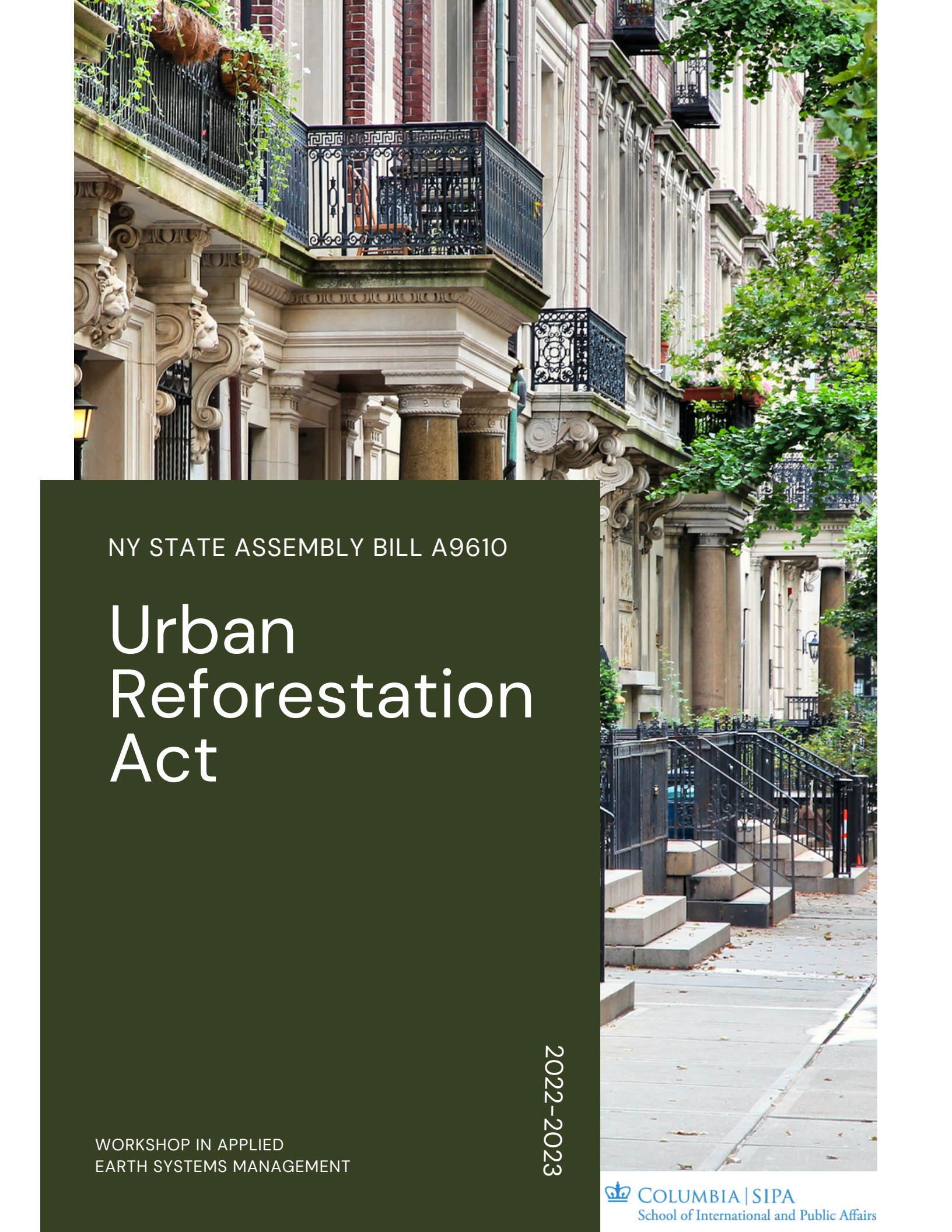




NY STATE ASSEMBLY BILL A9610

Urban Reforestation Act

WORKSHOP IN APPLIED
EARTH SYSTEMS MANAGEMENT

2022-2023

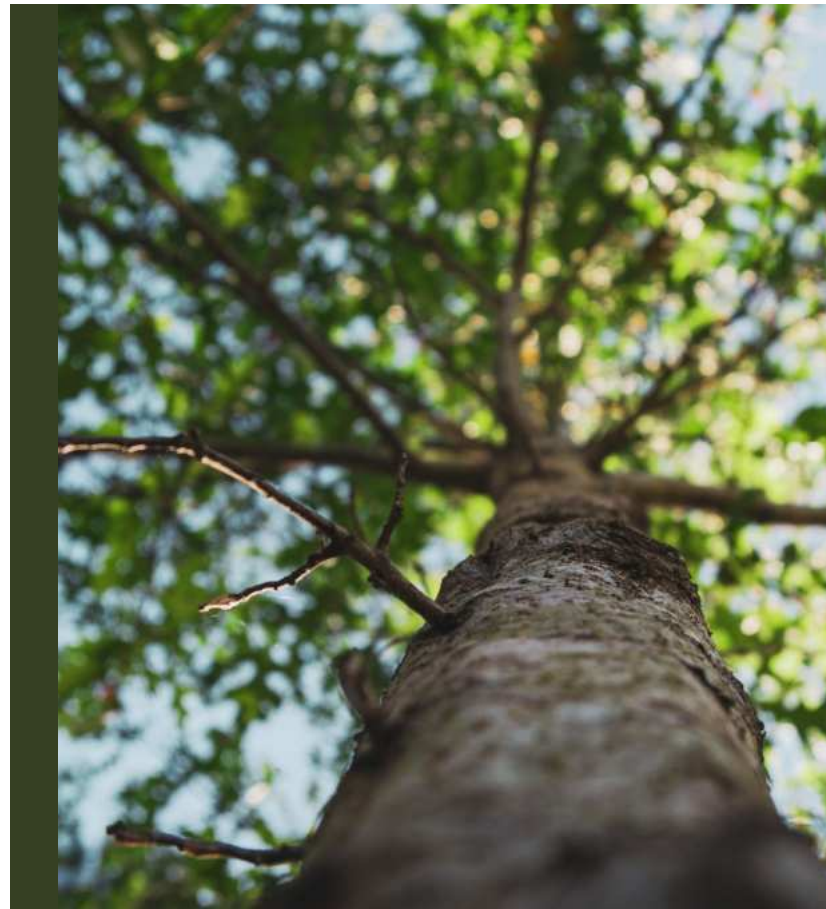


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Executive Summary

From 2001 to 2010, urbanization converted 637 square miles of New York state forest into cities—an area equivalent to more than 180 Central Parks. This builds on a legacy of land use change that diminished vegetation in cities and negatively impacted the ecosystems, human populations, and economies in urban areas. The **Urban Reforestation Act (URA)**, a proposed New York State Assembly Bill, creates a legislative framework and a dedicated, long-term revenue source to mitigate these issues. The following report details the problems addressed by the URA, the science behind the proposed solutions, potential roadblocks to passage of the law, and metrics for defining success.

To understand the context of **urban deforestation** in New York, this report details the state's geography, biome, and climate. It examines how deforestation in the 1800s, driven by rapid urbanization, disrupted the **ecosystem services** provided by the natural landscape and created problems unique to modern cities. The URA aims to fund **urban forestry** programs to mitigate elevated city temperature, stormwater and drainage issues, biodiversity loss, and air pollution in urban spaces. Next, this publication details the solutions to these problems and the science supporting proposed activities. It also describes additional benefits provided by increasing and maintaining vegetation in cities.

However, these benefits hinge upon long-term plant survival, a challenge in concrete-laden urban spaces. This report uncovers the scientific barriers to urban reforestation and roadblocks to passing the URA. Notably, politically-opposed lobby groups killed the legislation twice before—once in 1999 and again in 2008. Within the bill itself, gaps exist in direction for implementation and distribution of collected funds. Finally, this report defines the outcomes of this bill if passed and implemented successfully.

In conclusion, this bill uses a fee-based policy tool to play a small yet vital role in adding vegetation to New York state urban spaces. The URA can provide net economic, environmental, and health benefits to New York's cities, but the realization of these gains hinges upon proper implementation.

A team of eleven Masters of Public Administration candidates at Columbia University's School of International and Public Affairs compiled this research as part of a semester-long project. The team gathered information from New York state government documents, peer-reviewed academic journals, and interviews with field experts and politicians (including Assemblymember Karen McMahan and the bill's original author, former Assemblymember Sam Hoyt).

Introduction

New York State's Urban Reforestation Act (URA) aims to increase the scope of urban forestry in NY cities. This section discusses the state's biome, climate, population, and land use characteristics to contextualize the URA's impacts.

New York State's Population, Climate, and Biome

Biome

New York is an extensively forested state. According to the 2020 New York state Forest Action Plan, tree canopy covers 18.7 of the state's 30.2 million total acres, about 63%. **Urban and community forests** cover 1.3 million acres, roughly 7% of the 18.7 million acre tree canopy. The **Department of Environmental Conservation (DEC)** defines urban forests as "All of the trees within a town, village, or city...(including) street and yard trees, parks, cemeteries, golf courses, school grounds, and undeveloped green spaces." Notably, private landowners manage 13.6 million acres, or 74%, of forested land in New York state. State or city governments manage the remaining 24%, comprising 4.5 million acres. Overall, trees in the maple, beech, and birch group make up 55% of forestland, while oak and hickory trees make up 18% (Hart et al., 2020). The remaining 10% of vegetation includes tidal **wetlands** along the Hudson River and Long Island Estuary.

Climate & Climate Change

The Köppen Classification system defines New York's climate as predominantly "humid continental," while the southeast portion of the state, including New York City, Westchester County, and Long Island, lies in the warm and humid subtropical climate zone. Climate change drives increased frequency and intensity of extreme precipitation in New York state, especially in the winter and spring. Precipitation from storms has increased by 70% since 1958. Temperatures have risen by almost 2.5 degrees Fahrenheit since the start of the 20th century and may rise across New York state by up to 10.1 degrees Fahrenheit by 2080. Rising temperatures have started to change natural patterns – for example, in many areas of New York, the first leaf date is more than 8 days earlier versus the 1950's baseline (Impacts of Climate Change in New York, 2014). Additionally, sea levels could rise 1 to 4 feet by 2100 under the current greenhouse gas (GHG) emissions trajectory (Kunkel, 2022; "What Climate Change Means for New York," 2016).

Population & Geography

About 19.8 million people call New York state home. Roughly 18 million residents (about 91%) live in urban towns and cities with populations between 20,000 and 1 million people (U.S. Census Bureau QuickFacts, n.d.). Urban areas make up 10.3% of New York's total land area, approximately 3.5 million acres. Urban expansion materially increased between 2000 and 2010, with city area expanding by 7.2% (Hart et al., 2020).

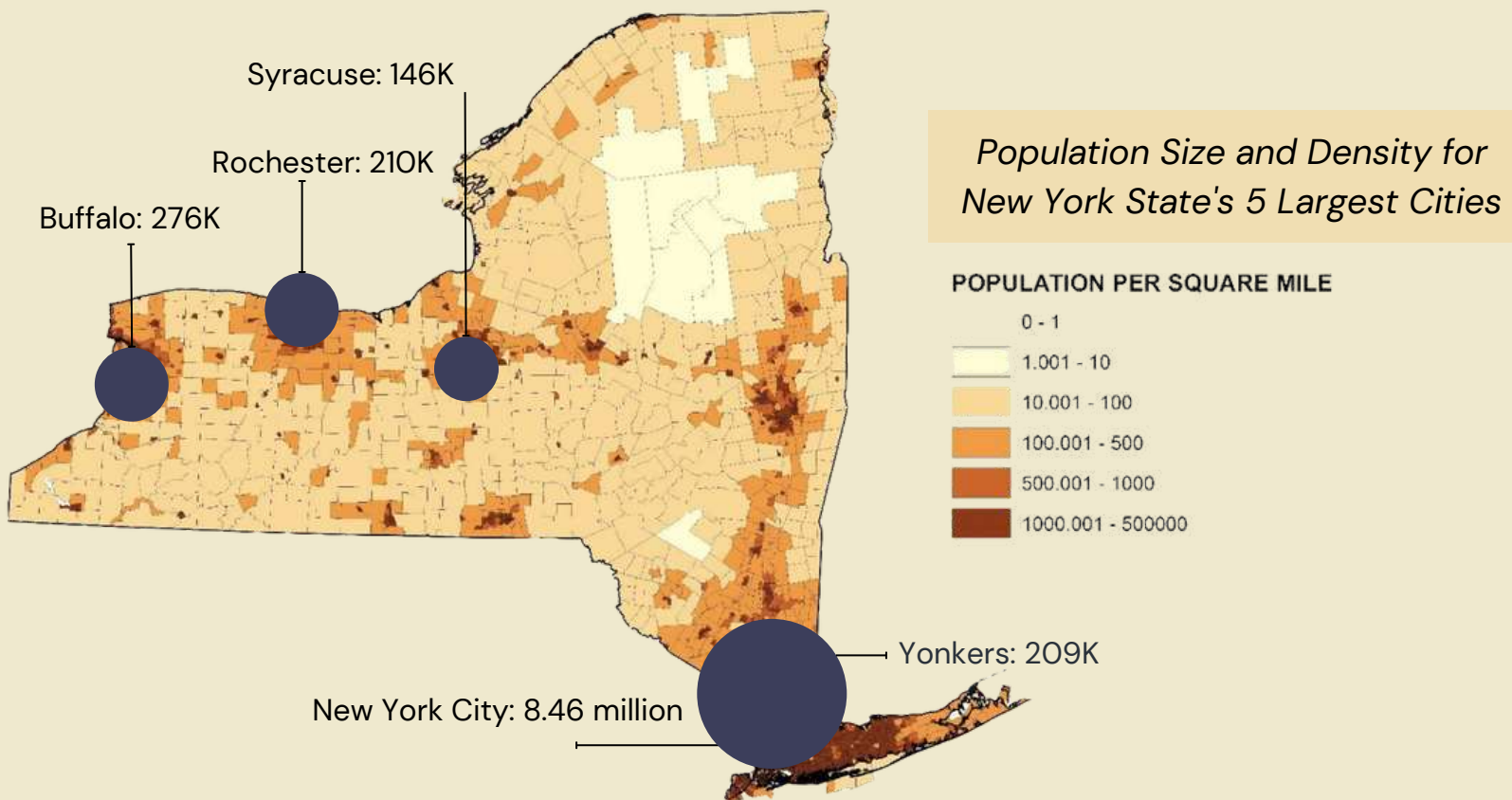
Key population centers are linked together through a series of waterways connecting the Great Lakes and Hudson River watersheds. Buffalo, Rochester, Syracuse, Utica, and Albany were historically connected east to west along the Erie Canal. Albany is currently linked to New York City in the south via the Hudson River, which links New York to the Atlantic Ocean.

Disrupted Natural Systems

Converting forests to urban areas and decreasing urban vegetation has disrupted natural systems within New York state's cities. This drastic land use change has intervened in the **hydrological cycle** by increasing stormwater runoff, a phenomenon that is already exacerbated by climate change. A lack of vegetation also weakens cities' ability to regulate temperatures, posing health and infrastructure risks.

Loss of urban vegetation has decreased air quality in cities and reduced the environment's ability to naturally filter pollutants. In addition, reduced vegetation has also led to biodiversity loss and **habitat fragmentation**. According to the New York DEC, habitat fragmentation occurs when a "continuous forest is broken up by development of roads and homes, commercial uses, and agricultural purposes." Fragmentation disrupts flora and fauna habitats, leading to species endangerment.

Introduction



Infographic by team member Diana Bunge
with original map from NY State Forest Action Plan

From 2001 to 2010, humans converted **165 kilo-hectares**, or 637 square miles, of New York State forest into urban spaces. For context that is **180+ Central Parks**.

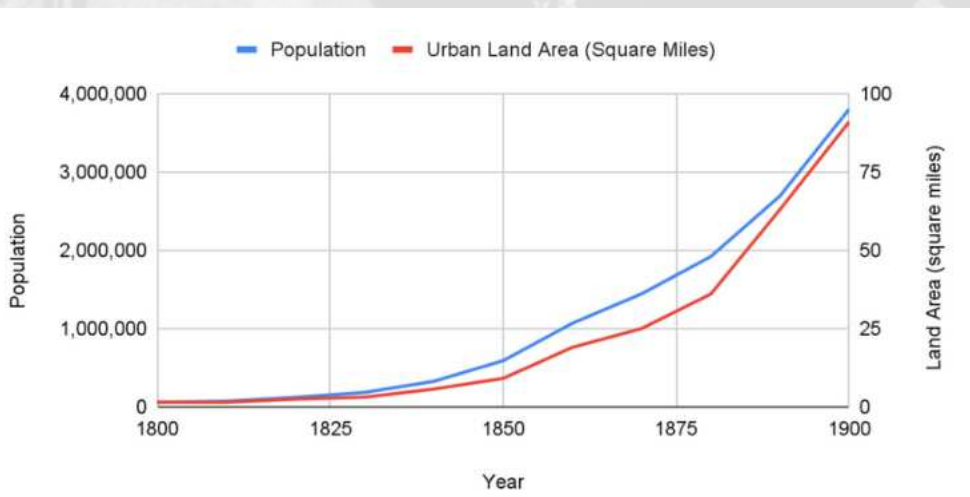
Urban forest cover loss is driven by a legacy of land use change.

Historic Land-Use Change in New York State

When European settlers first arrived in modern-day New York in the 17th century, they encountered a heavily forested landscape. However, they saw the stands of oak, hickory, and American chestnut trees as obstacles and dramatically altered the landscape to clear land for settlement to harvest timber as a resource (History Of State Forest Program, n.d.).

Deforestation dramatically accelerated in the 19th century. The opening of the Erie Canal in 1820 galvanized the state's economic development. The canal established the state's economic primacy as commodities produced in the US interior and Midwest flowed through the state. Water-borne transport was the easiest and cheapest transport option, so New York's plentiful waterways provided a large commercial advantage. This, coupled with the state's abundant hydropower, activated an industrial renaissance that precipitated land use change in New York's largest cities (Glaeser, 2005).

Figure 1: Change in New York state's population and urban land area, 1800 - 1900. (New York Urbanized Area: Population & Density from 1800 (Provisional), 2005)



*At the end of the 19th century, forested land had shrunk to less than **25%** of pre-colonial levels due to expansion of agriculture and over-logging. By 1900, New York's forest land began to recover and has been restored to 20 million acres.*

Introduction

Land Use Change Post-Erie Canal

Rochester

Rochester became America's first "boom town" in the 19th century after the opening of the Erie Canal. The 90-foot Genesee High Falls powered flour mills that churned Midwest wheat into flour. By 1838, Rochester had become the largest flour-producing city in the US. Its hydropower resources, coupled with the inflow of trade from the Midwest and Europe through New York City, catalyzed the manufacturing and garment industries and drove a population and footprint expansion (Hopkins, n.d.).

Buffalo

The opening of the Erie Canal transformed Buffalo from a frontier outpost into a prosperous trading center for Midwestern goods that flowed through the Canal. Its population also exploded as the milling and steel industry took root, using hydropower to convert Midwestern grain and Appalachian ore into valuable products (Mehaffy, 2016).

By 1840, New York state was home to seven of the nation's 30 largest cities.

New York

New York's population and urban land cover increased dramatically after 1820, building on growth that had taken off starting in 1790. Between 1790 and 1860, New York's population grew by 50% each decade, aside from the war-torn 1810s (Glaeser, 2005). There are two drivers behind the city's population and land cover expansion.

The first driver was New York City's dominance of American shipping and immigration, building on geographical superiority. This superiority was based on the New York port's proximity to the Atlantic Ocean, protection from ice, and large depth, which best accommodated large-tonnage ships most typical of 19th-century shipping. As a result, the goods that flowed through the Erie Canal were predominantly exported through here, while European imports also favored entering this location. In addition, the Hudson River reached deeper into the American continent than other Northeastern rivers, providing navigation farther into the continent. These factors led to New York's establishment as the primary entry point for European immigration.

The second driver was New York's manufacturing boom, especially in the sugar, publishing, and garment industries. These industries took root in New York City because of its status as an import/export hub, large labor force from immigration, and a sophisticated financial industry that emerged to secure and finance maritime commerce. Industries like sugar and garments needed to be close to the port because their businesses relied on minimizing transport costs and reaching economies of scale.

Introduction

Land Use Change from 1800s–Present Day

The state's economic dominance spurred massive conversion of forest to agricultural land in order to feed a growing population, house urban residents, and create industrial sites. By 1880, forested land cover in New York state reached its nadir, with only 25% of pre-colonial forest stocks remaining (Forests and the Environment, n.d.).

By the early 1900s, the glaring change in forest cover prompted the New York Forest Fish and Game Conservation Commission to sound the alarm. **The 1929 State Reforestation Act and 1931 Hewitt Amendment** pioneered statewide reforestation efforts, resulting in the state of the rural forests today (History Of State Forest Program, n.d.). However, this reforestation did not extend to the rapidly-expanding urban environments built to house and transport a booming population.

Suburbanization took off in the 1950s, fueled in part by the automobile emerging as the dominant mode of transport and allowing longer commutes. The migration of industries, first to the Sunbelt and ultimately overseas, also spurred this change. This is exemplified in cities like Buffalo, which tried to combat offshoring by connecting central business districts to outlying suburbs through highways. However, urbanization in the region continued to expand on the state's periphery and shrink at the center. This reduced forest cover by cutting through forested land to accommodate infrastructure for commuting residents (Mehaffy, 2016).

The legacy of these land-use changes lives on today. New York's cities are now realizing the ecological, social, and economic ramifications of this oversight.



MillionTreesNYC

Past Initiatives and Shortcomings

The New York City parks department partnered with the New York Restoration Project to launch the MillionTreesNYC initiative in October 2007. The project complemented broader plans to expand the city and build climate change resiliency. Nearly 50,000 citizen volunteers mobilized to plant, with the one-millionth tree set in the ground in 2015. Under this program, urban canopy in New York City increased by 20% (*Mayor de Blasio Celebrates One Millionth Tree*, 2015). As part of the planting project, the city launched the TreeLC program to inform citizens on long-term tree maintenance. This effectively charged NYC residents with the responsibility of tree care (Lu et al., 2009). However, the program did not prioritize funding for long-term tree maintenance once the trees were planted. This oversight puts the long-term survival of planted trees at risk.

Trees require between 20 to 40 years to yield ecosystem services such as reducing stormwater runoff. But their path to maturity is more perilous in urban areas than in natural habitats due to poor soil quality and quantity, restricted space on sidewalks for roots to grow, and an amplified threat of invasive species. Early tree lifespan measurements after the initiative showed tree survival rates of 84% to 93%, a result considered positive based on previous research (Simmons, 2010). However, later studies showed that neighborhoods like Williamsburg–Greenpoint had a 2-year tree mortality of 22.3% (Ye & Schuerman, 2014), far exceeding the city average mortality range of 7–16%, demonstrating that trees planted under MillionTreesNYC died faster than other trees in New York City. By not codifying a long-term funding stream for care and maintenance, the program overlooked a key success factor required to achieve the benefits of tree planting.



Investing in **Resilient Cities**: Funding Natural Solutions for Health, Energy, and the Economy

The Urban Reforestation Act is a New York State Assembly Bill (A9610). It was introduced on March 23rd, 2022 in the 2021-2022 legislative session by Karen McMahon. McMahon is a Democrat representing the 146th Assembly District within the Buffalo-Niagara Falls metropolitan area.

3 out of 4 bill co-sponsors are New York City representatives:

- Maritza Davila and Jo Anne Simon – Brooklyn
- Edward Gibbs – Upper Manhattan

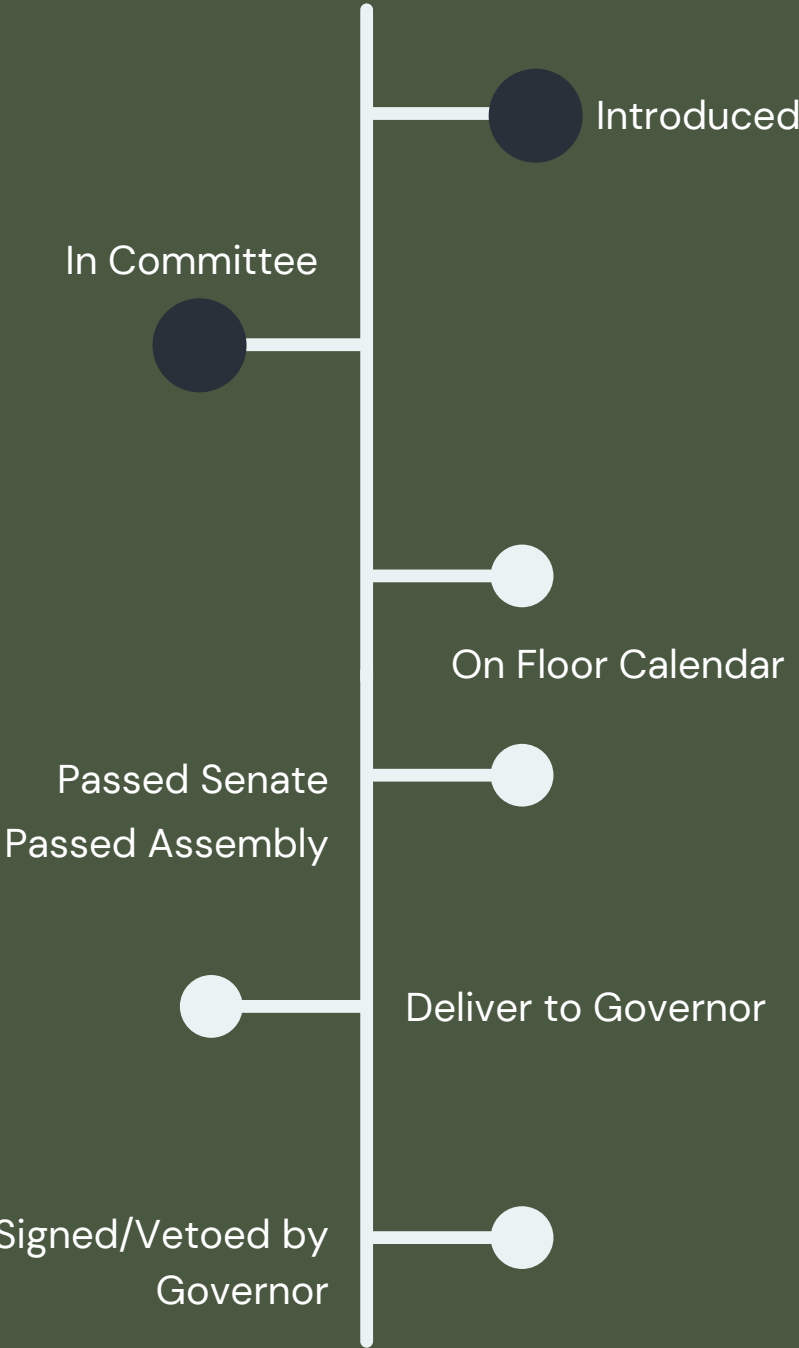
Aileen Gunther rounds out the co-sponsors by representing Orange County.

The URA is currently in the Committee on Transportation, where it will potentially be discussed during the 2022-2023 legislative session. If it passes through the Committee, it must be placed on the floor calendar to be voted on by both the New York State House and Senate.

“To create a fair and adequate funding mechanism for the development of New York's urban forests programs, as described in **Article 53** of the Environmental Conservation Law.”

URA Bill Purpose

A9610 Bill Status



A9610 Framework & Purpose

A9610 Purpose

The Urban Reforestation Act is a nature-based legislative solution that seeks to restore urban vegetation in New York state to mitigate environmental problems such as the urban heat island effect, stormwater runoff, poor air quality, and decreasing biodiversity. The URA aims to promote public health and well-being, encourage economic benefits such as increasing urban area aesthetic appeal, and finally work towards a more resilient New York in the face of climate change.

A9610 Builds on Existing State Law

Title 3 of Article 53 of the New York State Environmental Conservation Law was established to promote urban forestry and to address the issues caused by regular removal of trees and vegetation in urban areas of New York state. The Urban Reforestation Act enhances Article 53 as it provides a dedicated fund for urban forestry to ensure longevity in vegetation survival.

To achieve its stated goals, the Urban Reforestation Act builds upon three existing laws:

1. It amends the **New York State Transportation Law (Section 88)** by adding subdivision 5-a. This amendment imposes a \$1,000 annual fee per **billboard** but only if visible from an interstate or **primary highway**. It also creates a \$500 fine for non-compliance, with a \$100 fine for every additional day of non-compliance. There are exceptions, including government signs, signs advertising the business they are sited on, direction signs, and advertising owned by companies that own or rent five or fewer billboards.
2. It modifies the **New York State Finance Law** by adding **Section 91-H** to create the "NY State Urban Reforestation Fund" where all the revenue collected by fees and fines will be housed. This fund will be jointly administered by the state **comptroller** and **commissioner of taxation and finance**.
3. The URA's most critical amendment is **modifying and expanding Article 53** of the state's Environmental Conservation Law. Specifically, eight new subdivisions are added (8-15) to Section 53-0303 and an entire new section is added: Section 53-0309.

A9610 Specifications & Directives

The aforementioned amendments to Article 53 create work standards and directives for the hiring of forestry roles with the funds collected. The Bill mentions the need for specific roles involved in urban reforestation, mainly professional **foresters** (i.e. someone who has graduated from a school of forestry or is accredited by a professional forestry association). The necessity for these specific roles is justified by the expertise required to implement urban reforestation activities. These activities include **conservation, planting, pruning, removal, and maintenance**, which cover the entire lifecycle of reforestation from planning to maturity.

Finally, the URA allocates funding based on population size, population density, merit, and overall need for planting and maintenance. Figure 2 below shows this breakdown.

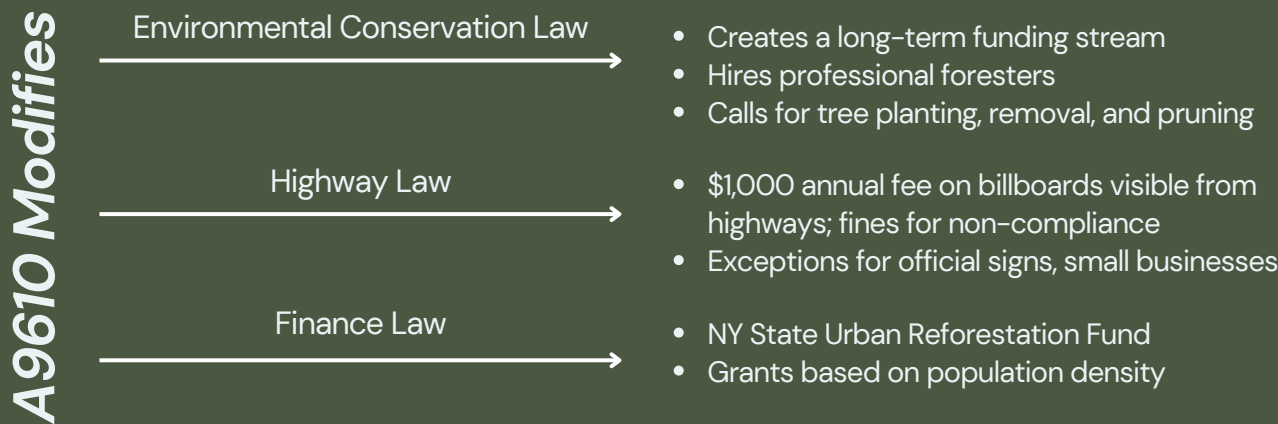
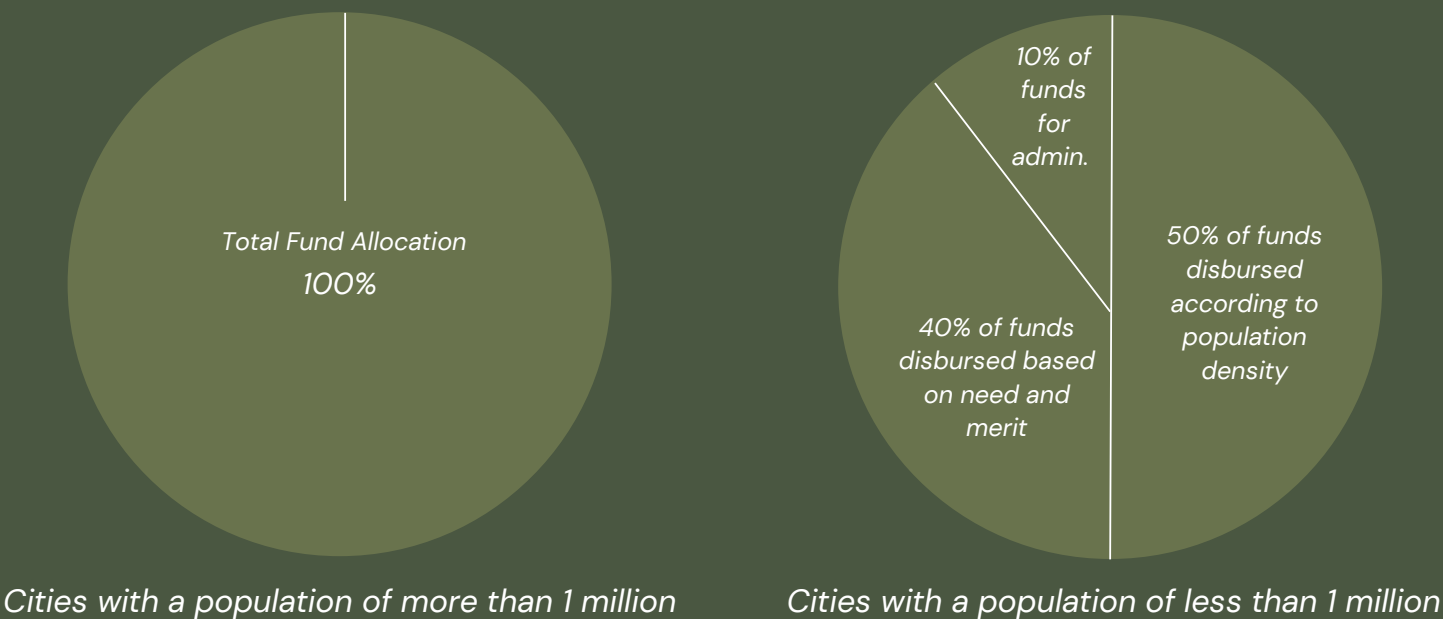


Figure 2: A9610 Funding Breakdown





THE PROBLEMS



Environmental Disruptions Caused by Urbanization

Overview

Urbanization over the last two centuries has disrupted the natural environments in New York cities. Degradation of ecosystems such as forests and wetlands negatively impacts the quality of life for residents, while making cities less resilient. This is especially true during extreme weather events, which will intensify with climate change. Cities are vulnerable to climate-induced disasters due to poor urban planning and the materials used in infrastructure.

Temperature Disruptions

1

Urban Heat Island Effect

2

Excess Absorption
of Solar Radiation

3

Urban Canyons

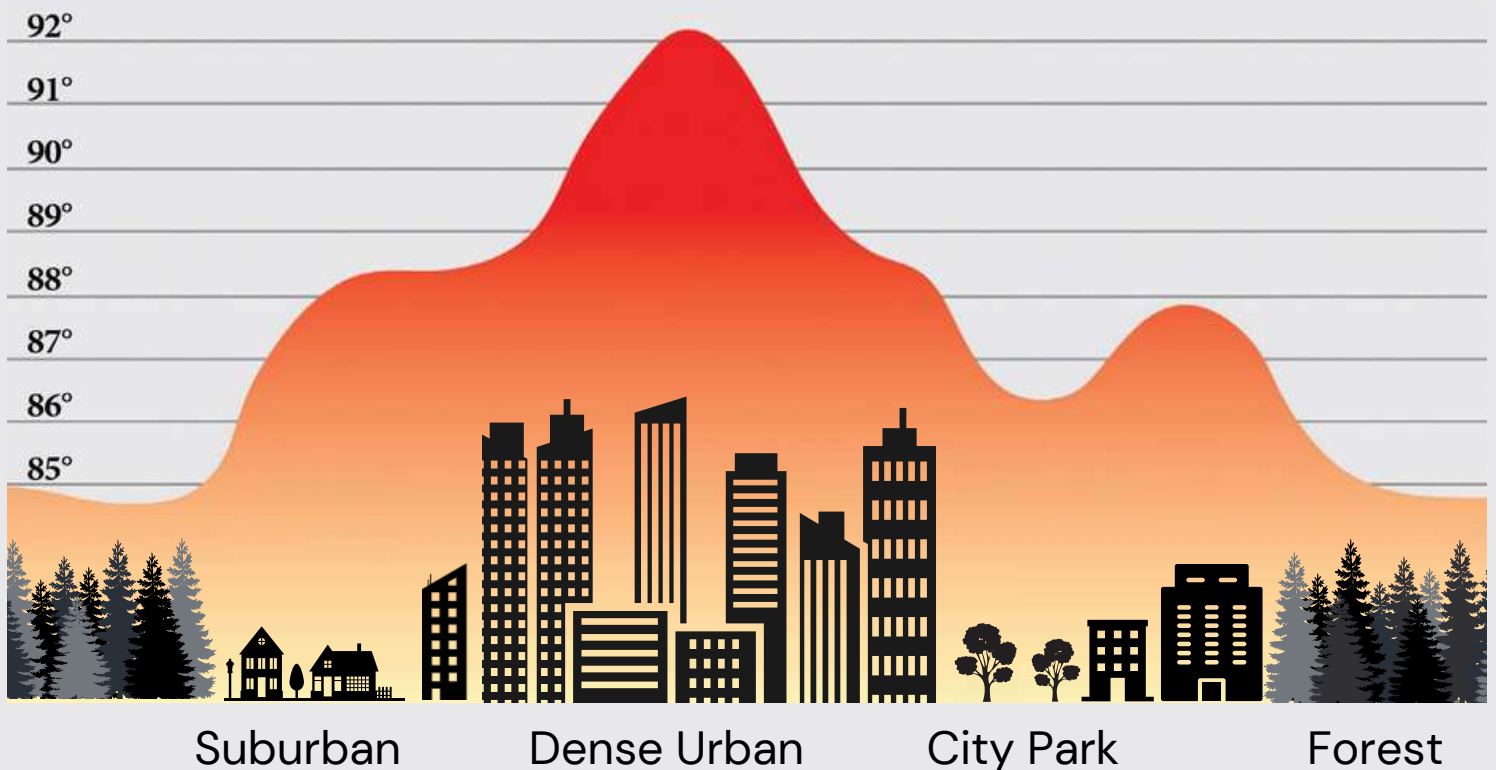
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Public Health
Impacts

1 Urban Heat Island Effect

When compared to a naturally vegetated landscape, the built environment absorbs more heat throughout the day and releases that heat slowly during the night. This phenomenon, known as the **urban heat island (UHI)** effect, results in urban temperatures 2 to 5 degrees Fahrenheit warmer than surrounding vegetated areas at night (US EPA, 2021). Most heat-related illnesses and deaths occur at night (2022 New York City Heat-Related Mortality Report, 2022). Increased absorption of **solar radiation** by the built environment and excess heat from human activities cause these higher ambient temperatures.

Temperature Profile of Heat Island

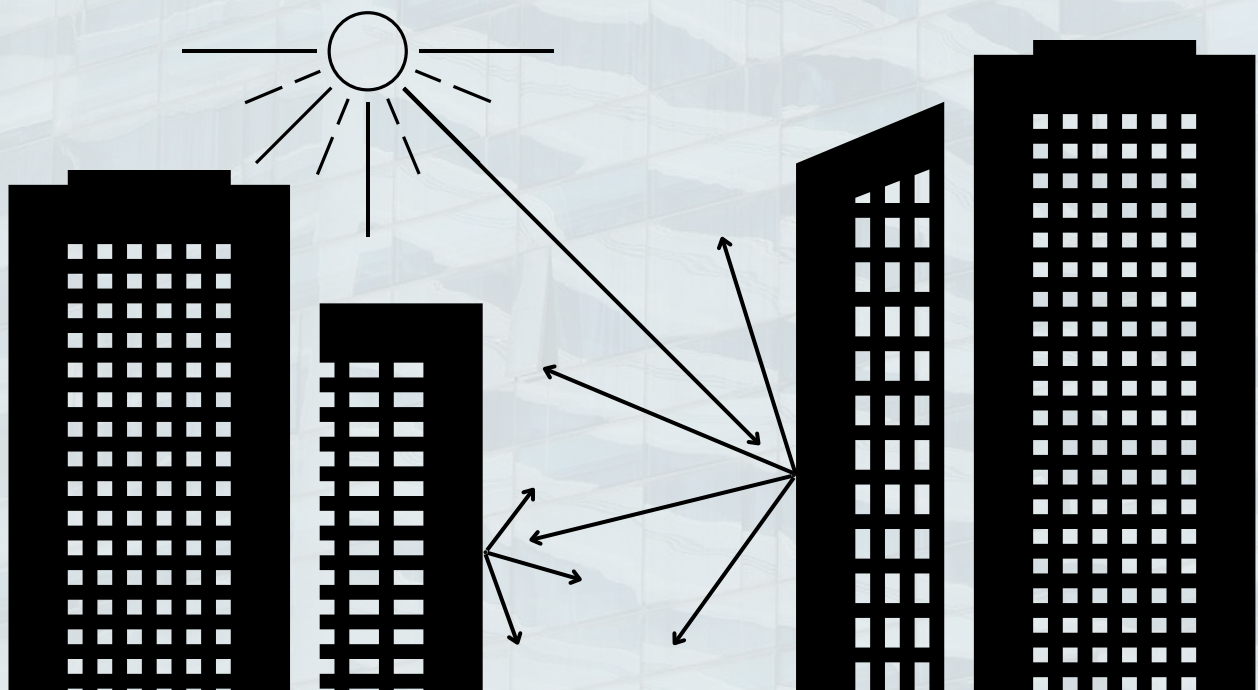


2 Excess Absorption of Solar Radiation

In natural ecosystems, plants reflect large portions of the sunlight that hits their leaves. The ratio of reflected light to incoming light is called **albedo**. Materials in the built environment, such as concrete and asphalt, generally have a lower albedo than the natural environment. This means they do not reflect most of the light that shines on them, causing them to appear black or gray. This light is instead absorbed and becomes thermal energy, i.e. heat.

3 Urban Canyons

Even buildings constructed from relatively high-albedo materials may absorb more solar radiation than a natural environment when tall structures are densely packed in arrangements known as **urban canyons**. Urban canyons trap heat depending on the shape, color, and orientation of the buildings as well as street width. When sunlight enters an urban canyon and hits a building, it reflects—scattering in all directions. Nearby buildings intercept most of this distributed light, preventing it from carrying its energy back out of the canyon. This trapped light will eventually be absorbed after bouncing between buildings multiple times. The energy absorbed will contribute to excessive heating of the city.



4 Public Health Impacts

In addition to causing discomfort for residents, rising temperatures pose a serious health threat. An increase of just 5 degrees Fahrenheit can double the risk of heat-related illnesses (New York State Department of Health, 2019). 239 people in New York City visited the emergency department in June 2021 for heat-related symptoms, up from just 149 in 2017 (Maldonado, 2021).



Common causes of death due to extreme heat include cardiovascular collapse, asthma, emphysema, stroke, and chronic kidney disease (Ebi et al., 2021).

Hydrological Disruptions

Paved roads, concrete buildings, and other **impervious surfaces** characterize New York's cities. According to Dr. David Nowak, Emeritus Research Forester, SUNY College of Environmental Science and Policy, impervious surfaces are 12 times more powerful in increasing stormwater runoff, compared to the reduction provided by trees (2022). The inability of these surfaces to absorb rainwater has drastically changed the hydrology of urban areas, making them more prone to flooding. During heavy rains, more water remains above ground and runs off compared to a natural environment where the water can percolate through the soil.



Hydrological Disruptions

1

Loss of Coastal and
Riparian Wetlands

2

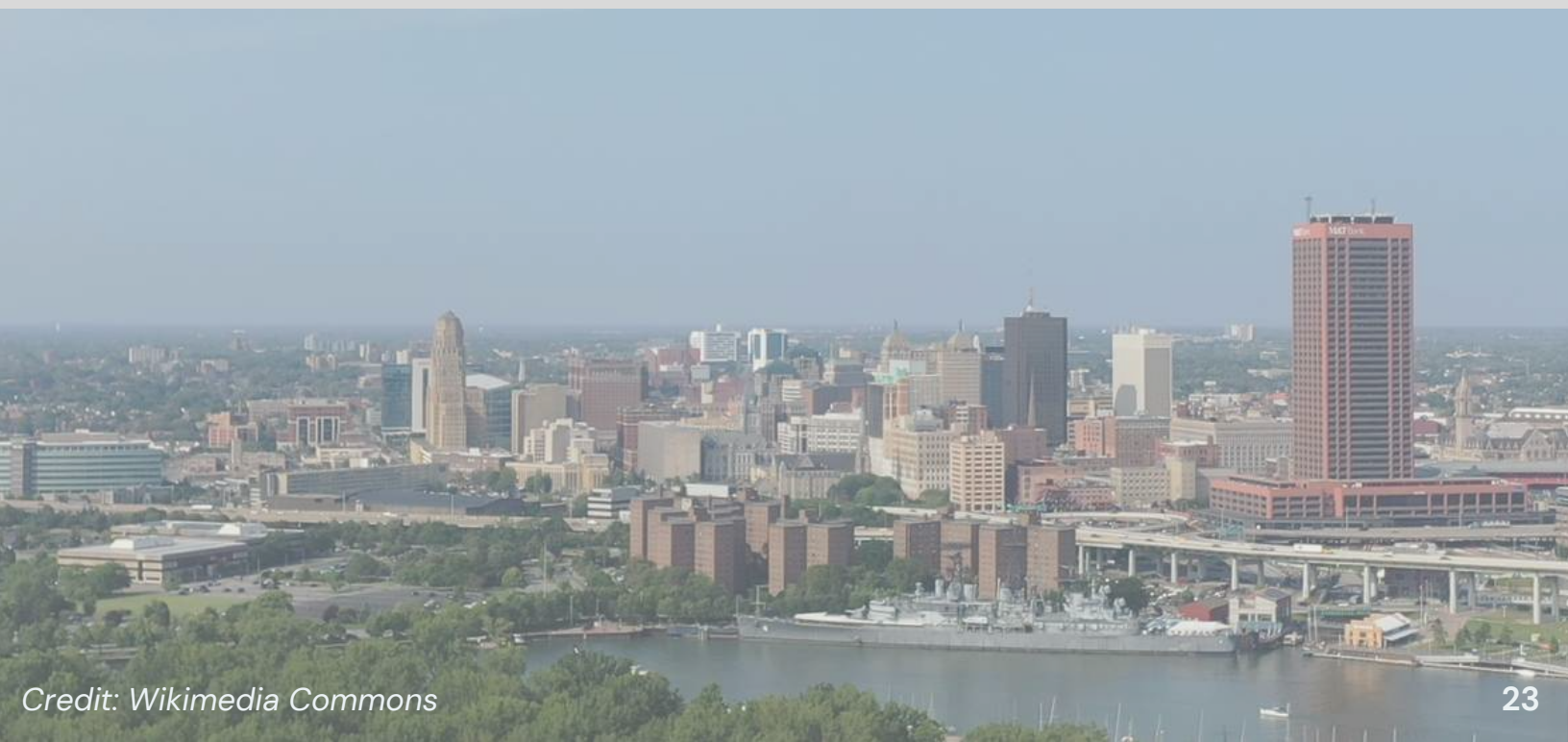
Runoff Impact to
Infrastructure

3

Public Health and
Local Ecosystem
Consequences

1 Loss of Coastal and Riparian Wetlands

Infrastructure displaced **riparian zones** and coastal wetlands in some areas, resulting in increased water runoff. Historically, the spaces between land and water helped reduce erosion and flash flooding by trapping and releasing water slowly. Some New York state cities, particularly New York City, have destroyed these natural ecosystem services by filling the wetlands for construction. Without these buffer zones, coastal towns are at a higher risk of damage during extreme weather events and are more vulnerable to sea level rise.





Credit: NARA & DVIDS Public Domain Archive

2 Runoff Impact to Infrastructure

Around 40 communities in New York state combine their rainwater drainage systems with their municipal sewer systems, treating both human waste and rainwater runoff at the same treatment plants. Runoff travels through these **combined sewer systems (CSS)** during rain storms, arriving at water treatment plants in high volumes. In cities that have not kept pace with population growth, treatment plants are sometimes overwhelmed by moderate precipitation (CSO in New York state – Shaping the Future of New York; “The History of Plumbing in New York City,” 2020). To prevent backup of the sewage system, combined storm runoff and municipal waste is discharged, untreated, into waterways — a phenomenon known as **combined sewer overflow (CSO)** (Combined Sewer Overflow (CSO), n.d.).

Problems

2 Runoff Impact to Infrastructure (cont'd)

The fate of sewage in the waterway depends on the local hydrology. The city of Buffalo faces a unique challenge as many of its combined sewer outfalls drain into the Buffalo River near where it enters Lake Erie. Changing water levels in the lake can slow or even reverse the flow of the Buffalo River.

One study used a hydrological model to analyze how CSO waste moves through this river. The model indicated that under certain conditions the river stagnates in areas near Buffalo's waterfront. During these events, CSO waste can reach high concentrations allowing particulates to settle into the sediment (Saharia et al., 2019). As a result, Lake Erie beaches are plagued with high levels of *E. Coli* bacteria, partially due to sewage. Combined with other bacteria and pathogens in the water, this can have severe health impacts on beachgoers, especially in vulnerable populations (Bush et al., 2014).



2 Runoff Impact to Infrastructure (cont'd)

Sewage brings a variety of ecologically disruptive pollution to waterways, including untreated human feces, pharmaceutical remnants, and household cleaners. The nitrate and phosphate nutrients in untreated human feces are particularly detrimental. When these nutrients reach the water, they cause **eutrophication**. Under eutrophic conditions, excess nutrients cause rapid algal growth, known as algal blooms. Once algae consume the nutrients, the organisms quickly die. Bacteria decompose the algae, consuming large amounts of dissolved oxygen. This depletion of oxygen, known as **hypoxia**, can displace or kill fish and other ecologically beneficial species.

Extreme eutrophication in Irondequoit Bay near Rochester, NY

Irondequoit Bay bordering Rochester offers one example of extreme eutrophication. Combined sewer overflows have degraded the Bay to the point where its sediments are persistently nutrient-enriched (Sansone, 2015). Pollution entering this body of water remains for 116 days on average due to its relatively low flow rate for its size (Bubeck & Burton, 1989).



3 Public Health and Local Ecosystem Impacts

Increased stormwater runoff is a threat to public health. Flooding can directly cause drowning or injuries. Eighteen people died by drowning in New York during Hurricane Ida over a span of 10 days (Hanchey et al., 2021). Flooding may also exacerbate existing health risks due to exposure to polluted water, increase of infectious diseases in crowded shelters, or lack of access to utilities (Lane et al., 2013).



Other Negative Impacts of Urbanization

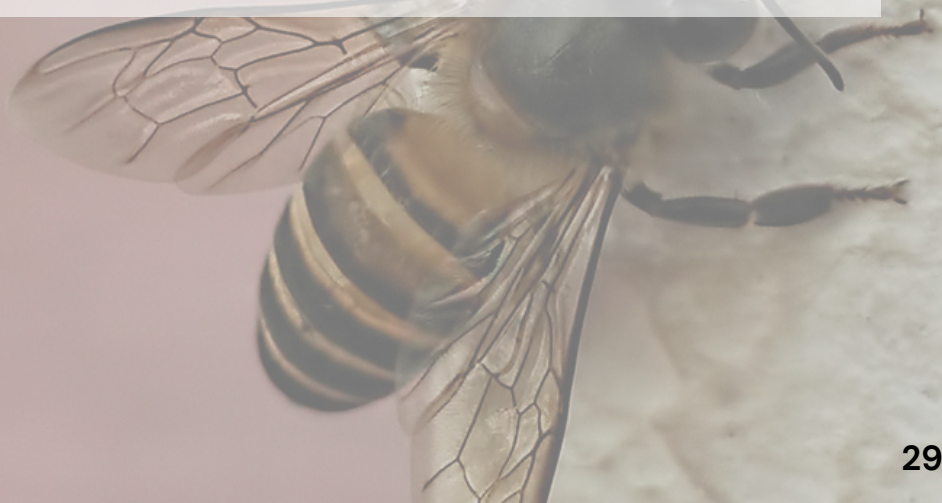
Air Pollution

Vehicular and industrial emissions in urban settings reduce air quality and pose significant health risks. Typical air pollutants include carbon dioxide, nitrogen oxides, sulfur oxides, particulate matter, and ozone. From 2006 to 2015, concentrations of most of these pollutants decreased across the New York state (Squizzato et al., 2018). For example, summer averages of solid particulate matter smaller than 2.5 micrometers in diameter (**PM_{2.5}**) decreased by 5% annually from 2005 to 2015. The state also saw declines in nitrous oxides as well, which ranged from 0.4% in Buffalo to 4.2% in Queens (Squizzato et al., 2018). These reductions were driven mostly by regulation and economic changes which lowered emission rates. Despite these improvements in air quality, pollutants in urban areas, especially in neighborhoods near major highways, remain at high concentrations. Exposure to these air pollutants results in an increased risk of cardiovascular and pulmonary diseases.

Other Negative Impacts of Urbanization

Loss of Natural Diversity

Deforestation is a driver of habitat fragmentation, increased incidence of animal-transmitted diseases, and species extinction and endangerment. Urban sprawl in New York state led to a loss of connectivity within similar habitats, causing habitat fragmentation and leading to native species decline and extinction. For example, 93% of New York City's 1,450 native plant species have been declining for the last century due to urbanization-caused habitat fragmentation and a lack of diverse urban vegetation (McPhearson et al., 2013). Bees also illustrate the limits of existing urban habitats—only 54 bee species out of New York state's 430 native bee species were observed in urban gardens of the Bronx and East Harlem in New York City (Matteson et al., 2008). As humans continue to move from rural to urban areas, deforestation poses an ever-increasing threat to existing ecosystems by disrupting delicate species balance.



Future Challenges

Problems like the UHI effect, increased stormwater runoff, and air pollution are concentrated in cities and exacerbated by **anthropogenic climate change**. Climatologists project an increase in the severity of extreme weather events over the next century. Under the current greenhouse gas (GHG) emissions trajectory, temperatures may rise across New York state by up to 10.1 degrees Fahrenheit by 2080 (Kunkel, 2022; “What Climate Change Means for New York,” 2016).

The impact of climate change on coastal storms is more uncertain, but statewide precipitation is expected to occur in more intense, less frequent events. Severe downpours will increase stress on stormwater infrastructure. New York urban ecologists see cities’ forests as critical infrastructure to prevent the worst climate change outcomes for cities, yet urban areas are losing trees at an alarming rate. Urban canopy cover in New York state decreased by 6,700 acres annually from 2008 to 2013 (Nowak & Greenfield, 2018).





THE SOLUTIONS

Ecosystem Benefits from Trees

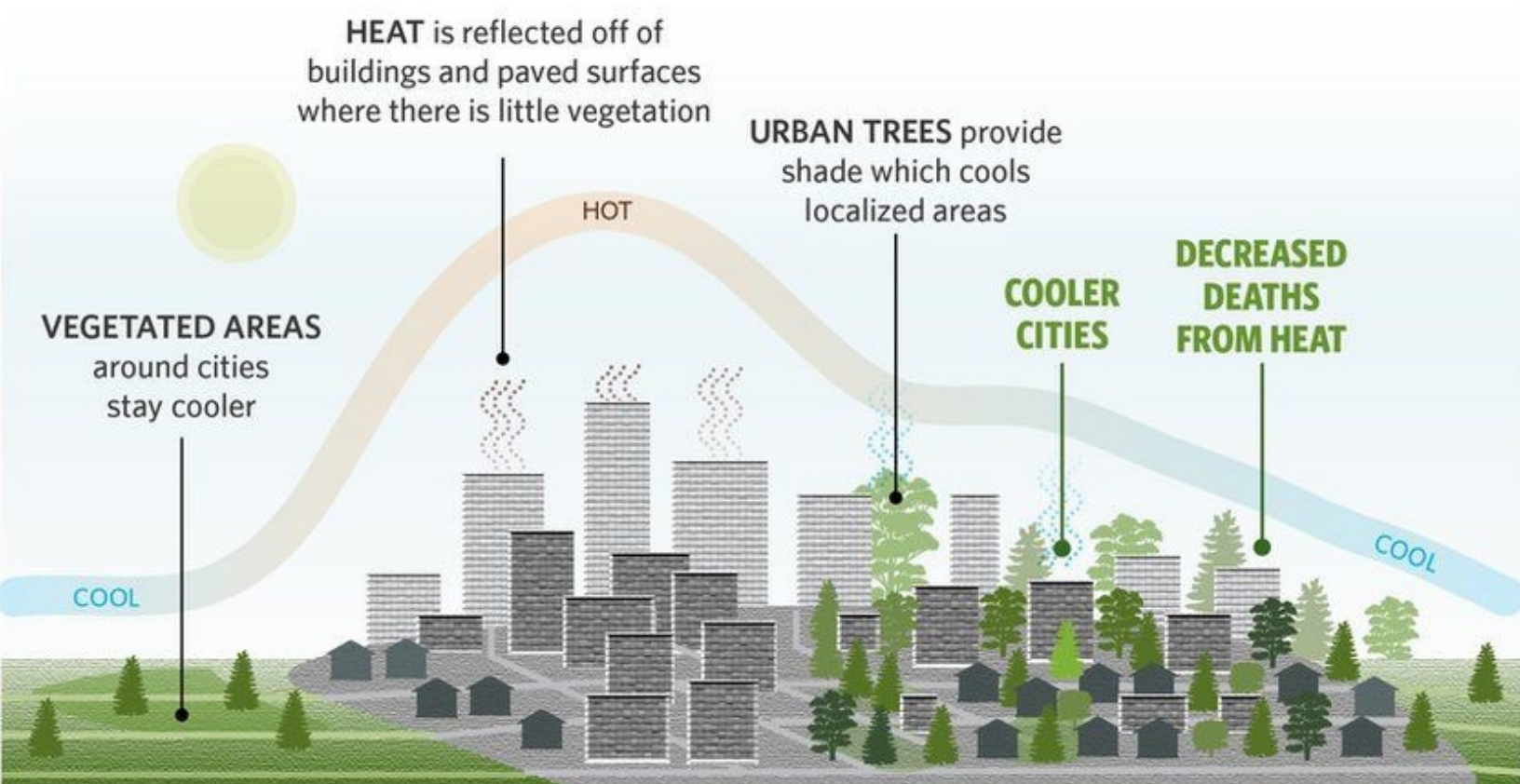
Overview

This section explores the addition of nature-based solutions such as trees and vegetation to urban landscapes as an effective mitigation technique for problems identified in the prior section, namely the urban heat island effect, stormwater runoff, air pollution, loss of biodiversity, and others.

Decrease Urban Heat Island Effect

Trees lower surface and air temperatures in two major ways. First, this happens through evapotranspiration of water vapor, which is the combined effect of evaporation and **transpiration**. Energy is released when water moves off the surface through evaporation, or by leaf cells known as **stomata** through transpiration (Rahman et al., 2020). Second, tree canopies prevent direct solar radiation from reaching the surface below, thereby preventing the transfer of heat to the ground.

Evapotranspiration, along with shade provided by trees, can reduce peak ambient air temperatures in a location by 2 to 9 degrees Fahrenheit when compared to a similar non-vegetated environment.



Case Study:

Urban Heat Island Mitigation in Rome

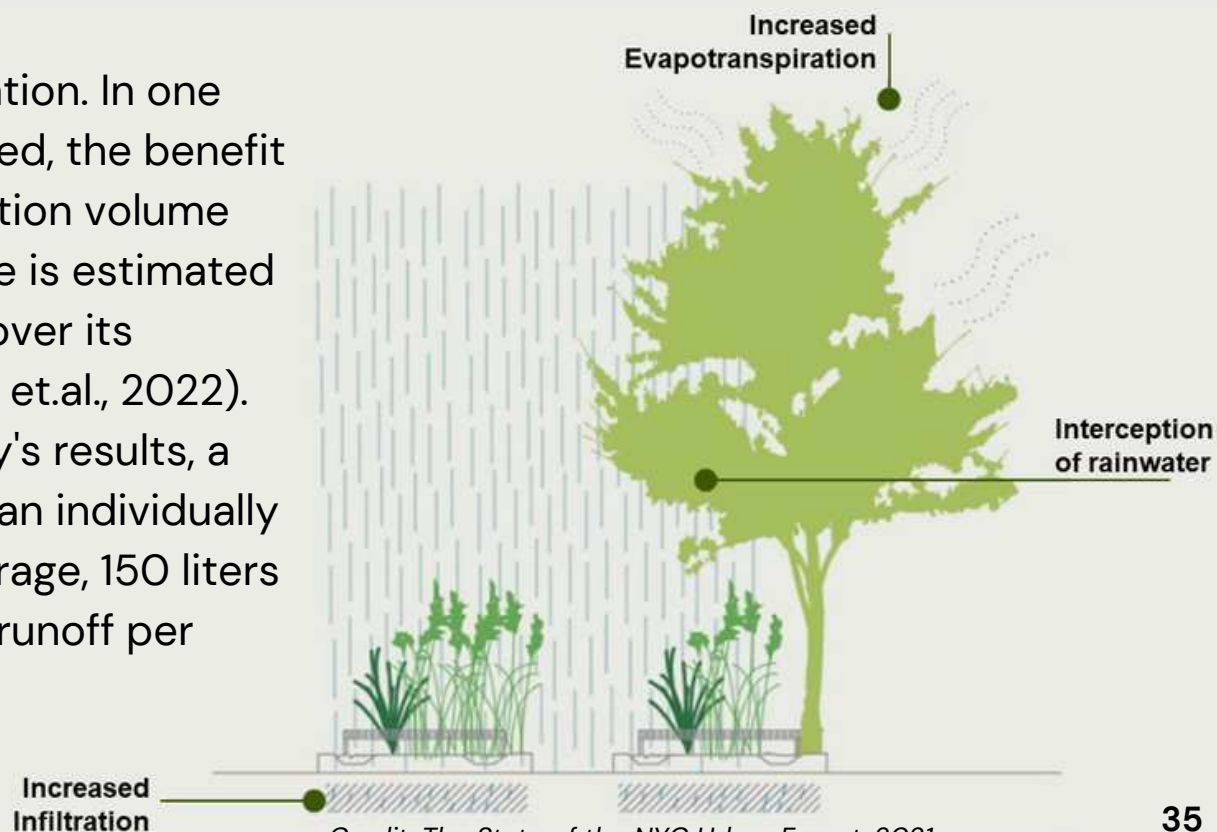
A study in Rome, which has a similar population density (5,781 people/square mile) to Rochester, New York (5,751 people/square mile), found that a 10% increase in tree cover can reduce ambient air temperatures by 5 to 7 degrees Fahrenheit (Westendorff, 2020).



Reduce Stormwater Runoff

Trees and vegetation improve drainage capabilities in cities by intercepting rain and retaining a portion of that water on their leaves and bark. Some of this retained rainwater evaporates, while the remaining water gradually soaks into the soil. At ground level, fallen leaves and other plant litter form a spongy layer, allowing water percolation. This percolated water slows runoff flow, preventing it from overwhelming cities' sewer systems. Trees also reduce erosion by anchoring topsoil through root growth.

Runoff reduction means decreasing the volume of stormwater runoff due to canopy interception, soil infiltration, and evapotranspiration. In one study conducted, the benefit in runoff reduction volume per mature tree is estimated at 6,376 liters over its lifetime (Selbig et.al., 2022). Using the study's results, a mature trees can individually reduce, on average, 150 liters of stormwater runoff per storm.

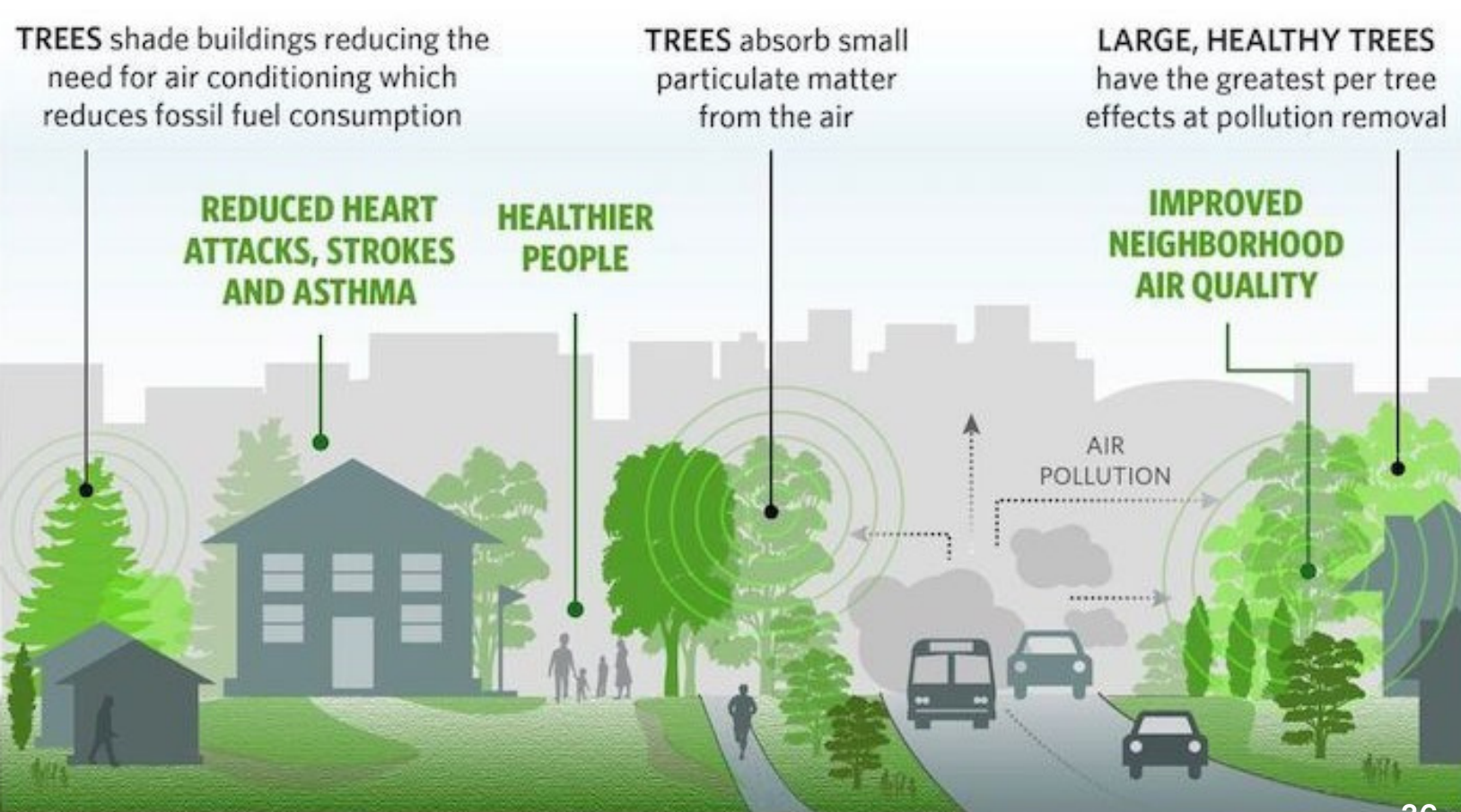


Credit: The State of the NYC Urban Forest, 2021

Improve Air Quality

Vehicles and industrial activities emit gases like ozone, nitrogen oxides, and sulfur oxides. In cities, these pollutants can reach harmful concentrations with health impacts like asthma and chronic bronchitis. Trees remove these gases such as PM2.5 through their stomata, openings on plant leaves that allow gas exchange for photosynthesis. Trees also remove pollution by obstructing airborne particles through their branches and leaves.

The urban forest of New York City removes approximately 735 tons of ozone, 242 tons of nitrogen dioxide, 88 tons of sulfur dioxide, and 41 tons of PM2.5 annually. This results in 1,106 tons of pollutant reduction in total (Treglia et al., 2021).



Additional Benefits

By intentionally placing trees in the path of wind and sunlight, urban forestation can reduce building energy consumption, protect buildings from direct solar radiation, lower wind speed, and reduce the infiltration of outside air into interior spaces. Together, these effects reduce buildings' energy demand for heating and cooling by roughly \$11.2 million annually in New York City (Nowak et al., 2007).

In addition to the health benefits from heat mitigation and air pollution reduction, urban vegetation provides several other public health benefits. Phytoncides, airborne chemicals from plants, interact with the human body to increase the number and activity of natural killer (NK) cells (Li, 2009). NK cells can eliminate cancerous and virus-infected cells in the human body, thereby boosting the immune system. Exposure to trees and vegetation can improve mood, reduce stress-related hormones, and lower blood pressure.

While trees provide a broad range of benefits, achieving these gains depends on the URA's provisions on implementing urban forestry activities and hiring key roles.

Science Behind the URA's Provisions



The URA creates funding for professional foresters and **landscape architects** to protect and manage each stage of the tree maintenance cycle: site and tree selection, planting, maintenance, pruning, and removal.

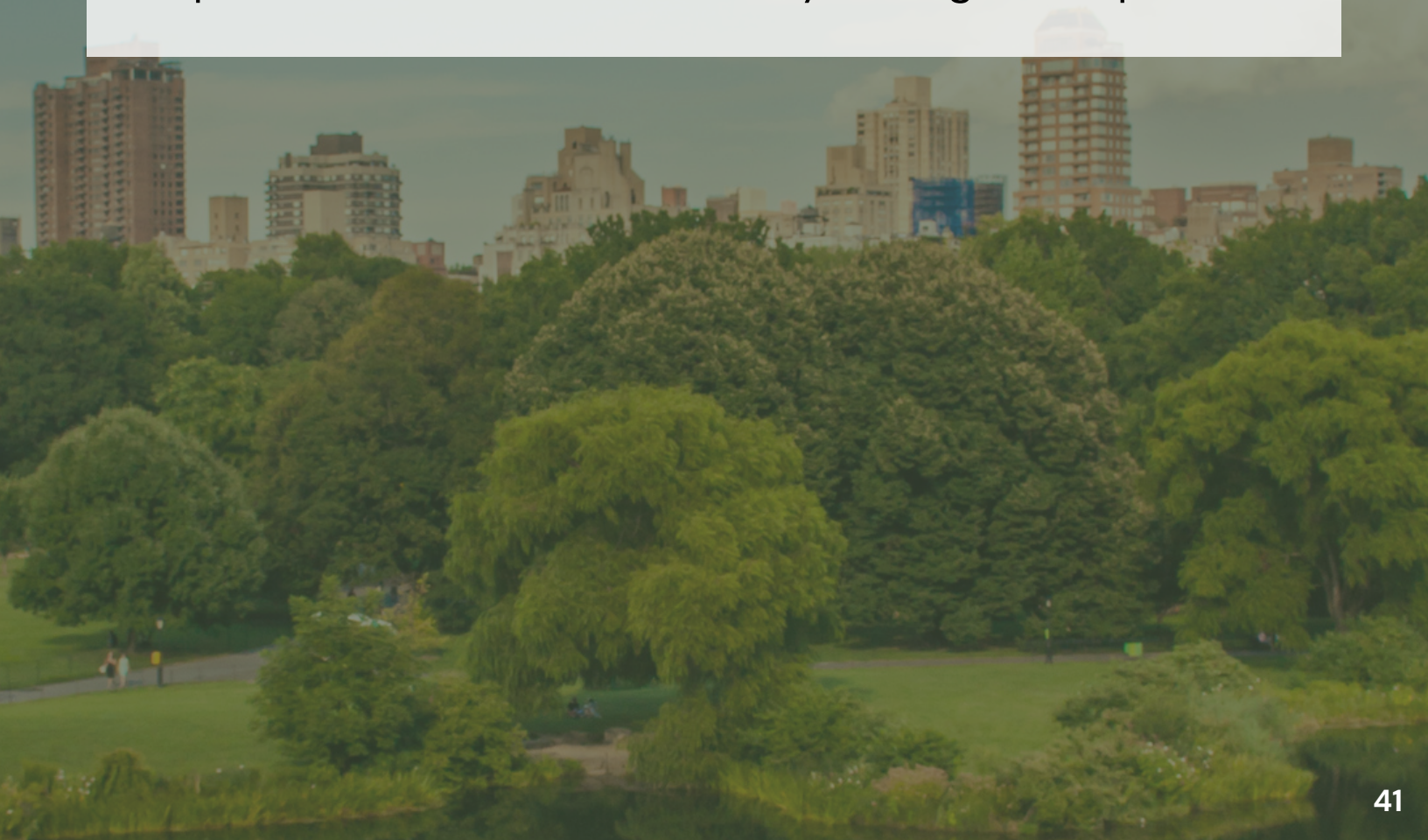
Solutions

- 1 Site Selection:** Foresters and landscape architects base site selection on climate, soil type, water availability, and biological and physiological factors. Possible sites in an urban landscape include streets, front yards, plazas, squares, open spaces, parking lots, brownfield sites, and underutilized land. After finding a site, foresters consider climate, water availability, maintenance demand, and canopy type to determine the best-suited tree species.
- 2 Tree Selection:** In New York state, large deciduous trees like red maple, London plane, and dawn redwood trees are preferred choices for streets as they provide a canopy, require less space, and are tolerant of pollution and drought.
- 3 Planting:** Cities consider key principles such as proximity to the curb, depth of soil, spacing of individual trees, and timing of planting. Optimizing these factors can maximize the longevity and benefits received from each tree.
- 4 Maintenance:** Regular tree maintenance includes mulching, removal of weeds, fertilizing, and watering. While local governments are charged with watering these trees, New York residents are also encouraged to water their street trees with 20 gallons weekly during the warmer seasons for the first three to five years, which are critical for tree growth (Kuser, 2000).
- 5 Pruning:** This involves the removal of dead or broken branches in bare rooted trees, torn roots, and roots. Pruning maintains plant energy reserves by improving root and branch structure. Precision pruning is another method that requires an additional trimming of inner branches, offsetting low soil volume in confined urban settings.
- 6 Removal:** Aging is one possible reason for tree removal, but infrastructural damage caused by branch spread, root overgrowth, or natural disasters is a primary reason as well.

Trees require different levels and types of care at various stages of their life cycle. By covering the tree maintenance cycle in its provisions, the URA prevents a significant step from being overlooked.

Nature-Based Solutions

New York state urban environments suffer from problems caused by large-scale urbanization and deforestation, where risks are magnified by climate change. The URA creates funding for nature-based solutions like urban reforestation. These solutions mitigate issues such as urban heat islands and poor drainage, while providing co-benefits including filtering pollution and reducing blood pressure. The legislation will direct funding to cities based on their population densities and land area to enable the preparation and implementation of urban forestry management plans.



THE CONTROVERSIES



Scientific Controversies

Introduction

Cities worldwide are planting trees to mitigate climate change-related effects. However, ensuring their long-term health and survival is particularly challenging amidst the unnatural concrete environment. Every benefit provided by trees, including stormwater runoff reduction and mitigation of the urban heat island effect, is far more effective by large, mature trees.

Trees Are Long-Term Investments

However, urban forestry professionals often struggle to maintain the trees under their care due to a lack of funding. This issue, coupled with expanding human development, results in diminishing urban vegetation. Therefore, trees in cities are subject to different threats than trees in natural forests, requiring intensive human care and maintenance.

Finally, urban vegetation grows in conditions with considerable unnatural restraints. For example, sidewalks and roads prevent water from percolating into the ground. This infrastructure leaves the soil underneath highly compacted, limiting root growth. Combined, these effects compromise and dehydrate the tree's structure. This presents a challenge, since many tree defenses rely on water. For example, trees produce sap to expel insects and capitalize on transpiration to prevent heat damage. When a tree's health is inevitably compromised by these conditions, urban foresters are forced to intervene early and remove the tree to reduce hazards to residents and property. Consequently, tree lifespans are much shorter in cities than in their natural ecosystems and urban forests are far more labor-intensive.

A fully mature tree has **70x** more air quality benefits than a new tree



Tree survival rates are lower in urban areas, with a mean life expectancy ranging from 19 to 28 years

Trees Require Care & Maintenance

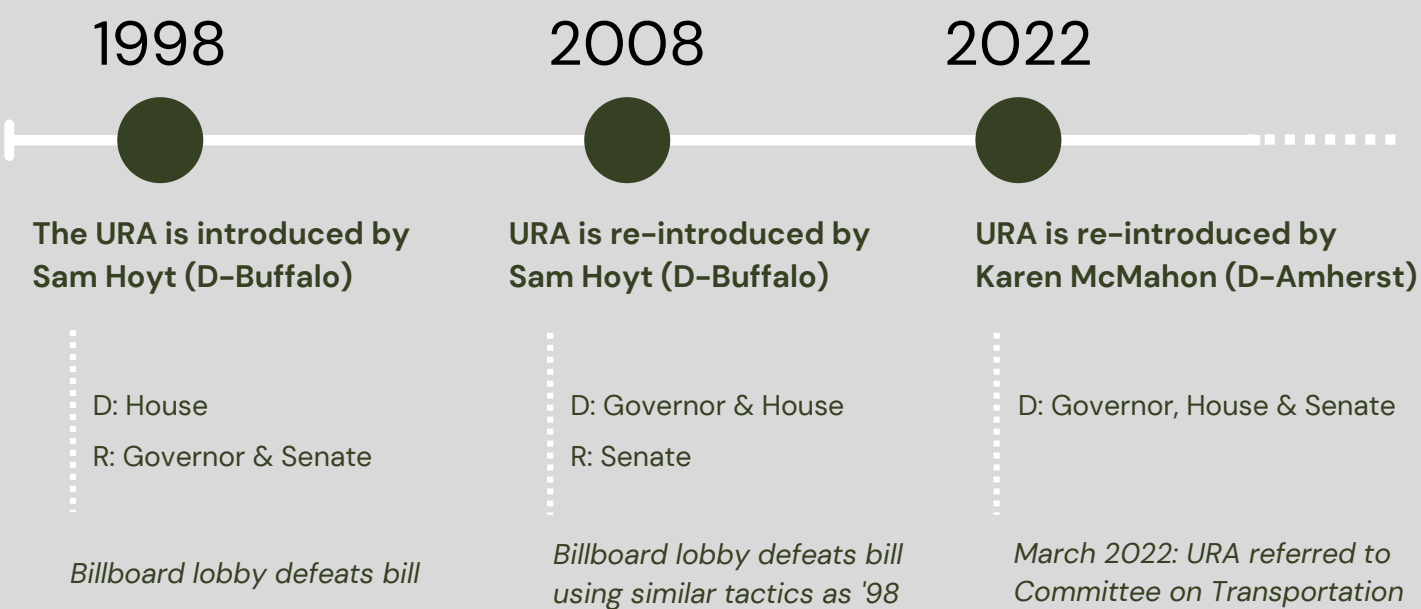
In New York state, native species, such as a red maple, London plane, or dawn redwood, would take approximately 20 to 30 years to provide benefits. Tree survival rates are lower in urban areas versus managed forests and nature reserves, with an average life expectancy ranging from 19 to 28 years depending on proper pruning, maintenance, and care.

Tree care guidance provided in the URA depends on city management and capacity. For example, the URA does not detail the selection of trees, who carries out maintenance, and under what timeframe. Furthermore, urban tree survival depends on soil volume and quality, water availability, and protection from pests. These conditions are all exacerbated by the urban environment which is on the front lines of trade and exchange. For example, pests like the European elm bark beetle can emerge suddenly, and avoiding tree plagues like Dutch Elm Disease can require vigilant monitoring and pruning. Additionally, vegetation in public streetscapes often conflicts with tree roots causing damage to sidewalks. This inhibits tree health and longevity by limiting root development and nutrient availability.

The Urban Reforestation Act's Rocky History

Assembly Bill A9610 is currently in the Committee on Transportation after being introduced by Karen McMahon (D-Amherst) in 2022. If passed, New York residents and local ecosystems will receive the benefits of added vegetation to urban landscapes. Billboard companies, on the other hand, will incur a monetary burden. Precedent shows that billboard lobby opposition is a likely threat to the URA's passage given billboard lobbyists prevented this bill from passing in 1999 and again in 2008.

On the other hand, several political tailwinds could make URA's passage more likely this time around. These include a Democratic supermajority controlling the Assembly, Senate, and Governorship, as well as increased voter support for environmental laws. New York state released one of the most ambitious climate change mitigation plans in the world in 2019, which the URA can complement (Roberts, 2019). Advocates of the bill could include the New York State Urban Forestry Council, the Nature Conservancy, and Re-Tree Buffalo, among others.



Gaps in the URA

Environmental Justice

The URA lacks explicit language to address socio-economic inequalities in its implementation. The bill specifies the distribution of funding based on population and density of urban areas, but does not prioritize money based on community need, despite the disproportionate impacts felt by low-income residents and communities of color. For example, increasing temperatures are causing hotter New York summers, and Black New York City residents are twice as likely to die from heat stress than White residents (2022 New York City Heat-Related Mortality Report, 2022).

Alternative Solutions

The URA creates a funding stream to increase trees in urban areas but lacks any language or alternative solutions. Other options—such as **natural landscaping, white roofs, and rain gardens**—are also effective measures of mitigating the impacts of extreme weather events in cities, especially when combined with adding trees. Additionally, when combined, added vegetation can improve and enhance a planted tree, working to protect its microenvironment.

“A rain garden is a depressed area in the landscape that collects rain water from a roof, driveway or street and allows it to soak into the ground.”
– Environmental Protection Agency



Credit: Sidewalk Stormwater Management Practices



MEASURING SUCCESS

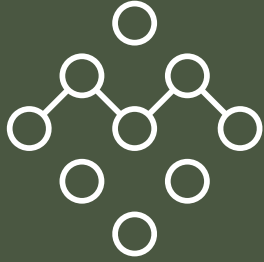
A Roadmap to Success

This section of the report defines indicators to track progress against the bill's outcomes, which include reducing the urban heat island effect, mitigating drainage issues, decreasing air pollution, and limiting biodiversity loss. We split our indicators into short-term and long-term benchmarks to account for the different needs of vegetation and the time required to yield benefits.



Methodology

Indicators were derived from the following models and tools:



Logic Model: a hypothesized description of inputs and outputs, leading to an outcome



Simulation Tools: quantitative and qualitative models such as iTree that predict the ecosystem benefits provided by a specified number and species of trees in a particular location



Government Data & Tools: an official reference of how institutions such as the New York State Department of Environmental Conservation evaluate and measure the effectiveness of urban tree planting and care

Methodology



Literature Review: Academic papers that highlight most commonly used and peer-reviewed measures and their scientific underpinnings



Expert Interviews: Applying indicators used by forest scientists and foresters with first-hand experience in forest management

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SMART: This evaluation criteria stands for Specific, Measurable, Achievable, Relevant, and Time-Bound. This framework provides evaluation criteria of each indicator (Boogaard, 2021)

Short-Term Indicators

The timeframe to estimate short-term progress begins with the planting of young trees and ends when they reach 20 years of age. The short-term outcomes are **tree survival and functionality** which can be measured using the following indicators:



Net Increase in Trees

This indicator ensures that the urban area is experiencing reforestation instead of deforestation.



Survival Rate of New Trees Under 3 years

This indicator measures the health of young trees, which are highly vulnerable to damage from the urban environment if not protected and carefully tended to.



Survival of Existing Trees

This indicator is crucial to evaluate the stability and long-term health of trees once planted.



Species Mix for New Trees

This is crucial to the long-term health of urban forests as diversifying tree species can limit exposure and risk to pests and diseases.

Long-Term Indicators

In addition to the previous indicators, **spatial distribution** is a crucial metric. However, this indicator is hard to measure due to a lack of available data and difficulty in assigning a standard for it. Additionally, trees take 20 to 40 years to reach maturation and provide maximum benefits. Indicators to measure the extent to which the URA has driven these benefits include:



Reduction in Surface & Ambient Temperatures

This indicator is highly related to the urban heat island effect (UHI). If the difference between urban and rural areas is within 2–5 degrees Fahrenheit or lower than 5 degrees Fahrenheit, the program has been successful as it has dampened the temperature increases from UHI. However, there will likely be confounding factors such as measures to reduce heat (e.g. white roofs).



Stormwater Runoff Reduction

Trees can reduce about 65% of stormwater runoff (How Trees Can Retain Stormwater Runoff, 2010). However, runoff reduction will be on a case-by-case basis due to each city's topography, sewer system carrying capacity, and other factors.



Air Pollution

Air pollution can be mitigated by uptake via leaf stomata from trees. Again, this will be evaluated on a case-by-case basis based on each city's tree species mix and baseline level of air pollution.



Public Health

Public health issues, such as heat illness and respiratory diseases caused by extreme heat, can also be mitigated by planting trees. This indicator will track the uplift provided by trees (e.g. decreased mortality rates from heat-related illnesses and air pollution).

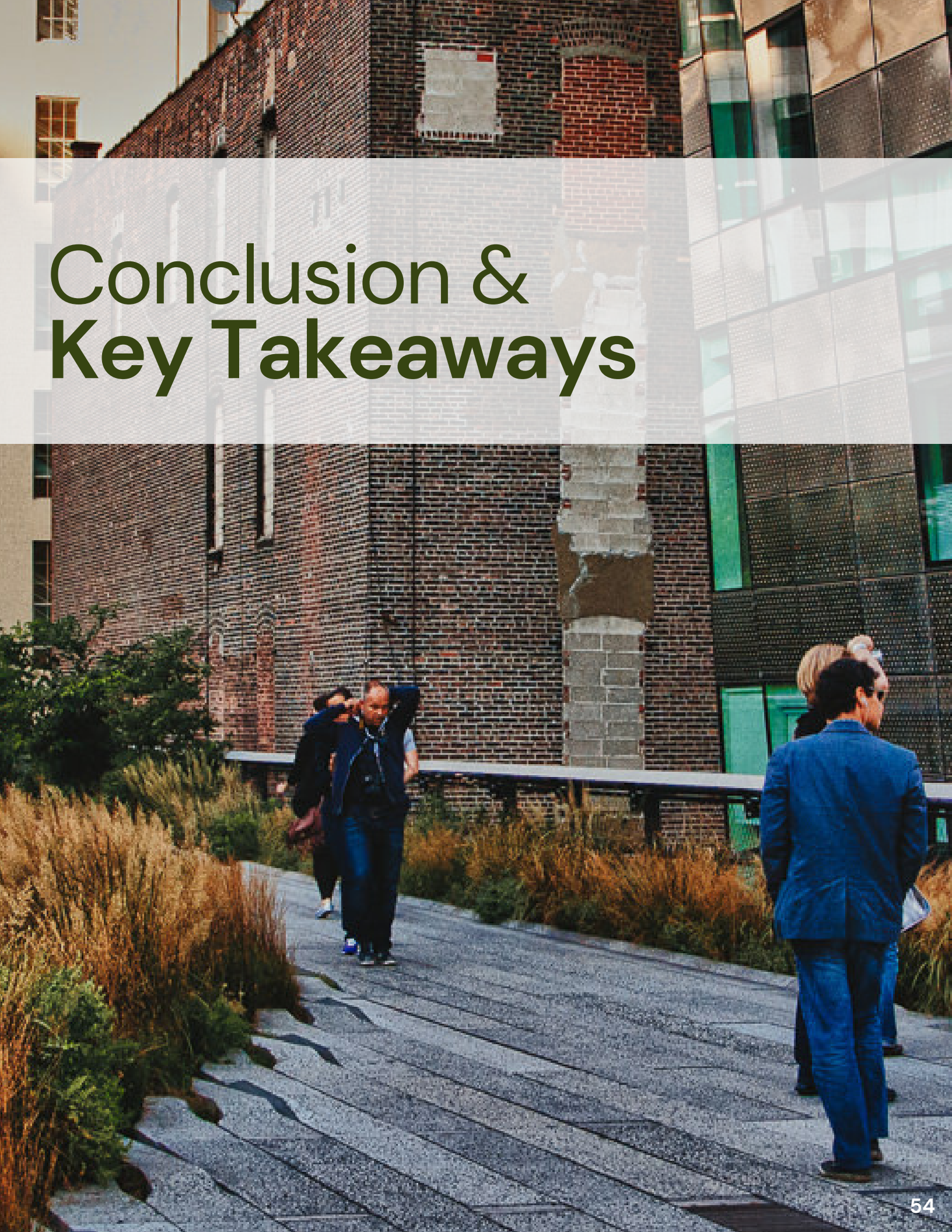
SMART Evaluation

The indicators were evaluated based on the SMART method. Findings are highlighted in the figure below:

SMART Evaluation					
	 Specific	 Measurable	 Achievable	 Relevant	 Timely
1. Net increase in trees	✓	✓	✓	✓	✓
2. Stormwater runoff reduction	✓	✓	✓	✓	✓
3. Survival of existing trees (> 3 years)	✓	✓	✓	✓	✓
4. Spatial distribution	✓	✓	✓	✓	✓
5. Species mix for new trees	✓	✓	✓	✓	✓
6. Reduction in surface, ambient temperature	✓	✓	✓	✓	✓
7. Stormwater runoff reduction	✓	✓	✓	✓	✓
8. Air pollution removal	✓	✓	✓	✓	✓
9. Public health improvements	✓	✓	✓	✓	✓



The indicators discussed above can be useful to evaluate the success of the URA in a comprehensive way as they encompass short-term and long-term inputs, outputs, and outcomes. Based on these indicators, it appears that mitigating urban environmental problems through urban reforestation is within reach.

The image is a full-page background photograph. It shows a modern architectural structure with a mix of old and new materials. On the left, there's a brick wall with some windows, some of which are boarded up. To the right, a newer section of the building features large glass panels and a perforated metal facade. In the foreground, a wide, light-colored stone path leads from the bottom left towards the building. Several people are walking on this path. One person in a blue suit is walking away from the camera on the right. Two other people are walking towards the camera on the left. The path is flanked by low-lying, dry, golden-brown plants. The overall scene suggests a blend of historical and contemporary architecture.

Conclusion & Key Takeaways

Learning from Past Mistakes

The Urban Reforestation Act remedies a key gap in prior efforts such as the MillionTreesNYC project, which put one million trees in the ground but did not provide continued maintenance. The URA does so by:

- a) Providing a **sustainable revenue source** to support vegetation planting and maintenance in urban environments suboptimal for vegetation.
- b) Creating a **net financial gain**. Nature-based solutions are cheaper to design and implement than engineered solutions for climate change adaptation.

Resilient NY: Planting for Future Generations

Land use change in New York state is a byproduct of development over the last 400 years. Beginning in the 17th century, European settlers converted forest and vegetation into agricultural land and resources for trade, settlement, and shipbuilding. The opening of the Erie Canal, the Industrial Revolution, and large-scale European migration through what is now New York City catalyzed deforestation. By the 1880s, New York state gained economic primacy at the expense of its forest canopy. At this point in time, the state enacted conservation policies to recover rural forests and vegetation cover, but continued to let cities expand—a developmental pattern that precluded environmental considerations and reduced vegetation in these cities.

This legacy of land use change is evident in New York's cities today. Cities bake under the urban heat island effect during the summers and experience combined sewer overflows during storms. They have also lost the natural filtration systems that reduce pollutants in the air. Urban expansion has fragmented wildlife habitats, reducing native fauna. With their attenuated natural systems, cities are now ill-equipped to cope with the threat multiplier of climate change. Climate change exacerbates environmental risks by increasing peak temperatures and intensifying the frequency and magnitude of storms. These risks translate into negative human health effects such as heat stress and reduces suitable habitats for flora and fauna. Climate change-induced extreme heat and storms also frequently overwhelm the tolerance threshold of infrastructure such as trains, roads, and sewage systems.

The New York State Urban Reforestation Act, Assembly Bill A9610, seeks to mitigate the environmental impacts mentioned above and partially undo the legacy of environmentally indifferent land use. The legislation relies on an outdoor advertising fee to fund nature-based solutions in New York's urban areas. In addition, the URA will increase chances of success for future green infrastructure projects by supplementing Article 53 of the New York State Environmental Conservation Law with a sustainable revenue source and directions for fund allocation.

The URA is not a sweeping solution to urban vegetation loss in New York state. It will not recover natural ecosystems in urban areas because of the irreversibility of land use change and high costs. However, if implemented correctly, the URA will provide much-needed, durable financial support for new vegetation and existing trees planted by initiatives such as the MillionTreesNYC project. Using these policy tools, this bill supports urban greening projects to create incremental yet essential progress in making New York state cities more livable, sustainable, and resilient.



Glossary

TERM	DEFINITION
Albedo	The ratio of the quantity of light reflected from an object's surface to the quantity of light shining on it
Anthropogenic Climate Change	Global scale changes in weather patterns caused by human emission of greenhouse gases
Article 53 of the New York State Environmental Conservation Act	Section within New York State's legislation that prioritizes and defines activities relating to tree conservation and urban forestry
Billboard	A structure built for the purposing of conveying a message or advertising a business and designed to be viewed from a road while driving
Bioswale	Vegetated channel which decelerates storm water runoff and allows it to seep into the soil
Combined Sewer Overflow (CSO)	The dumping of combined storm water runoff and municipal sewage into waterways when their flow exceeds water treatment capacity

Glossary

TERM	DEFINITION
Combined Sewer System (CSS)	Municipal sewer systems that drain surface storm water runoff in addition to commercial and residential wastewater
Commissioner of Taxation	Head of taxation and finance department, directs the state's efforts in the collection of taxes
Comptroller	State fiscal officer, overseeing the administration of state funds
Conservation	The planned management of natural resources for the benefit of society to prevent exploitation, destruction, or neglect
Department of Environmental Conservation (DEC)	New York state department overseeing its natural resources
Ecosystem Service	A social or economic benefit provided by a healthy natural ecosystem

Glossary

TERM	DEFINITION
Eutrophication	Excessive richness of nutrients in a lake or other body of water, frequently due to runoff from the land, which causes a dense growth of plant life and death of animal life from lack of oxygen
Forester	A person who has graduated from a school of forestry or is otherwise accredited or qualified
Habitat Fragmentation	The segmentation of habitat, usually of animals, into isolated sections, reducing their ability to survive or reproduce
Hydrological Cycle	The exchange of water between Earth's surface and atmosphere as well as its movement across Earth's surface
Hypoxia	Oxygen deficiency in a biotic environment
Impervious Surface	A surface, usually human-made, which does not allow for the transmission of water

Glossary

TERM	DEFINITION
Landscape Architect	A person who designs outdoor environments, especially harmonizing parks or gardens with buildings and roads
Natural Landscaping	The original landscape that exists before it is acted upon by human culture
PM2.5	Particulate matter, suspended in air, which has a diameter of less than 2.5 micrometers
Primary Highway	Main connection of roads designated as primary highway by the commissioner of transportation
Pruning	The cutting of tree limbs to improve tree health by removing dead, diseased, or damaged wood
Riparian Zone	A wetland area surrounding a river or stream

Glossary

TERM	DEFINITION
Section 88 of the New York State Transportation Law	A proposed section of the NYS Transportation Law, which would require the collection of annual outdoor advertising fees
Section 91-H of the New York State Finance Law	A proposed section of the NYS Finance Law, which would create and authorize the maintenance of a state fund for urban forestry
Site Selection	Decision on the location of a tree planting, decided on by factors such as climate, soil, and water availability
Solar Radiation	Light, including visible, infrared, and ultraviolet, which carries energy from the Sun to the Earth
Stomata	Cells on the surface of plant leaves which can open or close, allowing gas and moisture exchange
Transpiration	The release of water vapor from a plant's leaves via the stomata

Glossary

TERM	DEFINITION
Tree Maintenance	Provision of care to tree resources to assure the health of the urban tree resource
Tree Planting	Establishing the trees at a site, including site preparation, and installation of the tree
Tree Removal	Cutting of selected trees that are hazardous, dead, diseased or in some other way a danger to public welfare
Tree Selection	Decision on the tree species for a tree planting considering factors such as size, drought tolerance, and ability to provide ecosystem services
The Urban Reforestation Act (URA)	Also known as A9610, a proposed bill which would tax outdoor advertising to generate funds to promote urban forestry
Urban Canyon	The arrangement of tall buildings with narrow openings, which can restrict airflow and radiative cooling

Glossary

TERM	DEFINITION
Urban and Community Forests	Trees and other vegetation which exist in cities or densely populated areas and provide ecosystem services
Urban Deforestation	The removal or loss of trees and vegetation within cities or densely populated areas
Urban Forestry	The planning, establishment, protection and other management of trees and other vegetation in urban areas
Urban Heat Island Effect	A phenomenon in which areas of dense human population and buildings experience higher temperatures than the surrounding area
Wetlands	Terrestrial ecosystems in which soils are frequently highly saturated with water
White Roofs	Using white paint or light colored materials on rooftops to reflect higher levels of sunlight and reduce excess heating

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We thank you for your time, support, and commitment to climate resilience.

Acknowledgements

We'd like to take the time to thank Professor Louise Rosen for her continued time, effort, and support throughout this semester. We are so grateful for your commitment to our team. Additionally, we'd like to extend our thanks to the policy and scientific experts that aided in our research and exploration of this topic.

Special thanks to our **design leads and editors:**

Rafae Ghani (Manager)
Hannah Harasaki (Deputy Manager)
Diana Bunge
Julia-Grace Sanders

And with overwhelming gratitude to the **team:**

Alma Bauer
Eric Smith
John He
Katsuri Thorat
Matteo Chiadò Piat
Ipsita Dash
Zheqi Li

We dedicate this report to baby **Ethan He** who was born during this workshop