| LEHMAN COLLEGE

ENVIROMENTAL CASES

SEPTEMBER 16, 2021

0008

DURAN FIACK

South Bronx Sustainability

I.Sustainability

The contemporary characterization of sustainability emerged in the 1980s as a transformative idea, primarily shaped by the United Nations (U.N.) (Campbell 1996; Hempel 2012). The concept was initially introduced by the World Conservation Strategy in 1980 (IUCN 1980) and popularized with the release of the World Commission on Environment and Development's (Brundtland Commission) report, Our Common Future (WCED 1987). The report defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, 43). The Brundtland Commission's model of sustainability suggests that sustainable development can be by actions that simultaneously protect environmental quality, support economic development, and promote or improve social equity (Hempel 2009, 2012; Mazmanian and Kraft 2009; Portney 2015; WCED 1987). Historically, the three co-equal goals of sustainability have often been viewed as being at odds with one another. For example, efforts to support economic development may result in environmental degradation (e.g., natural resource extraction and consumption, pollution and waste production, etc.) and decreased social equity (e.g., increased income inequality, disproportionate exposure to poor environmental quality, etc.). A policy, within the context of sustainability, should protect environmental quality, while also enhancing social equity, and supporting economic development.

In 1992, the sustainability framework gained international legitimacy with the adoption of the Rio Declaration on Environment and Development and Agenda 21 by world leaders at the U.N. Earth Summit, held in Rio de Janeiro. The Rio Declaration consisted of 27 principles intended to guide future sustainable development, while Agenda 21 articulated a plan for putting the principles into practice (UN 1992). The documents catalyzed the emergence of sustainable development and sustainability as a widespread model for contemporary environmental governance (Hempel 2009; Portney 2015). Following the Earth Summit, the U.N. established a Commission on Sustainable Development to provide guidance and develop indicators to monitor progress in achieving the objectives laid out in Agenda 21 and the Rio Declaration. The Commission was charged with establishing measures that placed equal emphasis on the economic, social, and environmental dimensions of sustainability (UN 1995, 1996, 1997). The multidimensional characterization of sustainability was highlighted at the 2002 Earth Summit and, most recently, the adoption of the U.N. Sustainable Development Goals, which were designed to be "integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental" (UN 2015, 1). Graphically, the concept of sustainability is often presented in the form of three intersecting circles that represent social equity, environmental protection, and economic development (**Exhibit 1**). Alternative graphic representations of sustainability include the three dimensions of sustainability as nested concentric circles or pillars. Each of these depictions of the integrated and interrelated goals of sustainability can be found in various forms within academic and business literature, policy documentation, and online (Purvis, Mao, and Robinson 2019).

In its initial formulation of the modern sustainability movement, the U.N. paid significant attention to the activities of local governments and the critical role of civic leadership in advancing the sustainable development agenda (Hempel 2009; Portney 2015). The report by the Brundtland Commission identified cities in industrialized nations as a primary source of consumption and pollution (WCED 1987). Chapter 28 of the Agenda 21 resolution, "Local Authorities Initiatives in Support of Agenda 21," laid out the Local Agenda 21 process and the foundation for the International Council for Local Environmental Initiatives—Local Governments for Sustainability (UN 1992). Each document focused on sustainability planning and action at the local level. The early integration of cities as a focal point of sustainability initiatives, along with a developing criticism of sustainable development in the international context, and a growing concern about the quality of life in urban areas, led to the emergence of a tangential sustainability movement that focused on local governments (Hempel 2009; Ophuls 1996).
The so-called *sustainable communities* movement is characterized by decentralized policy efforts that focus on comprehensive planning and preventative, rather than remedial, interventions that support co-equal social, economic and environmental goals (Maser 1997; Mazmanian and Kraft 2009; Weber 2003; Wondolleck and Yaffee 2000). To facilitate the development of comprehensive policies, the sustainable communities approach to environmental governance advocates for cooperation across the public, nonprofit, and private sectors through the application of collaborative decision-making processes, public-private partnerships, and public education campaigns (Durant, Fiorino, and O'Leary 2004; Press and Mazmanian 2006).

The sustainability framework offers a practical approach for urban planners interested in designing solutions to crosscutting environmental problems, such as climate change. Such environmental challenges generally require collaboration and commitment across a diverse array of sectors and stakeholders to be addressed effectively (Agyeman and Evans 2004; Eriksen et al. 2011; Mazmanian and Kraft 2009). However, one of the fundamental challenges of establishing sustainable communities is the successful reconciliation of the three conflicting goals of becoming green, profitable, and fair, all at the same time. Scholars have suggested that fiscal constraints and political imbalances are likely to result in conflict amongst competing environmental, economic, and social interests, which can result in outcomes that fail to equally support all three sustainability objectives (Agyeman 2005; Agyeman, Bullard, and Evans 2003; Campbell 1996; Saha and Paterson 2008). Therefore, scholars have argued that achieving progress in one of the pillars of sustainability often comes with tradeoffs that have detrimental consequences to one or both of the remaining two (Campbell 1996). Research concerning the 'conflicting sustainability goals has supported this notion, concluding that efforts to implement sustainable development initiatives frequently produce outcomes that favor environmental and economic goals (Agyeman 2005; Portney 2013; Saha and Paterson 2008).

II. Sustainability and the South Bronx

The following case study applies the sustainability framework to focus on issues concerning environmental quality, social equity, and their interrelationships amongst residents living in the South Bronx region of the Bronx. In 2019, there were an estimated 1,418,207 people in The Bronx, of which 3.7% of the population identified as Asian, 29.0% identified as Black, 56.4% identified as Hispanic, and 8.8% identified as white (Furman Center 2021). The Bronx is one of five boroughs in New York City (NYC), and is home to the third-largest commercial district in the city (Fordham Road commercial district), one of the world's largest food distribution centers (Hunts Point Food Distribution Center), and several major hospitals, which count among the city's largest employers. The Bronx is also the third most densely populated county in the U.S. However, approximately one-quarter of the borough's area is open space, including Woodlawn Cemetery, Van Cortlandt Park, Pelham Bay Park, the New York Botanical Garden, and the Bronx Zoo (Office of the New York State Comptroller 2019).

For this study, the data are drawn from the NYC Environment and Health Data Portal (City of New York 2021a). The database includes environmental, socioeconomic, and public health data extracted from several reports, each grouped across seven regions of the Bronx. The analysis focuses on the portal's definition of the *Highbridge-Morrisania* and *Hunts Point-Mott Haven* neighborhoods, which include several zip codes located within the South Bronx region (**Exhibit 2**). With the exception of the Hunts Point neighborhood, the area includes most of the land bordered by Interstate Highway 87 (I-87) to the west, the Cross Bronx Expressway to the north, and the Bruckner Expressway to the east. The data used in the study were drawn from five reports, *Active Design, Physical Activity and Health*, *Asthma and the Environment*, *Climate and Health*, *Housing and Health*, and *Outdoor Air and Health*. Each report provides information concerning various environmental, human health, and socioeconomic conditions within the portal's definition of the Highbridge-Morrisania and Hunts Point-Mott *Haven* neighborhoods.

Despite its unique economic and environmental features, the Bronx is also the poorest urban county in the U.S., and the 15th Congressional District, located in the South Bronx, is the poorest in the country (Office of the New York State Comptroller 2019). The poverty rate in The Bronx was 26.4% in 2019 compared to 16.0% citywide (Furman Center 2021). Additionally, health outcomes for Bronx County residents are among the worst in the nation, and the county is ranked the least healthy in the state. Income is an essential consideration within the context of social equity and environmental quality, as it can serve as a relative measure for adaptive capacity. In this context, adaptive capacity refers to an individual's ability to adjust to, or recover from, exposure to some social, economic, or environmental impact. Adaptive capacity can generally be improved through access to financial resources, institutions (e.g., government or community programs), and social networks. A snapshot of a selection of socioeconomic, housing, and health data shows that South Bronx residents generally have more significant economic challenges than the rest of the borough and NYC (**Exhibit 3**). The portion of the population living in poverty in the Highbridge-Morrisania neighborhoods was nearly double, while the Hunts Point-Mott Haven neighborhoods were more than double, the rate found at the city level. The percentage of the population under five years of age living in poverty was also substantially higher. Adaptive capacity can generally be improved through access to financial resources, institutions (e.g., government or community programs), and social networks.

III. Environmental Quality and Equity in the South Bronx

The measurement of environmental quality in urban areas can be accomplished in a myriad of ways. Such measurements, sometimes called *urban environmental indicators*, are parameters that different urban stakeholders employ to measure, monitor, and evaluate city environmental quality and conditions. Such indicators mainly focus on environmental aspects of urban development and factors that significantly impact urban residents' quality of life and health conditions (Ji 2014). Shao et al.'s (2019) review of the literature on urban environmental quality indicators identified 29 commonly applied metrics that are used to assess environmental quality in cities (**Exhibit 4**). The indicators are distributed across six dimensions that collectively encapsulate the various natural and built environmental conditions that can influence the quality of life for individuals living in cities. The following analysis of environmental quality and equity in the South Bronx focuses on three dimensions of urban environmental quality, the natural environment, artificial environment, and pollution control. The study draws from recent data on four indicators: air quality, green coverage (green space), greenbelt area, and particulate matter (PM_{10}) concentration.

Urban Green Space

The phrase *urban green space* is commonly applied to describe undeveloped areas such as urban forests, city parks, cemeteries, lawns, and greenways primarily covered with grass, trees, shrubs, or other vegetation. Access to green space can provide many social benefits to urban residents that affect health and well-being such as: psychological relaxation and stress relief; opportunities for recreational, physical, and social activities; and reduced exposure to noise, air pollution, and excessive heat (Braubach et al. 2017; Hartig et al. 2014; Lachowycz and Jones 2013; Villanueva et al. 2015). An additional environmental benefit of green space in urban areas is the potential to support and maintain biodiversity by protecting natural habitats for endemic (native) plant and animal species (Aronson et al. 2017).

Mitigation of air pollution and excessive heat are two of the primary environmental benefits that green space in urban areas can provide to support human health. *Air pollution* is a term frequently used to refer to a complex mixture of nano- to micro-sized particles and gaseous pollutants. Particulate matter of various size ranges and gaseous pollutants are significant pollutants in the urban environment, and exposure to these pollutants has been linked with respiratory and cardiovascular diseases (**Exhibit 5**).[1] Greenspace has been shown to remove atmospheric particles through dry deposition onto plant surfaces (McDonald et al. 2007; Nowak et al. 2006) and absorption of gaseous pollutants through plant stomata (Harris and Manning 2010; Nowak et al. 2006; Yin et al. 2011). Additionally, the placement of green infrastructure, especially trees, between pollution sources (e.g., automobile traffic) and urban residents has been shown to act as a natural filtering barrier in urban areas (Abhijith et al. 2017).

[1] *Particulate matter* is the generic term used for air pollution that consists of liquid and solid particles suspended in the air.

In addition to potential air quality improvements, the preservation and restoration of green space in urban areas also serve as a mitigation strategy to address the *urban heat island effect*. This condition is likely to increase in frequency due to climate change. An *urban heat island* occurs when cities replace the natural land cover with dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat more than natural landscapes such as forests and water bodies (U.S. EPA 2020b). This phenomenon causes urban areas, where such structures are highly concentrated and green space is limited, to become *islands* of higher temperatures relative to areas with higher percentages of land allocated to green space or tree canopy coverage.[2]

For urban communities, exposure to higher daytime temperatures and reduced nighttime cooling can produce an increased demand for energy through the use of air conditioners to cool dwellings. In cases where electricity providers rely on the combustion of fossil fuels, greater energy demand can increase the emissions of greenhouse gases, such as carbon dioxide, which contribute to global climate change (U.S. EPA 2020a). Increased demand for fossil fuel-based energy can affect air quality by increasing ground-level ozone and fine particulate matter concentrations at the local level. High temperatures can worsen the human health impacts of these effects. Ground-level ozone, for example, is formed when nitrogen oxides and volatile organic compounds react in the presence of sunlight and hot weather (U.S. EPA 2020a). Therefore, an increase in the rate of fossil fuel combustion to meet increased energy demand and elevated temperatures can directly increase the rate of ground-level ozone formation, increasing the magnitude of human exposure to air pollution.

For urban residents, exposure to extreme temperatures and associated air pollution has been found to contribute to increased instances of heat-related deaths and illnesses such as general discomfort, respiratory difficulties, heat cramps, heat exhaustion, and non-fatal heat stroke (U.S. EPA 2008). The development of urban green space can help to mitigate the occurrence of urban heat islands, and their impacts on human health and well-being, through the use of trees and vegetation to lower surface and air temperatures by providing shade and increased rates of evapotranspiration (Akbari et al. 1997; Huang, Akbari, and Taha 1990; Kurn et al. 1994).[3,4] In addition to reducing the effect of direct exposure to extreme temperatures, when strategically planned, the use of trees and

---

[2] Day and nighttime temperatures in urban areas are approximately 1–7°F and 2–5°F higher than temperatures in outlying areas, respectively (U.S. EPA 2020b).
[3] Shaded surfaces may be 20–45°F cooler than the peak temperatures of surfaces without shade (Akbari et al. 1997).
[4] Evapotranspiration can help reduce peak summer temperatures by 2–9°F (Huang, Akbari, and Taha 1990; Kurn et al. 1994).

vegetation to mitigate the urban heat island effect has additional benefits. Some of the co-benefits include: reduced energy demand for air conditioning, improved air quality, a reduction in pollutants carried into storm drains by stormwater runoff, the preservation and protection of paved infrastructure, and improved quality of life for urban residents (U.S. EPA 2008).

Access to Green Space

Approximately 25 percent of the Bronx's 57 square mile area is dedicated to parks, and nearly 41 percent of the borough's land is covered in green space (e.g., forest, wetlands, grasslands, gardens, cemeteries, lawns, and backyards) (NAC 2020; NYS 2021). The borough is home to Orchard Beach, a 13-mile saltwater shoreline, and three of the city's ten largest parks, including the Pelham Bay Park (2,765 acres), Van Cortlandt Park (1,146 acres), and Bronx Park (718 acres). Pelham Bay Park is the city's largest park, while Bronx Park is located along the Bronx River and encompasses the New York Botanical Garden and the Bronx Zoo (NYC Parks 2021a). Despite the impressive amount of land dedicated to open space within the borough, a vital consideration is whether the distribution and access to these resources are equitably distributed. A cursory review of the spatial distribution of the parks within the Bronx reveals that the distribution of the city-owned green space is disproportionately located in the northern portion of the borough, with Van Cortlandt Park located in the Northwest, Pelham Bay Park in the Northeast, and Bronx Park at the center of the borough (**Exhibit 7**). Therefore, the large-scale environmental, recreational, and educational benefits of these natural areas are most immediately available to Bronx residents living in the borough's central, northwestern, and northeastern regions.

Despite the limited access to the Bronx's largest green space areas, South Bronx residents benefit from living within a patchwork of small- to medium-sized parks, offering residents a relatively high level of access to open space. As of 2017, 98 percent of residents in the High Bridge-Morrisania and 96 percent of residents in the Hunts Point-Mott Haven areas of the Bronx lived within walking distance of a park. In contrast, 87 percent of Bronx residents and 81 percent of city inhabitants overall had a park within walking distance of their residence (**Exhibit 4**).

A relatively high proportion of individuals living within the South Bronx have access to city parks. However, the composition of this space and the integration of vegetation along city sidewalks and buildings is important to consider when determining the distribution of environmental benefits that such land uses provide. **Exhibit 8** shows that, although a relatively high percentage of South Bronx residents have access to parks, the overall proportion of land dedicated to green space is comparatively low. For example, only 18 percent of the land located in the Hunts Point-Mott Haven neighborhoods is covered with green space (e.g., trees and grass). In contrast, 39 percent of land in the Bronx and 38 percent of land in NYC is classified as green space.

Similarly, a focus on tree canopy coverage, one of the primary mitigation strategies for addressing the urban heat island effect, shows that South Bronx residents have a relatively low portion of land area covered by tree canopy. In the Highbridge-Morrisania and Hunts Point-Mott Haven neighborhoods, 13 percent and 7.1 percent of the land area is covered by tree canopy, respectively. In contrast, 22.7 percent and 21.1 percent of the Bronx and NYC land area is covered by tree canopy, respectively (**Exhibit 8**). The analysis results indicate that, although the South Bronx boasts a relatively high distribution of parks and open space, the allocation of green spaces in the region is comparatively low.

Air Quality

The federal Clean Air Act requires the U.S. Environmental Protection Agency (EPA) to establish maximum acceptable levels for six common air pollutants due to their effect on human health and the environment. These levels are formally defined by what are known as National Ambient Air Quality Standards. They are established based upon concentration levels at which specific contaminants become harmful to human health, as well as the economic costs associated with controlling each pollutant. In some cases, the EPA establishes two standards, primary and secondary. Primary standards are established to protect public health, including the health of "sensitive" populations (e.g., asthmatics, children, and the elderly), while secondary standards provide public welfare protection (e.g., protection against decreased visibility and damage to animals, crops, vegetation, and buildings) (U.S. EPA 2021a). The standards are measured in units of parts per million (ppm), parts per billion (ppb), or micrograms per cubic meter ($\mu g/m^3$). Each measure refers to a pollutant concentration in the air and is typically compared to an averaging time. For example, the primary standard for sulfur dioxide (SO_2) set by the EPA is a one-hour average of 75 ppb. This means that measurements of SO_2 concentrations are averaged over a period of one hour.

Recent data for the South Bronx shows that, in general, the pollution levels of four of the six criteria air pollutants regulated by the EPA are below the levels established by the NAAQS (**Exhibit 10**). However, air quality in the region, with the exception of ground-level ozone, is generally lower compared to data observed throughout the entire borough and NYC. While sulfur dioxide levels are only slightly higher in the Highbridge-Morrisania and the Hunts Point-Mott Haven areas, relative to those observed throughout the city, fine particulate matter ($PM_{2.5}$) and, in particular, nitrogen dioxide levels are higher in the South Bronx relative to those observed in the borough and within the city overall (**Exhibit 10**).

Sources of Air Pollution

Air pollution in the South Bronx, and the NYC region more generally, is produced from various sources. The primary producers of ozone, sulfur dioxide, particulate matter, and nitrogen dioxide include car exhaust, the combustion of burning fuels, and construction and industrial activity. Air pollution produced from vehicles is a common challenge faced by urban areas, and is a significant source of ozone and particulate matter pollution (see **Exhibit 5**). Three major transportation corridors border a large portion of the South Bronx, Interstate Highway 87 (I-87) to the west, the Cross Bronx Expressway to the north, and the Bruckner Expressway to the east. Consequently, the neighborhoods within this area are likely to be exposed to large volumes of heavy vehicle traffic and associated pollution, affecting nearby residents.

Exhibit 11 shows that the Highbridge-Morrisania region of the South Bronx is exposed to exceptionally high levels of traffic density. Directly bordered by I-87 to the west and the Cross Bronx Expressway to the north, the communities living within this region, especially those living near these transportation networks, experience higher levels of car and truck traffic density relative to other communities in the South Bronx, the Bronx, and NYC overall. Research concerning the effect of traffic on human health has found that people who live within 150 meters of major highways or high traffic density roads are exposed to air pollution concentrations that are higher than ambient background concentrations (Hitchins et al. 2000). Consequently, neighborhoods in the South Bronx community located close to major transportation networks are likely to be exposed to relatively high levels of air pollution produced from automobile exhaust.

Although the Hunts Point-Mott Haven region of the South Bronx experiences comparatively low levels of traffic density, communities within the area experience the same level of nitrogen dioxide pollution and higher levels of particulate matter pollution. These two neighborhoods have a history of exposure to air pollution due to vehicle emissions and industrial activity, which has largely been attributed to high levels of diesel truck traffic en route to the 14 waste transfer stations located in industrial sections of these neighborhoods (TDT NYC 2016). A waste transfer station is a designated receiving facility where waste collection vehicles discharge their loads. Waste is transported to these locations, compacted, and loaded into larger vehicles for long-haul shipment to a final disposal site (e.g., a landfill, waste-to-energy plant, or a composting facility) outside the city. A 2019 study of vehicle traffic associated with waste transfer facilities in the

South Bronx found that the Hunts Point and Mott Haven neighborhoods experienced more than 750 commercial waste truck trips and received more than 2,500 tons of commercial waste per day, more than any other region in the city (TDT NYC 2019a).

Up until 2001, much of the residential waste in NYC was collected by the Department of Sanitation (DSNY), and private waste haulers that pick up commercially-generated waste, was trucked to marine-based transfer stations along the city's waterfront, where the trash would be loaded onto barges and floated over to be dumped at a municipal landfill in Staten Island known as Fresh Kills. Once the largest landfill in the world, in 1996, in response to consistent protest from Staten Island residents regarding the disproportionate burden of serving as a disposal site for the waste of all five boroughs, the city announced it would close Fresh Kills and cease operating the aged marine transfer stations (Iachan and Mulgaonkar 2018). Before the landfill's official closure in 2001, private sanitation companies decided to open or expand land-based waste transfer stations to procure city contracts to dispose of the 20,000 tons of garbage generated in NYC each day. The preferred location of these truck-intensive facilities were areas in, or close, to industrial or manufacturing zoned areas of the city, such as North Brooklyn, the South Bronx, and Southeast Queens (Iachan and Mulgaonkar 2018). Populations living near these locations were, and continue to be, predominately comprised of low-income, minority communities. As of 2018, 26 of the city's 38 waste transfer stations were located in these three regions of the city. Collectively, these facilities processed approximately 71 percent of the city's waste (New York City Council 2018). Facilities such as truck depots and cement and wastewater treatment plants are also clustered in these locations producing cumulative effects that disproportionately expose low-income communities of color to various environmental burdens such as air and noise pollution (Iachan and Mulgaonkar 2018).

Another significant source of air pollution in NYC, and within the Bronx in particular, are emissions produced from the combustion of heating fuels. In NYC, 72.9 percent of buildings rely on steam boilers for space and water heating. The boilers are powered through the combustion of natural gas or residual fuel oils.[5] Collectively the greenhouse gas emissions produced from the combustion of these fossil fuels account for nearly 40 percent of the city's total greenhouse gas emissions (City of New York 2020). In addition to their contribution to climate change, the combustion of fossil fuels to provide energy for steam boilers also affects air quality. Upon combustion, residual fuel oils yield high concentrations of air pollutants such as particulate matter, ozone, carbon monoxide,

[5] Residual fuel oils are diesel-based fuels that remain after gasoline and distillate fuels have been removed from crude oil (U.S. EIA 2021)

sulfur dioxide, lead, and nitrogen dioxide (Lewtas 2007). In comparison to residual fuels, natural gas is considered to be a cleaner-burning source of energy. However, the chemical process of combusting natural gas still releases several different kinds of air pollutants, including carbon dioxide, carbon monoxide, nitrogen oxides, and trace amounts of sulfur dioxide and particulate matter (U.S. EIA 2020). Despite their relatively high impact on air quality, residual fuel oils have historically been a cheaper energy source relative to lower impact fuels such as natural gas and, therefore, have served as a common source of energy for boilers throughout NYC (Gregory 2014).

The data in **Exhibit 12** shows the annual emissions for three pollutants, sulfur dioxide, fine particulate matter, and nitrogen oxides, as of January 2015.[6] The data show that neighborhoods in the Highbridge-Morrisania region experience comparatively high levels of emissions of each pollutant compared to the rest of the borough and the city. Sulfur dioxide emissions were more than double the levels observed throughout the borough and three times higher than levels found throughout the city. Emissions of nitrogen oxides were nearly twice as high as levels throughout the Bronx and three times higher than emissions experienced throughout the city. In contrast, the Hunts Point-Mott Haven areas experienced lower levels of sulfur dioxide and fine particulate matter pollution but high levels of nitrogen oxide emissions relative to those experienced throughout the city as a whole (**Exhibit 12**).

Social Impacts

Access to Green Space

The socioeconomic characteristics of the South Bronx may limit the adaptive capacity of a relatively high portion of residents living in the area. Therefore, the potential effects of limited access to green space (i.e., areas with vegetative and tree canopy coverage) and exposure to poor air quality can significantly affect the quality of life of community members. As noted above, the presence of green space provides a number of social benefits and supports mitigation of the urban heat island effect. **Exhibit 13** shows some of the environmental and social conditions that are influenced by exposure to extreme heat. The purpose of the data presented is not to draw a causal link between access to green space, but to illustrate how improvements in this environmental indicator may enhance the quality of life for residents of NYC and, in particular, members of the South Bronx community.

[6] The emissions are calculated using heating fuel type on NYC boiler permits and estimates of boiler activity.

The data indicate that the South Bronx is perhaps more likely to experience higher temperatures than those experienced in the Bronx and NYC overall. In-home air conditioners provide an opportunity for residents to control their exposure to extreme or high heat conditions. The data show that 82 percent and 83 percent of residents living in the Highbridge-Morrisania and Hunts Point-Mott Haven neighborhoods, respectively, reported having air conditioning in the home, a lower portion of residents compared to the overall population living in the Bronx (85.6 percent) and NYC (91 percent). Higher rates of poverty in these neighborhoods and the added energy costs of in-home air conditioners are likely to be important factors affecting the decision for residents to purchase these appliances. Additionally, the disproportionate exposure to high temperatures may contribute to higher rates of heat stress (e.g., heat cramps, heat exhaustion, heat rash, or heat stroke) amongst a population. In 2014, the communities located within the Hunts Point-Mott Haven neighborhoods of the South Bronx experienced higher overall rates of heat stress related emergency room visits when compared to the borough and NYC as a whole, a potential indication of the disproportionate health impacts of exposure to higher temperatures.

An important caveat concerning the data presented in **Exhibit 13** is the limited ability to form conclusive determinations from the samples collected. For example, data regarding heat stress emergency room visits for both the Highbridge-Morrisania and the Hunts Point-Mott Haven communities are based on a limited sample size, therefore the accuracy of the figures is limited. Additionally, there are no data reported on the proportion of residents 65 years and older with air conditioning in the home for the Hunts Point-Mott Haven neighborhoods therefore comparisons are not possible. Therefore, there is a margin of error in the numbers presented which limits the confidence in the comparisons and conclusions that can be drawn from the information presented. This occurrence exhibits some of the challenges and limitations that researchers may encounter when collecting and analyzing social science data.

Exposure to Poor Air Quality

Among the most well-documented and widespread concerns regarding chronic exposure to air pollution in the South Bronx is the prevalence of asthma among the region's residents. *Asthma* is a respiratory disease characterized by hyper-responsiveness, constriction, inflammation, and recurrent obstruction of the airway passage to the lungs (bronchial tubes). Bronx County has some of the highest rates of asthma in the U.S., and death rates from asthma are about three times higher in the Bronx than the national average. While the development of asthma is multi-factorial, and not fully understood, among the risk factors and triggers for its development are genetic predisposition and environmental factors such as allergen exposure, tobacco smoke, socioeconomic status, nutrition, low birth weight, history of infections, and ambient levels of air pollution (i.e., particulate matter, ozone, diesel exhaust) (Pandya et al. 2002). In the South Bronx, the high portion of the population who are African-American and Latino (two groups that are more likely to be diagnosed with asthma) and exposed to air pollution, as well as other environmental factors, such as mold, pests, and dust, have likely contributed to high asthma rates among children and adults living within the region.

Exhibit 14 shows that children living in the South Bronx experience higher rates of asthma relative to children of the same age living throughout the Bronx and NYC overall, with asthma rates among children living in the Hunts Point-Mott Haven neighborhoods exhibiting particularly high levels. The rates of asthma amongst adults living in the South Bronx are not as prevalent compared to the Bronx as a whole, although they are greater than rates found amongst the entire population of NYC. However, as noted above, conclusions drawn from this particular subset of the data should be made with caution due to the relatively small sample size. The figures concerning the rates of asthma-related emergency room visits offer perhaps a more stark depiction of the disproportionate health impacts borne by South Bronx residents. Adults in the High Bridge-Morrisania neighborhoods experienced nearly 1.5 and 3 times more asthma-related emergency room visits relative to those experienced throughout the Bronx and NYC as a whole, respectively. The rate of asthma-related emergency room visits for those living in the Hunts Point-Mott Haven communities were more than 1.5 and 3 times higher. For children, the rates of asthma-related emergency room visits in the South Bronx are just over 1.25 times greater than the borough's overall rate, and more than twice the rate of children when compared with rates throughout the city.

The high rates of asthma and asthma-related emergency room visits present in the South Bronx are likely due to many factors, including genetic predisposition, levels of poverty, and in-home environmental conditions, among others. However, excessive exposure to low air quality conditions is widely accepted as a significant contributor to the prevalence of respiratory illness in these communities (Pandya et al. 2002). Although children and adults are both affected by asthma, due to their relatively high level of vulnerability, several studies have focused on young people's exposure to poor ambient air quality. For example, a 2009 study conducted by the Institute for Civil Infrastructure Systems at the New York University Wagner School of Public Service found that about a fifth of all pre Kindergarten to 8th grade public school students in the South Bronx attend schools within 500 feet of major highways, where air pollution concentrations exceed background levels, compared to far less (10 percent) in NYC as a whole, and about half attend schools located within 500 feet of a highway or truck route (ICIS 2009). The same study found that about half of all pre Kindergarten to 8th grade students in the South Bronx attend schools close to industrially-zoned land within 660 feet (1/8 of a mile) containing waste transfer stations and other facilities associated with high diesel truck traffic and pollution emissions (ICIS 2009). Thus, while formal efforts to suppress the disproportionate presence of asthma in the South Bronx will undoubtedly need to address several social issues, reducing the proximity of public schools to transportation corridors and industrial activity is likely to be a critical component of such policy discussions

IV. Advancing Sustainability in the South Bronx

In NYC, residents of the South Bronx community experience relatively high levels of poverty, poor health, and exposure to poor environmental conditions. In particular, the analysis above has shown that members of this community have low access to green space and are exposed to higher levels of poor air quality compared to the city overall. The concept of sustainability offers a practical model for improving the quality of life in cities. Low-income, communities of color are among the most vulnerable to social, economic, and environmental impacts due to the lower levels of adaptive capacity amongst these populations and their disproportionate exposure to poor environmental conditions. Therefore, for this population, achieving the co-equal goals of sustainability offers perhaps the greatest benefit.

In practice, implementing policies that simultaneously support economic development, the protection, and enhancement of environmental quality, and improvements in social equity can be a difficult. Meeting the demands of a diverse array of stakeholders who's interests and needs may be in competition with one another often challenges policymakers. For example, efforts to dedicate more land to city parks and green space may produce an increase in the value of surrounding properties, producing an increase in the cost of rent, which may disproportionately impact low income residents. Additionally, such efforts may be opposed by groups that support more land dedicated to economic growth through, for example, the development of commercial or residential buildings. Thus, policymakers are tasked with employing innovative approaches to support the development, implementation, and assessment of policy solutions that balance the three co-equal goals of sustainability while addressing problems such as those faced by the South Bronx.

V.Conclusion

The analysis above has revealed that residents of the South Bronx are disproportionately exposed to poor air quality and have lower levels of access to green space. Each of these environmental conditions can produce adverse public health outcomes, such as respiratory illness and heat stress, which are likely to become more severe as temperatures increase due to global climate change. Furthermore, the relatively high levels of poverty in the South Bronx reduce residents' adaptive capacity, potentially inhibiting their ability to respond to such environmental stressors and increasing their health risks and vulnerabilities. These conditions likely contribute to the higher rates of heat stress and respiratory illness experienced by South Bronx residents, the effects of which are likely worsened by the socioeconomic and public health conditions that characterize this region. Thus, existing social inequities (i.e., poverty and poor health) in the region are likely to leave individuals with low adaptive capacity and high exposure to poor environmental quality, which can increase social inequalities by worsening preexisting health conditions and increase economic strains. Within the context of sustainability, improving environmental conditions in the South Bronx can support environmental quality objectives while also enhancing social equity through improvements in public health conditions.

VI.References

Abhijith, K.V., Kumar, P., Gallagher, J., McNabola, A., Baldauf, R., Pilla, F., Broderick, B., Di Sabatinom, S., & Pulvirenti, B. (2017). Air pollution abatement performances of green infrastructure in open road and built-up street canyon environments – a review. *Atmospheric Environ*ment, 162: 71-86.

Agyeman, J. (2005). *Sustainable Communities and the Challenges of Environmental Justice*. New York, NY: New York University Press.

Akbari, H., Kurn, D., Bretz, S.E., & Hanford, J.W. (1997). Peak power and cooling energy savings of shade trees. *Energy and Buildings*, 25:139–148.

Aronson, M.F., Lepczyk, C.A., Evans, K.L., Goddard, M.A., Lerman, S.B., MacIvor, J.S., Nilon, C.H. & Vargo, T. (2017). Biodiversity in the city: key challenges for urban green space management. *Frontiers in Ecology and the Environment*, 15(4):189-196.

Braubach, M., Egorov, A., Mudu, P., Wolf, T., Thompson, C.W., & Martuzzi, M. (2017). “Effects of urban green space on environmental health, equity and resilience”. In *Nature-based Solutions to Climate Change Adaptation in Urban Areas*, eds. N. Kabisch, H. Korn, J. Stadler, and A. Bonn, 187-205. Cham, Switzerland: Springer.

Campbell, S. (1996). Green Cities, Growing Cities, Just Cities?—Urban Planning and the Contradictions of Sustainable Development. *Journal of the American Planning*

Association, 62(3):296–311.
City of New York. (2020). Inventory of New York City Greenhouse Gas Emissions. New York City Mayor's Office of Sustainability. Retrieved from: https://nyc-ghg-inventory.cusp.nyu.edu/
___ . (2021a). Environment and Health Data Portal. Retrieved from: https://a816-dohbesp.nyc.gov/IndicatorPublic/QuickView.aspx?report_id=77
___ . (2021b). *Active Design, Physical Activity and Health*. Environment and Health Data Portal. Retrieved from: https://a816-dohbesp.nyc.gov/IndicatorPublic/QuickView.aspx?report_id=77
___ . (2021c). *Asthma and the Environment*. Environment and Health Data Portal. Retrieved from: https://a816-dohbesp.nyc.gov/IndicatorPublic/QuickView.aspx?report_id=77
___ . (2021d). *Climate and Health*. Environment and Health Data Portal. Retrieved from: https://a816-dohbesp.nyc.gov/IndicatorPublic/QuickView.aspx?report_id=77
___ . (2021e). *Housing and Health*. Environment and Health Data Portal. Retrieved from: https://a816-dohbesp.nyc.gov/IndicatorPublic/QuickView.aspx?report_id=77
___ . (2021f). *Outdoor Air and Health*. Environment and Health Data Portal. Retrieved from: https://a816-dohbesp.nyc.gov/IndicatorPublic/QuickView.aspx?report_id=77
Durant, R.F., Fiorino, D.J., & O'Leary, R. (2004). *Environmental Governance Reconsidered: Challenges, Choices, and Opportunities*. Cambridge, MA: MIT Press.
Furman Center for Real Estate and Urban Policy (Furman Center). (2021). The Bronx. Neighborhood Profiles. Retrieved from: https://furmancenter.org/neighborhoods/view/the-bronx
Gregory, K. (2014, April 6). Cost among Hurdles Slowing New York City's Plan to Phase out Dirty Heating Oil. *The New York Times*. Retrieved from: https://www.nytimes.com/2014/04/07/nyregion/cost-among-hurdles-slowing-new-yorks-plan-to-phase-out-dirty-heating-oil.html
Harris, T.B., & Manning, W.J. (2010). Nitrogen dioxide and ozone levels in urban tree canopies. *Environmental Pollution*, 158:2384-2386.
Hartig, T., Mitchell, R., De Vries, S., & Frumkin, H. (2014). Nature and health. *Annual Review of Public Health*, 35:207–228.
Hempel, L. (2009). "Conceptual and Analytical Challenges in Building Sustainable Communities". In *Towards Sustainable Communities: Transition and Transformation in Environmental Policy*, eds. D.A. Mazmanian and M.E. Kraft, 33-62. Cambridge, Massachusetts: MIT Press.

___ . (2012). “Evolving Concepts of Sustainability in Environmental Policy”. In *The Oxford Handbook of U.S. Environmental Policy*, eds. M.E. Kraft and S. Kamieniecki, 67-92. New York, NY: Oxford University Press.

Hitchins, J., Morawska, L, Wolff, R., & Gilbert, D. (2000). Concentrations of Submicrometer Particles from Vehicle Emissions Near a Major Road. *Atmospheric Environment*, 34:51-59.

Huang, J., Akbari, H., & Taha H. (1990). The Wind-Shielding and Shading Effects of Trees on Residential Heating and Cooling Requirements. Proceedings of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA, *96*(pt. 1).

Innes, J.E., & Booher, D.E. (2000). Indicators for Sustainable Communities: A Strategy Building on Complexity Theory and Distributed Intelligence. *Planning Theory & Practice*, 1(2):*173–186*

Institute for Civil Infrastructure Systems (ICIS). (2009). *South Bronx Environmental Health and Policy Study*. New York, New NY: New York University Wagner School of Public Service

Ji Y. (2014). Urban Environmental Indicators. In *Encyclopedia of Quality of Life and Well-Being Research*, ed. A.C. Michalos. Dordrecht, Netherlands: Springer.

Krautkraemer, J. A. & Batina, R. G. (1999). On sustainability and intergenerational transfers with a renewable resource. Land Economics, 167-184.

Kurn, D.M., Bretz, S.E., Huang, B., & Akbari, H. (1994). The potential for reducing urban air temperatures and energy consumption through vegetative cooling (No. LBL-35320). Berkeley, CA: Lawrence Berkeley Laboratories.

Lachowycz, K. & Jones, A.P. (2013). Towards a better understanding of the relationship between greenspace and health: development of a theoretical framework. *Landscape and Urban Planning*, 118:62–69.

Lewtas, J. (2007). Air pollution combustion emissions: Characterization of causative agents and mechanisms associated with cancer, reproductive, and cardiovascular effects. *Mutation Research/Reviews in Mutation Research*, 636:95–133.

Maser, C. (1997). *Sustainable Community Development: Principles and Concepts.* Delray Beach, FL: St. Lucie Press.

Mazmanian, D.A., & Kraft, M.E. (2009). “The Three Epochs of the Environmental Movement”. In *Towards Sustainable Communities: Transition and Transformation in Environmental Policy*, eds. D.A. Mazmanian and M.E. Kraft, 3-32. Cambridge, MA: MIT Press.

Mazmanian, D.A., & Nijaki, L.K. (2012). “Sustainable Development and Governance”. In The Oxford Handbook of U.S. Environmental Policy, eds. M.E. Kraft and S. Kamieniecki, 184-206. New York, NY: Oxford University Press.

McDonald, P.J., Aptaker, P.S., Mitchell, J., & Mulheron, M. (2007). A unilateral NMR magnet for sub-structure analysis in the built environment: The Surface GARField. *Journal of Magnetic Resonance*, 185(1):1-11.

Natural Areas Conservancy (NAC). (2020). *NYC Nature Map: Bronx*. Retrieved from: https://naturalareasnyc.org/map

New York City Council. (2018, June 19). Committee on Sanitation and Solid Waste Management. City Hall, New York, NY.

New York State (NYS) (2021). *Bronx*. Counties. Retrieved from: https://www.ny.gov/counties/bronx

Nowak, D.J., Crane, D.E., & Stevens, J.C. (2006). Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry & Urban Greening*, 4(3-4):115-123.

Office of the New York State Comptroller. (2019) An Economic Snapshot of the Bronx. State of New York.

Ophuls, W. (1996). "Unsustainable Liberty, Sustainable Freedom". In *Building Sustainable Societies: A Blueprint for a Post-Industrial World*, ed. D. Pirages. Armonk, NY: M. E. Sharpe.

Pandya, R.J., Solomon, G., Kinner, A., & Balmes, J.R. (2002). Diesel exhaust and asthma: hypotheses and molecular mechanisms of action. *Environmental Health Perspectives*, 110(suppl 1):103-112.

Portney, K. (2013). *Taking Sustainable Cities Seriously: Economic Development, the Environment, and Quality of Life in American Cities*. Cambridge, MA: MIT Press.

Portney, K. (2015). *Sustainability*. Cambridge, MA: MIT Press.

Press, D., & Mazmanian, D.A. (2006). "The Greening of Industry: Combining Government Regulation and Voluntary Strategies". In *Environmental Policy*, 6th edition, eds. N.J. Vig and M.E. Kraft, pp. 264–287.

Purvis, B., Mao, Y., & Robinson, D. (2019). Three pillars of sustainability: in search of conceptual origins. *Sustainability Science*, 14(3):681-695.

Saha, D., & Paterson, R.G. (2008). Local Government Efforts to Promote the 'Three Es' of Sustainable Development: Survey in Medium to Large Cities in the United States. *Journal of Planning Education and Research*, 28:21–37.

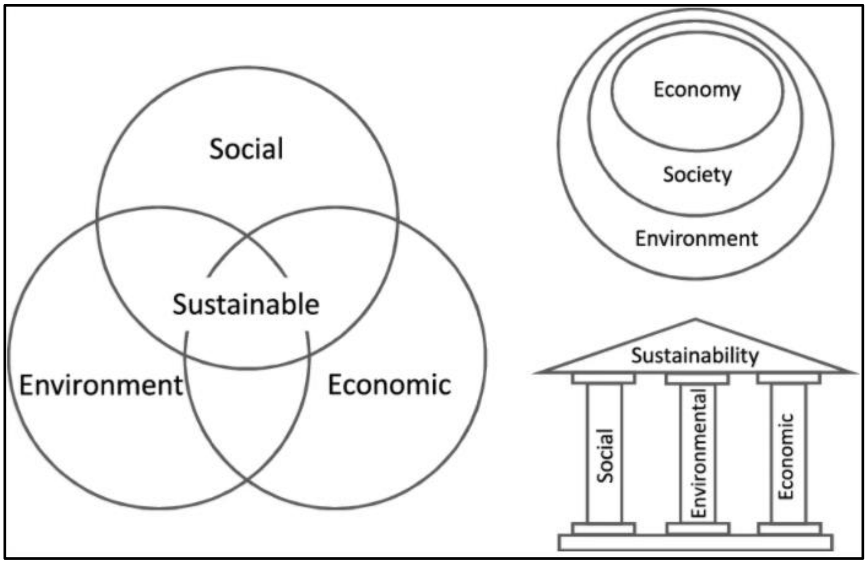
Shao, Q., Weng, S.S., Liou, J., Lo, H.W., & Jiang, H. (2019). Developing A Sustainable Urban-Environmental Quality Evaluation System in China Based on A Hybrid Model. *International journal of Environmental Research and Public health*, 16(8):1434.

United Nations (UN). (1992). Agenda 21. New York, NY: United Nations

___ . (1995). Workshop on indicators of sustainable development for decision-making. Commission on sustainable development third session (E/CN.17/1995/32). New York, NY: United Nations

___ . (1996) Indicators of sustainable development framework and methodologies. New York, NY: United Nations
___ . (1997) Overall progress achieved since the United Nations conference on environment and development. Commission on sustainable development fifth session (E/CN.17/1997/2). New York, NY: United Nations
___ . (2015). Transforming our world: the 2030 Agenda for sustainable development. Resolution adopted by the general assembly on 25 September 2015 (A/RES/70/1). New York, NY: United Nations
United Nations Conference on Environment and Development (UNCED). (1992). *Agenda 21*. New York, NY: United Nations
U.S. Energy Information Administration (U.S. EIA). (2021). Residual Fuel Oil. Retrieved from: https://www.eia.gov/tools/glossary/
U.S. Environmental Protection Agency (U.S. EPA). (2008). *Reducing urban heat islands: Compendium of strategies*. Retrieved from: https://www.epa.gov/heatislands/heat-island-compendium
___ . (2020a). *Heat Island Impacts*. Urban Heat Islands. Retrieved from: https://www.epa.gov/heatislands/heat-island-impacts#energy
___ . (2020b). *Learn About Heat Islands*. Urban Heat Islands. Retrieved from: https://www.epa.gov/heatislands/learn-about-heat-islands
___ . (2021a). *NAAQS Table*. Criteria Air Pollutants. Retrieved from: https://www.epa.gov/criteria-air-pollutants/naaqs-table
___ . (2021b). Criteria Air Pollutants. Retrieved from: https://www.epa.gov/criteria-air-pollutants
Villanueva K, Badland H, Hooper P, Koohsari M.J., Mavoa S., Davern M., Roberts R., Goldfeld S., Giles-Corti B. (2015). Developing indicators of public open space to promote health and wellbeing in communities. *Applied Geography*, 57:112–119.
Weber, E.P. (2003). *Bringing Society Back in: Grassroots Ecosystem Management, Accountability, and Sustainable Communities*. Cambridge, MA: MIT Press.
Wondolleck, J.M., & Yaffee, S.L. (2000). *Making Collaboration Work: Lessons from Innovation in Natural Resource Management*. Washington, D.C.: Island Press.
World Commission on Environment and Development (WCED). 1987. *Our Common Future*. New York, NY: Oxford University Press.
Yin, S., Shen, Z., Zhou, P., Zou, X., Che, S., & Wang, W. (2011). Quantifying air pollution attenuation within urban parks: an experimental approach in Shanghai, China, *Environmental Pollution*, 159:2155-2163.

Exhibit 1. Representations of the "Three E's" of sustainability.



Source: Purvis, Mao, and Robinson 2019

Exhibit 2. Neighborhoods Included in the Case Study.

Geographic Measure	Highbridge-Morrisania	Hunts Point-Mott Haven
Zip Codes	0456,10451,10452	10454,10455,10459,10474
Neighborhoods	Highbridge, Mount Eden, Concourse, Melrose, and the southern portions of Claremont and Morrisania	Foxhurst, Longwood, Woodstock, The Hub,Mott Haven, and Hunts Point

Source: City of New York 2021a

Exhibit 3. Poverty and Health in the South Bronx.

Indicator	Highbridge-Morrisania	Hunts Point-Mott Haven	Bronx	NYC
Living in poverty (percent), 2013-17	38.7	41.4	29.7	19.6
Children under 5 years old in poverty (percent) 2013-17	48.1	51.0	40.6	26.5
Adults with health insurance (percent), 2017	85.3	86.0	87.3	88.1
Adults with overweight or obesity (percent), 2017	72.8	78.4	69.3	57.4
Premature mortality (age-adjusted rate per 100,000), 2016	283.0	306.3	237.3	189.4

Source: City of New York 2021a, c, e

Exhibit 4. Dimensions and Indicators of Urban Environmental Quality, adapted from Shao et al. 2019.

Dimension	Indicator	Definition
Natural environment	• Air quality	• Reflects the degree of air pollution
	• Wetland area	• An ecosystem that is inundated by water
	• Green coverage rate	• The ratio of the vertical projected area of vegetation to the total land area of the city
	• Biodiversity	• The variety and variability of life on city
	• Land use	• The management and modification of natural environment or wilderness into built environment
Artificial environment	• Green belt area	• A protected area of green space, farmland, forests in city
	• Public health	• Prevent disease, prolong life and promote human health through organized efforts
	• Sustainable transportation	• The ability to supply the source energy indefinitely in city
	• Green infrastructure	• A network providing the "ingredients" for solving urban and climatic challenges by building with nature
	• Green building	• A structure and application of processes that are environmentally responsible
Energy management	• Wastewater treatment	• A process used to convert wastewater to the water with minimum impact on the environment, or directly reused
	• Water quality	• The chemical, physical, biological, and radiological characteristics of water
	• Reuse of reclaimed water	• Reclaimed water can be used for other purposes
	• Rainwater utilization	• Rainwater harvesting system, rainwater interception and infiltration system
Water management	• Materials treatment	• Use high-tech process materials to reduce environmental hazards
	• Food waste management	• Reduce the pollution of food waste to urban environment
	• Hazardous waste management	• The city adopts systems and technologies for managing hazardous waste
	• Other waste management	• The way to manage other waste, like construction rubbish
Pollution Control	• Greenhouse gas emissions	• The atmosphere absorbs solar radiation reflected from the ground and re-emits some of the radiated gas, like CO_2, NO_2
	• Annual mean PM_{10} concentration	• An average annual distribution density of particles with a particle size below 10 microns
	• SO_2 concentration	• The flue gas concentration cannot be satisfied when the contact method is self-heating to produce sulfuric acid
	• Ozone layer destruction	• Degree of damage to the ozone layer over the city
	• Acoustical environmental quality	• The impact of urban noise on residents' lives
	• Brightness level	• City night illumination
	• Carbon strength	• CO_2 emissions per unit of GDP

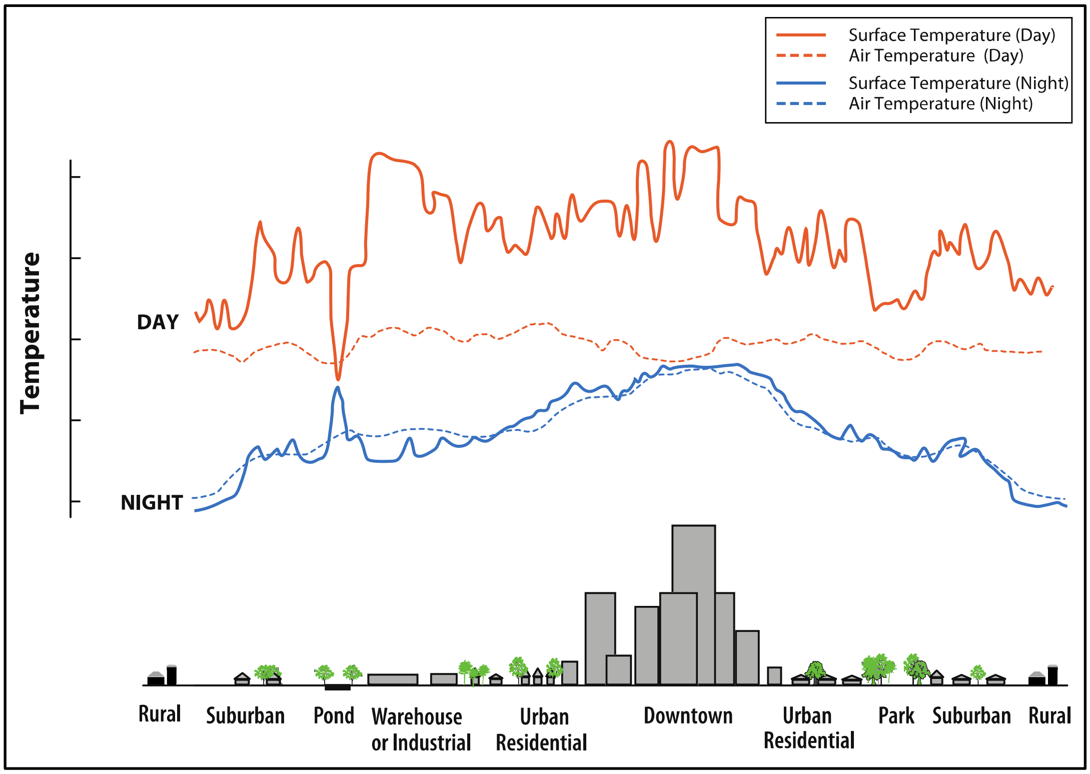
Source: Shao et al. 2019

Exhibit 5. Sources of Common Urban Air Pollutants.

Pollutant	Causes	Impacts
Ozone (O_3)	Occurs naturally in the Earth's upper atmosphere, where it forms a protective layer that shields us from the sun's harmful ultraviolet rays. O_3 is also formed near ground level, when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other sources react chemically in the presence of sunlight.	Linked to many health problems, including: irritation of the respiratory system, reduced lung function, aggravation of asthma, and damage to the lining of the lung.
Nitrogen dioxide (NO_2)	Main sources of NO_2 are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels.	Short-term exposure can cause increased respiratory illness in young children and harm lung function in people with existing respiratory illnesses. Long-term exposure can lead to increased susceptibility to respiratory infection and may cause alterations in the lung.
Sulfur dioxide (SO_2)	Formed when fuel containing sulfur (mainly coal and oil) is burned, as well as during metal smelting and other industrial processes.	Health concerns associated with exposure to high concentrations of SO_2 include effects on breathing, respiratory illness, alterations in pulmonary defenses, and aggravation of existing cardiovascular disease. Children, the elderly, and people with respiratory illneses are most susceptible to adverse health effects from exposure.
Particulate matter (PM_{10} and $PM_{2.5}$)	Particulate pollution comes from many sources, including factory and utility smokestacks, vehicle exhaust, wood burning, mining, construction activity, and agriculture.	Particles of special concern are those known as fine particles, less than 2.5 microns in diameter, which can be inhaled into the lungs where they can be absorbed into the bloodstream or remain embedded for long periods. Especially harmful to people with lung disease such as asthma and chronic obstructive pulmonary disease, as well as people with heart disease.

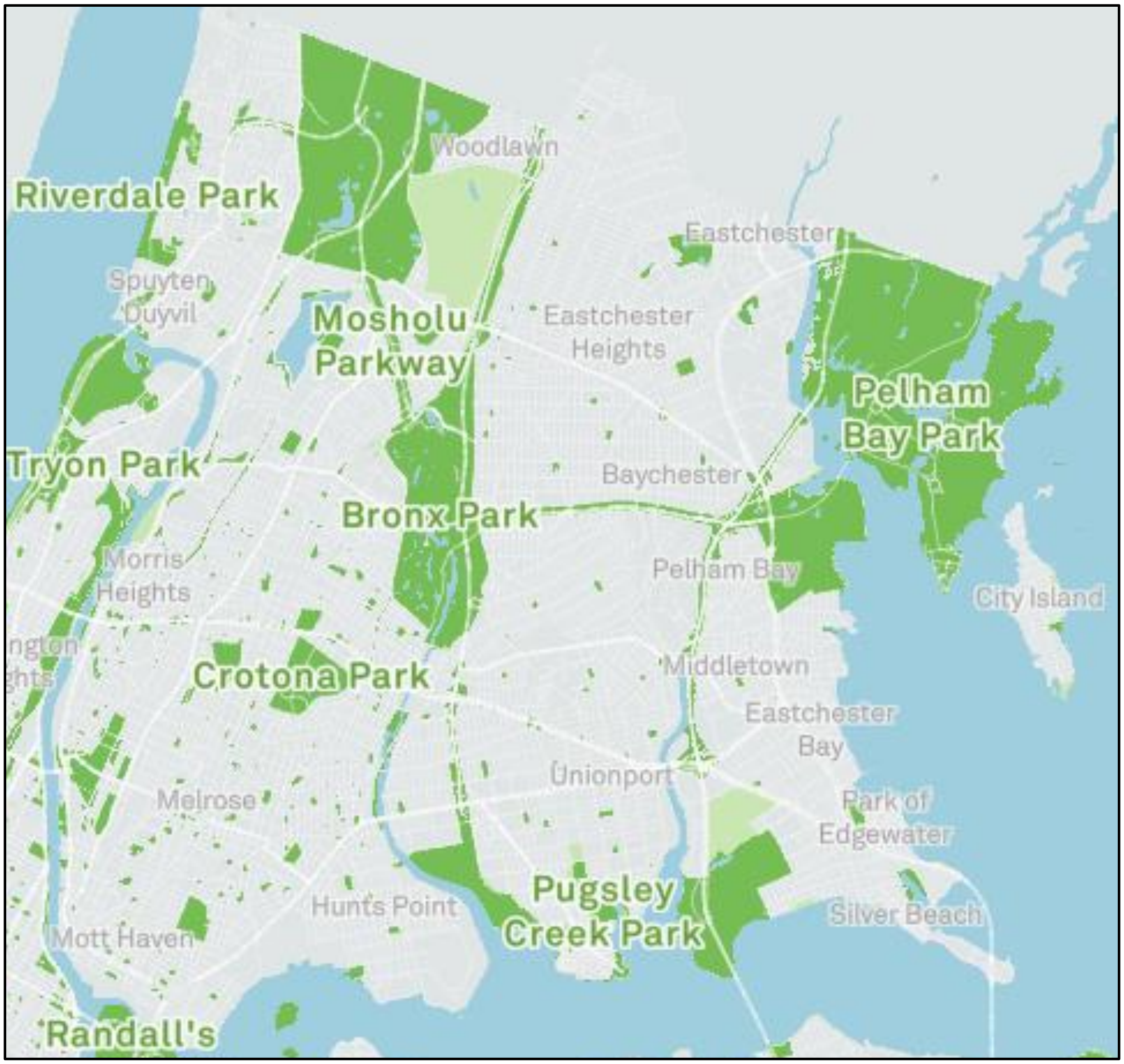
Source: ICIS 2009; US. EPA 2021b

Exhibit 6. The Urban Heat Island Effect.



Source: U.S. EPA 2020b

Exhibit 7. City Parks in the Bronx.



Source: NYC Parks 2021b.

Exhibit 8. Green Space Access and Coverage.

Indicator	Highbridge-Morrisania	Hunts Point-Mott Haven	Bronx	NYC
People living in walking distance to a park (percent), 2017	98.0	96.0	87.0	81.0
Area with vegetative cover including trees and grass (percent), 2017	21.0	18.0	39.0	38.0
Tree canopy cover (percent of land area), 2014	13.0	7.1	22.7	21.1

Source: City of New York 2021b, d

Exhibit 9. National Ambient Air Quality Standards.

Pollutant		Primary/Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		Primary	8 hours 1 hour	9 ppm 35 ppm	Not to be exceeded more than once per year
Lead (Pb)		Primary and secondary	Rolling 3 month average	0.15 μg/m^3	Not to be exceeded
Nitrogen Dioxide (NO_2)		Primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Primary and secondary	1 year	53 ppb	Annual mean
Ozone (O_3)		Primary and secondary	8 hours	0.070 ppm	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particulate Matter (PM)	$PM_{2.5}$	Primary	1 year	12.0 μg/m^3	Annual mean, averaged over 3 years
		Secondary	1 year	15.0 μg/m^3	Annual mean, averaged over 3 years
	PM_{10}	Primary and secondary	24 hours	150 μg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)		Primary	1 hour	75 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Secondary	3 hours	0.5 ppm	Not to be exceeded more than once per years

Source: U.S. EPA 2021a

Exhibit 10. Outdoor Air Pollutants.

Pollutant	Highbridge-Morrisania	Hunts Point-Mott Haven	Bronx	NYC
Ozone (O_3) (mean ppb), Summer 2019	28.6	29.6	29.9	30.6
Sulfur Dioxide (SO_2) (Mean ppb) Winter 2015-16	0.4	0.3	0.3	0.2
Fine Particulate Matter (PM2.5) (Mean mcg per cubic meter) Annual Average 2019	7.1	7.5	6.9	6.6
Nitrogen Dioxide (NO_2) (Mean ppb) Annual Average 2019	18.8	18.8	16.0	15.6

Source: City of New York 2021f

Exhibit 11. Traffic Density in the South Bronx, Bronx, and NYC.

Traffic Density[1]	Highbridge-Morrisania	Hunts Point-Mott Haven	Bronx	NYC
Cars 2016	27.9	18.6	21.9	21.7
Trucks 2016	3.8	1.3	2.0	1.2
All vehicles 2016	31.8	20.2	24.0	23.0

1. Estimated millions of annual vehicle miles traveled per km^2.
Source: City of New York 2021f

Exhibit 12. Emissions from the Combustion of Heating Fuels.

Heating Fuel Emissions[1]	Highbridge-Morrisania	Hunts Point-Mott Haven	Bronx	NYC
Sulfur dioxide (SO_2) tons 2015	12.9	1.7	6.3	3.5
Fine particulate matter ($PM_{2.5}$) tons 2015	1.9	0.3	0.9	0.5
Nitrogen oxides (NO_X) tons 2015	72.2	35.5	39.5	27.4

1. Estimated annual boiler emissions per km^2 as of January 2015.
Source: City of New York 2021f

Exhibit 13. Indicators of Exposure and Vulnerability to Extreme Heat.

Indicator	Highbridge-Morrisania	Hunts Point-Mott Haven	Bronx	NYC
Spatial average of surface temperature (Degrees Fahrenheit), 11:22 AM, July 17, 2018	99.4	100.7	97.1	98.6
Homes reporting air conditioning (percent) 2017	82.4	83.3	85.6	91.0
Heat stress emergency department visits (per 100,000 residents), 2014	3.2*	5.6*	4.1	3.7

* Estimate is based on small numbers so should be interpreted with caution.
Source: City of New York 2021d, e

Exhibit 14. Asthma Rates Among Children and Adults.

Asthma Rates Among Children and Adults (Rates per 10,000 residents)	High Bridge-Morrisania	Hunts Point-Mott Haven	Bronx	NYC
Asthma among public school children ages 5 to 14 years old (per 1,000 children), 2013-2014	105.2	131.9	102.5	73.8
Adults ages 18 years and older with asthma in the past 12 months (age-adjusted percent), 2017	4.6*	6.4*	6.8	4.3
Asthma emergency department visits among children ages 5 to 17 years (per 10,000), 2016	488.2	498.6	384.2	215.3
Asthma emergency department visits among adults ages 18 years and older, 2016	275.3	309.1	192.4	99.1

* Estimate is based on small numbers so should be interpreted with caution
Source: City of New York 2021c,f