 16, Section 2105 of the United States Code) [8]. This section of the older bill details the creation of a “program of education and technical assistance” for urban and community forestry, which over time grew to become the USDA Forest Service’s Urban and Community Forestry (UCF) program [9]. The amendment proposed in the Climate Change Relief for Urban Areas Act of 2023 specifies that priority should be given to state foresters and/or other state officials serving areas with the lowest tree equity scores. The proposed amendment calls upon the usage of a tree equity score that is either similar to that developed by American Forests or of any successor conservation organization. This score is required to be based on the intersection of environmental and socioeconomic factors, namely how existing tree canopy and surface temperatures correspond with income, employment, race, age, and health factors. It also must be developed in consultation with community-based organizations and community representatives. Figure 2.1 discusses how this, along with the garden equity score mentioned in the next section, will be developed to deliver environmental justice benefits to communities. Finally, the Act amends the allocation period of the 1978 bill, proposing a \$30 million authorization of funds from 2023 to 2028.

As with any federal bill, it is likely to undergo markup as it advances through both chambers of Congress. Likely markup items include increasing clarity around the tree equity score being one developed separate from that developed by American Forests and removing the annual funding allocation from 2023 to 2028. For the former, using the American Forests version or showing preference for it in advance of the federal procurement process could be construed as a violation of the Federal Acquisition

Regulation, a set of laws governing how the U.S. government can obtain services and goods from private and nonprofit entities. For the latter, the Inflation Reduction Act had already appropriated \$1.5 billion to the Urban and Community Forestry Program for fiscal years 2023 to 2028, making passage of additional funds extremely unlikely.

2.3 Rooftop Gardens in Public Schools

Section 3 covers the development of a \$30 million pilot grant program to establish rooftop gardens in public elementary and secondary schools [10]. The Act calls for the development of a garden equity score, which addresses environmental and socioeconomic factors such as location, population density, race, incidence of respiratory illness, number of urban gardens, food sovereignty, and average surface temperature. This score will then be used to help the Department of Agriculture determine priority for federal grants toward rooftop garden-oriented projects. The funds of the grant program could be used for the following purposes:

- Assessing land area for rooftop garden viability
- Applying for construction permits
- Developing a financial plan for new construction or expansion
- Designing a rooftop garden that provides environmental benefits
- Designing a lesson plan on urban agriculture and/or its ecosystem services as part of the educational curriculum

If a rooftop garden were to be constructed, the Act mandates that the garden must contain at least 20% native species, contain no invasive species, and that organic farming practices must be utilized in its establishment and maintenance. Additionally, rooftop gardens constructed with grant funding will be subject to annual inspections and review by the Department of Agriculture.

2.4 Environmental Justice Ethos of the Act

While not explicitly stated, environmental justice is a critical element behind the implementation of the bill. The bill places particular attention towards “income, employment, race, age, and health factors” with respect to tree equity and “area in which the eligible entity is located, the population density, racial composition, incidence of respiratory illness, number of urban gardens, food sovereignty, and average surface temperature” with respect to garden equity, all of which are critical determinants of environmental justice at the community level.

Given the connection to the Urban and Community Forestry program, which is part of the Biden Administration’s Justice40 initiative, the bill will likely use communities designated as disadvantaged as a primary lens for targeted implementation. Disadvantaged communities, as defined by the Council on Environmental Quality (CEQ), are

communities that experience a number of economic, social, political, and environmental disparities that have been prioritized by the federal government in the Justice40 initiative [11]. These disparities have been identified in census tracts across the United States and the designated tracts have been mapped in the Climate and Economic Justice Screening Tool (CEJST). The tool defines a census tract as a disadvantaged community if it is both:

- 1. At or above the threshold for one or more environmental, climate, or other burdens (see appendix for specific thresholds).
- 2. At or above the threshold for an associated socioeconomic burden.

2.5 Comparisons to Other Legislation

The Act is not the only urban greening bill that has been introduced within this Congress - several others including the SHADE (Saving Hazardous And Declining Environments) Act [12], the Stay Cool Act,

[13], and the Public School Green Rooftop Program bill [14] have been introduced as well. These bills vary in implementing agency and grant amounts, however, they all share a similar premise of increasing the planting of urban green infrastructure through fortifying existing grant programs or developing new grant programs. However, the unique aspect of the Act is the heavy implied focus on environmental justice, and the explicit use of an equity score metric to determine priority as it relates to urban green infrastructure programs. ■

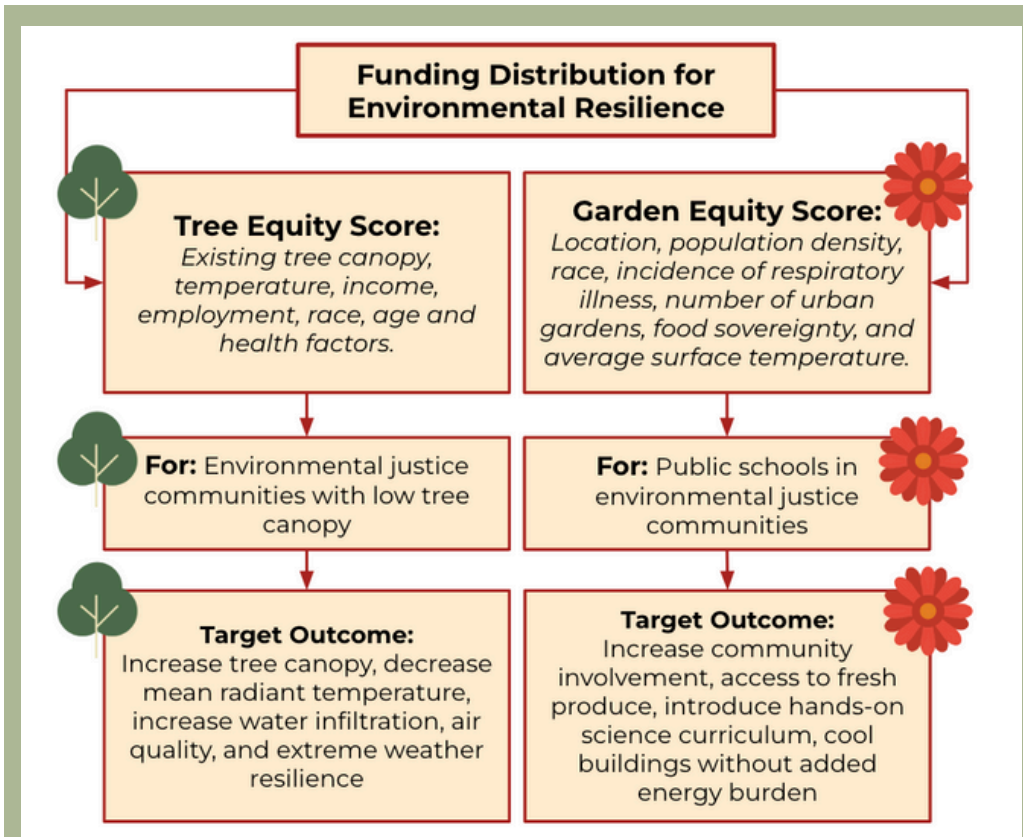


Figure 2.1: Schematic detailing the equity scores enshrined in the Act and their expected outcomes

KEY PERFORMANCE INDICATOR

GRANT APPROVAL PROCESS

Target Outcome: To get funding to eligible Environmental Justice communities

GOALS AND MEASURES

Define a way to provide equitable funding, and use federal resources to promote urban greening

BENCHMARK TIMELINE

YEAR 1

Designing the Garden Equity Scores and application processes.

YEAR 3

Identification and targeting of the communities with an Equity Score of less than 70 in order to provide them with the necessary funding.

YEAR 5

Supporting communities through reporting and provide technical assistance.

LONG-TERM STABILIZATION

Establish an equitable granting program that assures funding gets to environmental justice communities, assuring funding is available for future



Section 3

Defining the Environmental Problem



Manhattan, Kimberly Liu, 2024

3.1 Overview

The continual evolution of climate change in addition to land use change has resulted in various consequences within natural landscapes. The establishment of impervious surfaces and urban spaces has disrupted stable temperature, air quality, and precipitation nationwide. Darker, heat-absorbent surfaces facilitate an increase in temperatures in urbanized areas, especially the experienced ambient temperature on the surface. Caused by heat-absorbing surfaces, exacerbated by radiative forcing, the rise in temperature also results in an

increased risk of heat-related illnesses for residents within cities.

In addition, impervious urban surfaces have also resulted in high rain runoff over short periods of time. The stormwater runoff overwhelms sewage and drainage systems that are equipped for less extreme precipitation events increasing the risk of catastrophic flooding and infrastructure damage. Furthermore, air pollutants and particulate matter can travel long distances, resulting in dangerous exposure for urban residents that can lead to respiratory-related illnesses.

As climate change intensifies, the problems that urban areas already face will only worsen. Global climate change increases the frequency and duration of extreme heat events in summer [15]. Furthermore, increases in temperatures which in turn worsen air quality and pre-existing air pollution [16]. Rising temperatures have also increased atmospheric water vapor, leading to more intense rainfall [17]. The increase in these extreme events will exacerbate pre-existing urban environmental problems.

3.2 Environmental Justice

Disadvantaged communities are disproportionately impacted by urban environmental problems and climate change. Green spaces and green infrastructure can mitigate the effects of climate change within cities. However, low-income communities often lack sufficient green space due to historical land use practices that have prioritized industrial and residential development over

environmental considerations [18]. In turn, the lack of green spaces causes urban populations to experience exacerbated climate change effects. As a result, low-income and BIPOC communities face higher rates of illness or death from heat- or pollution-induced issues, and higher energy burden.

3.3 Greenhouse Effect

Since the Industrial Revolution, production and consumption by humans have greatly impacted Earth systems. One major human-impacted system is the greenhouse effect, which occurs when solar energy absorbed by the Earth's surface is re-radiated and trapped by greenhouse gases. While this process is essential for maintaining temperatures that support life, human activities - such as fossil fuel burning, deforestation, and industrial processes - increase concentrations of greenhouse gases. This, in turn, exacerbates climate change and promotes extreme weather events, such as intense precipitation and

GREENHOUSE GAS EFFECT, EXPLAINED

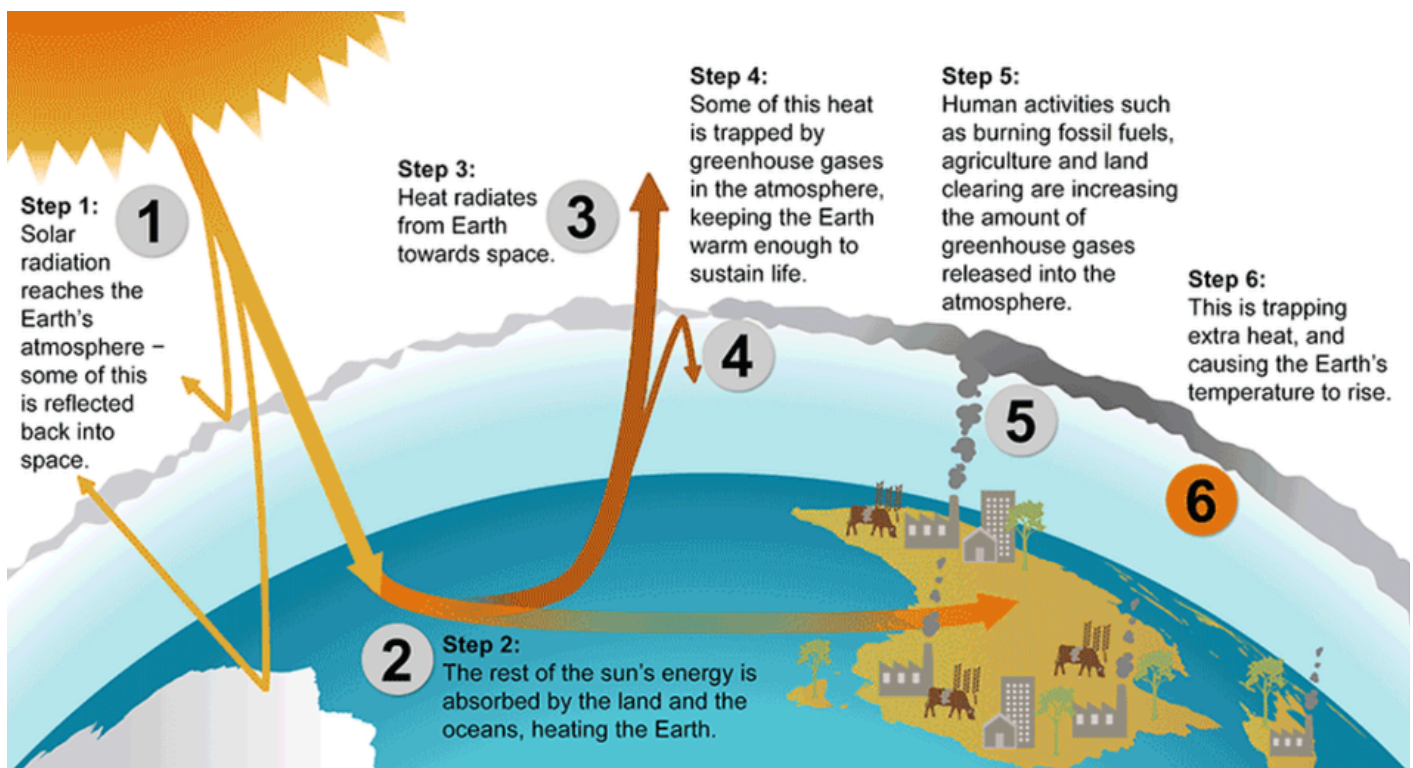


Figure 3.1: How the greenhouse gas effect is disrupted by human activities [19].

heat waves. In 2022, the United States emitted nearly 5.5 trillion metric tons of carbon dioxide equivalents of greenhouse gases into the atmosphere (adjusting for GHGs sequestered throughout the year by land) [20].

3.3.1 The Urban Heat Island Effect

As urbanization continues and green spaces are replaced with gray infrastructure, cities face the threat of the urban heat island effect (UHIE). The urban heat island effect is a phenomenon where urban areas experience higher temperatures. In New York City, tree cover has decreased by 188,000 hectares from 2001 to 2023, leaving only 22% canopy cover today [21]. Daytime temperatures in urban areas are about 1-7 °F higher than in parks or suburban areas outside of the city. More than 6.1 million New Yorkers experience temperatures around 9 °F hotter than outlying suburban and rural areas due to UHIE [22]. Both the absorption of heat by urban surfaces and the increased greenhouse gas effect from human activities cause these higher surrounding temperatures.

In addition to higher temperatures, neighborhoods within cities can experience intra-urban heat islands. This happens due to an uneven distribution of urban

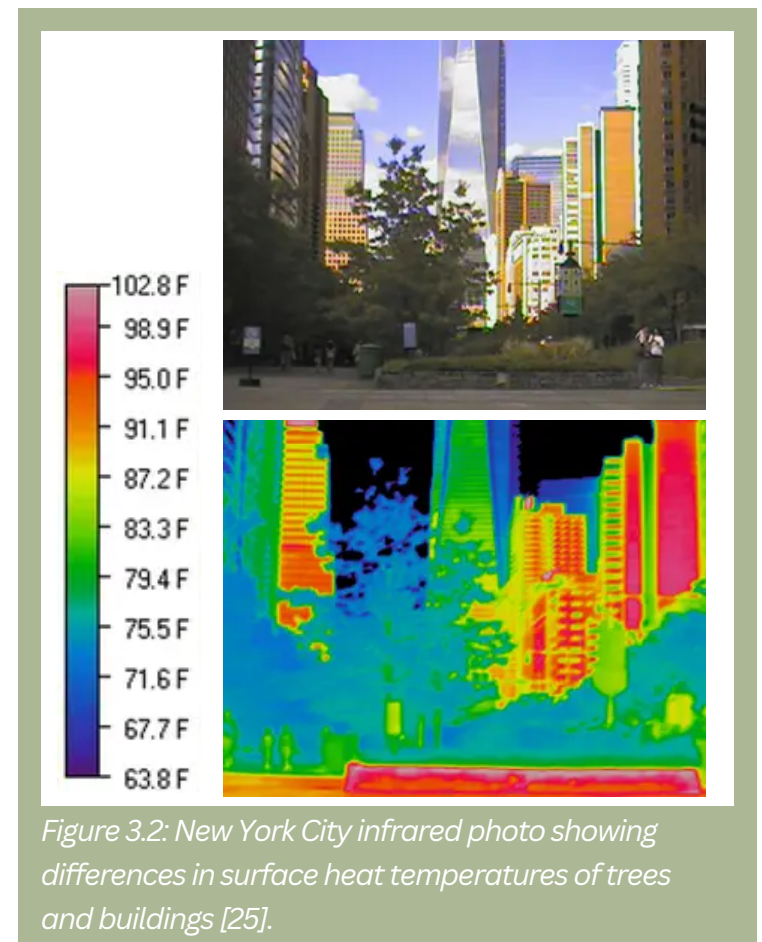


Figure 3.2: New York City infrared photo showing differences in surface heat temperatures of trees and buildings [25].

land cover, where there is more gray infrastructure and less cooling green spaces [23]. The lack of greenery and tightly compacted city has lower reflectivity, or albedo, compared to vegetated areas. Urban infrastructure, such as concrete, buildings, and asphalt do not reflect

URBAN HEAT ISLAND EFFECT



Figure 3.3: Causes of the Urban Heat Island Effect (Graphic by Caroline Benedetti)

sunlight effectively. These dark surfaces rather absorb most of the sunlight and re-emit heat back into the surrounding environment. In cities like Portland, Oregon, some neighborhoods are experiencing 10 °F warmer temperatures than the entire city due to densely packed, heat-absorbing structures [24].

3.3.2 Heat-related Illnesses

The UHIE, combined with frequent and intense heat waves from global warming, poses severe health risks [26]. In Miami, urban development is increasing temperatures and creating a health burden for residents. During the summer, Miami experiences an average heat index of 105°F, despite minor heat-related conditions becoming prevalent at a heat index of 80°F [27]. The heat index is the temperature that the body feels when relative humidity combines with ambient temperature. High heat indexes bring great discomfort to the human body [28]. As a result, incidences of major heat-related illnesses, including heat stroke, cardiovascular issues, and exhaustion have greatly increased over the years. Even at night,

there is no relief as night temperatures remain high because the heat absorbed is slowly released back into the surrounding environment. The consequences of high temperatures are far worse for those who do not have access to air conditioning or green spaces. The lack of vegetation worsens these conditions by preventing access to shade from trees and cooler surrounding air, as plants have natural cooling processes like evapotranspiration [29].

3.4 Urban Air Pollution

The increase in land use change due to urbanization is accompanied by an increase in urban air pollution. The urban heat island effect and higher temperatures are also exacerbated by air pollution and greenhouse gases. From the construction of buildings to the maintenance of cities, air pollution emerges as a pervasive issue with multiple point sources. The combination of stationary and mobile sources such as transportation, factories, and landfills emit toxic air pollutants and are largely attributed to the combustion of fossil fuels [31]. While the greenhouse gasses of CO₂, CH₄, N₂O, and O₃ have decreased due to extensive regulations, high concentrations of greenhouse gasses are still prevalent in industrial areas and communities that are close in proximity to highways [32]. Furthermore, a Harvard study shows that disparities in air exposure exist and disproportionately impact LMI communities that tend to live in highly industrialized areas [33].

3.5 Flooding & Combined Sewer Overflow Events

Extreme weather events such as droughts and severe precipitation are becoming more frequent around the world due to climate change. An EPA report showed that since 1901, the average total precipitation increased by an average of 0.2 inches

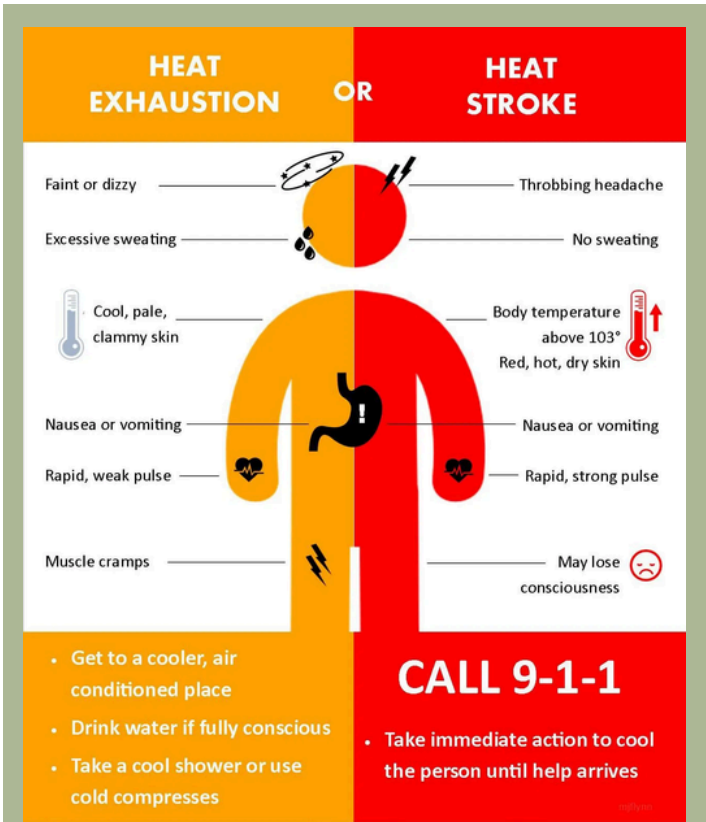


Figure 3.4: Illustration of heat-related illness [30].

inches per decade [34]. The changes in weather patterns have caused areas like the Southwest to experience less precipitation than usual while other areas like the Northeast experience an increase in rainfall. Nine of the ten single-day extreme precipitation have happened in the last 30 years [35]. A reduction in cooling effects of evapotranspiration and shading is observed due to the drying out of vegetation as well. According to the US Forest Service, increased tree cover could reduce surface temperatures by approximately 11-19 degrees Fahrenheit, and increase the cooling effects in urban areas [36]. The decrease in temperatures is an indication of water vapor being absorbed by the atmosphere creating that cooler effect but also reducing floods and their intensity due to less water availability. Furthermore, a study in Baltimore indicates an increase in tree canopy could reduce the effects of stormwater runoff and decrease flooding risks due to water absorption and release to the atmosphere [37].

Urban stormwater runoff can cause great degradation of local streams and rivers' water quality because it can carry pollutants such as

sediment, bacteria, oil, heavy metals, pesticides, and harmful toxins into water bodies [38]. Stormwater flooding can also cause erosion which would lead to habitat destruction and topsoil loss. These pollutants can harm aquatic ecosystems, contaminate drinking water, and pose health risks to humans and wildlife. Furthermore, the drainage system in cities can be overwhelmed by flood water, causing damage to properties and risks to the safety of the citizens. According to the EPA, stormwater runoff is responsible for approximately 30% of pollutants found in the nation's waters [39]. The systems designed to catch stormwater runoff are not designed with the capacity to withstand the recent increases in rainfall due to climate change. High levels of stormwater runoff can result in sewage systems being overwhelmed by excess water. As a result, combined sewer overflows occur when untreated sewage and wastewater spill over into nearby rivers and lakes, causing contamination and environmental degradation.

Low-income communities of color are hit worse by these issues because they are less likely to have the adequate infrastructure, financial means, and



NYC Sewer During a Rainstorm [40]

and resources to deal with extreme flooding events. Discriminatory practices, such as redlining, prevented these communities from buying homes and residing in certain neighborhoods. This meant that they were pushed to congregate in neighborhoods with fewer trees, low-lying areas, and more impervious pavement which increased the risks of faster-moving stormwater runoff and localized flooding in these areas [41]. Another problem faced in these neighborhoods is outdated sewer systems that are not built to handle heavy precipitation events. The combination of these problems has a synergistic effect on one another, impacting underserved communities greatly compared to more affluent, white communities that have the built infrastructure and greenery.

3.5.1 Extreme Precipitation

In normal processes of evaporation, water vapor is released into the air moving from a liquid to a gaseous state. Under abnormal conditions, the rising of temperatures leads to an increase in evaporation and water vapor. As the atmosphere can hold more water vapor, when water moves back to a liquid from a gaseous state, precipitation also drastically increases. Climate change disrupts the water cycle and combined with urbanization, there are disastrous effects [42].

3.5.2 Impervious Surfaces

Extreme precipitation events are a problem for urban areas. Urban surfaces, such as sidewalks, streets, and roads are not built for extreme precipitation because all these surfaces are impervious. When it rains, water is not able to infiltrate the ground, as it would in vegetated landscapes. Instead, there are higher chances of stormwater runoff leading to flooding events.

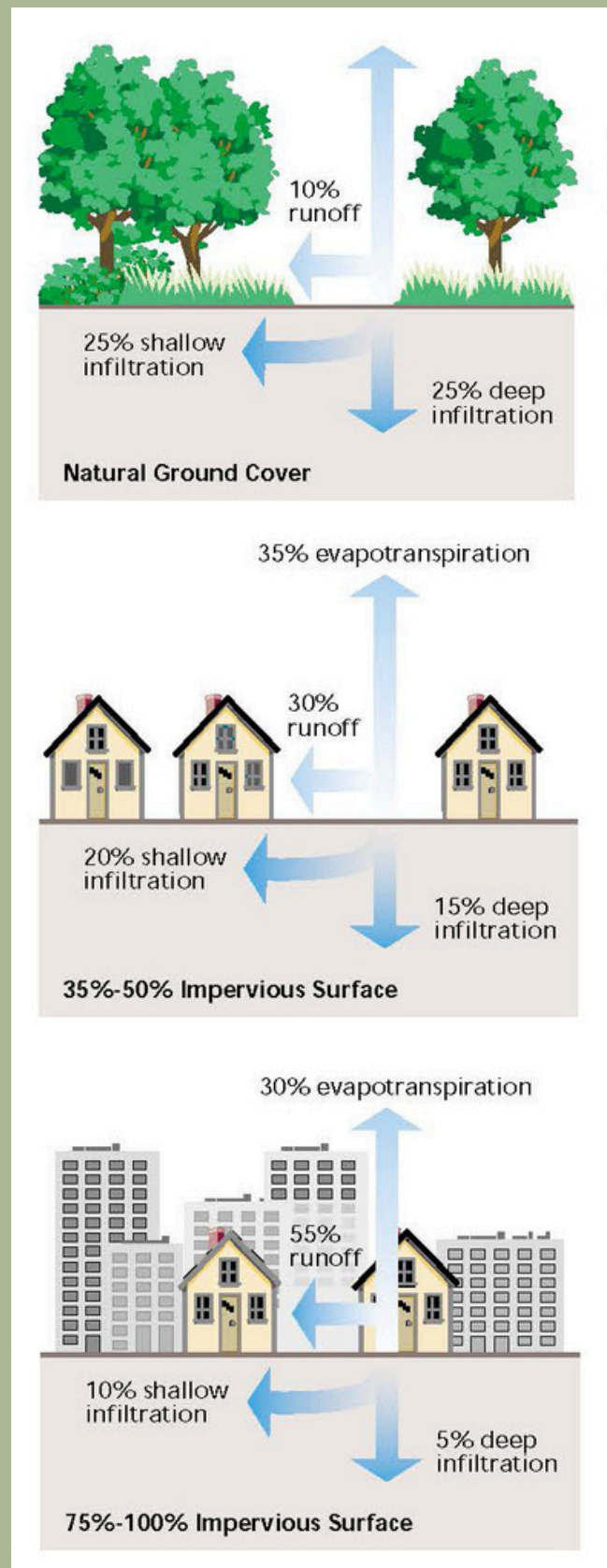


Figure 3.5: Infiltration rates in areas with highly vegetated areas and urban areas with impervious surfaces [43]

3.5.3 Combined Sewer Overflow Events

Around 60% of New York City uses a single pipe that carries both wastewater and stormwater runoff to the same local treatment plant [44]. This combined sewer system (CSS) can pose problems during heavy rainstorms, when runoff overwhelms the treatment plants by bringing high volumes of water. When the flows exceed capacity. The mix of stormwater and wastewater is discharged into local waterways to prevent damage to the treatment plant; these phenomena are known as combined sewer overflows (CSO) [45].

3.5.4 Human Health Impacts

Untreated sewage is a serious threat to human health when these CSOs occur. For instance, in Schenectady, NY, aging stormwater and sewer systems lead to an increased risk of untreated sewage overflow during heavy rains, drastically impacting water quality and aquatic life. The overflow carried high levels of bacteria, like *Enterococcus* (a common fecal indicator bacteria), into the Mohawk River. It not only diminished the quality of the water, but it also led to health incidents, including multiple gastroenteritis outbreaks at Union College [47].

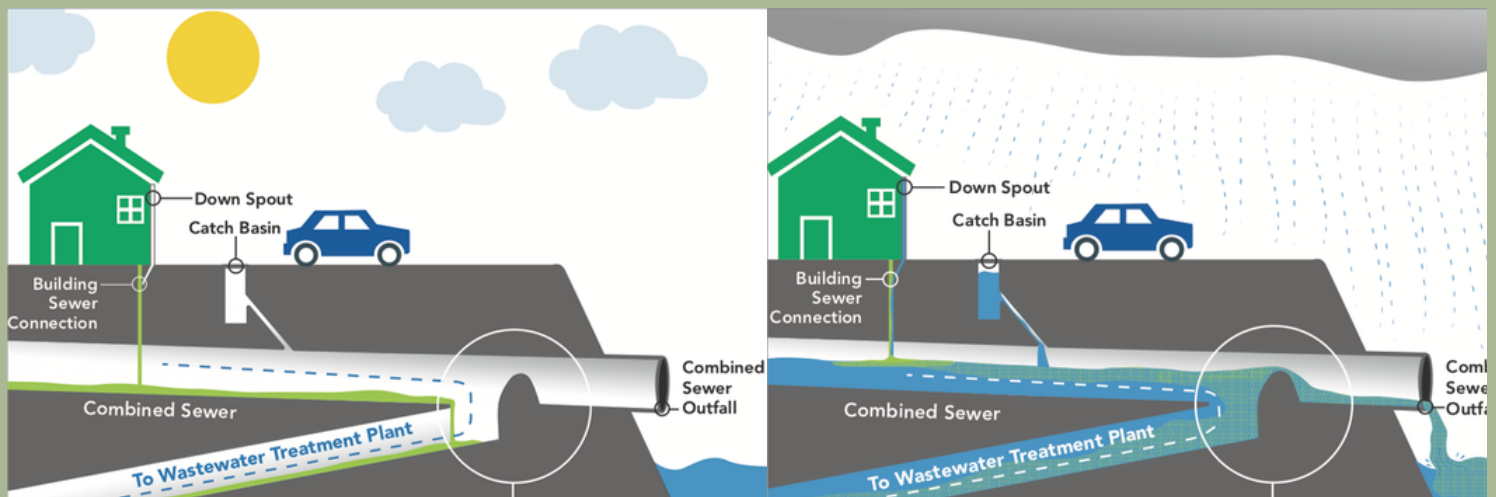


Figure 3.6: Combined Sewer Systems during sunny days and heavy precipitation events, when they lead to a combined sewer overflow [46]

3.5.5 Disruptions of Aquatic Ecosystem

Stormwater runoff threatens aquatic life in two main ways: temperature changes and pollution contamination. Urban surfaces are much hotter during the summer months. As water runs over hot pavements, these flows warm up the surrounding bodies of water, such as lakes, ponds, and rivers. Fish and other aquatic life are sensitive to these temperature fluctuations. They are not able to tolerate hotter temperatures leading to stress, disease susceptibility, and even death [48].

Stormwater runoff is also dangerous because it introduces pollutants to aquatic ecosystems, creating toxic conditions. The hot stormwater carries heavy metals, particulates, organic waste, and sediments. Nitrogen and phosphorus from pesticides and household cleaning products are particularly harmful because they stimulate increased algae growth in the water, known as eutrophication. These algal blooms reduce the amount of available sunlight for other plants. As algae decays, aquatic systems lose dissolved oxygen, which can lead to hypoxia, or the depletion of oxygen, which can result in the

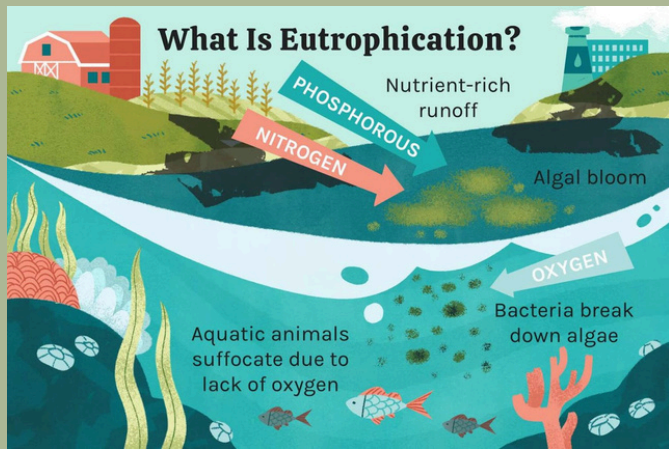


Figure 3.7: Pollutants from stormwater runoff leading to eutrophic aquatic environments and disrupting ecosystem stability [51].

Implementing green infrastructure can mitigate these effects by absorbing, cooling, and filtering stormwater more effectively than impervious surfaces. A satellite-based study showed that with a 10% increase in green space, 3.8% of total runoff flow and 2.2% of the sudden incidence (“flashiness”) of floods can be reduced [50].

3.6 Food Accessibility

For many Americans, food accessibility has proven to be a critical issue in relation to overall health. Many low-income communities across the United States are living in food deserts, which are areas that do not have sufficient access to fresh and healthy foods. Low-income communities are characterized by “low access” to food which can be defined as living over a mile away from a food store in urban regions. In 2015, a study found that

approximately 12.7 percent of U.S. census tracts are classified as low-income, low-access (also known as LILA) [52]. Furthermore, food insecurity has proven to be exacerbated by the increase in food prices [53] due to inflation and economic shifts in recent years. In Houston, as many as 18% of households live in food deserts and are unable to access fresh food due to distance, price, and time [54]. In LILA areas, the available food tends to be highly processed, cheap food that results in a myriad of health consequences.

HOUSTON FOOD DESERTS

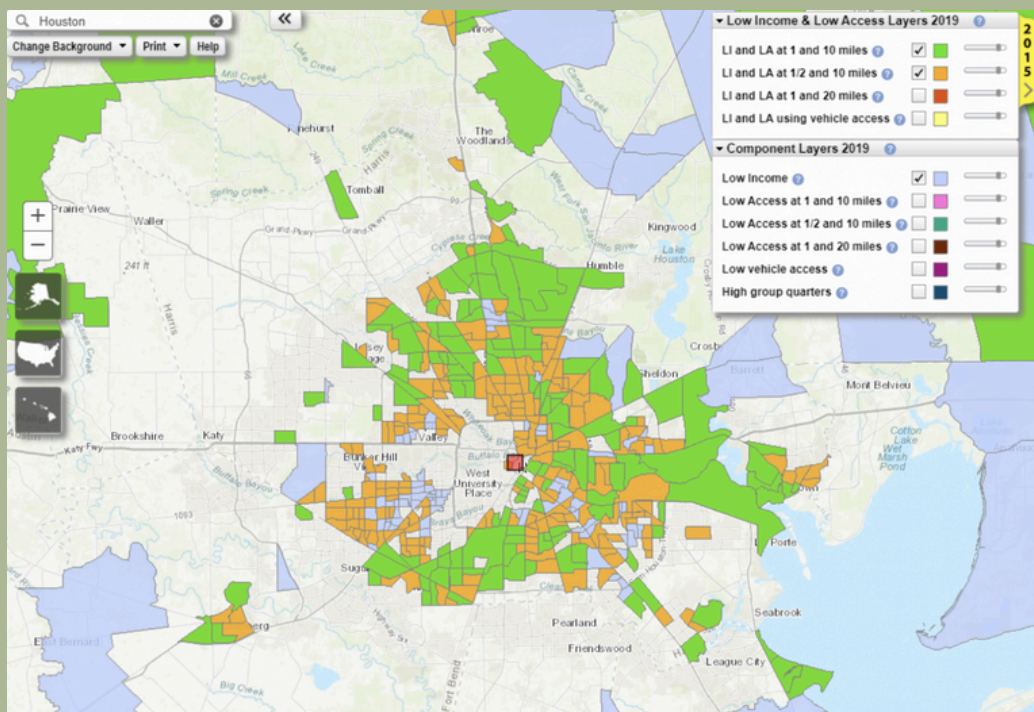


Figure 3.8: Food desert map showing distance from grocery stores where green areas show residents without grocery stores access within 1 mile. Orange areas show residents without grocery stores within half a mile [E].

The lack of access to healthy foods creates a variety of health risks, such as diabetes and obesity, because many of the available food options, like fast food, are low in nutritional value and energy-dense. Food insecurity is also exacerbated as a result of increasing extreme weather patterns, such as certain Houston communities after Hurricane Harvey in 2017 [55]. As many as 200,000 homes and 500,000 cars were destroyed, and grocery stores were closed and boarded up after being damaged [56]. The development of urban areas and increasing extreme weather events present a dangerous problem. As floods destroy crops and grocery stores, decrease the limited availability of food, and displace people, more communities will become food deserts, leading to food insecurity [57]. ■

“APPROXIMATELY
12.7 %
U.S. CENSUS
TRACTS ARE
CLASSIFIED
**AS LOW-
INCOME,
LOW-
ACCESS**”



Figure 3.9: Communities experiencing food deserts have little or no access to fresh and healthy food, but more access to energy-dense, processed foods [58].

CASE STUDY

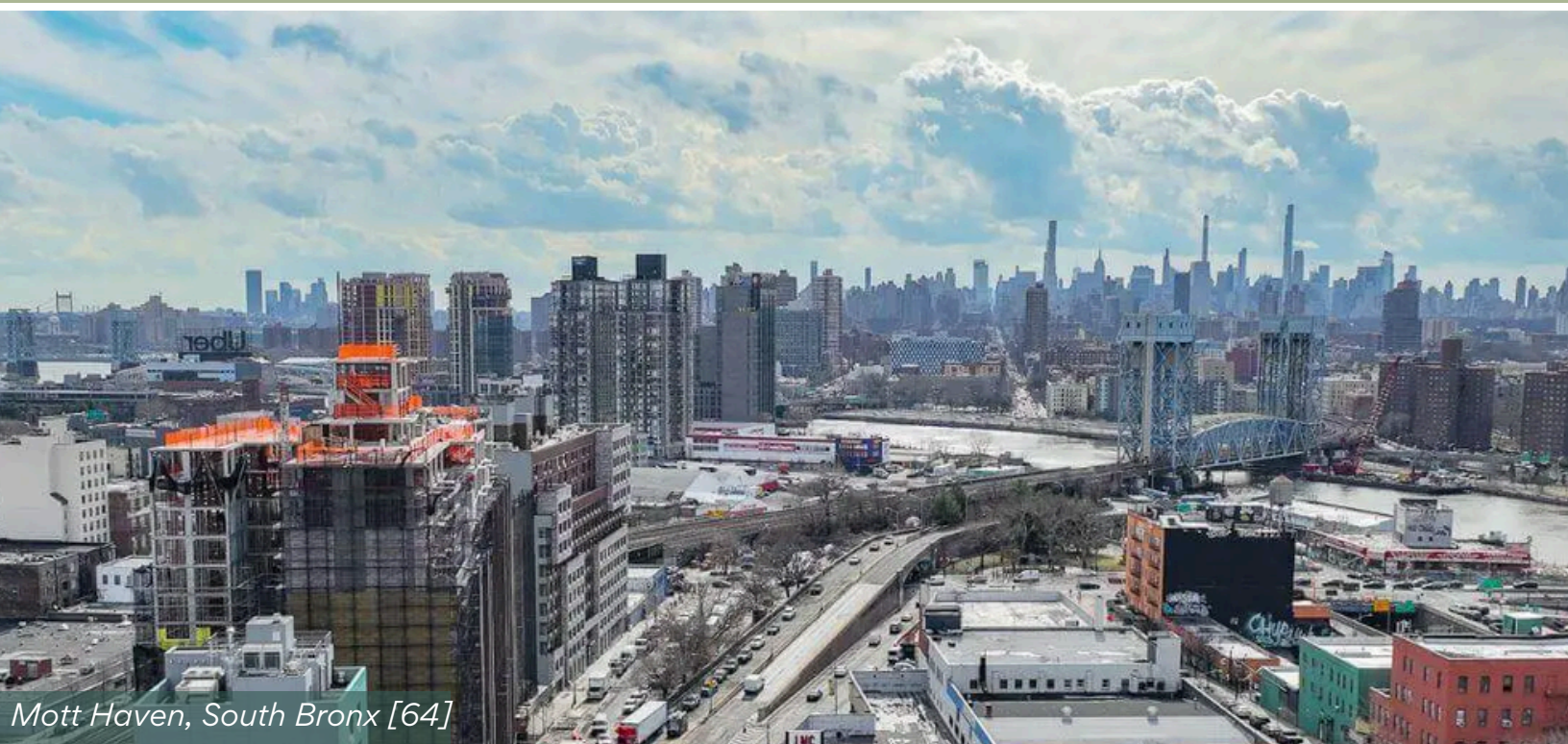
SOUTH BRONX: AN ENVIRONMENTAL JUSTICE PERSPECTIVE

The South Bronx, a neighborhood in New York City, is a stark example of an environmental justice community grappling with a multitude of socio-economic and environmental burdens. As one of the poorest congressional districts in the United States, the South Bronx has witnessed a significant population increase of 7.5% between 2011 and 2021, growing from approximately 1.396 million to 1.501 million residents [59]. This growth has been paralleled by rising surface temperatures, exacerbating the already harsh living conditions in the area.

In the summer of 2018, residents of the South Bronx experienced an alarming 1,300 hours of extreme heat, with temperatures ranging between 105 and 130 degrees Fahrenheit, compared to an average of 86 degrees in New York City [60].

This extreme heat exposure places the South Bronx at the highest level on the Heat Vulnerability Index for New York City. The area's predominantly Black and Hispanic population—64% Hispanic and 31% Black—is particularly vulnerable, with Black New Yorkers twice as likely to die from heat-related illnesses according to the city's Environment and Health Portal [61].

Income disparity further intensifies the vulnerability of South Bronx residents. The community's lower tree canopy cover, a mere fraction of what is seen in wealthier neighborhoods like the Upper East Side, directly contributes to higher surface temperatures. The Upper East Side, with a 52% tree canopy, enjoys temperatures that are on average 9 degrees Fahrenheit cooler than those in the South



Mott Haven, South Bronx [64]

Bronx [62]. This disparity highlights the direct correlation between low-income levels, reduced space, and increased environmental stressors [63].

Higher asthma risks are significantly influenced by environmental and socio-economic factors, with the South Bronx experiencing disproportionate impacts. According to the New York City Department of Health, asthma hospitalization rates in the South Bronx are among the highest in the city, with children particularly affected at a rate of 70.4 per 10,000, compared to the citywide rate of 22.9 per 10,000 [65]. Contributing to this disparity, a 2020 mechanical engineering study highlights the role of extreme heat, which exacerbates respiratory issues by increasing ground-level ozone and particulate matter concentrations, further intensifying asthma symptoms in vulnerable populations [66]. Additionally, research from SUNY indicates that the prevalence of asthma in the South Bronx is not only linked to environmental pollutants but is also compounded by socio-economic stressors, such as inadequate housing conditions and limited access to healthcare, which collectively heighten the risk of severe asthma outcomes [67]. These findings underscore the urgent need for targeted interventions in high-risk communities to address both environmental and social determinants of health.

Urbanization trends, coupled with the ongoing impacts of climate change, place the South Bronx at greater risk of suffering from the destruction of natural systems. The neighborhood meets the eligibility criteria for being classified as a disadvantaged community according to the Climate and Economic Justice Screening Tool (CEJST), which considers both environmental and

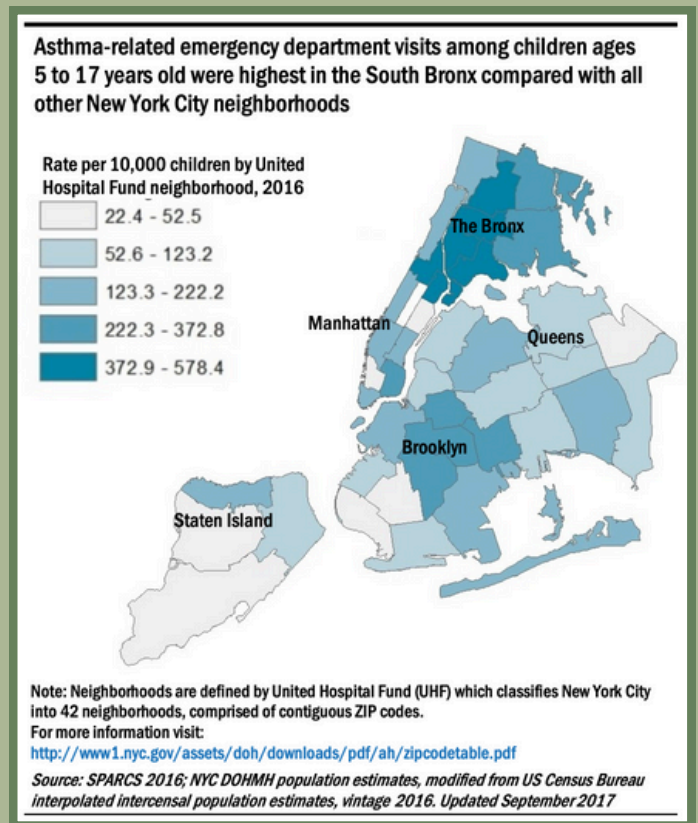


Figure 1: The Bronx region of New York City sees highest instances of asthma in children [68]

socioeconomic burdens. As an urban area with over 5,000 residents, the South Bronx is a prime candidate for funding aimed at mitigating the impacts of climate change and promoting environmental justice.

For instance, urban forestry assistance offered by the Act could prioritize the South Bronx due to its low tree canopy, high BIPOC population, and high surface temperatures. Given the neighborhood's original biome and current building density, increasing the tree canopy could significantly alleviate heat-related stress and improve residents' quality of life. Similarly, the Rooftop Garden Grant could address the lack of urban gardens, high surface temperatures, and low food sovereignty in the community. Implementing these solutions would not only improve environmental conditions but also enhance food security and community resilience in the face of climate change.



Section 4

The Proposed Solution



4.1 Introduction

Rapid urbanization has led to the urban heat island effect, poor air quality, and stormwater pollution, problems exacerbated by climate change and disproportionately impacting low-income and racially marginalized communities. Being trapped in a cycle of disinvestment, the burden of climate change and disrupted natural systems will continue if no investment is made to mitigate extreme effects and build urban resilience. Reintroducing nature to the built environment can reverse some of the disruption

that urbanization has caused, reducing the disproportionate impact. The addition of green infrastructure, such as increased canopy, green spaces, and community and rooftop gardens, as proposed in the Climate Change Relief for Urban Areas Act, can restore the land's ability to manage environmental issues like flooding, combined sewer overflows (CSOs), urban heat, and local air pollution [69]. These nature-based solutions, which improve the health and well-being of urban residents, must be implemented in disadvantaged communities to ensure equitable benefits.

4.2 The Science of the Solution

4.2.1 Urban Heat Mitigation

Vegetation helps mitigate urban heat islands by providing shade, enhancing evapotranspiration, and increasing solar reflection. Trees offer shade, reducing the solar radiation absorbed by buildings and streets, which helps lower surface temperatures [70]. Trees further reduce heat because surfaces with high albedo reflect more sunlight and absorb less heat. The reflective surfaces of leaves have a higher albedo, meaning they can deflect more solar radiation and contribute to cooler ambient temperatures by minimizing heat absorption in urban environments. During summer,

only about 10% - 30% of the sun's radiation reaches the area underneath a tree [71]. Evapotranspiration involves the transfer of moisture from the soil and plants into the atmosphere, which consumes heat and cools the surrounding air [72].

On rooftop gardens, vegetation and soil layers absorb and store less heat than traditional roofing materials. Vegetation typically has a higher albedo compared to conventional roofing materials like asphalt or concrete, meaning that plants reflect a greater portion of incoming solar radiation, thereby reducing heat absorption [73]. Plants in rooftop gardens also evapotranspire, consuming heat energy and cooling the surrounding air [74].

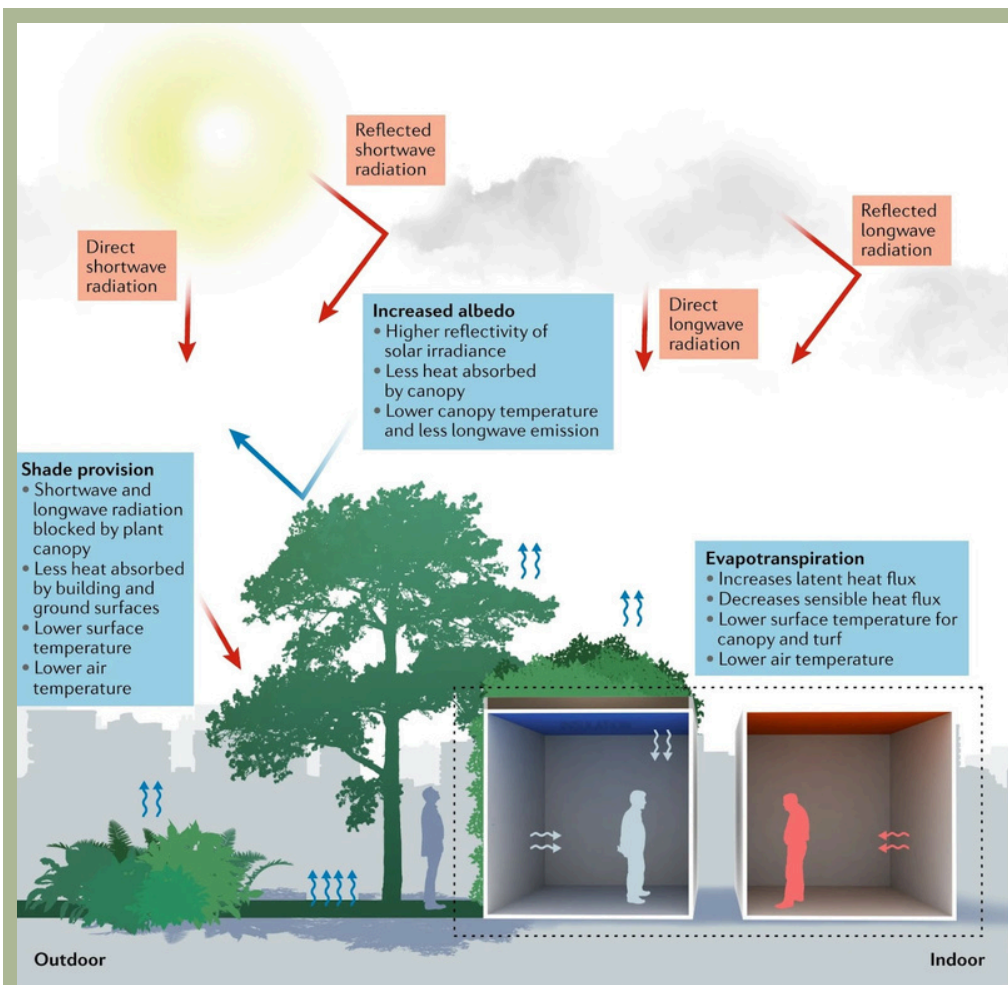


Figure 4.1: Illustration of the impact of increased albedo, shade provision, and evapotranspiration from increased vegetation [77].

Soil and vegetation also have a higher thermal mass than typical roofing materials. Typical rooftops absorb solar radiation during the day, becoming warmer than ambient temperature, and re-radiate the absorbed heat at night. As the roof heats up and cools, it expands and contracts, causing thermal stress on the rooftop membrane and making it more prone to damage and leaks, decreasing the lifetime of rooftops. On green rooftops, the growing medium minimizes temperature variation and, therefore, stress on the rooftop [75]. This can extend the rooftop lifetime by 20 years or more [76].

KEY PERFORMANCE INDICATOR

URBAN HEAT MITIGATION

Target Outcome: Reduce urban heat island effects and improve overall urban climate resilience.

GOALS AND MEASURES

Reduction in ambient temperatures in and near green spaces; decrease in heat-related illnesses and deaths; reduce energy burden

BENCHMARK TIMELINE

YEAR 1

Identify and procure viable saplings, trees and new vegetation.

YEAR 3

A reduction of at least 3.0 °F in surface temperature; reduced school energy demand.

YEAR 5

Increase in the tree equity score for the communities identified as high risk to at least 75.

LONG-TERM STABILIZATION

Reductions in ambient temperatures by 5 °F during the hottest time of day; Reductions in heat-related deaths and hospitalizations; Reduced energy spending in EJ communities

4.2.2 Stormwater Management

Increased urban greenery and rooftop gardens trade impervious surfaces for permeable ones. The porous ground soaks excess water that would otherwise accumulate over pavements and overwhelm sewage systems [79]. Roots of trees can promote infiltration, or the downward entry of water, into the surface of the soil [80]. Tree roots also absorb soil moisture and release it through evapotranspiration, increasing the water storage potential of the soil [81]. Furthermore, leaves, branches, and trunks intercept and absorb rainfall, reducing the speed at which it reaches the ground [82]. In general, the larger the tree, the greater the stormwater runoff mitigation. However, small soil plots, as often seen in cities, limit the extent of a tree's growth. By providing a tree the soil and space needed to grow, large trees can remain healthy stormwater capture systems [83]. A 10% increase in greenspace results in a 3.8% reduction of total water flow and a 4.7% reduction of peak flows [84]. Plants

on rooftops have a similar effect; in a Kansas City experiment, green roofs retained up to 29 inches of stormwater per year on average [85].

Green infrastructure also helps improve the quality of urban waterways by filtering pollutants from rainwater before it reaches water bodies. When stormwater runoff impervious sources, it picks up pollutants like trash or chemicals as it flows into waterways [86]. This process occurs as rainwater passes through soil and vegetation, which can trap and break down pollutants. Vegetation, such as trees and plants in rooftop gardens, absorbs heavy metals, nutrients, and other contaminants through their roots and foliage. Harmful chemicals may be transformed into less harmful substances, used as nutrients, or stored in tree systems [87]. Soil microorganisms also play a big part in breaking down organic pollutants and harmful substances [88].

ROOFTOP GARDEN MECHANISMS

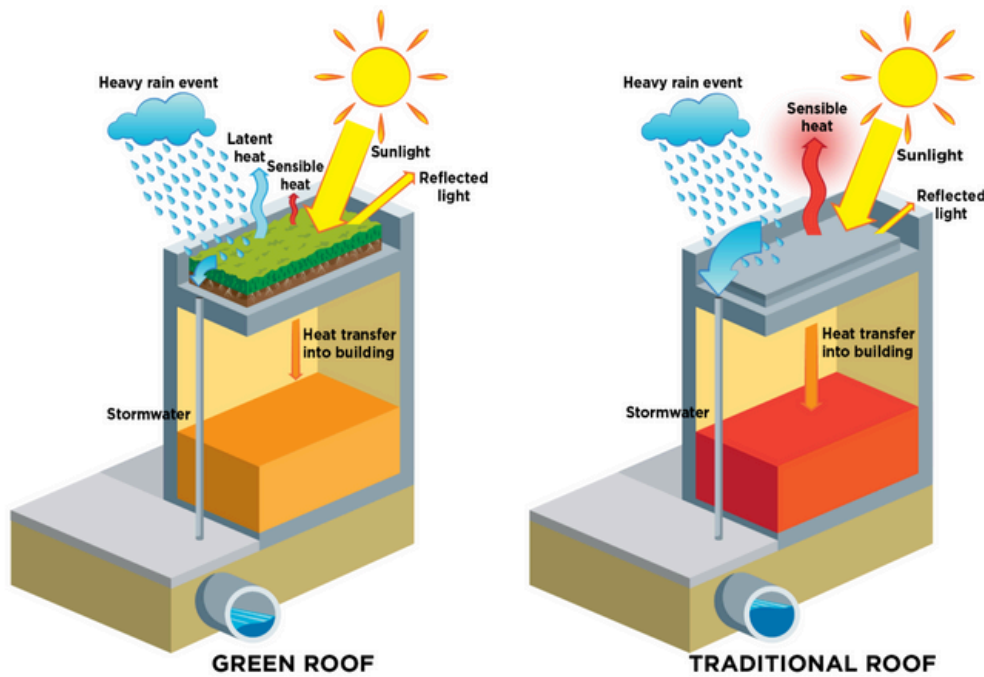


Figure 4.2: Comparison between traditional and green roofs' impact on heat transfer into buildings and stormwater runoff [78].

Figure 4.2 demonstrates the positive impact rooftop gardens have on buildings.

Energy is released or absorbed through latent and sensible heat. Despite both being labeled "heat" latent heat is felt as humidity. Sensible heat is felt as changes in temperature. Green rooftops reflect more solar radiation and release energy primarily through latent heat, rather than sensible heat. As a result, less heat is transferred into the building below.

Green rooftops also absorb water during heavy rainfall, reducing the amount that flows to the sewers.

KEY PERFORMANCE INDICATOR

STORMWATER MANAGEMENT

Target Outcome: Slow and reduce rainwater runoff

GOALS AND MEASURES

Reductions in frequency and intensity of flooding events, flood-related damages, and frequency of CSO events in relevant watersheds

BENCHMARK TIMELINE

YEAR 1

Identity and procure viable saplings, trees and new vegetation suitable for city-specific geo-climate context

YEAR 3

Observe deeper stormwater infiltration, runoff reduction by 30%-50%, and reduced flood peak by 1-2 minutes [89]

YEAR 5

A clear reduction in stormwater runoff (continued), alleviated combined sewage system stress by 10-20%, reduced flashiness by 2-3 minutes

LONG-TERM STABILIZATION

Reductions in frequency and intensity of flooding events, flood-related damages, and frequency of CSO events in relevant watersheds

4.2.3 Improving Air Quality

Urban green spaces improve air quality by acting as natural air filters, using different mechanisms to absorb and process pollutants. Trees and plants absorb CO₂ through photosynthesis, converting it into oxygen and organic matter. This helps sequester carbon, reducing the greenhouse gasses in the atmosphere [90]. For pollutants like SO₂ and NO_x, plants uptake these gasses through their stomata and metabolize them within their tissues, reducing their concentration in the air [91]. Volatile organic compounds are similarly absorbed and broken down by plants. Ozone is absorbed through leaf stomata and detoxified in plant tissues. Additionally, certain plants are capable of containing contaminants in their root and releasing them into the air as less toxic substances, a process known as phytoremediation that can filter and sequester heavy metals from soil and water, though this process primarily impacts soil and water quality rather than directly improving air quality [92]. Research also indicates that a 1°C temperature reduction can significantly lower ozone concentration [93].

4.2.4 Reducing Cost Burden

Green roofs offer long-term cost savings by decreasing the energy required for heating and cooling, thus lowering utility bills. A study demonstrated that rooftop gardens could reduce energy demand by over 75% compared to bare roofs [94]. As previously mentioned, vegetation and soil layers act as thermal insulators, keeping the building beneath cooler in the summer and warmer in the winter. This insulation effect reduces the stress on HVAC (Heating, Ventilation, and Air Conditioning) systems, leading to lower maintenance costs and increased system lifespan. Additionally, green roofs protect the roof membrane from extreme temperature fluctuations, extending its life and reducing replacement costs [95].

4.2.5 Mental and Physical Health

Access to nature and green environments has been shown to reduce stress, enhance mood, and improve overall well-being by promoting the release of endorphins and reducing levels of cortisol, a stress hormone [96]. For children, particularly those in urban schools, exposure to green spaces can enhance cognitive functioning, attention, and academic performance. Green spaces also provide opportunities for physical activity. Activities such as walking, jogging, and gardening promote physical fitness and reduce the risk of chronic diseases [97]. The aesthetic value of green spaces also contributes to a sense of community well-being and quality of life.

Research consistently demonstrates the health benefits of urban greenery. Incorporating agricultural or gardening lesson plans into the school curriculum can enhance students' understanding of environmental and scientific principles from an early age and increase the likelihood of participating in environmental initiatives [98]. Early exposure to environmental education fosters a sense of responsibility towards nature and encourages the development of critical thinking and problem-solving skills [99]. Furthermore, exposure to natural environments has been associated with reducing symptoms of depression and anxiety, highlighting how green spaces can potentially support mental health [100].

4.3 Types of Green Structures

While the Act requires the increase of urban green spaces, this can take many forms. Depending on the spacing and geology, different forms of green infrastructure may be better suited for specific local contexts. This section delves into the different types

KEY PERFORMANCE INDICATOR

COMMUNITY ENGAGEMENT

Target Outcome: Community consent and support on the placement of greenspace and garden

GOALS AND MEASURES

Increase community participation and shared decision-making; Achieve community support for tree initiatives

BENCHMARK TIMELINE

YEAR 1

Identify suitable and recognized spaces to implement UGI plans; Engage local leaders to report on community reception and project impact

YEAR 3

Create sustainable communication systems for long-term initiative success; Gain community support, consent, and participation in tree initiatives.

YEAR 5

Increase social and free time for community members, availability of public interaction spaces, and higher community trust.

LONG-TERM STABILIZATION

Ensure sustainable funding and proper outreach for community projects to avoid burden on underserved neighborhoods.

of urban green infrastructure that could be implemented as well there mechanisms. Among them, tree pits and rooftop gardens are likely the best for environmental justice communities because of their very low cost and maintenance requirements.

4.3.1 Microforests

A microforest is a dense, tiny forest with high biodiversity. The technique is different from reforestation as its goal is to plant trees where there weren't before instead of restoring existing forests. Microforests are planted densely so that they can attract more insects and small animals, replacing areas that have little plant life or biodiversity in the first place. They also absorb significant amounts of carbon. In urban areas, these patches of forest improve health, cool cities more effectively than ornamental vegetation, and remove pollutants. Urban forests have other benefits as well, including creating a buffer against disasters like tsunamis or hurricanes [101].

4.3.2 Tree Pits

Tree pits are effective for stormwater management in dense urban areas because of their small footprint, relatively low cost, and the co-benefits they may bring through improved street tree growth. Studies show that it is possible to achieve a 90% reduction in annual runoff even in dense urban streetscapes with low conductivity soils if the tree pits are sized between 2.5% and 8% of the impervious catchment area. In practice, to achieve this ratio, streetscape will require more consideration in the planning stages of development works and is expected to be most feasible through the implementation of tree pits alongside a suite of other complementary stormwater control measures [102].

This proves that tree pits are significant agents to

reduce stormwater runoff as long as the conditions are met. It is more feasible to have the soil be open next to the roads so that the trees and other plantations can grow freely without the limitation of the solid blocks of the sidewalk. This can not only reduce the cost but can also support a greater amount of vegetation to mitigate runoff. Another important factor to consider is the top layer of the soil. It is better to cover the edge of the roads with loam instead of clay and sand so the plants can have a healthier environment [103].



Figure 4.1: Tree pits substitute impermeable surfaces for permeable ones [104].

4.3.3 Rain Gardens

A rain garden is a garden of native plants in a small depression formed on a natural slope. The vegetation in the rain garden can filter the rainwater collected by it into the soil, and in the meantime, recharge groundwater aquifers and wash off pollutants. It can temporarily hold the rainwater runoff that flows from roofs, driveways, or lawns. Rain gardens are effective in removing up to 90% of nutrients and chemicals and up to 80% of sediments from the rainwater runoff. Compared to a conventional lawn, rain gardens are 30% more effective in soaking water into the ground. In addition

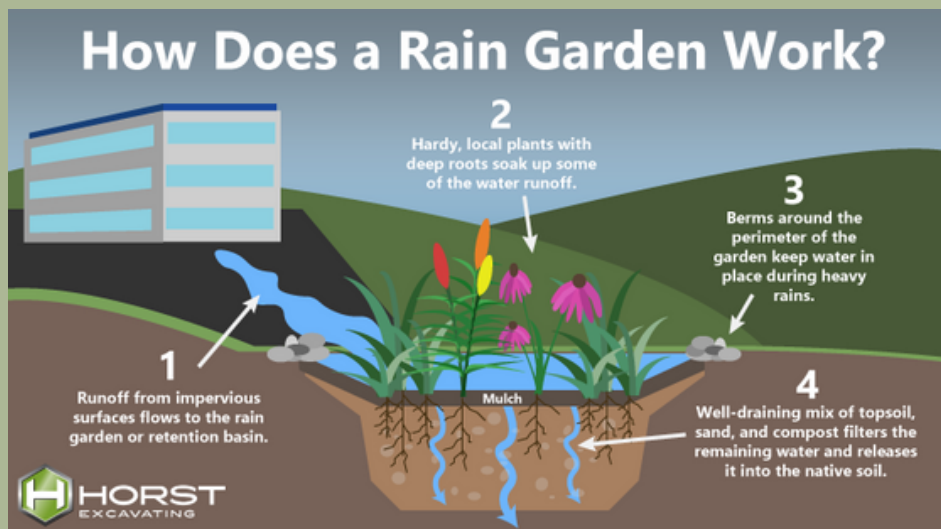


Figure 4.3: Explanation of the functionality of rain gardens. [107]

roof. In fact, while rooftop gardens can be initially more expensive than traditional roofs, the rooftop garden's prolonged life span and lower energy costs lead to a 5.25% lower cost than conventional roofs over a 40-year period (the typical lifespan of a rooftop garden before renovation) [108].

Traditionally, extensive roofs use a variety of sedum, which

to heat mitigation and stormwater management mentioned above, the benefits of a rain garden include:

- Preserves native vegetation.
- Attracts beneficial birds and pollinators.
- Easy to maintain after establishment [105].

They can also be of any size. They can be as big as parking lots, or as small as a tree pit. For a low-income community, it is a good idea to combine the tree pits on sidewalks with rain gardens, just like how the Bronx area of New York does for its runoff mitigation [106]. There can be a small opening on the side of the tree pits to collect rainwater, and once a garden is full, the rainwater will move on to the next pit. Because rain gardens require little space and upkeep money, this is an effective way to manage runoff in environmental justice communities.

4.3.4 Rooftop Gardens

Rooftop gardens are gardens built on a roof that can cool down the temperature directly above the roof to decrease the energy demand of indoor areas. They can also store water to provide better stormwater management, and attract pollinators and other insects to increase urban biodiversity. These are particularly good options for environmental justice communities, as they reduce heating and cooling costs, as well as prolong the lifetime of the

is a low-growing, low-maintenance, drought-tolerant ground cover flowering plant seen in many landscapes and rock gardens. These plants are easy to grow, spread quickly, and generally tend to crowd out other less desirable plants [109]. They are the most suitable plants for a rooftop garden. In the meantime, rooftop agriculture can increase access to healthy food. Rooftop farming in urban areas provides more people with access to self-grown food. Growing food where it is consumed reduces the need for long-distance transportation, making local produce cheaper and fresher due to fewer food miles [110]. This is essential for poorer communities as food security is generally an issue.



Figure 4.4: Chicago city court house green roof [111].

CASE STUDY

OTTAWA ROOFTOP GARDEN



Figure 1: Ottawa Rooftop Garden on NRC building. (Source: Government of Canada) [113]

Ottawa, Canada's capital, has multiple rooftop gardens that are accompanied by various benefits and environmental services. With a population of 1,070,889, the city has the potential to employ green infrastructure to improve energy efficiency, stormwater runoff, and temperature regulation. For instance, the National Research Council of Canada (NRC) has constructed a green roof on its Ottawa campus that spans 70 m² (800 ft.²). The plants on the rooftop regulate surrounding air temperatures through evapotranspiration and shading [112].

The Ottawa Rooftop Garden was established upon a building in Ottawa as part of UGI. This project demonstrated multiple benefits of rooftop gardens in terms of temperature regulation, stormwater management, and energy efficiency. In this case, when outdoor temperature reached 95°F, the bare roof temperature reached 158°F, while the vegetated roof temperature was only 77°F. This significant temperature difference highlights the potential of vegetation to mitigate the urban heat island effect.

Additionally, the rooftop garden delayed runoff by 45 minutes and absorbed at least 2 mm of water before runoff occurred. This indicates the effectiveness of rooftop gardens in reducing stormwater runoff and preventing flooding. Its vegetation cover and soil layer act as insulation, reducing heat loss and absorption by the building.

The green roof reduced the average daily energy demand from 6.0-7.5 kWh/day (20,500-25,600 BTU/day) of the traditional roof to less than 1.5 kWh/day (5,100 BTU/day). This 75% reduction lowers the use of air conditioning and heating systems.

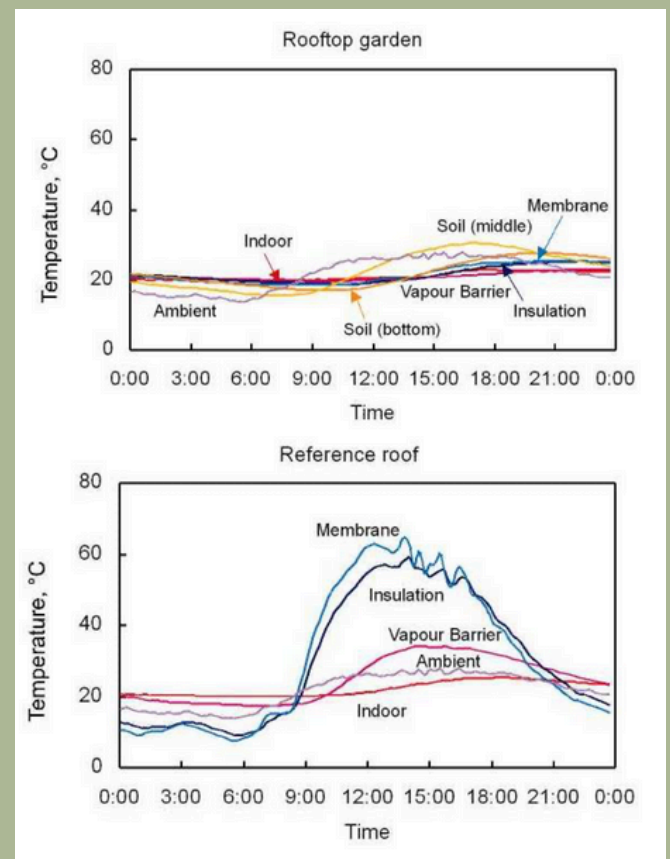


Figure 2: Temperature profile within the roofing systems on a hot, sunny summer day indicated that the rooftop garden reduced the temperature fluctuations within the roofing system [114].

4.3.5 Bioswales

Bioswales are linear, vegetated ditches that allow for the collection, conveyance, filtration, and infiltration of stormwater. The primary benefits of the bioswale are the treatment of stormwater quality and the added vegetation can be visually appealing if decorative plant species are chosen. Additionally, the added green space could provide habitat for some wildlife species [115].

Without the bioswale, water flows off asphalt surfaces into storm gutters or along curbs until it reaches a storm sewer drain. On the other hand, a

bioswale replaces the conventional concrete gutter with a natural, earthen one. The vegetation within the bioswale slows down the water's flow allowing the water to be filtered into the soil, reducing the pollution that would have been gathered by the storm gutters [116].

Bioswales are suitable for disadvantaged communities because they are cheap and easy to construct. On top of that, they do not need much care and maintenance since the vegetation only serves to slow down the water flow.

BIOSWALE

With community input and volunteer assistance, The Watershed Project is creating bioswales along the Richmond Greenway. The bioswale captures the stormwater and slows it down, keeping the water from flooding homes, the Greenway path, and nearby streets, where it creates potholes. The bioswale helps clean the water before it enters the San Francisco Bay as well. The native plants in the bioswale also create habitats for birds and butterflies.

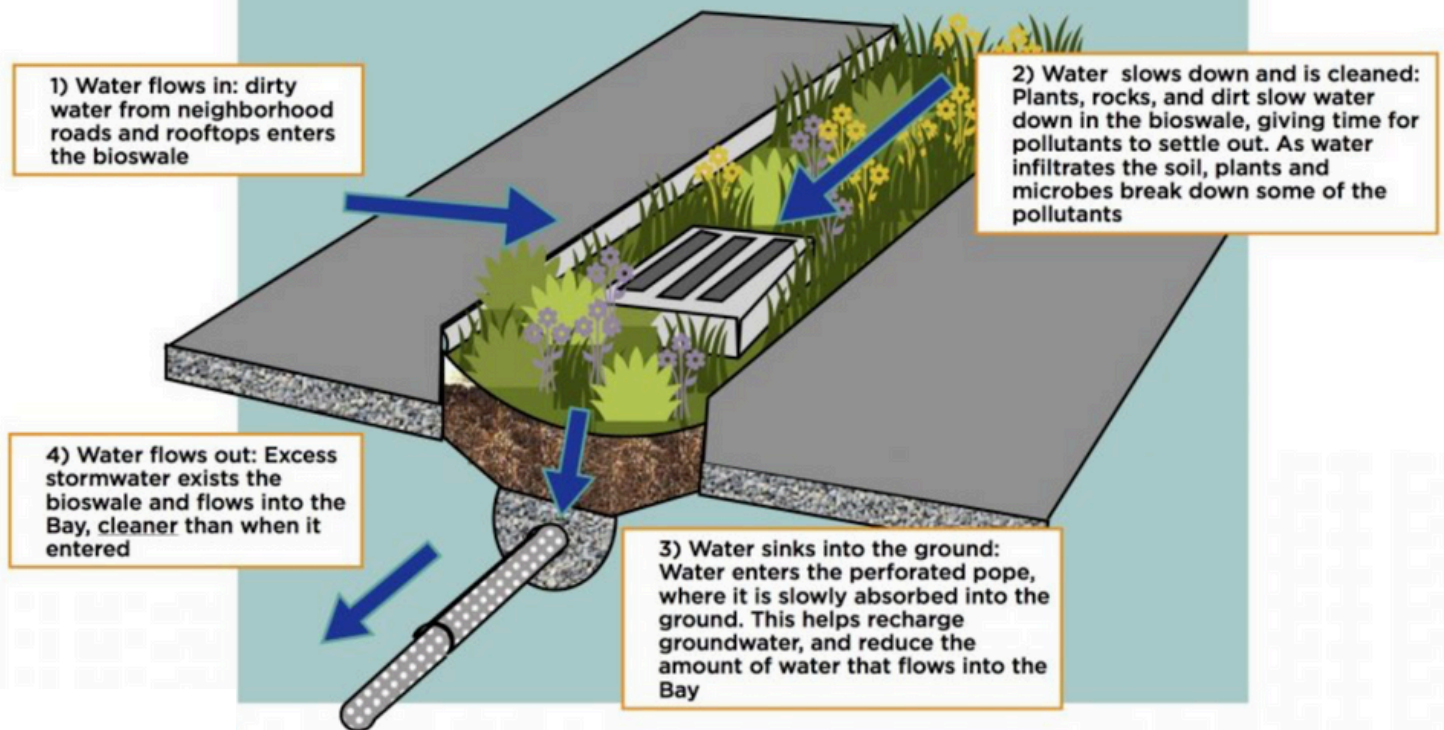


Figure 4.5: Diagram of a Bioswale [117].

4.3.4 Raised Flower Beds

Raised beds are generally more productive than in-ground beds. This is because their soil is less compacted, they have better drainage, and they warm up faster in the spring. These advantages can promote earlier plant growth. Additionally, raised beds are easier to maintain as they typically experience less pressure from perennial weeds [118].

The main advantage of the raised flower beds is that they can reduce the risk of contaminants. The layer of landscape fabric of the raised flower beds will prevent plant roots from entering the contaminated soil below the bed [119]. This means that this type of greenery structure can support plant life in more contaminated areas. Especially in the environmental justice communities, people can use these raised flower beds to grow vegetation without worrying about the soil pollution they might be facing, increasing their food security and greenery coverage.

4.4 Greenery Selection

Species selection is always contextually important. Depending on climate and geography, the most suitable and cost-efficient plants are not always the same from city to city. Many considerations need to be made for selecting the best greeneries to plant in green spaces and gardens, including soil type, nitrogen availability, climate adaptation, aesthetics, shading sizes, tolerance for human activity, and much more. As outlined explicitly by the bill, native greenery is also necessary as they are the foundation of the biodiversity of an area. The selected plants and vegetation need to be species that can survive in harsh and urban environments with little maintenance, and be flooding and drought-resistant as the weather patterns are changing across the United States. Urban areas often lack good quality soils, enough spaces for roots to



Figure 4.6: Image of raised flowerbeds within an urban garden [120].

expand, as well as varying levels of heat and pollution. In this section, we will examine the selection of native species, trees, and general vegetation.

4.4.1 Native Vegetation

The bill requires 20% of the species to be planted to be native species. Although the rationale for that number is not clearly enumerated, there are various benefits to the implementation of native species. Native plants and trees are the ones that are naturally found in a region or specific location [121]. They represent important habitats for animals and wildlife from those same regions. They are often adapted to the local environment which might mean they require less maintenance, are water efficient to the region's climate, and fare better against diseases and pests [122]. The enhancement of biodiversity and climate adaptation are the reasons the bill pushes for their incorporation into the solution.

American Hornbeam

The American Hornbeam is an excellent choice for both garden and street trees, particularly when grown with sufficient crown clearance. While they grow slowly, they are relatively easy to transplant

with proper techniques. The American Hornbeam has a modest root flare and non-aggressive root growth [123]. This means that the chance of infrastructure being damaged by the tree branch is very low, making it a suitable tree species to plant in crowded urban areas, or in more compact organizations.

Flowering Dogwood

The Flowering Dogwood is a vibrant and fruit-bearing tree native to the eastern United States. It has gained popularity among city planners and homeowners for its resilience and the numerous benefits it offers to wildlife. This tree provides year-round support to various species, including supplying pollen to pollinators, nourishing birds, mammals, and insects, and offering essential habitat for wildlife. Additionally, the fruits of the Dogwood are rich in calcium and fats, making them a valuable food source. These trees also enhance the surrounding soil as they grow, which can contribute to the overall health of the ecosystem [125].

4.4.2 Tree Selection

Selecting trees that will be implemented in the urban environment of the selected environmental justice communities is a process that considers many factors. Species that will be prioritized are those that thrive in harsh environments, with exposure to high and extended periods of heat, both periodic

flood and drought conditions, and possibly limited access to direct sunlight because of neighboring buildings. On top of that, it is important to select species that have an extended canopy that will cover large surfaces, to increase the amount of shaded areas and to also decrease the speed of rainfall. Although the bill is looking to promote native species, the selection is not limited to those. Professor Matthew Palmer PhD, an urban ecology professor at Columbia University, stated that while restoring all-native plants sounds attractive, implementing non-invasive non-native species should be considered in the species selection process as some of them might be used to surviving in arid and harsh environments that climate forecasts predict for the future.

Ginkgo Tree

This tree can tolerate both hot and cold temperatures. It can thrive in harsh urban environments full of air pollution, soil pollution, and water pollution. This makes them the perfect tree species to select for urban greenery as they have low requirements and can still deliver the water management function efficiently. The ginkgo is not picky about soil type or most soil conditions and will tolerate both acidic and alkaline soil, as well as compacted soil like clay. As a matter of fact, they are much more tolerant of compacted soil than

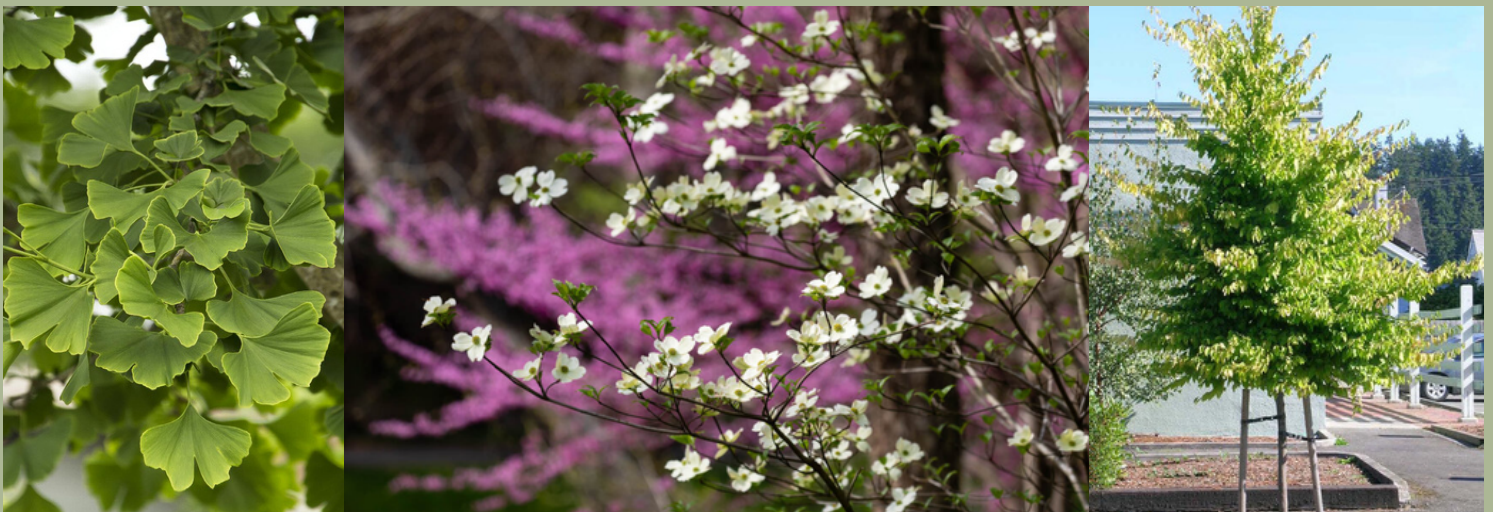


Figure 4.7: Image of Ginkgo Tree leaves [128], the Flowering Dogwood [126], and the American Hornbeam [124]

most other types of trees. They do prefer well-drained sandy soil or loam with a pH in the 5.0 to 8.0 range [127].

4.4.2 Vegetation Selection

When it comes to selecting the vegetation that will be implemented on the rooftop gardens, similar criteria as the one mentioned for tree selection will be considered. It is important for the vegetation that is selected, to be from species capable of surviving heat waves that are experienced in those areas. They need to survive in soils that have a low nutrient count as well as survive extreme weather events. One important factor in vegetation selection is the selection of water-thirsty plants that will absorb the water from precipitation, redirect runoff from storm drains, and protect the roofs. Food sovereignty is a crucial component of the bill so selecting nutritious and calorie-dense fruits and vegetables will be part of the process. To boost environmental stewardship and community cohesion, it is also implied that aesthetically pleasing plants will be chosen.

Example considerations for both vegetation and tree selection include:

- Procureability
- Suitable for urban environments (being able to withstand excess rain, periods of drought, poor soil quality and quantity, heat)
- Excellent transpiration with high plant coefficients for maximized water uptake
- Low maintenance
- Provide aesthetic value
- Be 20% native and include all non-invasive species.

Panicum virgatum

This plant is native to North America, adaptable and able to grow under a variety of environmental conditions. It is drought - and wet-tolerant, with low soil requirements, and can grow in a variety of soil types from poor sandy soils to rich loams. It can also adapt to different PH environments. Also, longbeard

grass is popular in horticultural design because of its tall posture and detailed leaves and is often used in landscaping. It is also used to prevent soil erosion and improve soil structure. Long whiskers provide important habitat for a wide variety of wildlife. Its dense grass provides shelter and feeding grounds for birds, small mammals, and insects [129].

Ferns

Ferns are adapted to relatively high temperatures and can survive in urban areas. These urban ferns could serve as a practical and low-maintenance solution for addressing urban heat island effects [131]. In an urban setting, ferns can absorb CO₂ from the atmosphere and release water vapor, thus improving the effects of climate change. They are also able to make forests healthier and more resilient [132]. ■



Figure 4.8. Image of switchgrass [130].

CASE STUDY

HIGH LINE PARK IN NEW YORK



Graphic: An iconic aerial of the High Line at Little West 12th St. Graphic from Friends of the High Line [138].

New York City has been among the most urbanized in the world in recent centuries, Manhattan's average floor area ratio (FAR)--the ratio of a building's total floor area to the land on which it sits--to double between 1910 and 2010.

The High Line Park is a unique example of Urban Green Infrastructure (UGI). It is 1.45 miles long and built on a disused elevated railway track. It runs through several neighborhoods in Manhattan's West Side, from Gansevoort Street to 34th Street [133]. Since its opening in 2009, the High Line Park has become an iconic example of urban greening, providing multiple environmental, economic, and social benefits.

The High Line Park effectively reduces pollutants such as carbon dioxide and particulate matter (PM_{2.5}) by approximately 37% from the air with its rich vegetation and green spaces [134]. An additional analysis suggests that the average PM_{2.5} concentration is approximately 7.7 $\mu\text{g}/\text{m}^3$ greater on the footpath than the High Line. However, a large standard deviation in the data is noted and a 95% confidence interval suggests that this difference may be as low as 2.8 $\mu\text{g}/\text{m}^3$. [135]

Its design not only improves the local air quality but also provides a fresh living environment for citizens. Besides, the park's vegetation and green spaces help lower the surrounding area's temperature by up to 5°C (9°F) during warmer months, mitigating the urban heat island effect [136].

It also has stormwater management, such as reducing runoff by its permeable surfaces and plant covers and collecting rainwater for irrigation and reuse. For biodiversity, the High Line Park hosts over 500+ plant species, providing habitat for birds, insects, and other wildlife [137]. The green belt contributes to the restoration and protection of biodiversity acting as a "green corridor" in the city.

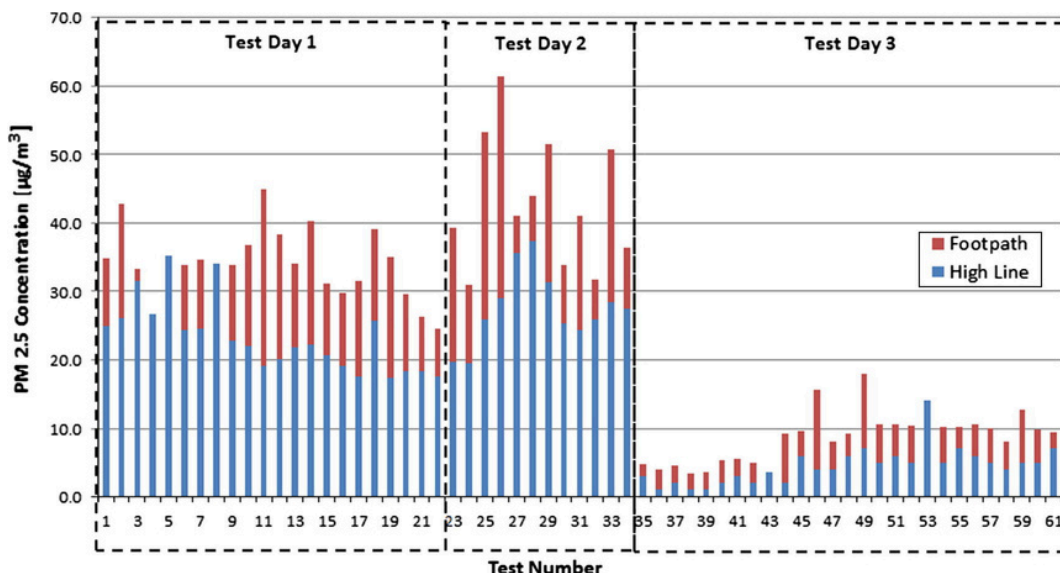


Figure A: Blue represents Highline air quality, red represents roadside air quality [139].

Air quality measurements made as participants walked from the start to the end of the measurement path on both the Highline and by the road.

CASE STUDY

RICHMOND, VIRGINIA: ENVIRONMENTAL INITIATIVES



Reclaimed industrial space, the Low Line [140].

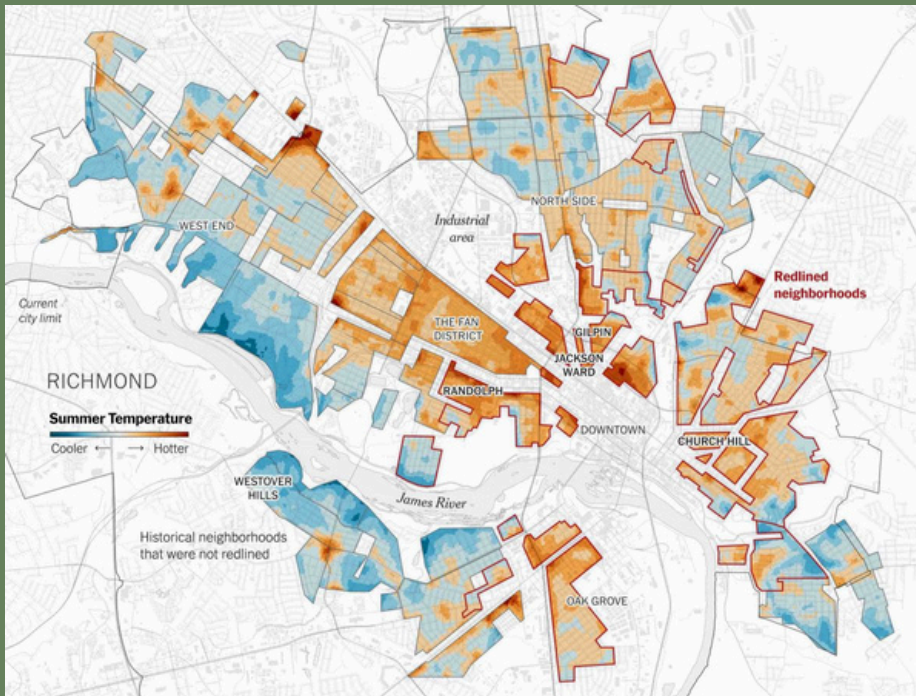
Gilpin, a neighborhood within Richmond, Virginia, is shaped by a history of redlining, resulting in a variety of environmental and socioeconomic disparities [141]. During the 1930s, redlining practices diverted investments away from neighborhoods based on race. The denial of mortgages created a cycle of poverty within Richmond and across the US, where little accumulation of wealth passed down to the following generations in redlined neighborhoods compared to their wealthier, white counterparts that received loans. White neighborhoods with higher property values often had more time to self-advocate in city governments for beautification and green spaces that provide shade, cooling, and recreational benefits [142]. Meanwhile, as homeownership deteriorated in Gilpin and other black neighborhoods, landlords failed to invest in these areas.

We see this in formerly redlined neighborhoods within Richmond which currently have 12% tree and parks cover compared to 42% in wealthier neighborhoods [144]. City planners also targeted the cheap land within redlined areas for construction projects such as highways, public housing, and warehouses. As a result, black neighborhoods became

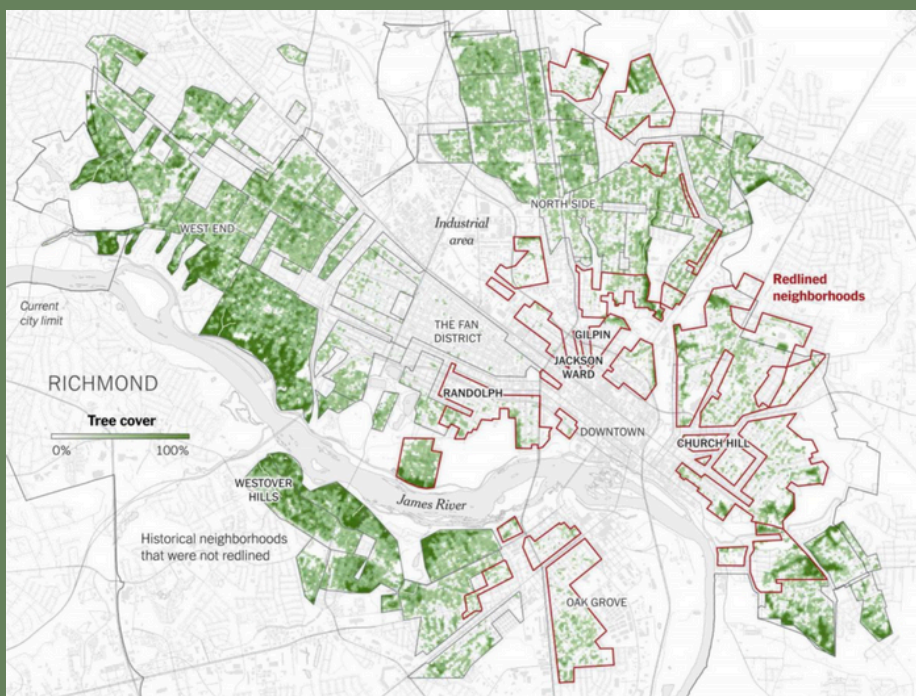
characterized by bare sidewalks, impervious surfaces, and heat-absorbing asphalt.

The dangerous mix of heat and poverty result in a variety of harmful implications for Gilpin's residents. The urban heat island effect serves to exacerbate existing health issues such as asthma, diabetes, and high blood pressure in addition to creating additional heat-related illnesses and psychological stress. Residents within Gilpin also do not live in close proximity to a doctor's office or grocery store, so they are forced to travel significant distances to meet their needs.

The presence of green spaces, such as community gardens, has proven to be a powerful tool in mitigating the adverse effects of urbanization and climate change. In Richmond, the



Temperature disparities between redlined Black neighborhoods and white neighborhoods. White neighborhoods were more likely to be cooler, whereas Black neighborhoods experienced the hottest temperatures due to lack of trees and more urban infrastructure [145].



Percentage of tree cover comparing formerly redlined areas and those that were not. Darker green areas show a higher percentage of tree cover, whereas historically redlined areas have fewer or almost no tree coverage [143]

Southside neighborhood exemplifies the positive impacts of these green spaces [146]. The installation of a lush community garden in Southside has provided residents with fresh fruits, sourced directly from newly planted fruit trees, and has offered significant cooling effects through the process of evapotranspiration. Additionally, these green spaces foster positive social connections by serving as venues for recreational activities and incidental interactions, thereby strengthening community bonds. This combination of social interaction and close proximity to nature enhances individual and community well-being [147].

Richmond's city planning reflects a deep commitment to expanding the benefits of green spaces, particularly in historically excluded communities. The city's master plan, Richmond 300, outlines a comprehensive strategy to improve walkability and establish extensive greenway networks across the city. This plan works in conjunction with the RVAgreen 2050 Framework, which highlights the racial and socioeconomic disparities within Richmond and integrates an Equity Screening Tool and

Climate Equity Index to identify the regions most in need of environmental, transportation, building, and community resilience improvements [148].

These initiatives are crucial steps toward addressing the legacy of redlining and ensuring that the benefits of urban green infrastructure (UGI) are equitably distributed.

Richmond's ambitious goal is to ensure that by 2037, 100% of its residents live within a 10-minute walk of a park [149]. The Richmond Greenway project is a key part of this vision, transforming underutilized and often neglected spaces into green corridors that offer recreational opportunities while also acting as critical buffers against flooding and urban heat. By converting former industrial sites into parks and gardens, the project has introduced essential vegetation and tree cover, which play a vital role in reducing temperatures and improving air quality in surrounding areas.

The Bellemeade neighborhood is another area where UGI has had a profound impact. Initiatives led by the Green Infrastructure Center and Capital Trees have resulted in the installation of rain gardens, bioswales, and extensive tree planting. These efforts have been particularly effective in managing stormwater, reducing runoff, and lowering the risk of flooding in this low-lying area [150]. The increased vegetation not only contributes to cooling the local environment but also provides relief to residents who have historically borne the brunt of extreme heat events.

“RICHMOND’S
AMBITIOUS GOAL
IS TO ENSURE
THAT BY 2036
100%
OF RESIDENTS
LIVEN WITHIN A
**10-MINUTE
WALK OF A
PARK”**



Section 5

Scientific Issues and Controversies



5.1 Introduction

Urban green infrastructure efforts have an extensive research body and incorporate the perspectives and involvement of a multitude of stakeholders. Although the majority of research agrees on the temperature, stormwater damage, and air pollution reduction benefits of urban green infrastructure, many scholars disagree on the scales of impact that urban green infrastructure can generate. Simultaneously, socio-economic and political barriers to urban green infrastructure efforts can undermine and potentially prevent urban greening programs from being

successful and serving disadvantaged communities. Addressing scientific inconsistencies through research and socio-economic and political controversies through meaningful engagement and targeted advocacy is essential to the success of the urban green infrastructure programming being supported by the Act.

5.2 Scientific Issues and Controversies

The scientific community largely recognizes that climate change and urban land use are negatively

extreme precipitation and flooding, and food deserts. Solutions research has mostly agreed on key benefits such as climate resilience, improved air quality, reduced energy consumption, and improvements to health and well-being [151]. However, the implementation of the urban green infrastructure might be site-specific due to varying conditions, like climate, space, and human influence, and the potential return on investment varies greatly as a result. Disagreements arise regarding the

effectiveness and implementation of these solutions in cities, and there remain many issues that still need more research.

5.2.1 Viability of Urban Ecosystems

While urban areas are the target vlocation for increasing tree canopy, they can pose serious threats to plant health due to the harshness of the urban environment. Urban trees are susceptible to

CASE STUDY

NYC TREES PESTS AND DISEASES

One of the most significant challenges trees face in urban areas is diseases and pests, which make it harder to implement and maintain urban green infrastructure. Many tree programs across the U.S. began using ash trees to replace elm tree populations that were destroyed by Dutch elm disease. This is because ash trees are favored as a tolerant species that can withstand urban environments. In NYC, there are an estimated 121,000 ash trees along the sidewalks and in parks [152]. Unfortunately, ash trees are facing emerald ash borer infestations that were first detected in 2009 when tree initiatives, like MillionTreesNYC, became popular. Emerald ash borers are invasive beetles that lay eggs on the bark of ash trees. Once these eggs hatch, they burrow into the tree and feed on the tissue. The feeding destroys trees because they create tunnels that damage the circulatory system of a tree needed for transporting water and food [153]. Once a tree is infected, it is hard to recover it. There is a loss of benefits that ash trees would provide, like heat mitigation and increased air quality. As climate change worsens, trees are becoming more vulnerable to insect and disease outbreaks. Cities are starting to see more tree diseases destroying different species, such as beech leaf disease and



Image of emerald ash borer infestation within tree bark [155]

oak wilt. In urban parks, these diseases are devastating because diversity is important for building resilience in a forest ecosystem. In urban areas, where trees are already susceptible to different stressors [154]. Tree planting may not be a solution as these urban stressors make them more susceptible to diseases and pest infestations.

extreme heat, floods, droughts, diseases, human activity, and poor soil conditions. In New York City, the MillionTreesNYC initiative planted, researched, and cared for 1 million trees over 8 years [156]. However, more than 25% of those trees have already died or gone missing due to unfavorable climate conditions and human intervention. In this case, trees are not able to grow to full maturity with a large canopy of leaves to benefit surrounding areas with shade and cooling.

5.2.2 Water Usage

Most scientists agree vegetated lands have better infiltration compared to impervious surfaces. It is also agreed that implementing more green infrastructure will be able to mitigate stormwater runoff, slow down water flow, and reduce flooding in urban areas. However, tree planting programs rarely consider the historical climate of the area. In historically dry and desert environments, maintaining urban forests requires extensive maintenance. These unfavorable conditions limit soil-water content putting stress on trees' biological functions. As climate change worsens, droughts and high temperatures could damage trees and gardens and increase their water demands [157]. In Los Angeles, for example, urban forests could consume up to 62% of water use due to high transpiring species [158]. In places that are already experiencing water shortages, green infrastructure might be risky when so many residents rely heavily on an already budgeted water supply. It may also not be a viable option because lack of water availability damages a tree's stomates or the small openings that control water loss [159]. During droughts, stomata close to conserve water and if the soil is dry, they may not open at all. In extreme drought cases, like in Los Angeles, the benefits of cooling from trees through evapotranspiration (ET) would be lost because ET relies on the availability of soil water and stomatal functions [160].



Figure 5.1: Lake Oroville California water source depletion from 2019 to 2021 due to extended droughts [161]

5.2.3 Air Quality and VOCs

Increased green space may also contribute to air pollution, leading to worse health outcomes for surrounding residents. Many planted species emit volatile organic compounds (VOCs) or organic chemicals that turn into vapor to attract pollinators and repel predators [162]. They are precursors to smog, ozone, and PM_{2.5} formation [163]. Once reacting with these chemicals, they form larger compounds and may react with greenhouse gas emissions from human activities, such as fossil fuel burning [164]. In urban areas, low biodiversity and an overabundance of pollen producers are linked to concentrated pollen emissions and can trigger pollen allergies [165]. Other studies have found that the presence of air pollutants (i.e., CO₂) can enhance the allergenic potential of pollen grains [166]. This happens when gaseous pollutants, like sulfur dioxide, damage pollen grains reducing their size. Microscopic particles are then able to penetrate the respiratory tract. Overall, urban pollutants and tree

pollen have a synergistic effect that has been shown to contribute to a higher prevalence of asthma within cities [167].

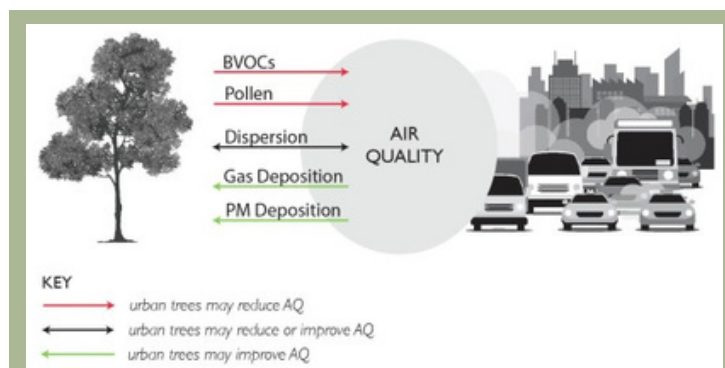


Figure 5.3: How VOCs from trees and urban air pollution combine to reduce air quality in cities [168].

5.2.4 Extreme Heat Impacts

While the science agrees on the heat-reducing benefits of urban greenery, studies have not determined a specific amount of tree canopy cover needed to make large-scale impacts in cooling

surface temperatures [169]. In a Phoenix study, an increase of around 10% to 25% in tree cover showed 2.0 °C of cooling at a local scale, but other studies in different cities have shown similar benefits with varying tree canopy increases [170]. More studies are needed to understand how much tree canopy cover can mitigate UHIE in urban areas, especially on a wider scale.

5.2.5 Public Health Effects

The link between health and increased urban green infrastructure is hard to measure because of many confounding variables. For example, green roofs have the potential to reduce extreme heat, which is also linked to mental health outcomes [171]. Many studies focus on health benefits obtained from recreation opportunities resulting from access to nature, but further studies are

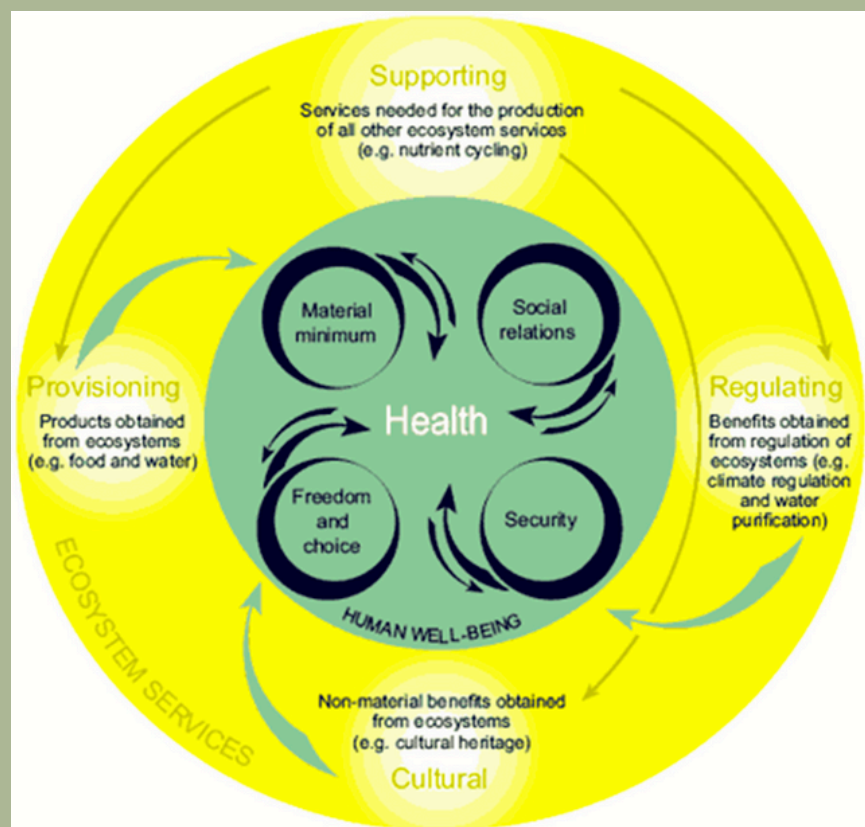


Figure 5.2: Health effects of implementing urban green infrastructure [173].

needed to quantify the impact of confounding variables versus increasing green space on human health [172]. For example, the implementation of green infrastructure can have a variety of benefits, like decreased flood risks, mitigating UHIE, and building urban resilience to other climate-related issues. UGI can lessen anxiety and bring feelings of comfort due to surrounding urban stressors and burdens being reduced.

5.3 Socio-Economic and Political Controversies

In addition to certain disagreements about the scale of impact laid out by the scientific community, the political and socio-economic nature of urban greening efforts allows for certain controversies to arise. Urban greening involves a multitude of stakeholders, including lawmakers and administrators at various levels of government,

practitioners, academics, community organizations, and the general public. Figure 5.4 showcases the flow of resources and perspectives as they relate to stakeholders within the urban greening “ecosystem”. As stakeholders exchange resources and perspectives, political and socio-economic tensions can rise, creating room for controversy - the most prevalent controversies being political partisanship at the federal and local levels of government, availability of resources across all stakeholders, and green gentrification at the community level.

5.3.1 Partisanship in Congress

Action taken in Congress determines the amount of federal funding received at the state and local levels. In addition to allocations made within new legislation, federal programs require appropriations to be made in order to receive funding. However, with Democrats and Republicans varying greatly in their response to environmental problems, Congress faces frequent gridlock on bills concerning the expansion of green spaces.

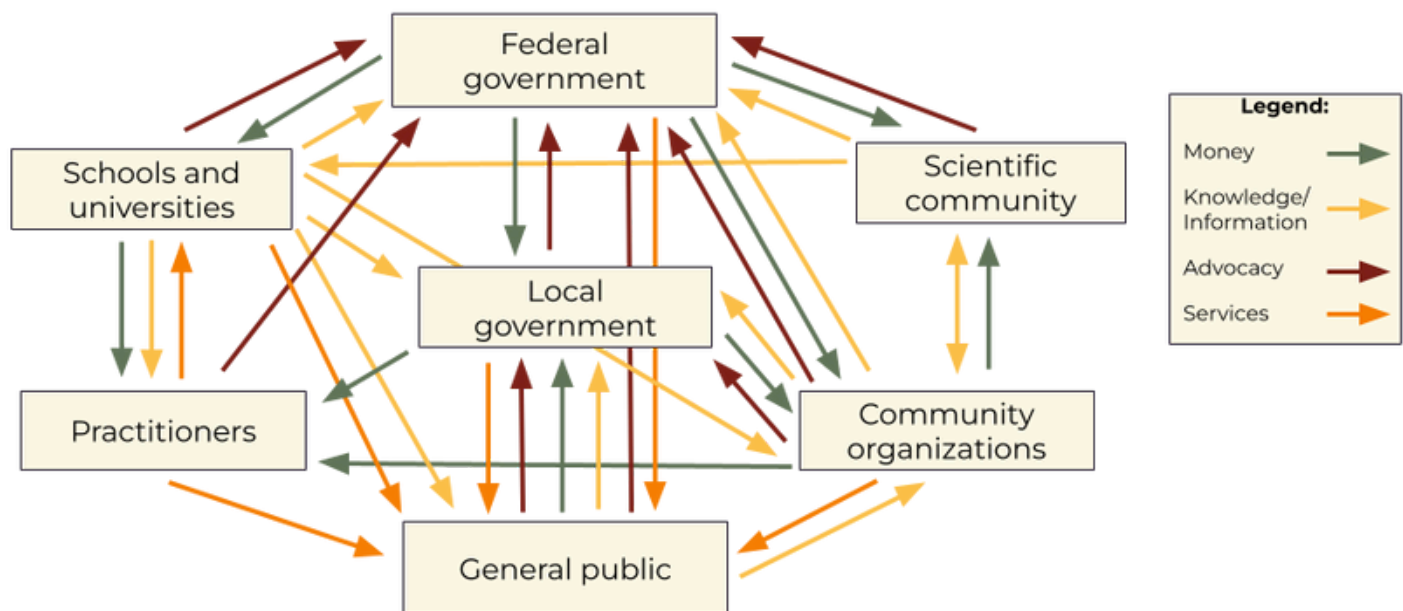


Figure 5.4: Stakeholders in the urban green infrastructure space and their systemic inputs.

In fact, no actions have been taken on the Climate Change Relief for Urban Areas Act of 2023 since May 2023 [174]. Democrats in Congress recognize the importance of addressing climate change through new legislation, as well as through federal whole-of-government initiatives such as Justice40 within the Biden administration. In fact, similar urban greening bills also have only received Democratic cosponsors, including the SHADE Act, Supporting Urban and Innovative Farming Act , and Stay Cool Act (see Table below). Meanwhile, many Republicans in Congress have chosen to ignore climate change altogether. A Center for American Progress study found that 109 representatives and 30 senators within the 117th Congress were openly climate deniers [175], despite Republican districts being more susceptible to fire and flood damage over the next 30 years and increasing public demand for green infrastructure. Moreover, constituents within Republican districts are demanding greater urban green infrastructure efforts by their decision makers. Of the 373 projects receiving funding from the US

Forest Service’s Urban and Community Forestry program in 2023, 128 of them are located in congressional districts with a Republican representative [176]. Republicans, as of late, have become somewhat receptive to messaging around extreme heat as an independent phenomenon that needs to be addressed, with some bipartisanship being shown in the introduction of bills such as the Extreme Heat Emergency Act, which authorizes funding by the Federal Emergency Management Agency (FEMA) to fund disaster relief for extreme heat events [177]. This reframing of the problem to appease Republican members of Congress, in conjunction with greater receptivity to hear the needs of their constituents, could help encourage bipartisan efforts toward increasing green space in urban areas.

5.3.2 Resource Availability

Besides partisanship, decision makers at the federal, state and local levels often value urban green infrastructure differently, especially amidst finite resource budgets. Public management requires a

Urban Greening and Extreme Heat Mitigation Bills	Democratic Cosponsors	Republican Cosponsors
H.R. 2786: Climate Change Relief for Urban Areas Act of 2023	19	0
H.R. 4314: Stay Cool Act	15	0
S. 2591/H.R. 5915: Supporting Urban and Innovative Farming Act of 2023	Senate: 7 House: 16	0
H.R.4817: Saving Hazardous And Declining Environments (SHADE) Act	47	0

balancing of public needs such as food, shelter, healthcare, and defense, and due to a number of factors, certain needs are prioritized over others. This can have compounding effects, especially when all levels of government deprioritize urban greening efforts. According to a survey of 325 communities of varying size, an average of 72% of their urban greening budget comes from the municipal general fund [178], which is the same competitive pool of funding used for other local priorities. While the remaining funding comes from taxes, fees, and fines, levying more of them could be politically unfavorable.

Moreover, supplies and resources required to plant gardens and trees are expensive and limited in quantity. The United States has faced a national seedling shortage for years and according to one study of nurseries in 20 northern states, 56 out of 605 nurseries are able to meet national demands for conservation and reforestation [179]. In addition, the urban green infrastructure workforce is small in size, and in its current state, cannot meet the demand of urban greening initiatives. Each year, as many as 8,300 tree care workers are needed, and over 159,800 job postings in the landscaping industry become available [180]. Meeting resource demands, especially at the local level is quintessential for the success of urban greening programs. Public-private partnerships, in addition to targeted funding to address resource gaps, would be critical to mitigate resource unavailability across jurisdictions.

5.3.3 Green Gentrification

Communities are also concerned about the negative impacts on livelihoods that increasing green space brings. Green gentrification, the process by which increasing green space or other environmental improvements, contributes to the pricing out of longtime, lower-income residents, is an externality well understood by many of the communities served by the bill. For instance, in Portland, OR, researchers found that for every 1% increase in tree canopy, home values increased by \$882 [181]. This issue

expands out to other American cities, as many cities that have undergone greening efforts in the 1990s have faced correlated gentrification in the 2000s and 2010s [182]. This poses difficulties in mobilizing lower-income communities and communities of color towards increasing green spaces in their neighborhoods as the fear of being displaced becomes pervasive. As of late, cities have been exploring “just green enough” initiatives as they prioritize urban greening - planting just enough trees or setting up just enough green infrastructure to yield community benefits without generating the negative impact of gentrification. However, new approaches are being considered, as many cities are investigating parks-oriented anti-displacement strategies, which leverage public parks as community anchors to ensure disadvantaged communities have access to established green spaces [183]. Many of these strategies involve intentional community engagement, inclusionary zoning practices, rent controls, anti-eviction policies, and other tactics aimed at encouraging and keeping disadvantaged communities nearer to parks and green spaces [184]. At minimum, intentional and highly participatory community engagement is necessary so that green gentrification can be mitigated, as localities and communities need to work in tandem with each other to design neighborhoods that keep existing residents while also delivering the benefits of green space [185]. ■



Section 6

Conclusion



Manhattan, Kimberly Liu, 2024

The Climate Resilience for Urban Areas Act of 2023 seeks to address the pressing environmental challenges exacerbated by decades of urbanization and climate change, particularly in low-income and marginalized communities. The proliferation of impervious surfaces, urban heat islands, and insufficient green spaces have compounded the risks of heat-related illnesses, air pollution, and catastrophic flooding, disproportionately affecting vulnerable populations.

This legislation recognizes historical issues in the present context and aims to counter these threats by reintegrating nature into urban environments by introducing green infrastructure. Measures such as increased tree canopy, green spaces, and rooftop gardens are designed to mitigate the impacts of climate change, enhance stormwater management,

and improve air quality. By prioritizing disadvantaged communities, the Act strives to ensure that the benefits of these nature-based solutions are equitably distributed, addressing both environmental and social injustices.

However, the implementation of urban green infrastructure presents challenges, including site-specific effectiveness and potential unintended consequences. To see the success of these initiatives, it is crucial that local communities are engaged, with ongoing monitoring to align outcomes with the needs of those most affected by environmental inequities. Collaboration between policymakers, community members, and experts is essential to ensure that the Act not only mitigates environmental issues but also rectifies historical injustices, fostering a more resilient and equitable urban landscape. ■

GLOSSARY

Albedo: The proportion of the incident light or radiation that is reflected by a surface. [186]

American Forests: American Forests is a 501 non-profit conservation organization, established in 1875, and dedicated to protecting and restoring healthy forest ecosystems [187].

Anthropogenic: Originating in human activity, chiefly related to pollution or environmental change [188].

Biogeochemical cycle: The movement of nutrients and other elements between biotic and abiotic factors [189].

Bioswale: A bioswale looks like a dry creek bed with plants growing inside. The bioswale is engineered with gravelly soil, so stormwater is absorbed quickly and deeply [190].

BIPOC: Black, Indigenous, and People of Color Canyon Effect: The creation of an artificial canyon by the dense concentration of tall buildings in an urban area [191].

Climate and Economic Justice Screening Tool (CEJST): An equity tool that was developed under Executive Order 14008 to identify disadvantaged communities to carry out the Justice40 initiative [192]

Combined Sewer System (CSS): The predominant sewer system in major US urban areas, which collects rainwater runoff, domestic sewage, and industrial wastewater in one pipe [193]

Combined Sewer Overflow (CSO): Outfalls of untreated wastewater and stormwater into urban waterways, which occur when the amount of stormwater runoff exceeds the capacity of a city's combined sewer system (CSS) [194].

Cooperative Forestry Assistance Act of 1978 (16 U.S.C. 2105): An Act that provides the framework for federal cooperation with stakeholders to support and promote the management and protection of non-federal forest lands, aimed at ensuring the health and productivity of the nation's forests [195].

Carbon Dioxide (CO₂): A greenhouse gas that comes from the extraction and burning of fossil fuels, wildfire events, and natural events such as volcanic eruptions [196].

Council on Environmental Quality (CEQ): A division of the Executive Office of the President that coordinates federal environmental efforts in the United States and works closely with agencies and other White House offices on the development of environmental and energy policies and initiatives [197].

Environmental Justice (EJ): The just treatment and meaningful involvement of all people, regardless of income, race, color, national origin, Tribal affiliation, or disability, in agency decision-making and other Federal activities that affect human health and the environment [198].

Environmental Science and Policy (ESP): A one-year master's program for future environmental sustainability leaders at the School of International and Public Affairs at Columbia University [199].

Federal Acquisition Regulation: A set of laws governing how the U.S. government can obtain services and goods from private and nonprofit entities [200].

Food desert: A geographic area, majorly in low-income communities, where the residents have limited access to affordable and nutritious food [201].

Garden Equity Score: A score developed to address environmental and socioeconomic factors such as location, population density, race, incidence of respiratory illness, food sovereignty, and average surface temperature [202].

Geographic Information Systems (GIS): A computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface [203].

Green Gentrification: The process by which the expansion of green space leads to increases in the perceived desirability of an urban area, resulting in higher property values and rents [204].

Greenhouse Gasses (GHGs): Gasses that trap heat in the Earth's atmosphere and can contribute to climate change if they exceed their natural concentrations. Common examples include carbon dioxide, methane, nitrous oxide, and fluorinated gases [205].

Green Roof: A roof that is completely or partially covered with vegetation and/or plant materials [206].

Inflation Reduction Act: Signed into law on August 16th, 2022, this act is a significant effort for clean energy and to combat climate change. Specifically, a \$1.5 billion grant is given to support the US Forest Service's Urban and Community Forestry program [207].

Key Performance Indicators (KPIs): Critical and quantifiable indicators of progress toward an intended result [208].

Lenni-Lenape Indigenous People: An indigenous people who originally resided in the Delaware (or Lenni Lenape or Lenape) confederation. This group of Algonquian-speaking North American Indians originally occupied the Atlantic seaboard [209].

Linguistic Isolation: A term used by the US Census Bureau for limited English speaking households. For example, more than 40% of Californians speak a language other than English at home. About half of those do not speak English well or at all [210].

Nitrogen Oxides (NOx): A group of molecules composed of nitrogen and oxygen atoms such as NO (nitric oxide) and NO₂ (nitrogen dioxide) [211].

Normalized Difference Vegetation Indices (NVDIs): A measurement used to quantify the amount and density of vegetation in a geographic area [212].

pH: An expression of hydrogen ion concentration in water [213].

Particulate Matter (PM_{2.5}): Tiny particles of solids or liquids in air that may include dust, dirt, soot, smoke, or drops of liquid [214].

Phytoremediation: The treatment of pollutants or waste (as in contaminated soil or groundwater) by the use of green plants that remove, degrade, or stabilize the undesirable substances (such as toxic metals) [215].

Rain Garden: A rain garden accomplishes stormwater filtration by collecting water on low gradients, slowing it, and allowing the water to infiltrate into a porous surface, instead of flowing across asphalt or concrete [216].

Rooftop gardens: A green roof or rooftop garden is a vegetative layer grown on a rooftop. Green roof systems include several different layers, including structural support, vapor barrier, thermal insulation, root barrier, drainage layer, filter membrane, growing medium, and vegetation [217].

Runoff: The draining of water and substances carried in it from precipitation on the surface of an area of land or building into nearby streams, ponds, or storm drains [218].

School of International and Public Affairs (SIPA): The international affairs and public policy graduate school housed within Columbia University in the City of New York [219].

Sulfur Oxides (SO_x): Group of molecules made of sulfur and oxygen atoms such as SO₂ (sulfur dioxide) and SO₃ (sulfur trioxide) [220].

Nitrogen Oxides (NO_x): A group of molecules composed of nitrogen and oxygen atoms such as NO (nitric oxide) and NO₂ (nitrogen dioxide) [221].

Tree Equity Score (TES): A score based on the intersection of environmental and socioeconomic factors, such as how existing tree canopy and surface temperatures correspond with income, employment, race, age, and health factors. This score is used to determine priority for urban and community forestry assistance [222].

Urban and Community Forestry Program (UCF): The Urban and Community Forestry Program (UCF) of the U.S. Department of Agriculture's Forest Service is the only Federal program dedicated to growing and maintaining urban trees, forests, and green spaces. Authorized under the Cooperative Forestry Assistance Act of 1978, Urban Forestry assists States and partner organizations in applying nature-based solutions to chronic and emergent economic, social, and environmental challenges [223].

Urban Green Infrastructure (UGI): Man-made infrastructure that aims to provide ecosystem services and other benefits by increasing amounts of vegetated land in urban areas [224].

Urban Heat Island Effect (UHIE): Refers to the creation of “urban heat islands” in densely populated cities, which are urbanized areas with higher temperatures than outlying regions due to increased building structures and less natural landscapes such as forests and water bodies [225].

Urbanization: The concentration of human populations into discrete and densely populated areas [226].

Volatile Organic Compounds (VOCs): Compounds that have high vapor pressure and low water solubility, which are used in a variety of products such as paint, cleaning supplies, and pesticides, and emitted into the atmosphere as gasses that contribute to the formation of harmful secondary air pollutants [227].

Wappinger Indigenous People: An indigenous group of people who originally resided in the Wappinger Confederacy in eastern North America. This group of Algonquian-speaking Indians originally settled along the east bank of the Hudson River during the 17th Century [228].

APPENDIX A

H. R. 2786

118TH CONGRESS
1ST SESSION

H. R. 2786

To amend the Cooperative Forestry Assistance Act of 1978 to prioritize urban and community forestry assistance for areas with low tree equity scores, to establish a grant program to enhance public elementary and secondary school rooftop gardens, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

APRIL 20, 2023

Mr. SCHIFF (for himself, Ms. BARRAGÁN, Ms. OCASIO-CORTEZ, Ms. BROWN, Ms. CLARKE of New York, Mr. ESPAILLAT, Mr. EVANS, Mr. GOMEZ, Mr. GRIJALVA, Ms. KAMLAGER-DOVE, Ms. MENG, Ms. SALINAS, Ms. SÁNCHEZ, Ms. SCANLON, Mr. TAKANO, and Mrs. WATSON COLEMAN) introduced the following bill; which was referred to the Committee on Agriculture, and in addition to the Committee on Education and the Workforce, for a period to be subsequently determined by the Speaker, in each case for consideration of such provisions as fall within the jurisdiction of the committee concerned

A BILL

To amend the Cooperative Forestry Assistance Act of 1978 to prioritize urban and community forestry assistance for areas with low tree equity scores, to establish a grant program to enhance public elementary and secondary school rooftop gardens, and for other purposes.

1 *Be it enacted by the Senate and House of Representa-*
2 *tives of the United States of America in Congress assembled,*

1 **SECTION 1. SHORT TITLE.**

2 This Act may be cited as the “Climate Change Relief
3 for Urban Areas Act of 2023”.

4 **SEC. 2. PRIORITIZATION OF URBAN AND COMMUNITY FOR-**
5 **ESTRY ASSISTANCE TO AREAS WITH LOW**
6 **TREE EQUITY SCORES.**

7 Section 9 of the Cooperative Forestry Assistance Act
8 of 1978 (16 U.S.C. 2105) is amended—

9 (1) in subsection (c), by adding at the end the
10 following: “In carrying out this section, the Sec-
11 retary shall give priority to providing assistance to
12 State foresters or equivalent State officials serving
13 areas with the lowest tree equity scores, as deter-
14 mined by the Secretary”;

15 (2) in subsection (h)—

16 (A) in paragraph (2), by striking “and” at
17 the end;

18 (B) in paragraph (3), by striking the pe-
19 riod and adding “; and”; and

20 (C) by adding at the end the following:

21 “(4) the term ‘tree equity score’ means a tree
22 equity score, as determined by the Secretary, that
23 is—

24 “(A) either—

25 “(i) substantially similar to the tree
26 equity score established by American For-

1 ests (or a successor tree equity score devel-
2 oped by such conservation organization or
3 other similar organization); or

4 “(ii) a tree equity tool that the Sec-
5 retary determines is most appropriate for
6 the communities served by such tool; and

7 “(B) based on how the tree canopy and
8 surface temperature of an area align with in-
9 come, employment, race, age, and health factors
10 of that area as determined by consulting with
11 community representatives or community-based
12 organizations.”; and

13 (3) in subsection (i), by striking “fiscal years
14 1991 through 1995” and inserting “fiscal years
15 2023 through 2028”.

16 **SEC. 3. PILOT GRANT PROGRAM TO PUBLIC ELEMENTARY**
17 **AND SECONDARY SCHOOL ROOFTOP GAR-**
18 **DENS.**

19 (a) **PILOT PROGRAM ESTABLISHED.**—The Secretary
20 shall establish a competitive grant program under which
21 the Secretary shall make grants to eligible entities to es-
22 tablish or expand rooftop gardens.

23 (b) **APPLICATION.**—To be eligible to receive a grant
24 under this section, an eligible entity shall submit to the
25 Secretary an application at such time, in such manner,

1 and containing such information as the Secretary may re-
2 quire, including the square feet of the proposed rooftop
3 garden (or expansion of such rooftop garden).

4 (c) PRIORITY.—In awarding grants under this sec-
5 tion, the Secretary shall give priority to the eligible entities
6 that have the lowest garden equity score, as determined
7 by the Secretary based on, with respect to the area in
8 which the eligible entity is located, the population density,
9 racial composition, incidence of respiratory illness, number
10 of urban gardens, food sovereignty, and average surface
11 temperature.

12 (d) USE OF FUNDS.—An eligible entity that receives
13 a grant under this section shall use the grant funds to
14 carry out each of the following:

15 (1) Assessing (including through architectural
16 analysis) if the area identified for purposes of estab-
17 lishing or expanding a rooftop garden can support
18 such garden or expansion and the construction
19 thereof.

20 (2) Applying for permits with respect to such
21 rooftop garden.

22 (3) Establishing a financial plan with respect to
23 the establishment or expansion of such rooftop gar-
24 den.

25 (4) Designing a rooftop garden—

1 (A) of which at least 20 percent is com-
2 prised of native plants, fruits, or vegetables;

3 (B) that does not include plants identified
4 by the State in which such garden is located as
5 invasive species;

6 (C) using best practices to reduce risk of
7 contaminants (such as using cleaning soil in
8 raised garden beds); and

9 (D) either—

10 (i) a strategy for increasing energy ef-
11 ficiency and increasing the surface ability
12 of a building to reflect sunlight and absorb
13 less solar energy; or

14 (ii) if the strategy in clause (i) is not
15 feasible, a strategy to increase habitat and
16 food availability for pollinators, manage
17 rainwater, or provide other benefits to the
18 community.

19 (5) Incorporating into the science curriculum of
20 the entity—

21 (A) an urban agriculture lesson plan; or

22 (B) a lesson plan on pollinator habitat,
23 green infrastructure for heat or stormwater
24 management, or remediation of soil and water
25 contaminants by plants.

1 (e) ORGANIC REQUIREMENT.—An eligible entity that
2 receives a grant under this section may only use organic
3 farming methods with respect to a rooftop garden estab-
4 lished or expanded by such grant.

5 (f) ROUTINE INSPECTIONS.—

6 (1) IN GENERAL.—The Secretary shall inspect
7 each rooftop garden for which a grant is awarded
8 under this section once each year.

9 (2) CONTRACT AUTHORITY.—The Secretary
10 may enter into contracts with appropriate entities to
11 carry out the inspections required under paragraph
12 (1).

13 (g) DEFINITIONS.—In this section:

14 (1) ELIGIBLE ENTITY.—The term “eligible enti-
15 ty” means a public elementary school or secondary
16 school.

17 (2) ESEA TERMS.—The terms “elementary
18 school” and “secondary school” have the meanings
19 given the terms in section 8101 of the Elementary
20 and Secondary Education Act of 1965 (20 U.S.C.
21 7801).

22 (3) SECRETARY.—The term “Secretary” means
23 the Secretary of Agriculture.

1 (h) AUTHORIZATION OF APPROPRIATIONS.—There is
2 authorized to be appropriated to carry out this section
3 \$30,000,000 for each of fiscal years 2023 through 2028.

○

APPENDIX B

Interview Key Takeaways

Mushtaq Ali

Senior Manager, GIS and Data Science, American Forests

- **Tree Equity Score (TES) Development and Updates:** TES was launched in June 2021, with a 2.0 version released the following year, incorporating public feedback and regional adjustments (e.g., California desert). Annual updates include data from sources like the American Community Survey, Health Burden Index, Landsat, and new temperature metrics focused on heat disparity.
- **Enhanced Data and Tools:** TES uses a new dataset from Microsoft for precise building density measurement, supported by Weyerhaeuser's grant for expanding to smaller urban communities. UI changes improve usability, and most datasets are publicly available, except for tree canopy data from Google.
- **Equity and Data Integration:** TES includes linguistic isolation as an equity priority indicator and normalizes data to reflect urban areas, not just incorporated cities. The tool balances standardization with real-world conditions, ensuring that each priority indicator, such as poverty and linguistic isolation, is equally weighted.
- **Community Engagement and Challenges:** TESAs play a crucial role in gathering local information and facilitating place-based conversations, though scaling these efforts to the federal level is challenging due to the complexities of data processing and community engagement.
- **TES as a Dynamic Tool:** TES aims to identify priority areas for tree planting, with a score of 100 indicating the regional goal has been met. The tool is seen as a starting point, with ongoing improvements based on resources, considering factors like the impact of newly planted trees and the uneven distribution of tree canopy within neighborhoods.

Matthew Palmer, PhD

Senior Lecturer, Department of Ecology, Evolution and Environmental Biology, Columbia University

- Urbanization leads to heat absorption and re-radiation by buildings and asphalt, causing cities to retain heat, particularly at night, in a process known as the Urban Heat Island (UHI) effect. A lack of green spaces intensifies the UHI effect.
- **Increasing Green Spaces:** Adding trees and rooftop gardens helps by increasing reflectivity, providing shade, and enabling evapotranspiration, which cools urban areas.
- **Surface Reflectivity:** Light-colored buildings and roofs reflect heat, but maintenance and potential glare issues exist.
- **Combination of Solutions:** A mix of increasing tree canopy, green roofs, and reflective surfaces offers partial relief but cannot fully eliminate the UHI effect.
- Environmental justice is crucial, directing resources to under-resourced communities to bridge disparities in heat exposure and green space access. These communities often face greater UHI impacts due to less access to green spaces and resources for cooling (like air conditioning).
- Green spaces improve stormwater management, reduce runoff speed, and enhance biodiversity by providing habitat for birds and insects. They also offer social benefits, such as improving community aesthetics and fostering social
- Urban greening should consider using a mix of native and non-invasive non-native species to withstand harsh urban conditions.
- Long-term maintenance is vital to ensure the survival and effectiveness of planted trees and green spaces, especially in low-income areas.
- Quantifying the benefits of urban greening (cooling effects, stormwater management, ecological improvements) is challenging but necessary for policy advocacy.
- Balancing qualitative data (community stories) with quantitative data is crucial for effective policymaking.
- With the growth in Urban population and the worsening of climate change, cities should plan for increased infrastructure demands and maintain the quality of life through resilient urban design.
- Understanding the trends of the population and preparing for the climate impacts in the future is essential for sustainable urban planning.

Yutian Wu, PhD

*Associate Research Professor, Lamont-Doherty Earth Observatory,
Columbia University*

- Greenhouse gases cause climate change and traps heat in the atmosphere, leading to higher global temperatures. These elevated temperatures increase the capacity of the atmosphere to hold water vapor, which can lead to more frequent and intense precipitation.
- Increased precipitation increases the amount of runoff, which can carry pollutants (SNOT: Sediment, Nutrients, Organic matter, and Trash) directly into water sources.
- The cycle intensifies: human emissions increase temperatures, which leads to more precipitation and runoff, further polluting water sources.
- The problems exacerbate each other: Human emissions → Higher temperatures → Increased precipitation → More runoff → Water pollution → Further environmental degradation.

APPENDIX C

CJEST Disadvantaged Communities Indicators

Climate change

Communities are **identified as disadvantaged** if they are in census tracts that:

ARE at or above the 90th percentile for [expected agriculture loss rate](#) OR [expected building loss rate](#) OR [expected population loss rate](#) OR [projected flood risk](#) OR [projected wildfire risk](#)

AND are at or above the 65th percentile for [low income](#)

Energy

Communities are **identified as disadvantaged** if they are in census tracts that:

ARE at or above the 90th percentile for [energy cost](#) OR [PM2.5 in the air](#)

AND are at or above the 65th percentile for [low income](#)

Health

Communities are **identified as disadvantaged** if they are in census tracts that:

ARE at or above the 90th percentile for [asthma](#) OR [diabetes](#) OR [heart disease](#) OR [low life expectancy](#)

AND are at or above the 65th percentile for [low income](#)

Housing

Communities are **identified as disadvantaged** if they are in census tracts that:

Experienced [historic underinvestment](#) OR are at or above the 90th percentile for [housing cost](#) OR [lack of green space](#) OR [lack of indoor plumbing](#) OR [lead paint](#)

AND are at or above the 65th percentile for [low income](#)

Legacy pollution

Communities are **identified as disadvantaged** if they are in census tracts that:

Have at least one [abandoned mine land](#) OR [Formerly Used Defense Sites](#) OR are at or above the 90th percentile for [proximity to hazardous waste facilities](#) OR [proximity to Superfund sites \(National Priorities List \(NPL\)\)](#) OR [proximity to Risk Management Plan \(RMP\) facilities](#)

AND are at or above the 65th percentile for [low income](#)

Transportation

Communities are **identified as disadvantaged** if they are in census tracts that:

ARE at or above the 90th percentile for [diesel particulate matter exposure](#) OR [transportation barriers](#) OR [traffic proximity and volume](#)

AND are at or above the 65th percentile for [low income](#)

Water and wastewater

Communities are **identified as disadvantaged** if they are in census tracts that:

ARE at or above the 90th percentile for [underground storage tanks and releases](#) OR [wastewater discharge](#)

AND are at or above the 65th percentile for [low income](#)

Workforce development

Communities are **identified as disadvantaged** if they are in census tracts that:

ARE at or above the 90th percentile for [linguistic isolation](#) OR [low median income](#) OR [poverty](#) OR [unemployment](#)

AND more than 10% of people ages 25 years or older whose high school education is less than a [high school diploma](#)

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