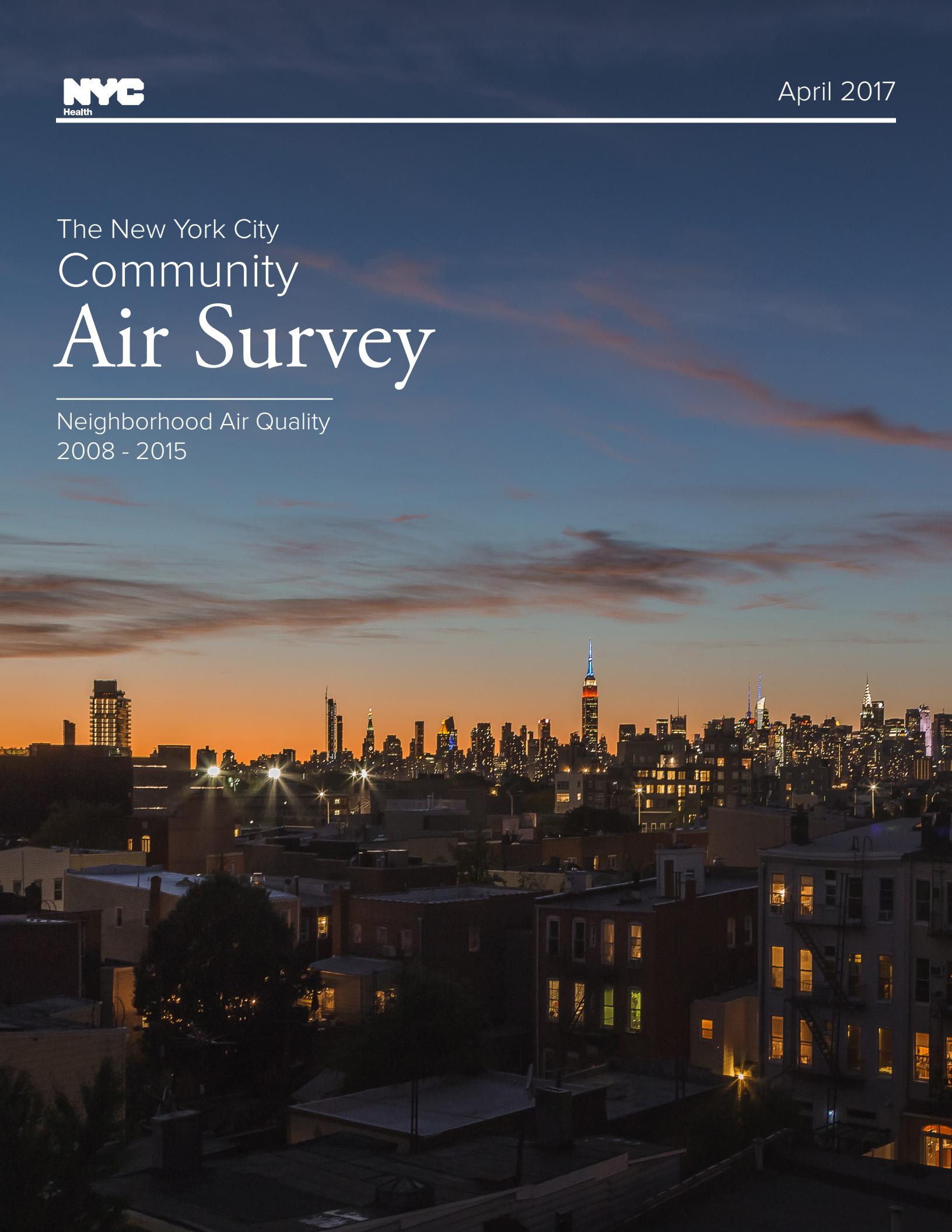
NYC Health

April 2017

The New York City

Community Air Survey

Neighborhood Air Quality
2008 - 2015



Contributors

New York City Department of Health and Mental Hygiene

Iyad Kheirbek
Sarah Johnson
Kazuhiko Ito
Kazue Anan
Chris Huskey

Queens College, City University of New York

Holger Eisl
John Gorczynski
Steven Markowitz

ACKNOWLEDGMENTS

We are grateful to colleagues from city agencies that provided logistical support and advice. We also appreciate the contributions, advice and leadership of Thomas Matte and Daniel Kass, the technical and logistical support of the New York State Department of Environmental Conservation; and the contributions to analysis, field activities, and laboratory work provided by Zev Ross, Jonah Haviland-Markowitz, Jung Kim, Christian Meyers, Paul McFarlane, and Laura Ruiz-Olivo.

Cover and report photos credit: Iyad Kheirbek

Contents

EXECUTIVE SUMMARY

Air quality in New York City has improved over the past several decades, but concentrations of multiple air pollutants remain at harmful levels, particularly for seniors, children, and those with pre-existing health conditions. In 2007, as part of New York City's first long-term plan for environmental sustainability, the Health Department established the New York City Community Air Survey (NYCCAS), the largest ongoing urban air monitoring program of any U.S. city. NYCCAS provides data to inform local air pollution policies, provide exposure estimates for health research, and track changes in air quality over time. Beginning in 2015, the annual reporting of these results is mandated by Local Law 103.

This report:

- Provides a summary of the air monitoring program, site selection process, air quality monitoring and analysis methods, and descriptions of the pollutants measured
- Describes the trend in air pollutant levels from winter 2008-2009 through fall 2015 in fine particulate matter ($PM_{2.5}$), nitrogen dioxide (NO_2), nitric oxide (NO), black carbon (BC), wintertime sulfur dioxide (SO_2), and summertime ozone (O_3)
- Identifies the sources that contribute to high levels of these pollutants in NYC neighborhoods
- Maps neighborhood air pollution levels, by year and by season

Major findings include:

- Citywide, annual average $PM_{2.5}$, NO_2 , NO, and BC levels have declined 18%, 23%, 28%, and 18%, respectively, between the first year of monitoring (2009) and the most recent year (2015).
- The largest declines have been observed for SO_2 due to heating oil regulations. Wintertime average levels have declined by 84% over the 7-year period between the first winter of monitoring (2008-2009) and the most recent winter (2014-2015).
- Citywide, summertime average O_3 levels remained relatively stable across the seven years.
- Higher levels of $PM_{2.5}$, NO_2, NO, and BC continue to be observed in areas of higher traffic density, building density, and heat and hot water boiler density, and in industrial areas. SO_2 levels remain higher in areas with residual oil boilers. O_3 levels remain higher in the outer boroughs, in areas that are downwind of high emissions density and in areas with fewer combustion emissions.

This report also summarizes two recent NYCCAS team publications: the first describes the impact of on-road motor vehicle pollution on public health and the second describes the spatial distribution of $PM_{2.5}$ metal components and their related sources. These case studies can be found at the end of this report.

This report underscores the need to continue to reduce emissions citywide. Implementing new strategies and expanding existing measures within the City's sustainability plan, OneNYC, and its roadmap to reduce greenhouse gas emissions, 80x50, will improve air quality and provide important public health benefits to all New Yorkers. These strategies and measures include converting the remaining residual oil boilers to ones that use cleaner heating fuels; transitioning to more efficient, less polluting light duty and heavy duty vehicles; reducing motor vehicle use by shifting more sustainable modes of transportation; creating more efficient freight networks and expanding truck retrofit and replacement programs; and reducing fossil fuel combustion in buildings. Additionally, reducing emissions from other widely distributed sources of pollution, such as commercial charbroiling, will contribute to improved air quality in the future.

INTRODUCTION

Air quality in New York City (NYC) has been improving over the past several decades because federal, state, and local measures have reduced pollutant emissions from power plants, building boilers, motor vehicles, and other sources. Despite this progress, air pollution remains a major cause of illness and death, particularly among vulnerable residents, such as the very young, seniors, and those with preexisting health conditions. Exposures to pollutants common in NYC's air have been linked to a variety of adverse outcomes, such as exacerbation of cardiovascular and respiratory diseases leading to emergency department visits, hospitalizations and premature deaths, as well as reduced birth weight and cancer.

As part of NYC's first long-term plan for environmental sustainability, in 2007 the Health Department established the New York City Community Air Survey (NYCCAS), which is the largest ongoing urban air monitoring program of any U.S. city. The air quality monitoring network, which began collecting data in December 2008, is a collaboration between the Health Department and Queens College of the City University of New York and provides data to help inform the City's sustainability plan, OneNYC. The objectives of NYCCAS are to:

- Measure air pollutants that affect public health across the city
- Identify local emission sources that impact neighborhood air quality
- Inform the public and city officials on air pollutant levels and clean air priorities
- Provide air pollution estimates for health studies

NYCCAS measures air pollutants that pose the most harm to the public's health. They include:

Fine particles ($PM_{2.5}$) are tiny airborne solid and liquid particles less than 2.5 microns in diameter. $PM_{2.5}$ is the most harmful urban air pollutant, small enough to penetrate deep into the lungs and enter the bloodstream, worsening lung and heart disease, and leading to hospital admissions and premature deaths. $PM_{2.5}$ is also a human carcinogen.

$PM_{2.5}$ can either be directly emitted or formed in the atmosphere from other pollutants. Important local sources include fuel combustion in vehicles, boilers in buildings, power plants, construction equipment, marine vessels, and commercial cooking. $PM_{2.5}$ in NYC's air also comes from outside the city, from sources far upwind.

Nitrogen dioxide (NO_2) and nitric oxide (NO) are part of a group of pollutants called "oxides of nitrogen" (NO_X). Exposures to NO_X are linked to increased emergency department visits and hospitalizations for respiratory conditions, particularly asthma. NO_X also react with other compounds in the atmosphere to form $PM_{2.5}$ and O_3. NO_X are produced from a variety of combustion sources in NYC, including motor vehicles, buildings, marine vessels, and construction equipment.

Sulfur dioxide (SO_2) in NYC is produced mainly from burning oils with high sulfur content, such as No. 4 and No. 6 oil (also known as residual fuel oil) or high sulfur No. 2 oil. Fuel oil in NYC is used mainly to heat buildings and for hot water, and some high-sulfur oil is also used to generate electric power and power marine vessels. SO_2 exposures can worsen lung diseases, causing hospitalizations and emergency department visits for asthma and other conditions. SO_2 also contributes to the formation of $PM_{2.5}$ in the atmosphere, resulting in exposures downwind of where it is emitted.

Ozone (O_3), at ground level, is formed through reactions in the atmosphere when NO_X emissions combine with other airborne pollutants in the presence of sunlight. Therefore, measured O_3 concentrations are often highest downwind from high-emissions areas. In areas where there are high concentrations of fresh combustion emissions, NO_X reacts with O_3 to reduce its concentrations. As a result, lower O_3 levels are observed near roadways, in city centers, and in other areas of high emissions density.

Black carbon (BC) is one component of $PM_{2.5}$ and is emitted from diesel exhaust and other sources, such as oil burning. Diesel exhaust particles, indicated by BC, can cause irritation of the breathing passages, respiratory symptoms such as cough, or asthma exacerbation, and may increase the risk of cancer. BC pollution is also a contributor to global climate change.

The results of NYCCAS monitoring have been published in multiple public reports, scientific manuscripts, and periodic online data updates. All Health Department reports and scientific studies are available on the NYCCAS website at www.nyc.gov/health/nyccas. All neighborhood-level data and detailed neighborhood air quality reports are available for download through the Department's Environment & Health Data Portal.

Beginning in 2015, the annual reporting of these results has been mandated by Local Law 103. This report documents trends in levels of pollutants that adversely impact health between winter 2008-2009 and fall 2015, identifies the sources that contribute to neighborhood differences in air pollutant levels, and provides maps and neighborhood estimates of pollutant levels.

METHODS

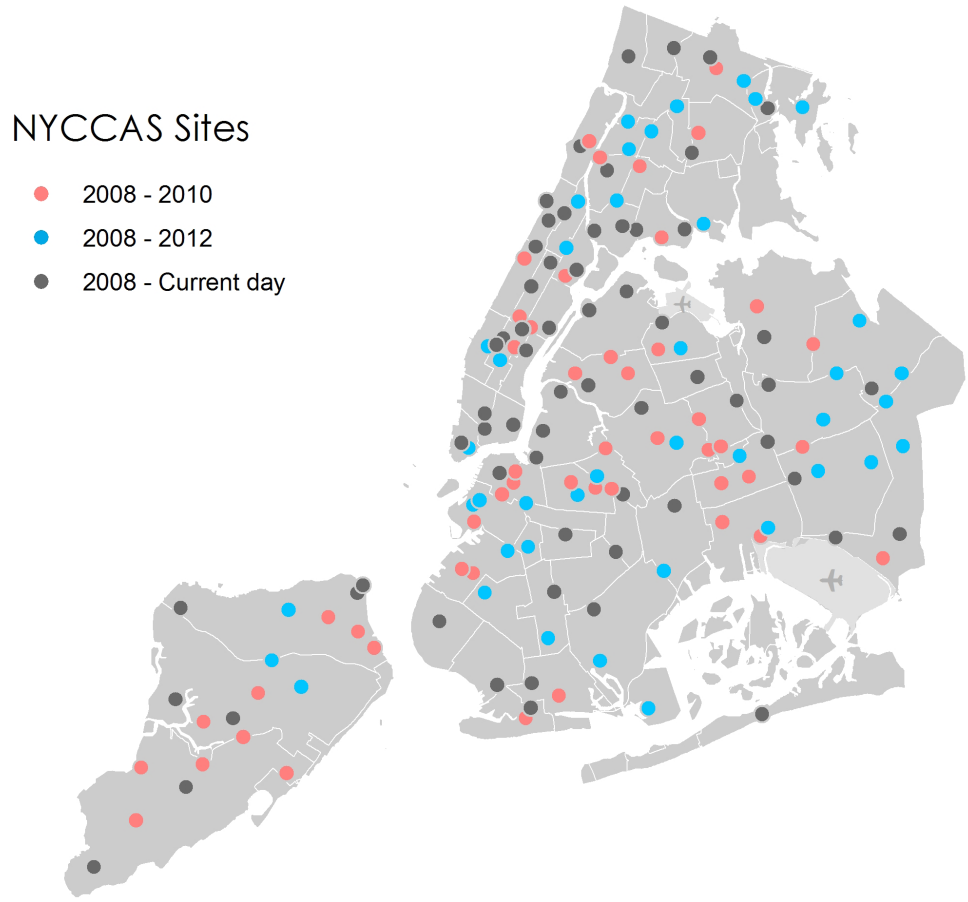
Since December 2008, NYCCAS has measured street-level concentrations of multiple air pollutants. Monitoring sites were selected to include the range of the predominant sources of air pollutant emissions in NYC neighborhoods. NYCCAS field teams sampled the air at 150 NYC locations per year during the first two years and at 60 to 100 locations per year in subsequent years (Figure 1). Samples are collected in all seasons for all pollutants, except O_3 and SO_2, for which samples are collected in the summer and winter seasons, respectively.

The original 150 monitoring sites were selected to ensure that the ranges of traffic conditions, size and number of buildings, and land uses in NYC were adequately included while providing a balance in spatial coverage throughout the city. To do this, a digital map of the city was divided into a grid of more than 7,500 squares, each 300 by 300 meters (m), and each square was classified based on its traffic and building density. A random selection of squares was then drawn from this set, with high building and traffic density areas having an increased chance of selection as these areas are concentrated in a relatively small area of the city. This random site selection was used to locate 80% of the sampling sites. The remaining 20% of sites were selected in places with large remaining gaps in coverage from the random selection or near areas of interest, such as high-traffic areas, transportation facilities, or major ongoing construction.

Each NYCCAS site is monitored for a two-week period in each season. The schedule of monitoring is assigned randomly so that the same number of sites across the city are monitored in each two-week period. In addition, 'reference' sites — centrally located and away from nearby traffic and commercial or industrial activities — are monitored during every two-week period, year round. Data from these 'reference sites' are used to adjust the measurements made at other sites for variation that occurs across the city over time, mainly due to weather conditions. For additional details on the 150 site selection methods, visit NYCCAS First Winter Results, NYCCAS Design and Implementation.

After the first two years of the study, the number of sites was reduced to between 60 and 100 sites, depending on the year, to meet budget constraints and to free up resources to measure other pollutants and conduct additional air quality and health studies. The balance of source density and spatial density was preserved, through use of random selection methodologies similar to those described above. The patterns in air pollutant concentrations remained

Figure 1: New York City Community Air Survey monitoring locations.



consistent year after year – areas of the city with higher concentrations tend to remain higher over time, while cleaner areas of the city remain cleaner – due to major emissions sources such as buildings and traffic remaining in fixed locations. In comparing year-to-year patterns in levels, we observed high correlations across all pollutants (range in correlation coefficients: 0.58 to 0.97). Because of this, NYCCAS is able to track the geographic pattern of air quality over time with fewer locations than in the original design. Currently, routine NYCCAS air sampling occurs once per season at 60 of the original 150 sites, known as the 'core' monitoring sites. The number of reference sites was reduced from five to three after the first four years.

NYCCAS sampling is conducted using monitoring units mounted on lampposts 10 to 12 feet off the ground. The monitors include an air pump and filters to collect $PM_{2.5}$ while passive samplers mounted on the outside of the units absorb the gaseous pollutants NO_X, SO_2, and O_3. Laboratory analysis of the filters and passive samplers determines the quantities of pollutants collected and their concentration in air is calculated. Quality control steps included confirming

Figure 2: NYCCAS team member deploys a monitor in the field.

that the sampling pump was operating normally and collecting duplicate and unexposed samples for comparison with study samples.

NYCCAS data were analyzed using a "land-use regression" (LUR) model. LUR models estimate associations among pollution levels, average traffic, building emissions, land use, and other neighborhood factors around the monitoring sites. These associations were used to estimate the seasonal average air pollution levels at locations across the city, including locations where no measurements were taken. The LUR model is also used to assess sources that appear to contribute most to differences in pollution concentrations. For more details on the analysis methods, please see the technical appendices and scientific manuscripts available at www.nyc.gov/health/nyccas.

RESULTS

Between winter 2008-2009 and fall 2015, levels of $PM_{2.5}$, NO_2, NO, BC, and SO_2 declined, with the largest declines observed for SO_2. Summertime O_3 levels have remained relatively stable over the same time period. The groups of neighborhoods with higher and lower levels of these pollutants, relative to the city overall, have also remained fairly consistent over time, reflecting the fact that the geographic pattern of predominant sources does not change rapidly from year to year.

In this section, data for each pollutant are summarized by showing:

1. Trends in seasonal average pollutant concentrations, stratified by important nearby sources

2. Maps of concentrations, as estimated by a LUR model. The maps first show levels from the most recent year for which data are available, 2015. Next to each map is a smaller set of maps depicting the trend across all years of NYCCAS.[1]

3. A description of the source indicators in the model most predictive of place-to-place differences in air pollutant levels.

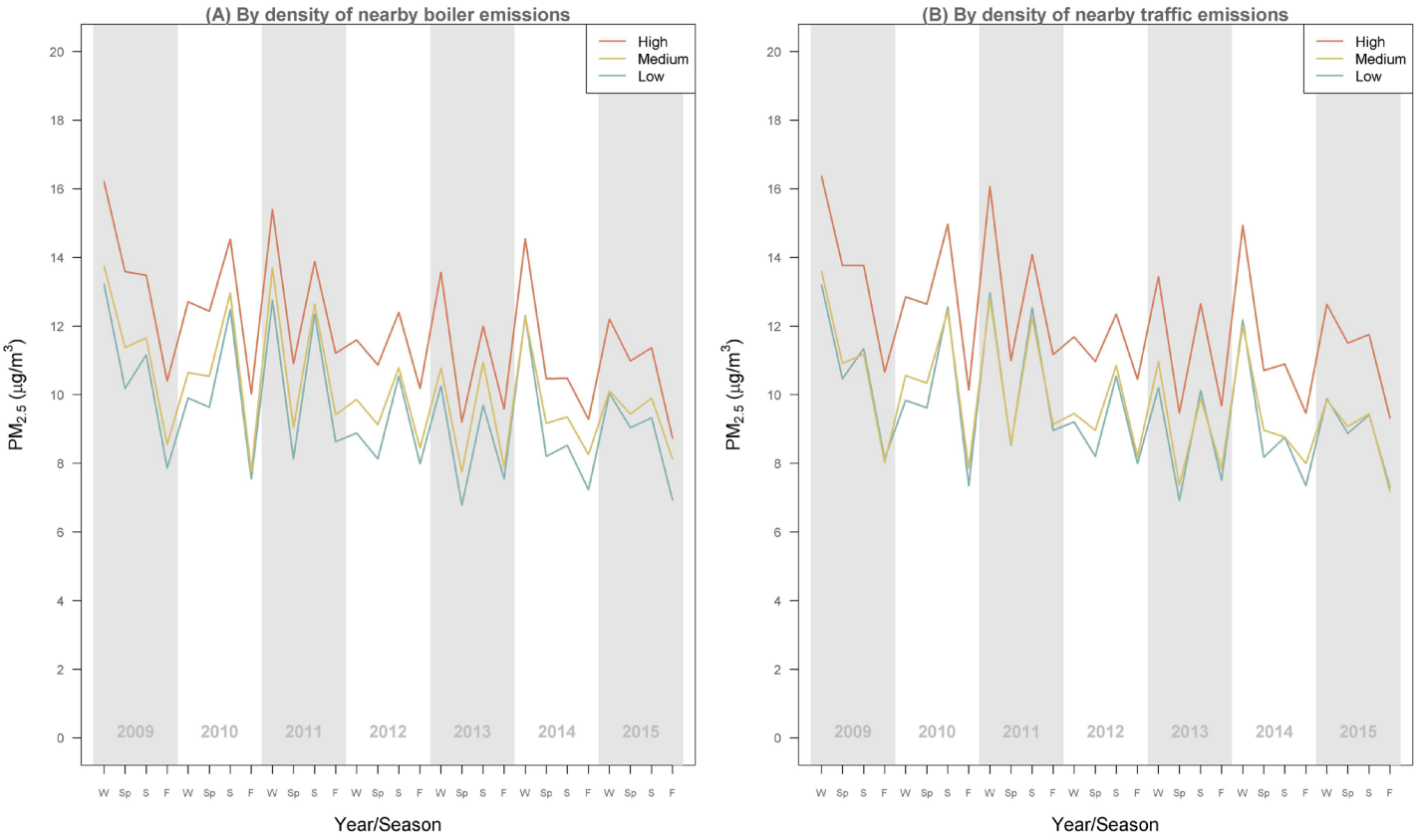
Annual, summer, and winter average pollutant concentrations for each neighborhood can be accessed through the Environment & Health Data Portal. For more detailed information on NYCCAS data collection and analysis methods, please visit www.nyc.gov/health/nyccas. Appendix 1 at the end of this report details the data sources for the source indicators used in the LUR model; Appendix 2 shows wintertime and summertime average maps for the pollutants measured in this report; and Appendix 3 reports annual average pollutant levels by community district and the rate of change in pollution concentration over the seven years of monitoring.

[1]Color scales of maps in this report have been updated to reflect the most current data, and therefore cannot be compared directly to maps published in previous NYCCAS reports..

FINE PARTICULATE MATTER

At NYCCAS sites measured in each season for seven years, seasonally adjusted street-level $PM_{2.5}$ concentrations declined by an average of 0.4 micrograms per cubic meter ($\mu g/m^3$) per year. Citywide, annual average levels at the 60 monitoring sites (locations measured across the seven years) declined by 18% between 2009 and 2015. In the most recent year (2015), seasonal average concentrations across NYCCAS monitoring sites ranged from 5.3 to 23.0 $\mu g/m^3$. Across the seven-year period, higher levels were consistently seen at sites with higher nearby boiler and traffic emissions (Figure 3).

Figure 3: $PM_{2.5}$ levels at NYCCAS monitors, by density of nearby boilers emissions (A) and traffic emissions (B)[2]



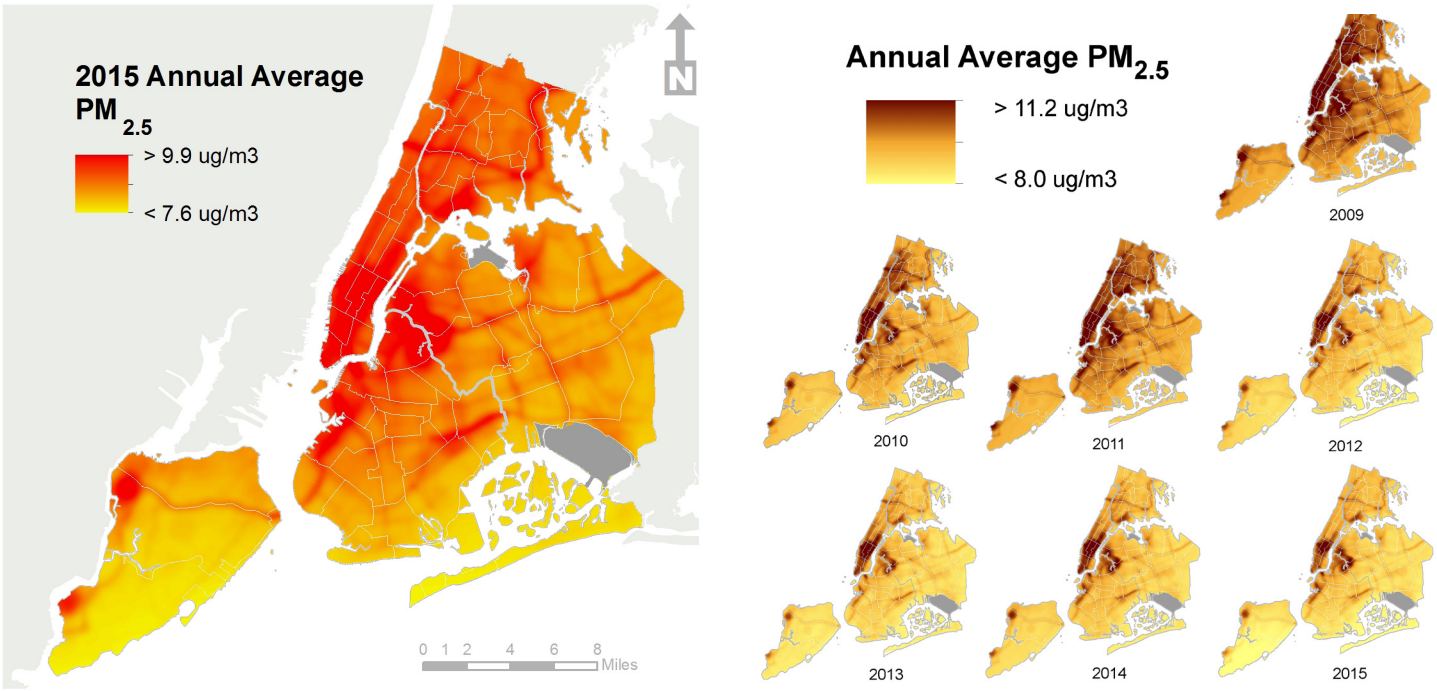
[2]Boiler emissions represent estimated $PM_{2.5}$ emissions from all boiler types within 1,000 m. Traffic emissions were estimated as total traffic density, weighted by vehicle-specific $PM_{2.5}$ emissions rates from on-road vehicles within 100 m. High, Medium, and Low represent one third of sites ranked by source indicator density.

In the LUR model, the most important predictors of $PM_{2.5}$ concentrations were, in order of importance:

Indicator	Associated Sources and Interpretation
$PM_{2.5}$ emissions from heat and hot water boilers in buildings within 1,000 m	Combustion of heating oil and natural gas
Area of industrial land use within 1,000 m	Diesel exhaust particles from trucks idling and traveling through industrial areas. Industrial combustion equipment.
Traffic density, weighted by relative $PM_{2.5}$ emissions rates by vehicle type (car, truck, bus) within 250 m.	$PM_{2.5}$ emissions from all on-road motor vehicles based on vehicle miles and the relative emissions rates of different vehicle types.

While these spatial predictors were based on a single year's data, the model allowed relationships to change from year to year, based on the patterns of $PM_{2.5}$ measurements in each year. $PM_{2.5}$ levels remained relatively higher throughout much of Manhattan, and in areas of higher traffic density, building density and industrial areas in the outer boroughs (Figure 4).

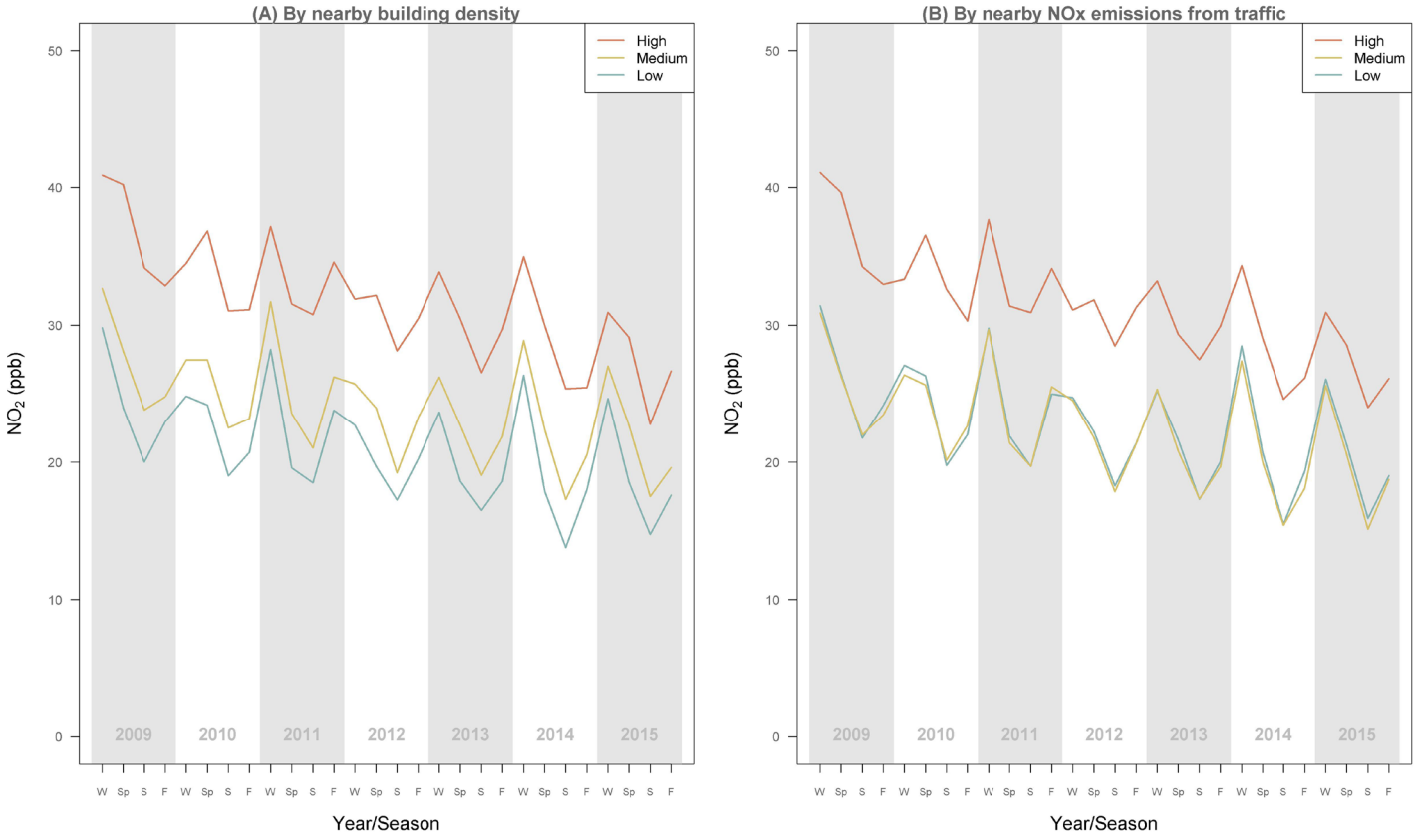
Figure 4: $PM_{2.5}$ concentrations, 2015 annual average (left) and 2009-2015 annual averages (right)



NITROGEN DIOXIDE

At NYCCAS sites measured in each season for seven years, seasonally adjusted street-level NO_2 concentrations declined by an average of 1.1 parts per billion (ppb) per year. Citywide, annual average levels at the 60 monitoring sites (locations measured across the seven years) declined by 23% between 2009 and 2015. In the most recent year (2015), seasonal average concentrations across NYCCAS monitoring sites ranged from 6.8 to 49.4 ppb. Across the seven-year period, higher levels were consistently seen at sites with higher nearby building and traffic emissions (Figure 5).

Figure 5: NO_2 levels at NYCCAS monitors, by nearby building density (A) and traffic emissions (B)[3]



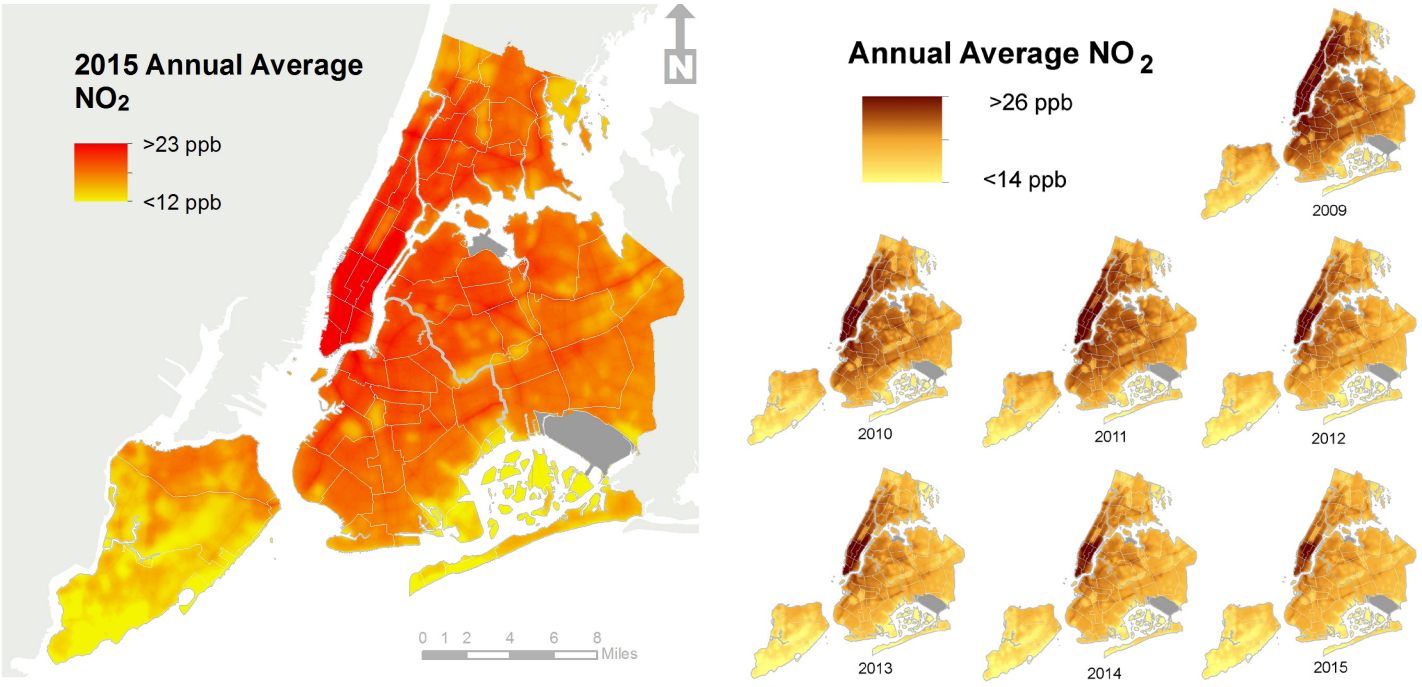
[3]Building density was estimated as total interior building area within 1,000 m of monitoring site. Density of nearby traffic emissions were estimated as total traffic density, weighted by vehicle-specific NO_x emissions rates from on-road vehicles within 100 m. High, Medium, and Low represent one third of sites ranked by source indicator density.

In the LUR model, the most important predictors of NO_2 concentrations were, in order of importance:

Indicator	Associated Sources and Interpretation
Area of interior building space within 1,000 m	Combustion of heating oil and natural gas
Percent impervious surface within 100 m	Emissions of motor vehicles on paved roadways
Traffic density, weighted by relative NO_x emissions rates and vehicle type (car, truck, bus) within 100 m	NO_x emissions from all on-road motor vehicles based on vehicle miles and the relative emission rates of different vehicle typess
Location on a bus route (compared to non-bus route locations)	Emissions from buses and other vehicles on busy roadways. Indicator of traffic congestion.

NO_2 levels remained relatively higher throughout much of Manhattan, as well as in areas of high building and traffic density in the outer boroughs (Figure 6).

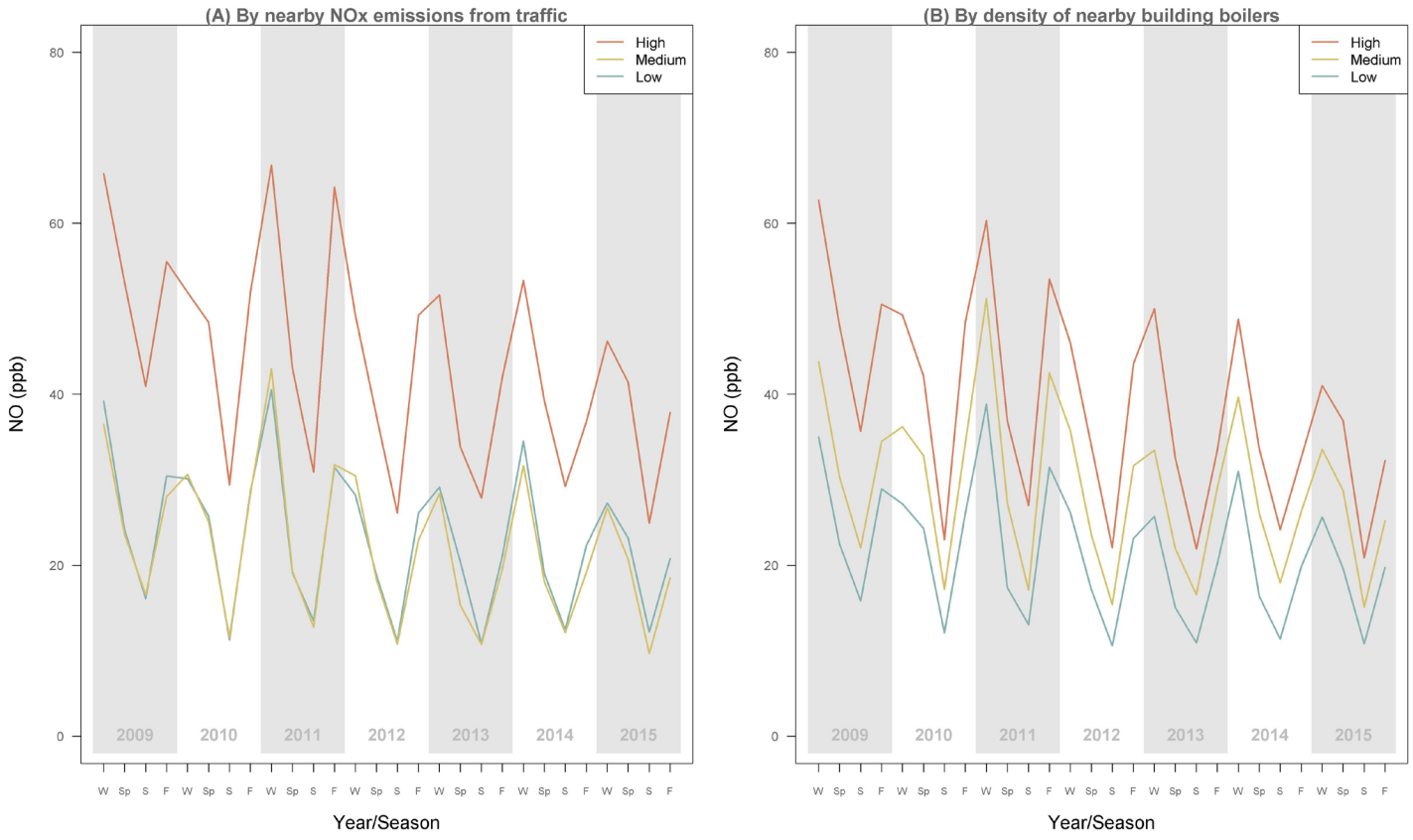
Figure 6: NO_2 concentrations, 2015 annual average (left) and 2009-2015 annual averages (right)



NITRIC OXIDE

At NYCCAS sites measured in each season for seven years, seasonally adjusted street-level NO concentrations declined by an average of 1.7 parts per billion (ppb) per year. Citywide, annual average levels at the 60 monitoring sites (locations measured across the seven years) declined by 28% between 2009 and 2015. In the most recent year (2015), seasonal average concentrations across NYCCAS monitoring sites ranged from 4.1 to 92.0 ppb. Across the seven-year period, higher levels were consistently seen at sites with higher nearby emissions from traffic sources and higher densities of nearby building boilers (Figure 7).

Figure 7: NO levels at NYCCAS monitors, by nearby NO_X emissions from traffic (A) and nearby building boilers (B)[4]



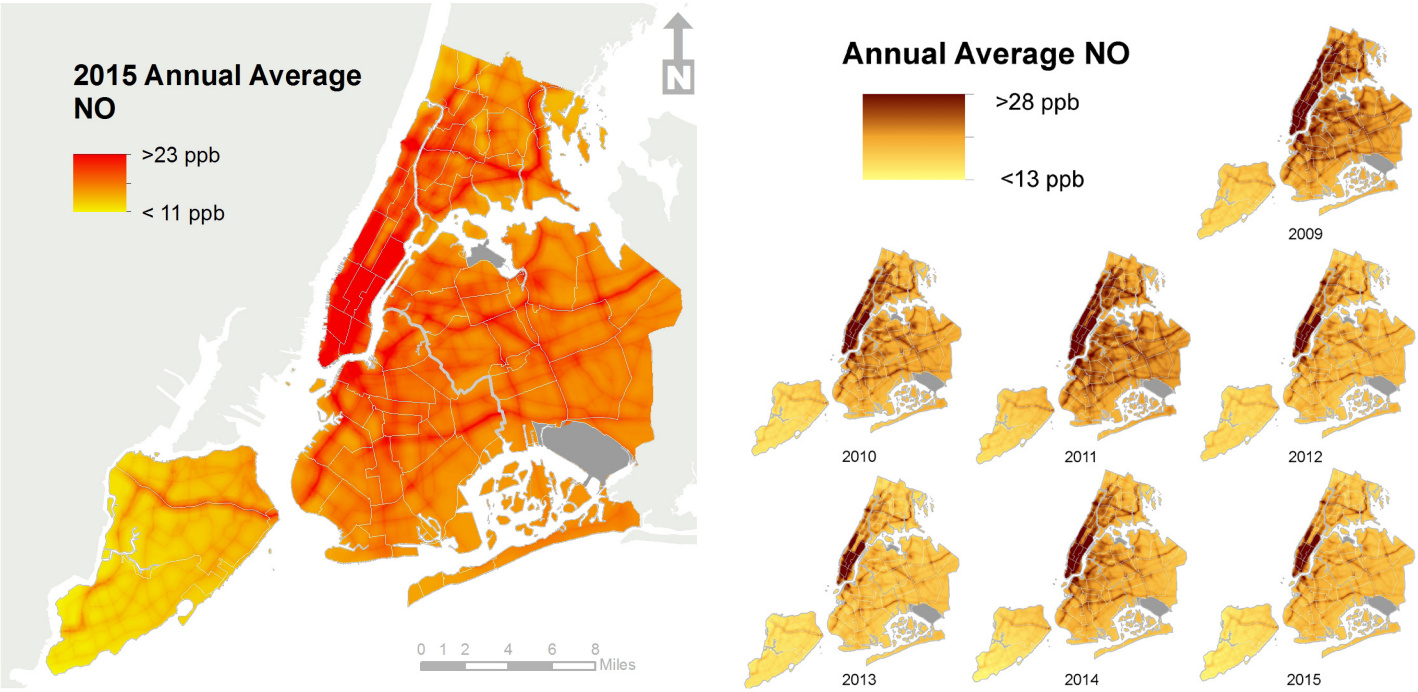
[4] Density of nearby traffic emissions was estimated as total traffic density, weighted by vehicle-specific NO_X emissions rates from on-road vehicles within 100 m. Nearby boiler density was estimated as the number of boilers within 250 m of monitoring sites, regardless of fuel type. High, Medium, and Low represent one third of sites ranked by source indicator density.

In the LUR model, the most important predictors of NO concentrations were, in order of importance:

Indicator	Associated Sources and Interpretation
Traffic density, weighted by relative NO_X emissions rates and vehicle type (car, truck, bus) within 100 m	NO_X emissions from all on-road motor vehicles based on vehicle miles and the relative emission rates of different vehicle types
Length of truck route within 50 m	Diesel exhaust
NO_X emissions from heat and hot water boilers in buildings within 400 m, taking into account changes in building heating fuels over time.	Combustion of heating oil and natural gas
Number of building boilers within 250 m	Combustion of heating oil and natural gas, traffic

NO levels remained relatively higher throughout much of Manhattan, as well as in areas of traffic and building density in the outer boroughs (Figure 8).

Figure 8: NO concentrations, 2015 annual average (left) and 2009-2015 annual averages (right)

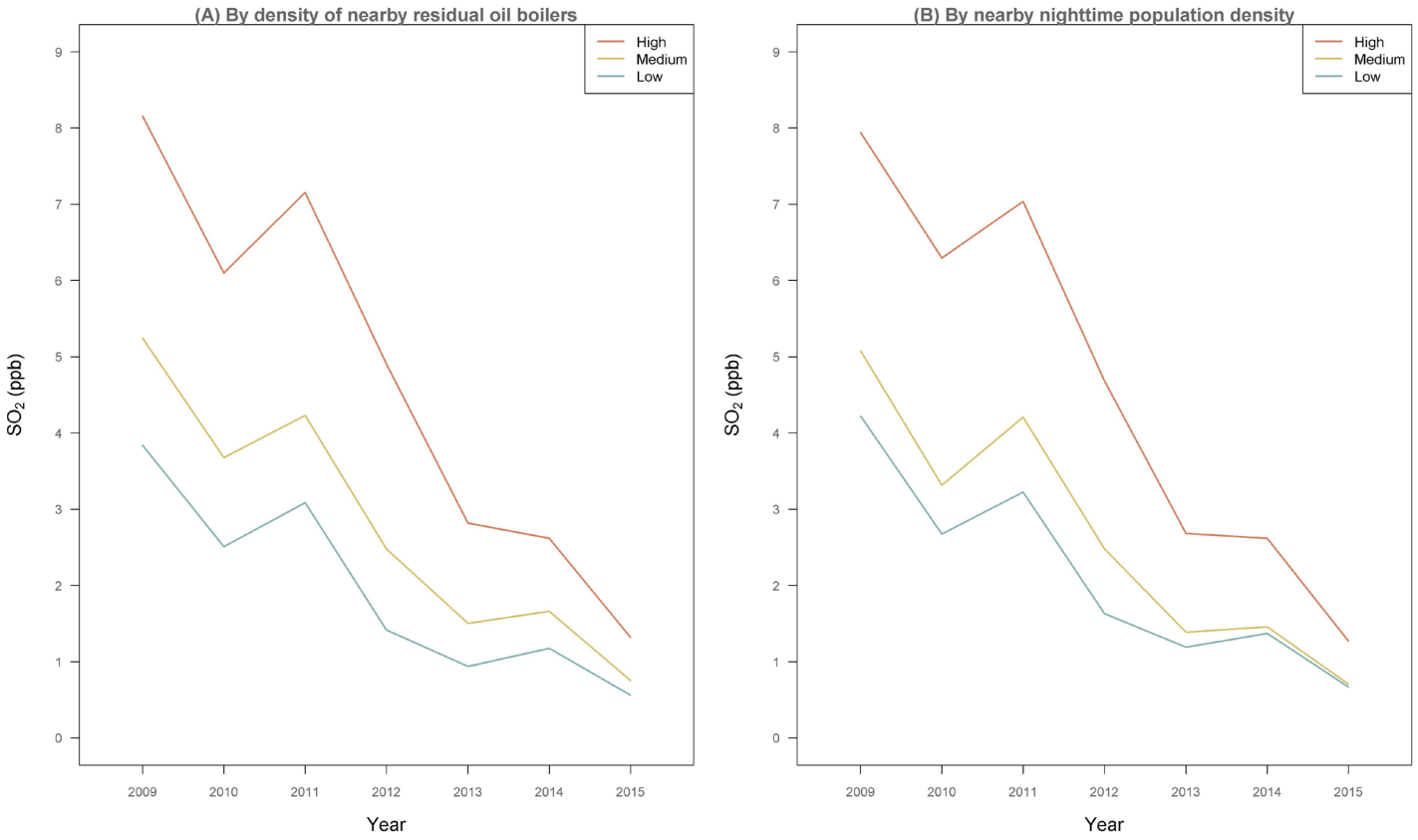


SULFUR DIOXIDE

At NYCCAS sites measured in each season for seven winters, seasonally adjusted street-level SO_2 concentrations declined by an average of 0.8 parts per billion (ppb) per year. Citywide, wintertime average levels at the 60 monitoring sites (locations measured across the seven years) declined by 84% between winter 2008-2009 and winter 2014-2015.

In the most recent winter (2014-2015), seasonal average concentrations across NYCCAS monitoring sites ranged from 0.1 to 2.7 ppb. Higher levels were measured at sites with the greatest densities of boilers using Nos. 4 and 6 oil (residual oil) and greater nighttime population density (a proxy of increased heating oil use) (Figure 9).

Figure 9: SO_2 levels at NYCCAS monitors, by density of nearby residual oil boilers (A) and nearby nighttime population density (B)[5]



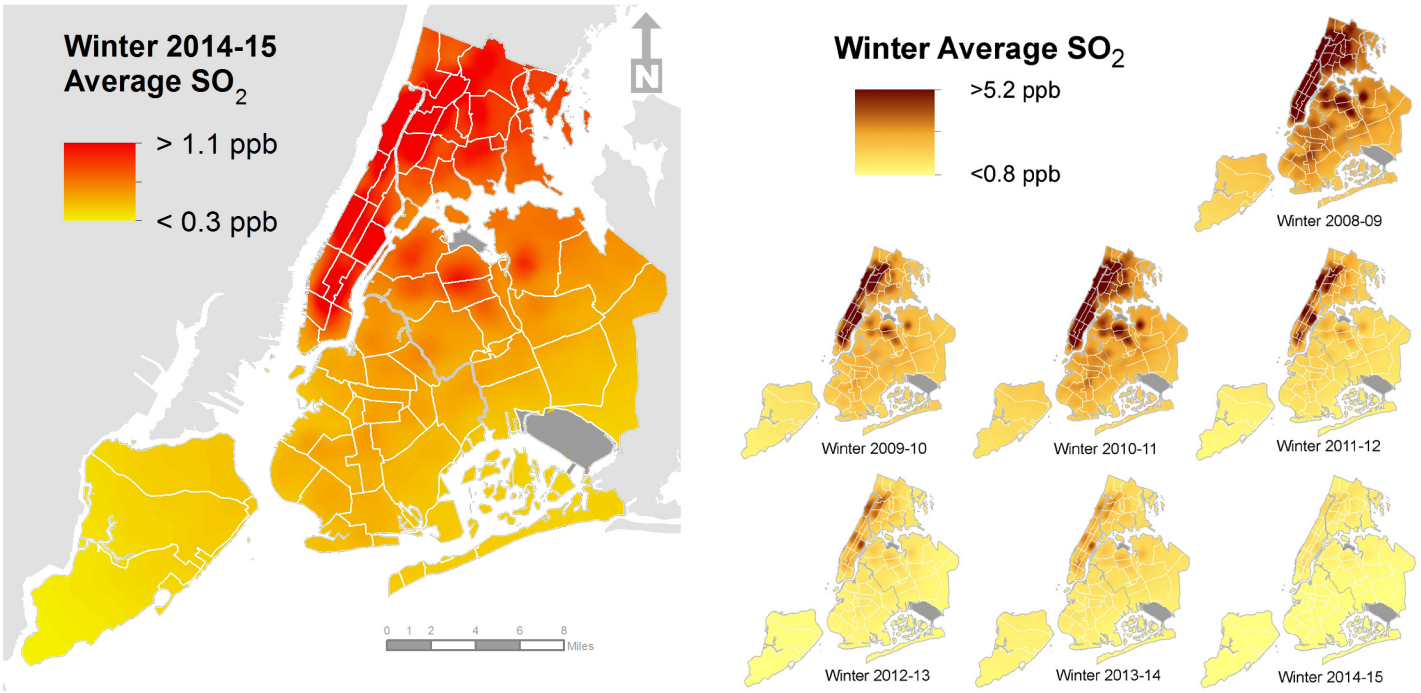
[5]Residual oil boiler density were estimated as number of Nos. 4 and 6 boilers within 1,000 m of monitoring sites. Nighttime population density was estimated as total nighttime population within 1,000 m of monitoring sites. High, Medium, and Low represent one third of sites ranked by source indicator density.

In the LUR model, the most important predictors of SO_2 concentrations were, in order of importance:

Indicator	Associated Sources and Interpretation
Time varying counts of boilers burning No. 4 and No. 6 oil within 1,000 m	Combustion of No. 4 and No. 6 heating oil, accounting for season-specific estimated counts of boilers.
Nighttime population within 1,000 m	Combustion of heating oil

SO_2 concentrations have declined significantly across the city, due to City and State efforts to phase out high sulfur fuels in the heating and power sectors. Despite this, relatively higher levels were observed in areas of the city with higher densities of remaining residual heating oil boilers and high building density, particularly areas of Manhattan and the Western Bronx (Figure 10).

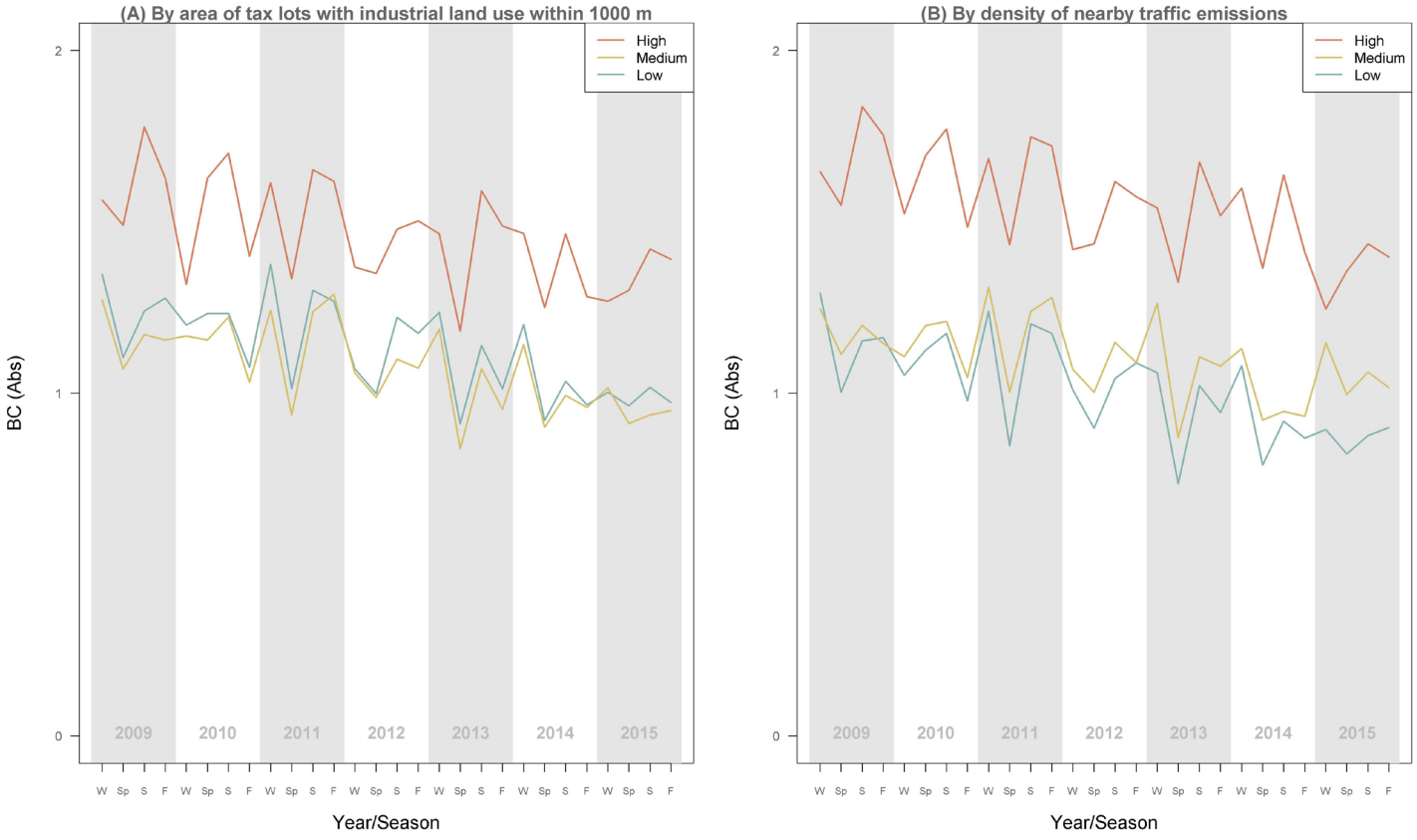
Figure 10: SO_2 concentrations, 2015 wintertime average (left) and 2009-2015 wintertime averages (right)



BLACK CARBON

At NYCCAS sites measured in each season for seven years, seasonally adjusted street-level BC concentrations declined by an average of 0.04 absorbance units (abs) per year. Citywide, annual average levels at the 60 monitoring sites (locations measured across the seven years) declined by 18% between 2009 and 2015. Across the seven-year period, higher levels were consistently seen at sites in industrial areas (reflecting increased truck traffic density) and in areas of high traffic emissions (Figure 11).

Figure 11: BC levels at NYCCAS monitors, by area of industrial tax lots (A) and nearby traffic emissions density (B)[6]



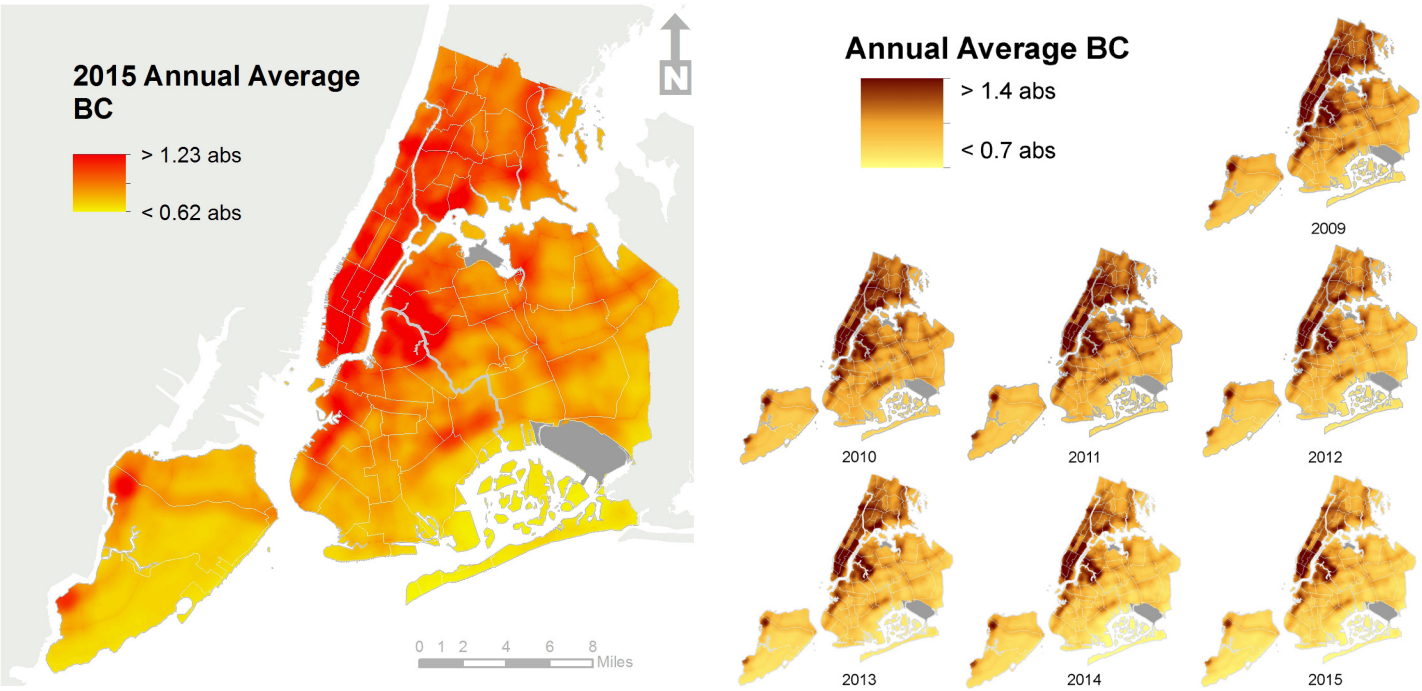
[6]Industrial land use area was estimated as the total area of industrial lots within 1,000 m. Density of nearby traffic emissions was estimated as traffic density, weighted by relative $PM_{2.5}$ emissions rates by vehicle type, within 1,000 m. High, Medium, and Low represent one third of sites ranked by source indicator density.

In the LUR model, the most important predictors of BC concentrations were, in order of importance:

Indicator	Associated Sources and Interpretation
Area of industrial land use within 1,000 m	Diesel exhaust particles from trucks idling and traveling through industrial areas, industrial combustion equipment
Traffic density, weighted by relative $PM_{2.5}$ emissions rates and vehicle type (car, truck, bus) within 1,000 m	$PM_{2.5}$ emissions from all on-road motor vehicles based on vehicle miles and the relative emission rates of different vehicle types
Number of building boilers within 200 m	Combustion of heating oil and natural gas, traffic
Road length, weighted by traffic, within 50 m	Emissions from motor vehicles
Percent impervious road surface within 250 m	Emissions of motor vehicles on paved roadways

In the most recent year (2015), seasonal average concentrations across NYCCAS monitoring sites ranged from 0.4 to 4.2 abs. BC levels are highest in the industrial areas of the city and areas with high traffic density (Figure 12).

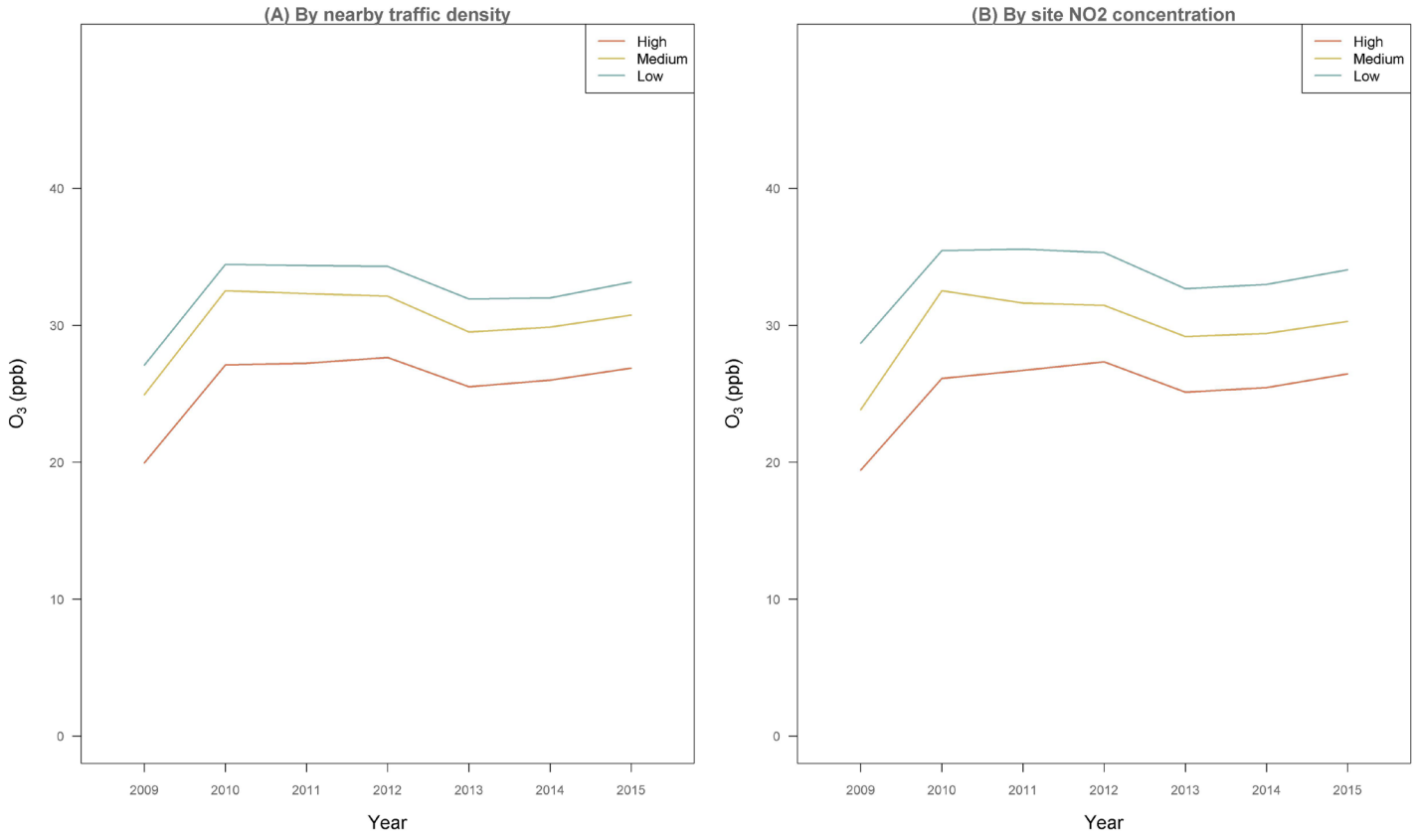
Figure 12: BC concentrations, 2015 annual average (left) and 2009-2015 annual averages (right)



OZONE

At NYCCAS sites measured in each season, summertime average O_3 levels remained relatively stable across the seven years. Since the first summer (2009), during which relatively cool temperatures contributed to lower levels of O_3 citywide, summertime average levels varied minimally year to year (ranging from 29.0 ppb to 31.4 ppb between 2010 and 2015), without a consistent trend over this time period. In the most recent summer (2015), seasonal average O_3 varied from 20.6 to 41.7 ppb across the monitoring sites. Higher levels were consistently measured at sites with lower traffic density and lower NO_2 concentrations, reflecting less removal of ozone from the atmosphere in areas of fewer fresh combustion emissions (Figure 13).

Figure 13: O_3 levels at NYCCAS monitors, by nearby traffic density (A) and co-located NO_2 concentration (B)[7]



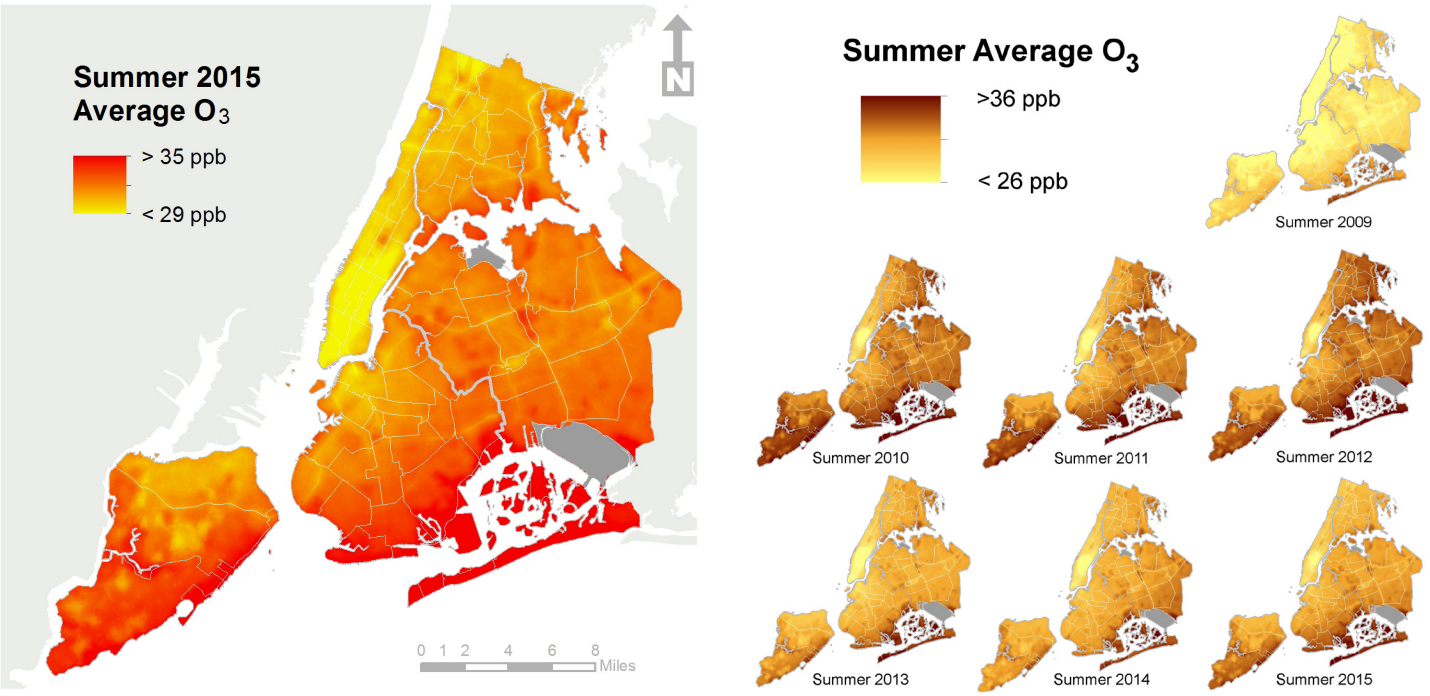
[7]Traffic density was estimated as annual average daily traffic (all types) within 1,000 m of monitoring sites. NO_2 concentrations are based on seasonal average monitored NO_2 levels at the same location. High, Medium, and Low represent one third of sites ranked by source indicator density.

In the LUR model, the most important predictors of O_3 concentrations were, in order of importance:

Indicator	Associated Sources and Interpretation
Level of NO_2 measured at the same location	Nitrogen oxides at elevated concentrations react with ground-level ozone and reduce levels
Tree cover within 50 m	Reduced levels through reactions of ozone with leaf surfaces

Higher levels of ozone were observed in the outer boroughs, in areas of fewer NO_X emissions (Figure 14).

Figure 14: O_3 concentrations, 2015 summertime average (left) and 2009-2015 summertime averages (right)



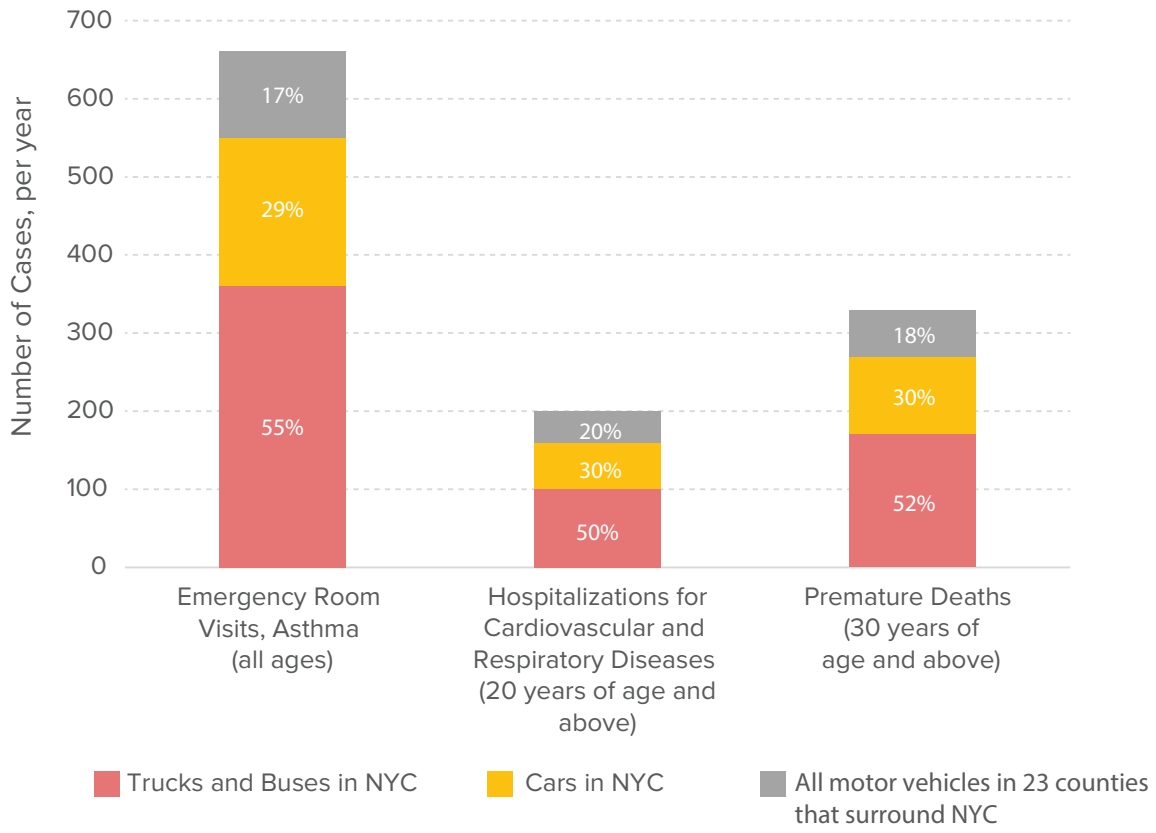
CASE STUDY:
PUBLIC HEALTH IMPACTS DUE TO VEHICLE EMISSIONS

On-road traffic is an important source of air pollutant emissions in NYC, contributing to adverse health outcomes. NYCCAS data have consistently shown that areas of the city with higher traffic density suffer from higher levels of air pollutants.

NYC Health Department researchers and their collaborators used computer model simulations to separately estimate the air quality impacts of traffic sources from within and outside the city on NYC residents. The simulations estimated the $PM_{2.5}$-attributable public health impacts of all on-road traffic sources within the 28-county metropolitan region and the five NYC counties, of passenger cars within the five NYC counties, and of trucks and buses within the five NYC counties.

The study, which was described in detail in the journal Environmental Health and summarized in an online infographic, found that within NYC, emissions of $PM_{2.5}$ and its precursors from traffic sources in the region contribute to 870 estimated hospitalizations and emergency department visits and 320 premature deaths annually. This accounts for 5,850 years of life lost per year. The largest share of adverse health outcomes from traffic came from trucks and buses traveling the city's streets, accounting for more than half of $PM_{2.5}$-related health outcomes from on-road traffic (Figure 15).

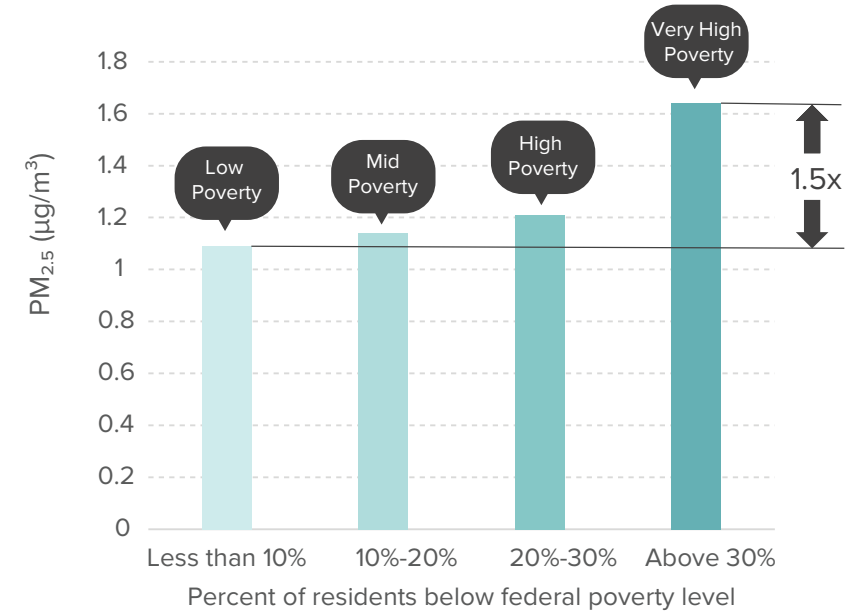
Figure 15: Annual health events due to $PM_{2.5}$ exposures from traffic sources

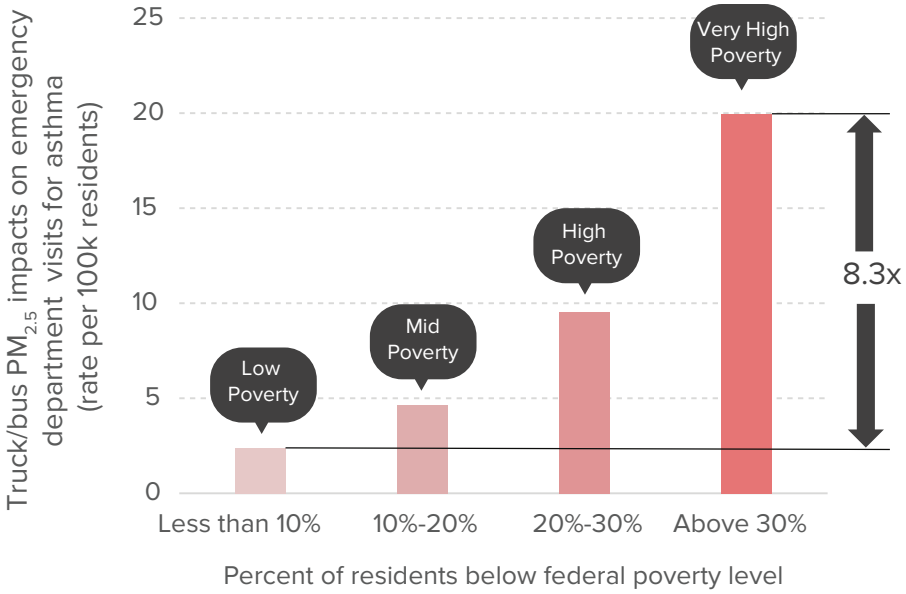


The study also found that traffic-related $PM_{2.5}$ exposures and their associated health effects disproportionately affect the city's low-income neighborhoods. Relative to more affluent neighborhoods, the city's highest-poverty neighborhoods experience 1.5-times-higher levels of $PM_{2.5}$ exposures from traffic sources and 8.3 times the rate of asthma emergency department visits due to $PM_{2.5}$ exposures from traffic sources (Figure 16). This disparity is even wider for impacts from trucks and buses, where the city's highest poverty neighborhoods experience 1.7- times-higher levels of $PM_{2.5}$ exposures and 9.4 times the rate of asthma emergency department visits due to $PM_{2.5}$ exposures, compared with the most affluent neighborhoods.

These findings underscore the need to reduce emissions from traffic in and around NYC to improve the health of New Yorkers, especially the most vulnerable residents. Interventions directed at the most polluting trucks and buses that travel roadways in the most burdened neighborhoods will maximize public health benefits and reduce health inequities across city neighborhoods.

Figure 16: $PM_{2.5}$ exposures (above) and $PM_{2.5}$-related asthma emergency department visits (bottom) due to traffic emissions in the 28-county region that includes New York City



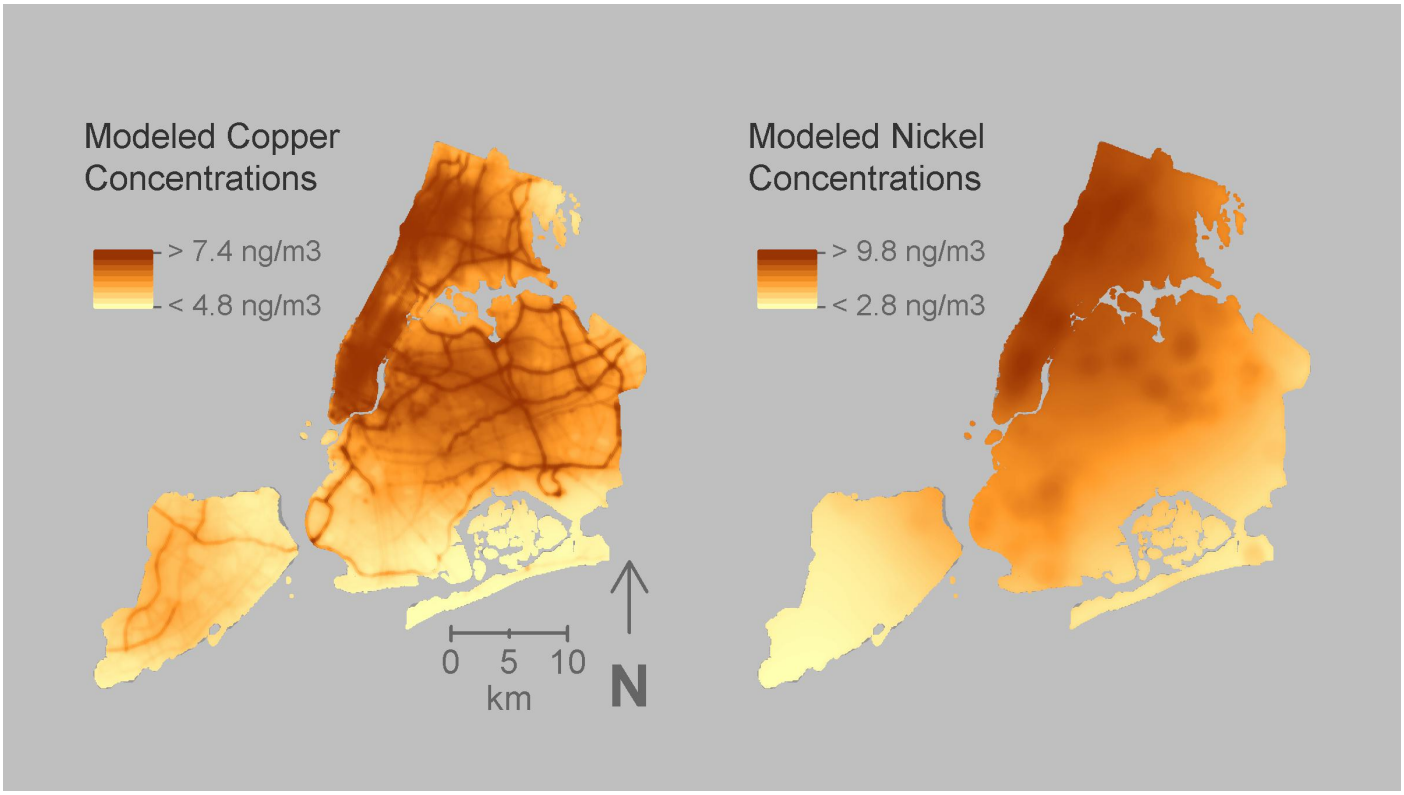


CASE STUDY:
ASSESSING TRACE METALS IN $PM_{2.5}$

$PM_{2.5}$ are tiny airborne solid and liquid particles that come from many different sources inside and outside NYC. In the city, a large fraction of $PM_{2.5}$ in our air comes from regional emissions sources often far upwind from the city and is evenly distributed across city neighborhoods. Some important local sources emit $PM_{2.5}$ with distinct "signature" trace elements that can be unevenly distributed across neighborhoods. These trace elements provide useful fingerprints that allow researchers to better understand how specific sources contribute to $PM_{2.5}$ levels in different neighborhoods.

Using laboratory techniques that identify concentrations of these trace elements in $PM_{2.5}$ samples, NYCCAS researchers evaluated levels of 15 elements (aluminum, bromine, calcium, copper, iron, potassium, manganese, sodium, nickel, lead, sulfur, silicon, titanium, vanadium, and zinc) across 150 NYCCAS sites from December 2008 to November 2012. Land use regression methods were employed to characterize spatial variation and identify important sources that contribute to high elemental levels at monitoring sites.

Figure 17: Modeled copper and nickel in $PM_{2.5}$ concentrations in 2009[8]



The study, described in detail in the journal Environmental Science and Technology, found that all the elements except sodium were statistically associated with at least one source. Strong associations between sources and elements persisted across years, including for residual oil burning (associated with $PM_{2.5}$ with high nickel and zinc content), near-road traffic (associated with $PM_{2.5}$ with high copper, iron and titanium content) and marine vessel traffic (associated with $PM_{2.5}$ with high vanadium content).

The highest levels of copper (Cu) were found along major roadways near areas of high traffic density, while the highest levels of nickel (Ni) were observed in Manhattan and the Bronx in areas with high densities of residual oil boilers (Figure 17).

These findings inform ongoing research focused on understanding how trace metals in $PM_{2.5}$ emitted by particular sources contribute to the negative health effects of pollution exposure.

[8]Reprinted with permission from Ito K, Johnson S, Kheirbek I, et al., Intraurban Variation of Fine Particle Elemental Concentrations in New York City. Environmental Science & Technology. 2016, 50: 7517–7526. Copyright 2016. American Chemical Society.

APPENDICES

1. DATA SOURCES FOR EMISSIONS INDICATORS

2. SEASONAL AVERAGE POLLUTANT MAPS

3. COMMUNITY DISTRICT AVERAGE POLLUTANT LEVELS

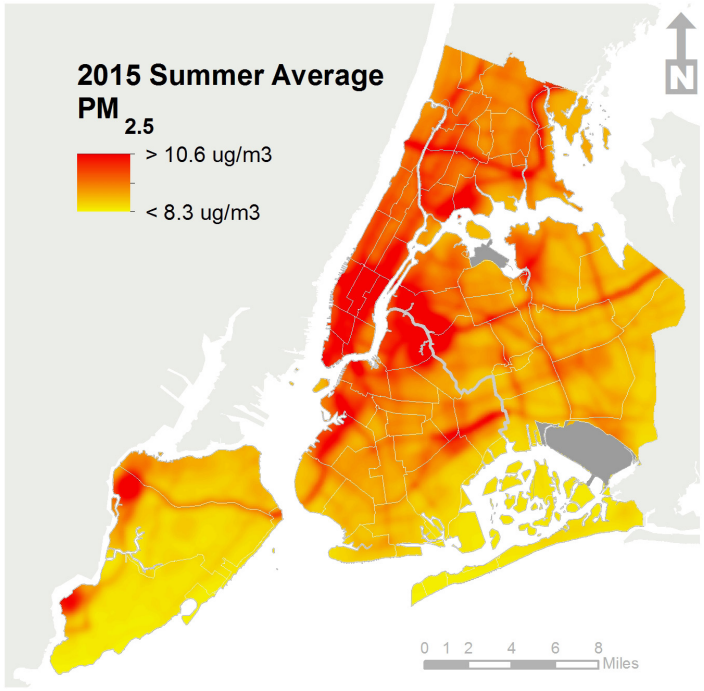
APPENDIX 1
DATA SOURCES FOR EMISSIONS INDICATORS

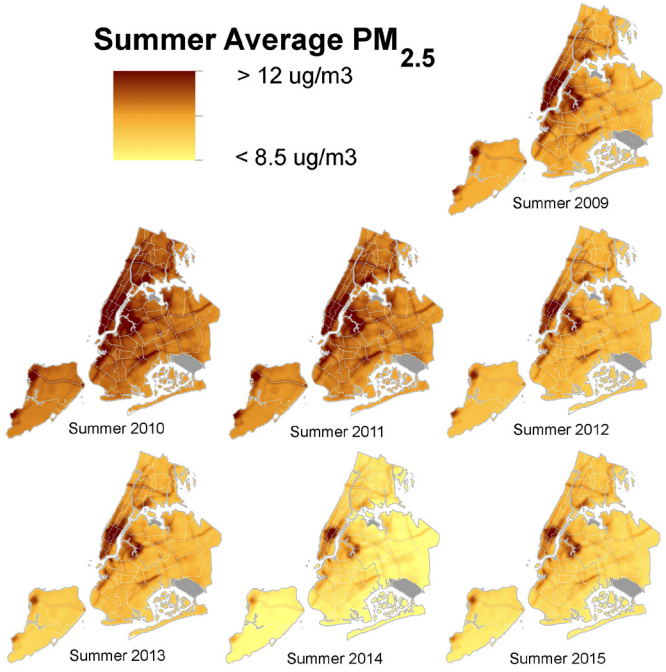
Source Category	Variables Examined (most calculated in buffers of 50 to 1,000 m)	Data Source
Cumulative Traffic Indicators	Unweighted and kernel-weighted traffic density	New York Metropolitan Transportation Council (NYMTC) traffic data, 2005; and U.S. Federal Highway Administration Highway Performance Monitoring System (HPMS) data, 2007
	Road density	Accident Location Information System (ALIS) road network data, 2008
	Kernel-weighed road density	ALIS network data
	Road density weighted by functional class	ALIS network; MPSI TrafficMetrix ™ data, 1989-2006
	Road density kernel-weighted by functional class	ALIS network; MPSI TrafficMetrix ™ data
	Traffic density weighted by relative emissions rates	NYMTC traffic data; emissions factors from Environmental Protection Agency's AP 42 database
	Number of signaled intersections	NYC Department of Transportation (DOT), 2008
Road-specific Measures	Average daily traffic on nearest major road	NYMTC traffic data
	ADT/ Distance to nearest major road	NYMTC traffic data
	Location on a bus route	NYC DOT
	Distance to nearest road, by functional class	ALIS network; MPSI TrafficMetrix ™ data

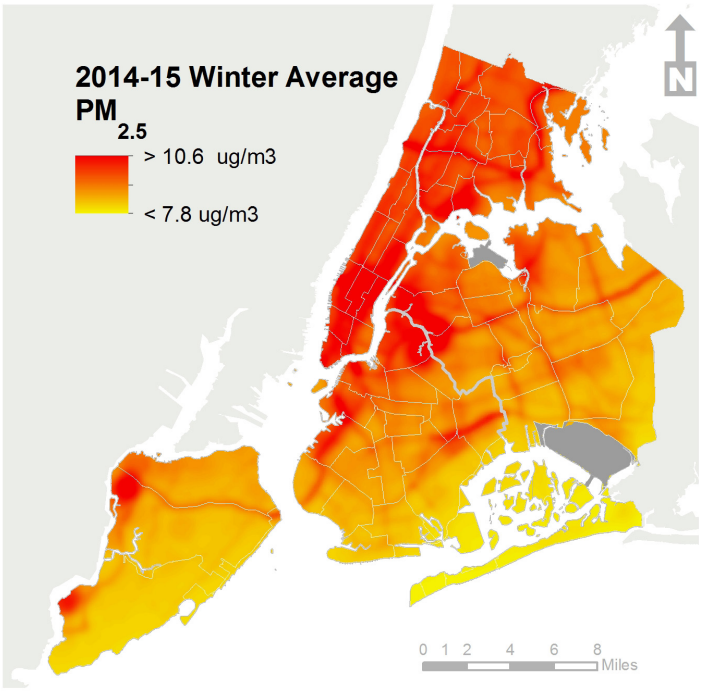
Source Category	Variables Examined (most calculated in buffers of 50 to 1,000 m)	Data Source
Truck/ Diesel-Related Measures	Unweighted traffic on designated truck routes	NYMTC traffic data
	Unweighted density of truck routes	NYMTC traffic data
	Kernel-weighted density of truck routes	NYMTC traffic data
	Distance to nearest truck route	NYMTC traffic data
	Trucks per day on nearest major road	NYMTC traffic data
Population Metrics	Census population density	U.S. Census Bureau 2000 data
	LandScan daytime, nighttime population density	Oak Ridge National Laboratory LandScan™ data, 2006
Built Space	Density of built space (building floor area)	NYC Department of City Planning Primary Land Use Tax Lot Output (PLUTO™) data, 2007
	Density of residential units	PLUTO™ data
	Total residential, factory, garage floor area	PLUTO™ data
	Estimated building boiler emissions for building heat and hot water	PLUTO™ data, EPA AP 42, NYC Department of Environmental Protection (NYC DEP) Registration and Certificate Permit Data, updated annually
	Area of commercial floor area	PLUTO™ data
Land Use	Area of industry and manufacturing	PLUTO™ data
	Area of heavy manufacturing	PLUTO™ data
	Area of gas stations	PLUTO™ data
	Area of tree cover	NYC Department of Parks and Recreation LiDAR data, 2010
	Percent impervious surface	United States Geological Survey, 2006
	Dominant land use type	PLUTO™ data

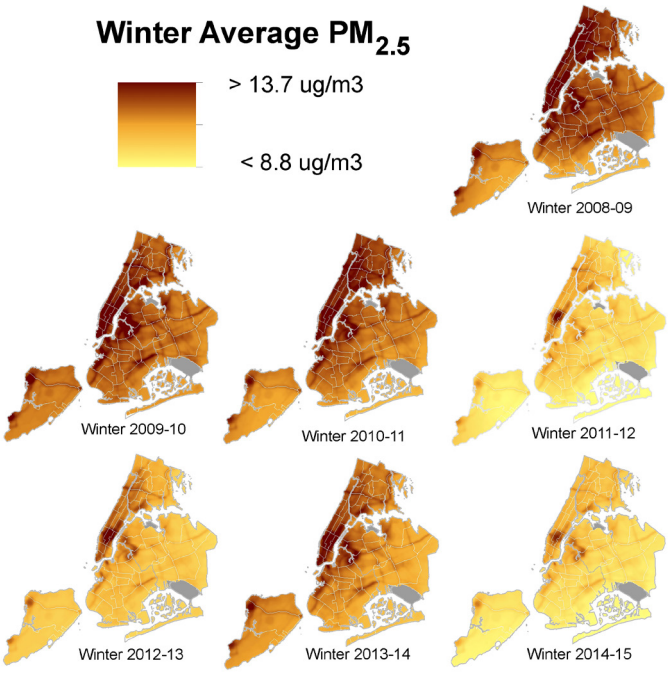
Source Category	Variables Examined (most calculated in buffers of 50 to 1,000 m)	Data Source
Permitted Emissions	Number of DEC permitted combustion sources	NYS Department of Environmental Conservation (DEC) permit data, 2005
	Number of DEP permitted combustion sources	NYC DEP permit data, 2008
	Number of DOB permitted boilers	NYC Department of Buildings (DOB) permit data, 2008
	Number of permitted combustion sources by fuel type (oil 2, 4, 6, natural gas)	DEP permit data, updated every 6 months
	Total BTU by fuel type (oil 2, 4, 6, natural gas)	DEP permit data
	Average BTU by fuel type (oil 2, 4, 6, natural gas)	DEP permit data
Transportation Facilities	Number of bus depots	NYC Department of Citywide Administrative Services (DCAS), 2008
	Minimum distance to bus depot, school bus depot	NYC DCAS; NYC Department of Education (DOE)
	Number of school bus depots	NYC DOE
	Number of school buses at nearest depot	NYC DOE
Distributed Facilities	Number of waste transfer stations	NYC Department of Sanitation inspections
	Minimum distance to waste transfer station, ferry terminal, water treatment facility	NYC DCAS
	Distance to nearest port, airport	NYC Office of Emergency Management

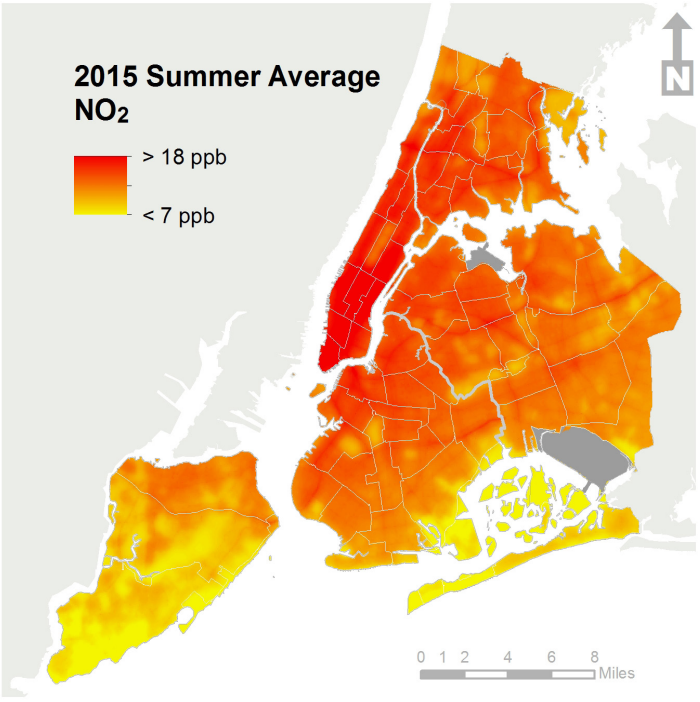
APPENDIX 2
SEASONAL AVERAGE POLLUTANT MAPS, $PM_{2.5}$, NO_2, NO, BC

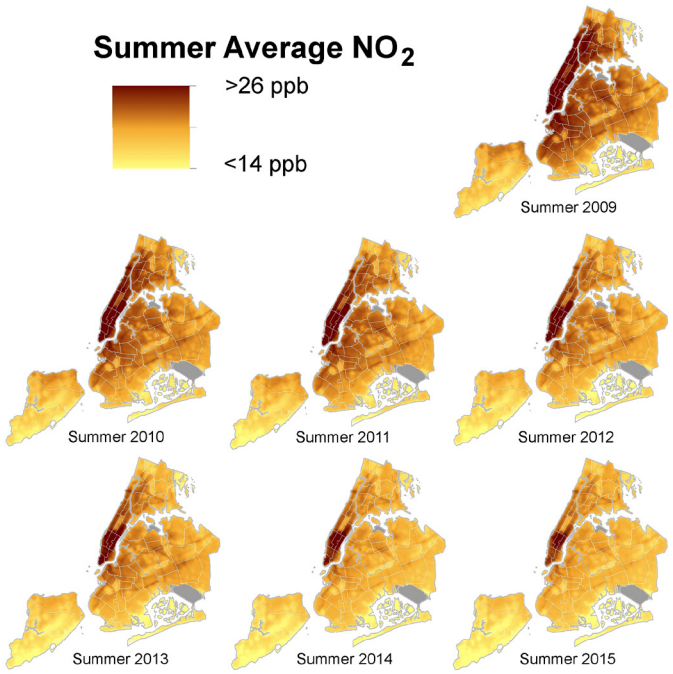


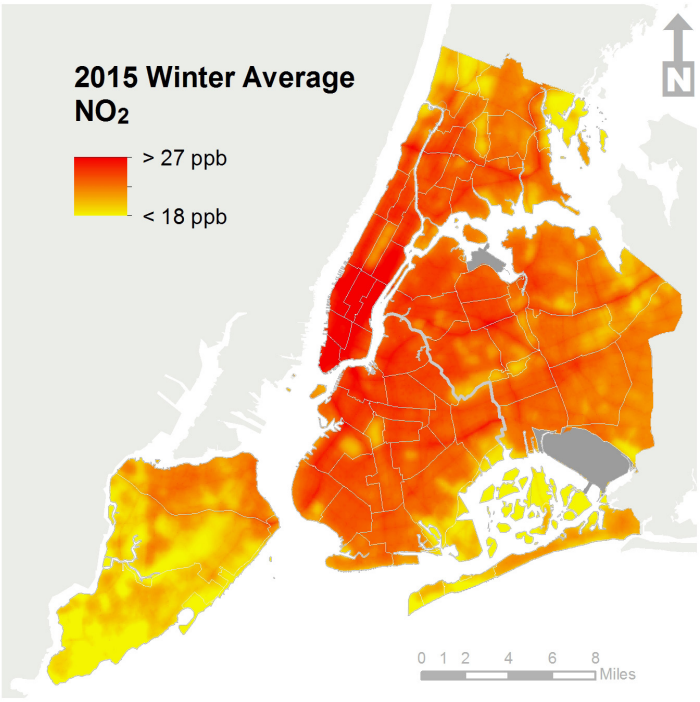


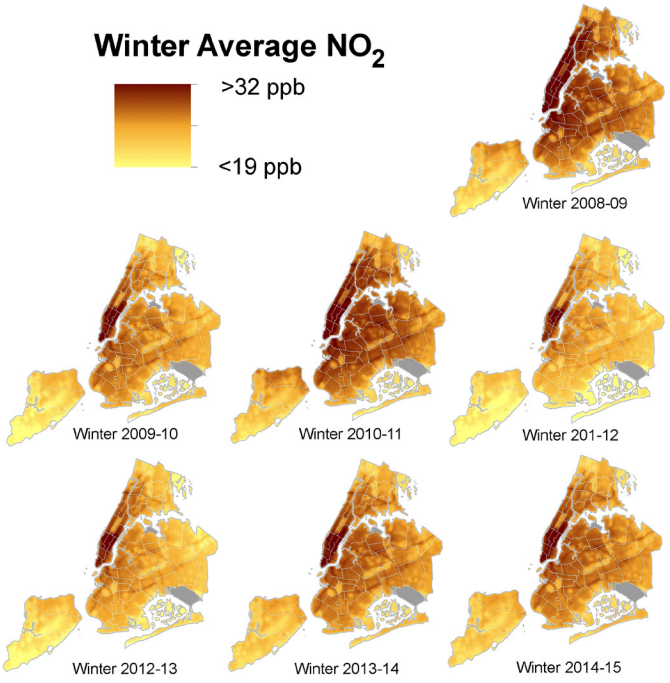


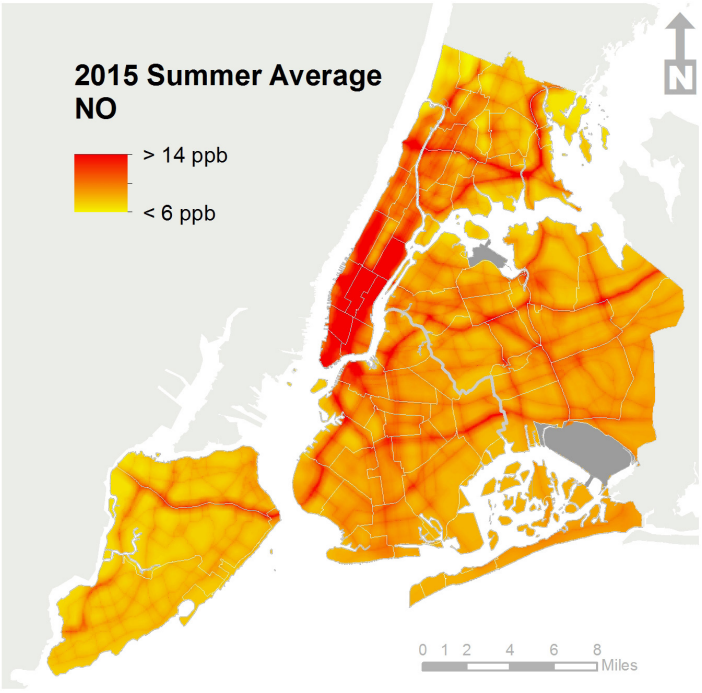


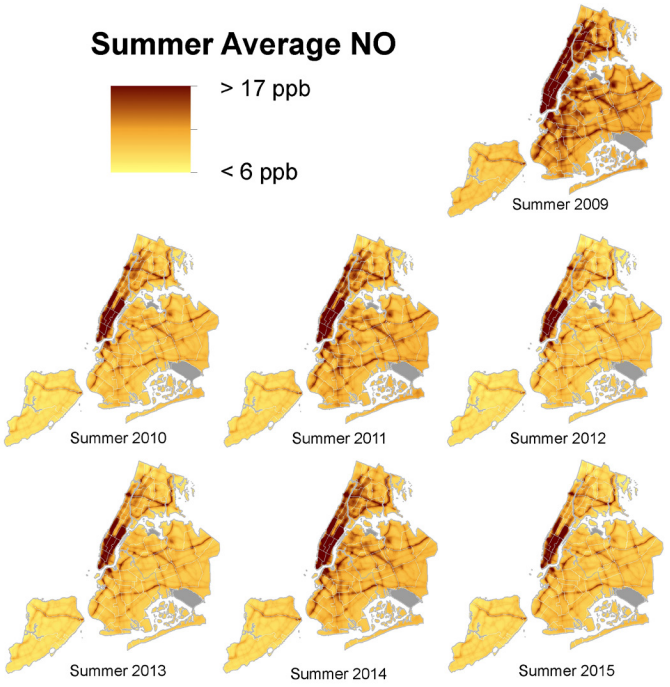

2015 Summer Average
NO2
> 18 ppb
< 7 ppb
N
0 1 2 4 6 8
Miles

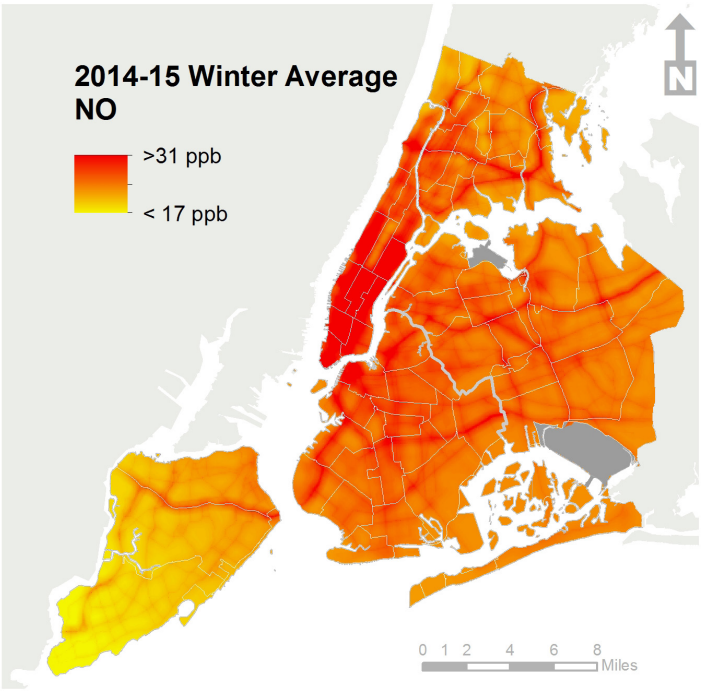

Summer Average NO2
>26 ppb
<14 ppb
Summer 2009
Summer 2010
Summer 2011
Summer 2012
Summer 2013
Summer 2014
Summer 2015

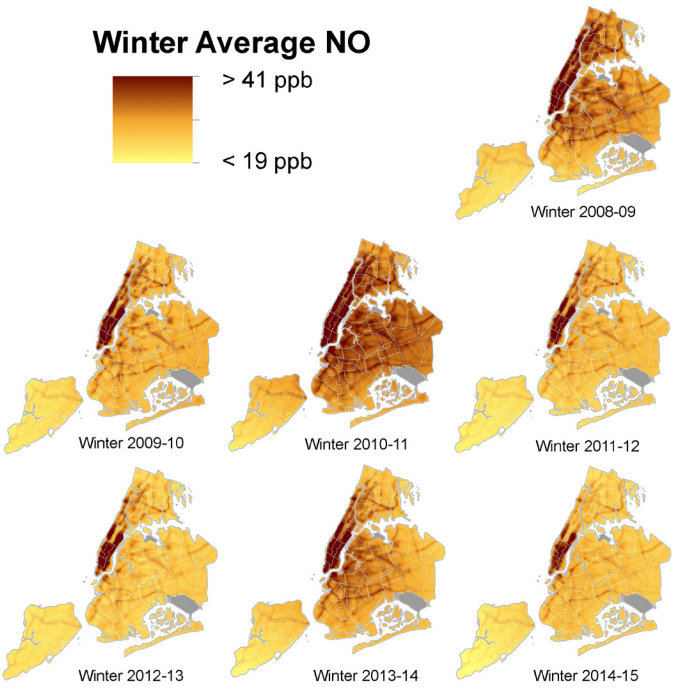

2015 Winter Average
NO2
> 27 ppb
< 18 ppb
N
0 1 2 4 6 8
Miles

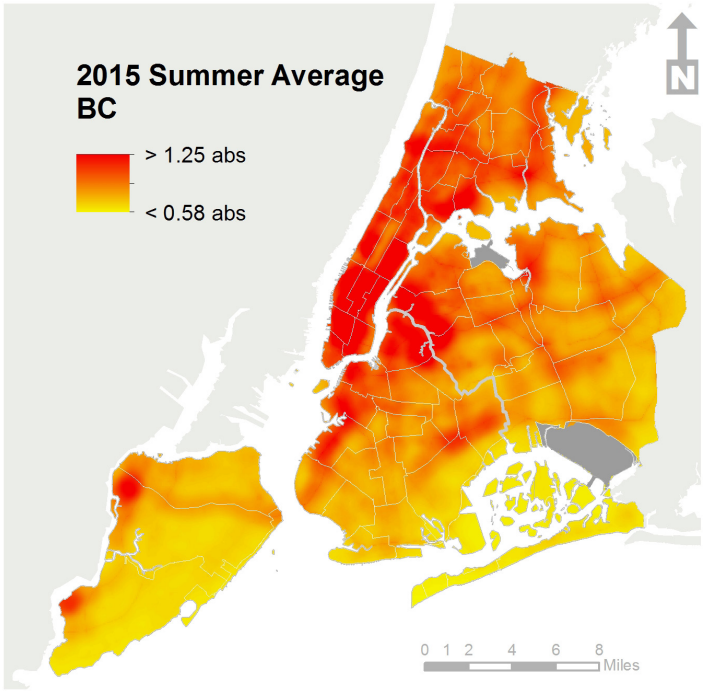

Winter Average NO2
>32 ppb
<19 ppb
Winter 2008-09
Winter 2009-10
Winter 2010-11
Winter 201-12
Winter 2012-13
Winter 2013-14
Winter 2014-15

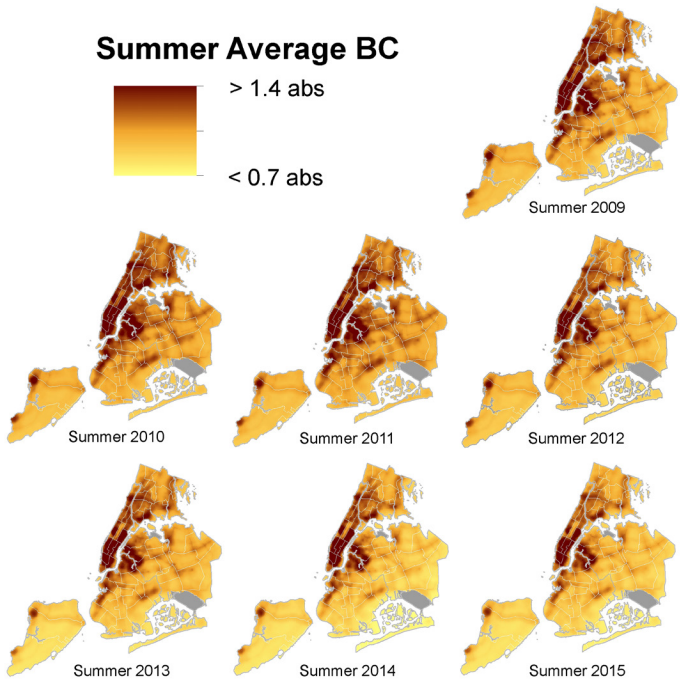

2015 Summer Average NO
> 14 ppb
< 6 ppb
N
0 1 2 4 6 8
Miles

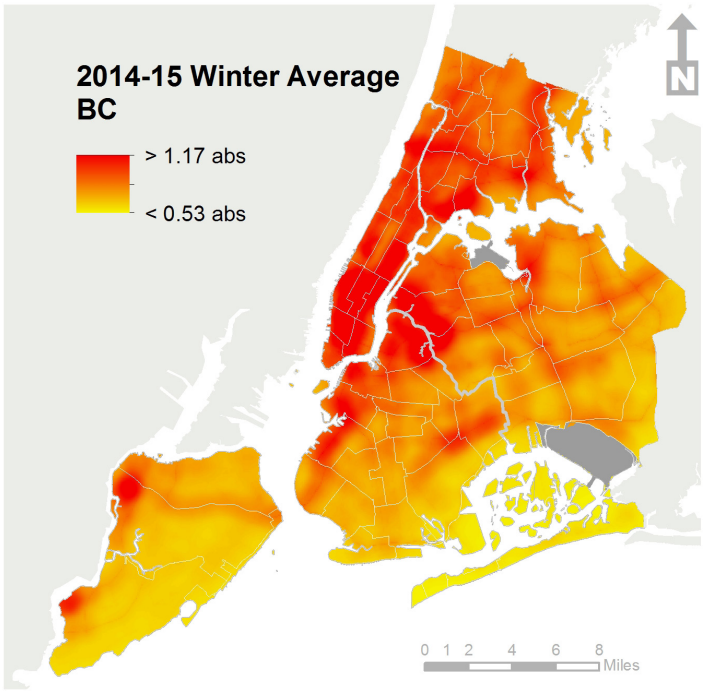

Summer Average NO
> 17 ppb
< 6 ppb
Summer 2009
Summer 2010
Summer 2011
Summer 2012
Summer 2013
Summer 2014
Summer 2015

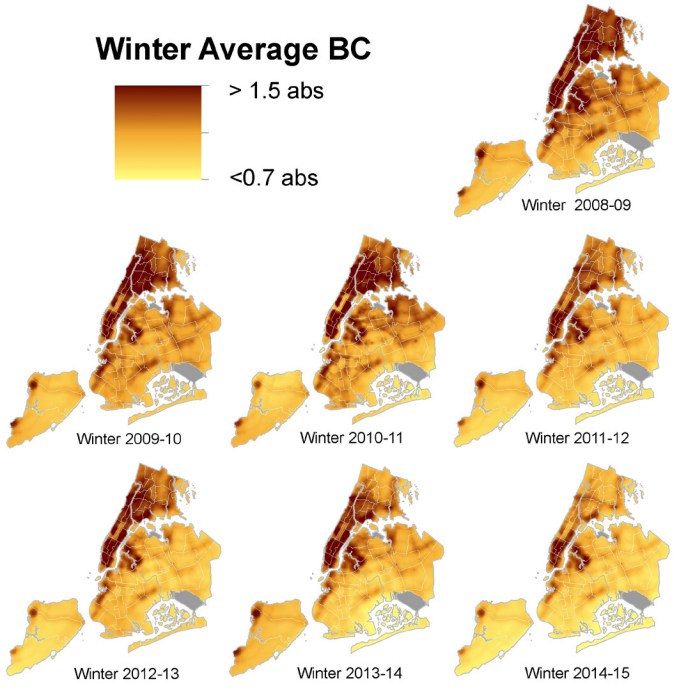

2014-15 Winter Average NO
>31 ppb
< 17 ppb
N
0 1 2 4 6 8
Miles


Winter Average NO
> 41 ppb
< 19 ppb
Winter 2008-09
Winter 2009-10
Winter 2010-11
Winter 2011-12
Winter 2012-13
Winter 2013-14
Winter 2014-15


2015 Summer Average BC
> 1.25 abs
< 0.58 abs
N
0 1 2 4 6 8
Miles


Summer Average BC
> 1.4 abs
< 0.7 abs
Summer 2009
Summer 2010
Summer 2011
Summer 2012
Summer 2013
Summer 2014
Summer 2015


2014-15 Winter Average BC
> 1.17 abs
< 0.53 abs
N
0 1 2 4 6 8
Miles


Winter Average BC
> 1.5 abs
<0.7 abs
Winter 2008-09
Winter 2009-10
Winter 2010-11
Winter 2011-12
Winter 2012-13
Winter 2013-14
Winter 2014-15

APPENDIX 3 COMMUNITY DISTRICT AVERAGE POLLUTANT LEVELS

Table A3-1: Community district, annual average $PM_{2.5}$ and per-year decline in levels

Borough	Geography	ID	Annual Average 2009	Annual Average 2010	Annual Average 2011	Annual Average 2012	Annual Average 2013	Annual Average 2014	Annual Average 2015	Slope (per year decline)
Manhattan	Midtown (CD5)	105	16.1	15.5	14.8	14.2	14.3	14.2	12.3	-0.52
Bronx	Fordham and University Heights (CD5)	205	12.1	11.4	11.7	10.5	10.1	10.1	9.8	-0.40
Bronx	Highbridge and Concourse (CD4)	204	12	11.2	11.6	10.4	10	10	9.7	-0.39
Manhattan	Stuyvesant Town and Turtle Bay (CD6)	106	14.1	13.1	13.1	12.3	12.3	12.4	11.2	-0.39
Bronx	Kingsbridge Heights and Bedford (CD7)	207	11.5	10.7	11.1	9.8	9.4	9.5	9.3	-0.38
Manhattan	Washington Heights and Inwood (CD12)	112	11.6	10.7	11.1	9.9	9.5	9.5	9.4	-0.38
Manhattan	Upper East Side (CD8)	108	12.9	11.9	12.1	11.2	11.1	11.2	10.2	-0.38
Bronx	Belmont and East Tremont (CD6)	206	11.5	10.7	11.2	9.9	9.5	9.6	9.4	-0.36
Bronx	Morrisania and Crotona (CD3)	203	11.4	10.6	11.1	9.9	9.4	9.5	9.3	-0.36
Manhattan	Central Harlem (CD10)	110	11.6	10.6	11.1	9.9	9.6	9.7	9.3	-0.36
Manhattan	Financial District (CD1)	101	13.1	12.1	12.3	11.3	11.1	11.4	10.6	-0.36
Manhattan	Morningside Heights and Hamilton Heights (CD9)	109	11.7	10.7	11.2	10.1	9.8	9.8	9.4	-0.36
Staten Island	Tottenville and Great Kills (CD3)	503	9.7	8.8	9.3	8.3	7.8	8.2	7.3	-0.35
Manhattan	Upper West Side (CD7)	107	12.2	11	11.5	10.4	10.3	10.4	9.8	-0.34
Queens	Rego Park and Forest Hills (CD6)	406	10.6	9.8	10.1	9.1	8.7	8.9	8.5	-0.34
Bronx	Riverdale and Fieldston (CD8)	208	11	10.1	10.7	9.3	8.9	9	9.2	-0.34
Bronx	Mott Haven and Melrose (CD1)	201	11.9	10.9	11.6	10.4	10	10.1	9.9	-0.33
Brooklyn	South Crown Heights and Lefferts Gardens (CD9)	309	10.6	9.9	10.2	9.1	8.6	9	8.7	-0.33
Bronx	Parkchester and Soundview (CD9)	209	10.8	10	10.7	9.4	8.9	9.1	9	-0.32
Brooklyn	Crown Heights and Prospect Heights (CD8)	308	10.8	10	10.4	9.2	8.8	9.2	8.9	-0.32
Queens	Kew Gardens and Woodhaven (CD9)	409	10.3	9.5	9.7	8.6	8.4	8.7	8.3	-0.32
Brooklyn	Brownsville (CD16)	316	10.8	10	10.3	9.1	8.8	9.2	8.9	-0.31
Brooklyn	East Flatbush (CD17)	317	10.6	9.9	10.2	9.1	8.7	9.1	8.7	-0.31
Brooklyn	Flatbush and Midwood (CD14)	314	10.3	9.7	10.1	8.9	8.6	8.9	8.4	-0.31
Queens	Hillcrest and Fresh Meadows (CD8)	408	10	9.3	9.7	8.6	8.2	8.4	8.2	-0.31
Manhattan	Greenwich Village and Soho (CD2)	102	12.8	11.6	12.1	11.1	10.9	11.2	10.6	-0.31

Borough	Geography	ID	Annual Average 2009	Annual Average 2010	Annual Average 2011	Annual Average 2012	Annual Average 2013	Annual Average 2014	Annual Average 2015	Slope (per year decline)
Queens	Elmhurst and Corona (CD4)	404	10.7	9.8	10.3	9.2	8.9	9.2	8.7	-0.31
Manhattan	East Harlem (CD11)	111	11.5	10.4	11.1	10	9.7	9.8	9.5	-0.31
Queens	South Ozone Park and Howard Beach (CD10)	410	9.8	9	9.2	8.1	8	8.2	7.9	-0.30
Queens	Jackson Heights (CD3)	403	10.3	9.2	9.9	8.8	8.4	8.7	8.3	-0.30
Manhattan	Clinton and Chelsea (CD4)	104	13.2	11.9	12.4	11.4	11.4	11.6	10.9	-0.30
Bronx	Hunts Point and Longwood (CD2)	202	11.6	10.7	11.5	10.3	9.8	10	9.8	-0.30
Brooklyn	Borough Park (CD12)	312	10.3	9.6	10.1	8.9	8.5	8.9	8.5	-0.30
Bronx	Morris Park and Bronxdale (CD11)	211	10.6	9.7	10.4	9.2	8.7	8.9	8.9	-0.30
Brooklyn	Bedford Stuyvesant (CD3)	303	10.8	9.9	10.4	9.2	8.8	9.3	9	-0.29
Queens	Flushing and Whitestone (CD7)	407	10.2	9.4	10.1	8.9	8.4	8.7	8.5	-0.29
Brooklyn	Bay Ridge and Dyker Heights (CD10)	310	10.2	9.4	10	8.8	8.4	8.8	8.4	-0.29
Brooklyn	Bensonhurst (CD11)	311	9.8	9.2	9.7	8.6	8.2	8.6	8	-0.29
Brooklyn	East New York and Starrett City (CD5)	305	10.5	9.7	10	8.9	8.7	9	8.7	-0.29
Staten Island	South Beach and Willowbrook (CD2)	502	9.8	8.8	9.5	8.3	8.1	8.5	7.8	-0.29
Brooklyn	Fort Greene and Brooklyn Heights (CD2)	302	11.6	10.5	11.1	9.9	9.5	10	9.8	-0.29
Brooklyn	Bushwick (CD4)	304	10.8	9.8	10.3	9.2	8.8	9.3	9	-0.28
Queens	Jamaica and Hollis (CD12)	412	9.9	9.2	9.5	8.4	8.3	8.4	8.2	-0.28
Brooklyn	Coney Island (CD13)	313	9.4	8.8	9.4	8.2	8	8.3	7.6	-0.28
Brooklyn	Sheepshead Bay (CD15)	315	9.6	8.9	9.5	8.3	8.1	8.4	7.8	-0.28
Queens	Ridgewood and Maspeth (CD5)	405	10.7	9.7	10.2	9.1	8.8	9.2	8.9	-0.28
Manhattan	Lower East Side and Chinatown (CD3)	103	11.8	10.6	11.3	10.1	9.9	10.3	9.9	-0.28
Brooklyn	Flatlands and Canarsie (CD18)	318	9.8	9.1	9.5	8.3	8.2	8.5	8.1	-0.27
Bronx	Williamsbridge and Baychester (CD12)	212	10.6	9.6	10.4	9	8.7	8.9	9.1	-0.27
Staten Island	St. George and Stapleton (CD1)	501	10	8.9	9.6	8.4	8.1	8.6	8.2	-0.27
Queens	Bayside and Little Neck (CD11)	411	9.7	9	9.7	8.5	8.1	8.3	8.2	-0.27
Brooklyn	Sunset Park (CD7)	307	11.1	10.3	10.9	9.7	9.2	9.7	9.6	-0.26
Bronx	Throgs Neck and Co-op City (CD10)	210	10.5	9.5	10.4	9.1	8.7	8.9	9	-0.26
Brooklyn	Park Slope and Carroll Gardens (CD6)	306	11.4	10.4	11.1	9.9	9.4	9.9	9.9	-0.26
Queens	Queens Village (CD13)	413	9.4	8.7	9.2	8.1	7.9	8	7.9	-0.26
Queens	Long Island City and Astoria (CD1)	401	10.7	9.4	10.4	9.2	8.9	9.2	9	-0.25
Queens	Woodside and Sunnyside (CD2)	402	11.9	10.6	11.5	10.3	10.1	10.5	10.3	-0.23
Queens	Rockaway and Broad Channel (CD14)	414	8.8	8	8.4	7.4	7.6	7.7	7.2	-0.22
Brooklyn	Greenpoint and Williamsburg (CD1)	301	12	10.7	11.6	10.4	10.1	10.6	10.6	-0.21

Table A3-2: Community district, annual average NO_2 and per-year decline in levelsls

Borough	Geography	ID	Annual Average 2009	Annual Average 2010	Annual Average 2011	Annual Average 2012	Annual Average 2013	Annual Average 2014	Annual Average 2015	Slope (per year decline)
Manhattan	Midtown (CD5)	105	46.8	42.1	41.8	40	38.7	37.1	32.9	-1.96
Manhattan	Stuyvesant Town and Turtle Bay (CD6)	106	39.9	36.2	36.4	34.5	33.4	32.2	29.3	-1.53
Manhattan	Financial District (CD1)	101	36.6	33.4	33.5	31.1	30.3	28.9	26.7	-1.50
Manhattan	Clinton and Chelsea (CD4)	104	36.3	32.9	33.5	31.4	30.6	29.2	27.3	-1.33
Manhattan	Upper East Side (CD8)	108	34.5	31.2	31.7	29.6	28.7	27.8	25.8	-1.28
Manhattan	Greenwich Village and Soho (CD2)	102	34.8	31.8	32.3	30.1	29.3	28.1	26.3	-1.28
Manhattan	Morningside Heights and Hamilton Heights (CD9)	109	31	27.6	28.1	25.5	25.2	23.6	22.9	-1.26
Manhattan	Central Harlem (CD10)	110	31.2	27.9	28.3	25.9	25.4	24	23.3	-1.23
Manhattan	Upper West Side (CD7)	107	31.9	28.6	29.3	27.1	26.5	25.1	23.9	-1.21
Bronx	Highbridge and Concourse (CD4)	204	29.7	26.6	26.9	24.5	24	22.7	22.4	-1.16
Manhattan	Lower East Side and Chinatown (CD3)	103	31.8	29.2	29.7	27.4	26.6	25.7	24.3	-1.16
Manhattan	Washington Heights and Inwood (CD12)	112	27.9	24.7	25	22.6	22.3	20.6	20.7	-1.16
Brooklyn	Fort Greene and Brooklyn Heights (CD2)	302	29.3	27.1	27.4	24.8	24.2	23.4	22.4	-1.12
Bronx	Fordham and University Heights (CD5)	205	29.6	26.5	26.8	24.6	23.9	22.7	22.7	-1.11
Manhattan	East Harlem (CD11)	111	29.8	27	27.6	25.2	24.7	23.6	22.9	-1.09
Brooklyn	Park Slope and Carroll Gardens (CD6)	306	27.7	25.9	26	23.3	22.7	22	21.4	-1.07
Brooklyn	Crown Heights and Prospect Heights (CD8)	308	27.8	25.9	26	23.4	22.8	22.3	21.3	-1.07
Brooklyn	Bedford Stuyvesant (CD3)	303	27.6	25.7	25.9	23.5	22.8	22.2	21.3	-1.04
Brooklyn	South Crown Heights and Lefferts Gardens (CD9)	309	27	25.3	25.2	22.7	22.1	21.7	20.8	-1.03
Bronx	Morrisania and Crotona (CD3)	203	27.7	25	25.3	23	22.3	21.6	21.4	-1.03
Bronx	Mott Haven and Melrose (CD1)	201	28.1	25.5	25.9	23.5	22.9	22.1	21.8	-1.03
Brooklyn	Sunset Park (CD7)	307	25.5	24	24	21.2	20.7	20.3	19.8	-0.99
Bronx	Kingsbridge Heights and Bedford (CD7)	207	26.7	23.8	24.2	22.5	21.5	20.7	20.9	-0.94
Bronx	Belmont and East Tremont (CD6)	206	27.1	24.4	24.8	22.8	21.9	21.4	21.4	-0.93
Brooklyn	Bushwick (CD4)	304	25.9	24.2	24.7	22.4	21.7	21.2	20.3	-0.92
Brooklyn	Brownsville (CD16)	316	25.6	24	24.2	21.9	21.4	20.9	20.1	-0.91
Brooklyn	Borough Park (CD12)	312	25.2	23.8	23.6	21.1	20.5	20.6	19.9	-0.91
Brooklyn	East Flatbush (CD17)	317	25.1	23.6	23.6	21.3	20.7	20.5	19.8	-0.89
Bronx	Riverdale and Fieldston (CD8)	208	23.2	20.1	20.8	19.1	18.2	17.1	17.8	-0.89
Brooklyn	Greenpoint and Williamsburg (CD1)	301	27	25.2	25.9	23.6	22.9	22.4	21.7	-0.88
Bronx	Hunts Point and Longwood (CD2)	202	26.1	23.9	24.3	22.1	21.3	21	20.9	-0.87
Brooklyn	Flatbush and Midwood (CD14)	314	24.4	23	22.9	20.5	19.9	20	19.3	-0.87
Queens	Rego Park and Forest Hills (CD6)	406	25	23.5	24.1	21.8	21.1	20.9	20	-0.83

Borough	Geography	ID	Annual Average 2009	Annual Average 2010	Annual Average 2011	Annual Average 2012	Annual Average 2013	Annual Average 2014	Annual Average 2015	Slope (per year decline)
Queens	Elmhurst and Corona (CD4)	404	26.9	25.3	25.9	23.7	22.8	22.8	21.9	-0.83
Brooklyn	East New York and Starrett City (CD5)	305	23.4	22	22.4	20.2	19.8	19.3	18.7	-0.79
Queens	Ridgewood and Maspeth (CD5)	405	24.1	22.6	23.3	21.1	20.4	20.1	19.4	-0.79
Queens	Long Island City and Astoria (CD1)	401	25.4	23.5	24.4	22.2	21.4	21.2	20.6	-0.79
Brooklyn	Bay Ridge and Dyker Heights (CD10)	310	23.6	22.4	22.6	20.1	19.5	19.6	19.2	-0.78
Queens	Kew Gardens and Woodhaven (CD9)	409	24.1	22.8	23.3	21	20.6	20.1	19.5	-0.78
Queens	Jackson Heights (CD3)	403	25.6	24	24.7	22.6	21.6	21.7	21	-0.77
Queens	Woodside and Sunnyside (CD2)	402	25.9	24.1	25.1	23	22.1	21.9	21.2	-0.77
Bronx	Parkchester and Soundview (CD9)	209	24.6	22.6	23	21.1	19.9	20.2	20.1	-0.76
Queens	Hillcrest and Fresh Meadows (CD8)	408	22.4	21.3	21.7	19.4	18.7	18.8	18.3	-0.73
Queens	South Ozone Park and Howard Beach (CD10)	410	22.2	21	21.5	19.3	19	18.6	18.2	-0.69
Brooklyn	Bensonhurst (CD11)	311	23	21.9	21.9	19.7	19	19.7	19.1	-0.68
Queens	Jamaica and Hollis (CD12)	412	22.3	21.3	21.6	19.4	19.1	18.9	18.5	-0.67
Staten Island	St. George and Stapleton (CD1)	501	20.7	19.3	20.5	18.1	17.6	17.1	16.9	-0.67
Queens	Flushing and Whitestone (CD7)	407	22.7	21.5	21.9	19.8	18.7	19.4	19	-0.66
Bronx	Morris Park and Bronxdale (CD11)	211	23.4	21.2	21.8	20.4	19	19.4	19.6	-0.64
Brooklyn	Flatlands and Canarsie (CD18)	318	20.3	19.2	19.2	17.3	16.7	17.1	16.6	-0.64
Queens	Bayside and Little Neck (CD11)	411	20.5	19.6	19.9	17.9	16.8	17.8	17.6	-0.55
Bronx	Williamsbridge and Baychester (CD12)	212	22.1	19.7	20.6	19.5	18	18.3	19	-0.53
Brooklyn	Sheepshead Bay (CD15)	315	20.4	19.4	19.4	17.6	16.8	18	17.4	-0.51
Queens	Queens Village (CD13)	413	19.9	19.1	19.3	17.4	16.9	17.3	17.2	-0.50
Staten Island	South Beach and Willowbrook (CD2)	502	16.5	15.2	16.3	14.5	13.8	14	13.6	-0.49
Bronx	Throgs Neck and Co-op City (CD10)	210	21.3	19.8	20.4	19	17.4	18.5	18.8	-0.47
Staten Island	Tottenville and Great Kills (CD3)	503	14.7	13	13.3	12.4	11.4	12.5	11.8	-0.41
Brooklyn	Coney Island (CD13)	313	18.4	17.6	17.7	16	15.1	16.6	16.1	-0.41
Queens	Rockaway and Broad Channel (CD14)	414	14.6	13.9	14.2	13	12.5	13.7	13.4	-0.20

Table A3-3: Community district, annual average NO and per-year decline in levels

Borough	Geography	ID	Annual Average 2009	Annual Average 2010	Annual Average 2011	Annual Average 2012	Annual Average 2013	Annual Average 2014	Annual Average 2015	Slope (per year decline)
Manhattan	Greenwich Village and Soho (CD2)	102	52.7	46.4	50.7	41.7	37.2	42.3	34.4	-2.74
Manhattan	Upper East Side (CD8)	108	51.8	46	50	42.2	37.7	41.3	34.2	-2.66
Manhattan	Midtown (CD5)	105	57.7	52.1	56	48.1	43.4	47.8	40.4	-2.61
Manhattan	Upper West Side (CD7)	107	46.6	40.9	44.6	37.4	33.2	37.3	30.4	-2.40
Manhattan	Stuyvesant Town and Turtle Bay (CD6)	106	49.3	44.7	48.2	41.2	37.4	42.3	36.4	-1.94
Manhattan	Clinton and Chelsea (CD4)	104	44.2	39.1	42.7	35.7	32.1	37.5	30.8	-1.93
Manhattan	Lower East Side and Chinatown (CD3)	103	40.9	36	39.6	31.9	28.7	34.4	28.1	-1.88
Manhattan	Central Harlem (CD10)	110	33.6	28.3	31.4	25.3	22.4	26.9	21.4	-1.73
Manhattan	Morningside Heights and Hamilton Heights (CD9)	109	34.1	29	31.9	26	23	27.5	22	-1.72
Bronx	Fordham and University Heights (CD5)	205	34.2	29.2	31.6	26.3	23.7	27.1	22.8	-1.65
Manhattan	Washington Heights and Inwood (CD12)	112	32.3	27.2	29.6	24.4	21.7	25.5	20.7	-1.65
Bronx	Kingsbridge Heights and Bedford (CD7)	207	31.1	26.1	28.4	23.3	20.8	23.6	20.1	-1.63
Bronx	Highbridge and Concourse (CD4)	204	32.3	27.7	30.2	24.9	22.2	26	21.8	-1.53
Bronx	Belmont and East Tremont (CD6)	206	29.7	25	27.5	22.4	20.2	23.4	20	-1.41
Manhattan	East Harlem (CD11)	111	33.4	28.9	31.9	26.2	23.5	28.3	23.4	-1.41
Manhattan	Financial District (CD1)	101	39.5	35.6	38.7	32.3	29.4	35.2	29.7	-1.41
Bronx	Riverdale and Fieldston (CD8)	208	24.4	19.6	21.5	17.1	15.1	18.5	15	-1.31
Bronx	Morrisania and Crotona (CD3)	203	27.6	23.2	25.8	20.6	18.4	22.1	18.8	-1.29
Brooklyn	Crown Heights and Prospect Heights (CD8)	308	28.3	25.3	27.9	21.6	18.9	24.1	20.6	-1.23
Bronx	Mott Haven and Melrose (CD1)	201	28.4	24.3	26.9	21.8	19.5	23.9	19.9	-1.20
Brooklyn	Bushwick (CD4)	304	26.2	23.3	25.8	19.5	16.9	22.2	18.9	-1.18
Bronx	Hunts Point and Longwood (CD2)	202	26.1	22.2	24.8	19.8	17.7	21.4	18.4	-1.14
Queens	Rego Park and Forest Hills (CD6)	406	27.5	24.9	27.3	21.5	19.4	23.2	20.8	-1.12
Bronx	Morris Park and Bronxdale (CD11)	211	23.7	19.8	22	17.4	15.8	18.4	16.5	-1.09
Bronx	Parkchester and Soundview (CD9)	209	25.8	22.2	24.6	19.8	17.9	20.9	18.8	-1.08
Bronx	Williamsbridge and Baychester (CD12)	212	23.1	18.9	20.9	16.6	15	17.6	15.9	-1.08
Brooklyn	Greenpoint and Williamsburg (CD1)	301	27.6	24.5	27.2	21.1	18.6	24.6	20.5	-1.06
Queens	Long Island City and Astoria (CD1)	401	24.7	21.2	24	18.5	16.3	21.3	17.4	-1.05
Queens	Hillcrest and Fresh Meadows (CD8)	408	24	21.8	24.3	18.9	17.1	19.2	18.4	-1.04
Queens	Elmhurst and Corona (CD4)	404	26.6	23.8	26.4	20.6	18.5	22.9	20.1	-1.04
Queens	Flushing and Whitestone (CD7)	407	23.1	20.4	23	17.8	16	18.3	17.2	-1.03

Borough	Geography	ID	Annual Average 2009	Annual Average 2010	Annual Average 2011	Annual Average 2012	Annual Average 2013	Annual Average 2014	Annual Average 2015	Slope (per year decline)
Queens	Jackson Heights (CD3)	403	24.9	21.8	24.5	18.9	16.8	21.1	18.3	-1.03
Queens	Bayside and Little Neck (CD11)	411	22.6	20.5	23.2	18.1	16.5	17.3	17.4	-1.03
Queens	Jamaica and Hollis (CD12)	412	23	21.3	23.7	18.5	16.8	18.3	17.8	-1.02
Queens	Kew Gardens and Woodhaven (CD9)	409	24.5	22.3	24.6	19	17	20.6	18.7	-1.01
Brooklyn	Bedford Stuyvesant (CD3)	303	25.7	22.9	25.4	19.4	16.9	22.4	19.5	-1.00
Queens	Woodside and Sunnyside (CD2)	402	27.1	23.9	26.6	20.9	18.7	24.3	20.2	-0.99
Brooklyn	Fort Greene and Brooklyn Heights (CD2)	302	30	27	29.7	23.8	21.4	27.3	23.3	-0.99
Queens	Queens Village (CD13)	413	21.3	19.9	22.4	17.6	16	16.2	16.7	-0.99
Brooklyn	South Crown Heights and Lefferts Gardens (CD9)	309	26.7	24.3	26.8	21.1	18.9	23.8	20.5	-0.98
Bronx	Throgs Neck and Co-op City (CD10)	210	24	20.7	23.1	18.4	16.9	19.1	18.2	-0.96
Brooklyn	Park Slope and Carroll Gardens (CD6)	306	25.9	23.2	25.9	20.2	17.6	23.2	19.8	-0.95
Brooklyn	Brownsville (CD16)	316	24.4	22.2	24.4	18.8	16.4	21.2	18.9	-0.95
Queens	Ridgewood and Maspeth (CD5)	405	23.9	21.4	23.7	18	15.9	20.9	18.1	-0.94
Queens	South Ozone Park and Howard Beach (CD10)	410	22.4	20.8	22.8	17.7	15.9	19	17.5	-0.90
Brooklyn	East New York and Starrett City (CD5)	305	23.8	21.9	24	18.6	16.6	20.8	18.7	-0.89
Brooklyn	East Flatbush (CD17)	317	24.3	22.4	24.7	19.5	17.5	21.9	19.4	-0.82
Brooklyn	Flatbush and Midwood (CD14)	314	24.4	22.6	25.2	20.3	18.3	22.1	19.6	-0.80
Brooklyn	Sunset Park (CD7)	307	23.6	21.4	24.1	19	16.8	21.5	18.7	-0.78
Brooklyn	Borough Park (CD12)	312	21.6	19.9	22.6	17.9	15.9	19.8	17.5	-0.69
Brooklyn	Bay Ridge and Dyker Heights (CD10)	310	21.1	19.4	22.3	17.9	15.9	19.5	17.5	-0.61
Queens	Rockaway and Broad Channel (CD14)	414	18.2	18	20.3	16.8	15.3	15.5	15.9	-0.60
Brooklyn	Bensonhurst (CD11)	311	20	18.7	21.4	17.4	15.5	18.4	16.9	-0.56
Brooklyn	Flatlands and Canarsie (CD18)	318	19.6	18.6	20.8	16.4	14.8	18.1	16.7	-0.56
Staten Island	St. George and Stapleton (CD1)	501	16.8	14.7	17.3	14.2	12.3	15.4	13.1	-0.53
Staten Island	Tottenville and Great Kills (CD3)	503	12.9	11.2	12.7	12.5	10.7	9.8	9.6	-0.53
Brooklyn	Sheepshead Bay (CD15)	315	19.2	18.5	21	17.3	15.6	17.8	17	-0.48
Staten Island	South Beach and Willowbrook (CD2)	502	14.7	12.8	15.1	13.2	11.3	12.9	11.5	-0.47
Brooklyn	Coney Island (CD13)	313	17.3	16.6	19.2	16.1	14.4	16.1	15.6	-0.39

Table A3-4: Community district, wintertime average SO_2 and per-year decline in levels

Borough	Geography	ID	Annual Average 2009	Annual Average 2010	Annual Average 2011	Annual Average 2012	Annual Average 2013	Annual Average 2014	Annual Average 2015	Slope (per year decline)
Bronx	Fordham and University Heights (CD5)	205	12.7	8.2	10.5	6.8	4.5	3.8	1.8	-1.70
Manhattan	Upper East Side (CD8)	108	12.1	8.5	10.4	6.3	4.1	3.8	1.5	-1.70
Bronx	Kingsbridge Heights and Bedford (CD7)	207	11.8	7.5	9.5	6.3	4	3.3	1.8	-1.57
Manhattan	Washington Heights and Inwood (CD12)	112	11.4	7.5	9.5	6.3	4.3	3.4	1.6	-1.53
Manhattan	Upper West Side (CD7)	107	11	7.6	9.4	6	4	3.5	1.4	-1.51
Manhattan	Midtown (CD5)	105	10.3	7	8.8	5.3	3.2	3.3	1.4	-1.42
Bronx	Highbridge and Concourse (CD4)	204	10.4	6.9	8.8	5.5	3.9	3.2	1.4	-1.40
Manhattan	Stuyvesant Town and Turtle Bay (CD6)	106	9.2	6.3	7.9	4.6	2.8	3	1.2	-1.28
Manhattan	Morningside Heights and Hamilton Heights (CD9)	109	9.3	6.3	7.9	5.1	3.5	2.9	1.2	-1.27
Manhattan	Greenwich Village and Soho (CD2)	102	8.7	5.7	7.3	4.3	2.4	2.7	1.1	-1.20
Manhattan	Central Harlem (CD10)	110	8.2	5.6	7	4.4	3.1	2.7	1.1	-1.11
Bronx	Belmont and East Tremont (CD6)	206	8.2	5.3	6.8	4.3	2.8	2.5	1.3	-1.08
Manhattan	Clinton and Chelsea (CD4)	104	7.3	4.9	6.2	3.8	2.3	2.4	1	-0.99
Manhattan	Lower East Side and Chinatown (CD3)	103	7	4.6	5.9	3.3	1.8	2.2	0.9	-0.97
Bronx	Morrisania and Crotona (CD3)	203	7	4.7	6	3.6	2.4	2.2	1	-0.95
Manhattan	East Harlem (CD11)	111	7	4.8	6	3.7	2.5	2.4	1	-0.94
Bronx	Riverdale and Fieldston (CD8)	208	6.7	4.2	5.4	3.8	2.3	1.7	1	-0.90
Queens	Elmhurst and Corona (CD4)	404	6.3	4.5	5.6	2.8	1.8	2.4	0.9	-0.86
Queens	Jackson Heights (CD3)	403	6.1	4.3	5.4	2.8	1.8	2.3	0.9	-0.83
Bronx	Parkchester and Soundview (CD9)	209	5.9	3.9	4.9	2.9	1.9	2.1	1	-0.76
Bronx	Morris Park and Bronxdale (CD11)	211	5.9	3.8	4.8	3	1.8	1.9	1.1	-0.76
Queens	Rego Park and Forest Hills (CD6)	406	5.3	3.8	4.7	2.3	1.3	1.8	0.7	-0.76
Bronx	Mott Haven and Melrose (CD1)	201	5.7	3.9	4.9	3	2.1	2	0.9	-0.75
Brooklyn	South Crown Heights and Lefferts Gardens (CD9)	309	5	3.4	4.2	2	1.1	1.3	0.5	-0.74
Bronx	Williamsbridge and Baychester (CD12)	212	5.8	3.6	4.5	3	1.7	1.7	1.2	-0.73
Brooklyn	Crown Heights and Prospect Heights (CD8)	308	4.8	3.2	4	2	1.1	1.3	0.5	-0.70
Brooklyn	Flatbush and Midwood (CD14)	314	4.7	3.1	3.8	1.8	1	1.1	0.5	-0.69
Bronx	Hunts Point and Longwood (CD2)	202	5.1	3.5	4.4	2.5	1.7	1.8	0.8	-0.68
Queens	Long Island City and Astoria (CD1)	401	5	3.6	4.5	2.5	1.7	1.9	0.8	-0.67
Brooklyn	Bedford Stuyvesant (CD3)	303	4.7	3.2	4	2	1.2	1.4	0.6	-0.67
Brooklyn	Bushwick (CD4)	304	4.7	3.3	4.1	2	1.3	1.5	0.6	-0.67
Manhattan	Financial District (CD1)	101	4.8	3	4	2.3	1.2	1.4	0.6	-0.66

Borough	Geography	ID	Annual Average 2009	Annual Average 2010	Annual Average 2011	Annual Average 2012	Annual Average 2013	Annual Average 2014	Annual Average 2015	Slope (per year decline)
Queens	Woodside and Sunnyside (CD2)	402	4.8	3.4	4.3	2.3	1.5	1.7	0.7	-0.66
Brooklyn	East Flatbush (CD17)	317	4.4	3	3.6	1.7	1	1.1	0.5	-0.65
Brooklyn	Fort Greene and Brooklyn Heights (CD2)	302	4.4	2.9	3.7	1.9	1	1.2	0.5	-0.64
Brooklyn	Borough Park (CD12)	312	4.4	2.8	3.6	1.7	0.9	1.1	0.5	-0.64
Brooklyn	Brownsville (CD16)	316	4.3	3.1	3.7	1.7	1.1	1.2	0.5	-0.64
Queens	Kew Gardens and Woodhaven (CD9)	409	4.2	3.1	3.7	1.8	1.1	1.4	0.5	-0.61
Brooklyn	Greenpoint and Williamsburg (CD1)	301	4.3	3	3.7	2	1.2	1.4	0.6	-0.60
Queens	Flushing and Whitestone (CD7)	407	4.5	3	3.9	2	1.2	1.9	0.7	-0.58
Queens	Ridgewood and Maspeth (CD5)	405	4.1	2.9	3.6	1.8	1.1	1.4	0.6	-0.57
Brooklyn	Park Slope and Carroll Gardens (CD6)	306	3.9	2.5	3.2	1.6	0.8	1.1	0.4	-0.56
Queens	Hillcrest and Fresh Meadows (CD8)	408	4	2.8	3.4	1.7	0.9	1.5	0.5	-0.56
Brooklyn	East New York and Starrett City (CD5)	305	3.8	2.8	3.3	1.5	1	1.1	0.5	-0.56
Bronx	Throgs Neck and Co-op City (CD10)	210	4.4	2.8	3.6	2.1	1.2	1.6	0.9	-0.55
Brooklyn	Sunset Park (CD7)	307	3.8	2.3	3.1	1.5	0.8	1	0.4	-0.54
Brooklyn	Bensonhurst (CD11)	311	3.6	2.4	2.9	1.3	0.8	1	0.5	-0.51
Queens	South Ozone Park and Howard Beach (CD10)	410	3.4	2.5	2.9	1.4	0.8	1.1	0.4	-0.50
Queens	Jamaica and Hollis (CD12)	412	3.4	2.5	2.9	1.4	0.7	1.2	0.4	-0.49
Brooklyn	Sheepshead Bay (CD15)	315	3.3	2.3	2.7	1.2	0.7	0.8	0.4	-0.49
Queens	Bayside and Little Neck (CD11)	411	3.7	2.4	3.1	1.6	0.8	1.5	0.6	-0.48
Brooklyn	Bay Ridge and Dyker Heights (CD10)	310	3.4	2.1	2.8	1.3	0.7	1	0.4	-0.48
Brooklyn	Flatlands and Canarsie (CD18)	318	3.2	2.3	2.7	1.2	0.8	0.9	0.4	-0.47
Queens	Queens Village (CD13)	413	3.1	2.2	2.5	1.3	0.6	1.1	0.4	-0.44
Brooklyn	Coney Island (CD13)	313	2.9	2	2.4	1	0.6	0.8	0.4	-0.42
Queens	Rockaway and Broad Channel (CD14)	414	2.4	1.9	1.9	0.9	0.5	0.6	0.3	-0.37
Staten Island	St. George and Stapleton (CD1)	501	2.6	1.4	2.1	1	0.5	1	0.3	-0.33
Staten Island	South Beach and Willowbrook (CD2)	502	2.2	1.2	1.8	0.8	0.4	0.9	0.3	-0.28
Staten Island	Tottenville and Great Kills (CD3)	503	1.8	1	1.5	0.6	0.4	0.7	0.2	-0.23

Table A3-5: Community district, annual average BC and per-year decline in levels

Borough	Geography	ID	Annual Average 2009	Annual Average 2010	Annual Average 2011	Annual Average 2012	Annual Average 2013	Annual Average 2014	Annual Average 2015	Slope (per year decline)
Bronx	Parkchester and Soundview (CD9)	209	1.3	1.3	1.3	1.1	1.1	1.1	1	-0.05
Bronx	Morrisania and Crotona (CD3)	203	1.4	1.4	1.4	1.2	1.2	1.2	1.1	-0.05
Brooklyn	Coney Island (CD13)	313	0.8	0.9	0.9	0.8	0.7	0.6	0.6	-0.05
Bronx	Highbridge and Concourse (CD4)	204	1.5	1.5	1.5	1.3	1.4	1.3	1.2	-0.05
Bronx	Mott Haven and Melrose (CD1)	201	1.5	1.5	1.5	1.4	1.4	1.3	1.2	-0.05
Bronx	Riverdale and Fieldston (CD8)	208	1.3	1.2	1.2	1.1	1.1	1	1	-0.05
Bronx	Belmont and East Tremont (CD6)	206	1.4	1.4	1.4	1.3	1.3	1.2	1.1	-0.05
Manhattan	Morningside Heights and Hamilton Heights (CD9)	109	1.4	1.4	1.4	1.3	1.3	1.2	1.1	-0.05
Manhattan	Washington Heights and Inwood (CD12)	112	1.4	1.4	1.4	1.3	1.3	1.2	1.1	-0.05
Brooklyn	East New York and Starrett City (CD5)	305	1.1	1.1	1	1	0.9	0.8	0.9	-0.05
Brooklyn	East Flatbush (CD17)	317	1	1.1	1	1	0.9	0.8	0.8	-0.05
Manhattan	Central Harlem (CD10)	110	1.5	1.4	1.5	1.3	1.3	1.3	1.2	-0.05
Brooklyn	Brownsville (CD16)	316	1.1	1.1	1.1	1	0.9	0.9	0.9	-0.04
Brooklyn	Crown Heights and Prospect Heights (CD8)	308	1.1	1.1	1.1	1	0.9	0.9	0.9	-0.04
Queens	Rego Park and Forest Hills (CD6)	406	1.1	1.1	1.1	1	0.9	0.9	0.9	-0.04
Queens	South Ozone Park and Howard Beach (CD10)	410	0.9	0.9	0.9	0.8	0.7	0.7	0.7	-0.04
Queens	Elmhurst and Corona (CD4)	404	1.2	1.1	1.1	1	1	1	0.9	-0.04
Staten Island	St. George and Stapleton (CD1)	501	1	0.9	0.9	0.9	0.8	0.8	0.7	-0.04
Bronx	Hunts Point and Longwood (CD2)	202	1.4	1.5	1.5	1.3	1.3	1.3	1.2	-0.04
Brooklyn	Borough Park (CD12)	312	1	1	1	0.9	0.8	0.8	0.8	-0.04
Brooklyn	Flatbush and Midwood (CD14)	314	1	1	1	0.9	0.8	0.8	0.8	-0.04
Brooklyn	Fort Greene and Brooklyn Heights (CD2)	302	1.3	1.3	1.3	1.2	1.1	1.1	1.1	-0.04
Queens	Kew Gardens and Woodhaven (CD9)	409	1	1	1	0.9	0.8	0.8	0.8	-0.04
Brooklyn	Bushwick (CD4)	304	1.1	1.1	1.1	1	1	0.9	0.9	-0.04
Brooklyn	Sheepshead Bay (CD15)	315	0.8	0.9	0.9	0.8	0.7	0.6	0.7	-0.04
Queens	Flushing and Whitestone (CD7)	407	1.1	1.1	1.1	1	1	0.9	0.9	-0.04
Queens	Ridgewood and Maspeth (CD5)	405	1.1	1.1	1.1	1	1	0.9	0.9	-0.04
Brooklyn	Bedford Stuyvesant (CD3)	303	1.1	1.1	1	1	0.9	0.9	0.9	-0.04
Brooklyn	Bensonhurst (CD11)	311	0.9	0.9	0.9	0.8	0.8	0.7	0.7	-0.04
Brooklyn	Flatlands and Canarsie (CD18)	318	0.9	0.9	0.9	0.8	0.8	0.7	0.7	-0.04
Bronx	Fordham and University Heights (CD5)	205	1.5	1.5	1.5	1.4	1.4	1.3	1.3	-0.04
Bronx	Kingsbridge Heights and Bedford (CD7)	207	1.3	1.3	1.3	1.2	1.2	1.1	1.1	-0.04

Borough	Geography	ID	Annual Average 2009	Annual Average 2010	Annual Average 2011	Annual Average 2012	Annual Average 2013	Annual Average 2014	Annual Average 2015	Slope (per year decline)
Brooklyn	Park Slope and Carroll Gardens (CD6)	306	1.3	1.3	1.3	1.2	1.2	1.1	1.1	-0.04
Queens	Woodside and Sunnyside (CD2)	402	1.5	1.5	1.5	1.4	1.4	1.3	1.3	-0.04
Bronx	Morris Park and Bronxdale (CD11)	211	1.2	1.2	1.2	1.1	1.1	1	1	-0.04
Bronx	Throgs Neck and Co-op City (CD10)	210	1.2	1.2	1.2	1.1	1.1	1	1	-0.04
Bronx	Williamsbridge and Baychester (CD12)	212	1.2	1.2	1.2	1.1	1.1	1	1	-0.04
Brooklyn	South Crown Heights and Lefferts Gardens (CD9)	309	1	1	1	0.9	0.9	0.8	0.8	-0.04
Brooklyn	Sunset Park (CD7)	307	1.2	1.2	1.2	1.1	1.1	1	1	-0.04
Queens	Hillcrest and Fresh Meadows (CD8)	408	1	1	1	0.9	0.9	0.8	0.8	-0.04
Queens	Long Island City and Astoria (CD1)	401	1.2	1.2	1.2	1.1	1.1	1	1	-0.04
Queens	Jackson Heights (CD3)	403	1.1	1	1.1	1	0.9	0.9	0.9	-0.04
Manhattan	Greenwich Village and Soho (CD2)	102	1.8	1.7	1.8	1.6	1.6	1.6	1.6	-0.04
Manhattan	Upper West Side (CD7)	107	1.5	1.4	1.5	1.3	1.3	1.3	1.3	-0.04
Manhattan	Lower East Side and Chinatown (CD3)	103	1.6	1.5	1.5	1.4	1.4	1.4	1.4	-0.03
Manhattan	Upper East Side (CD8)	108	1.6	1.6	1.6	1.5	1.5	1.5	1.4	-0.03
Queens	Queens Village (CD13)	413	0.8	0.9	0.9	0.8	0.7	0.7	0.7	-0.03
Staten Island	Tottenville and Great Kills (CD3)	503	0.8	0.8	0.8	0.8	0.7	0.7	0.6	-0.03
Manhattan	Stuyvesant Town and Turtle Bay (CD6)	106	1.7	1.6	1.6	1.5	1.5	1.5	1.5	-0.03
Staten Island	South Beach and Willowbrook (CD2)	502	0.9	0.9	0.9	0.9	0.8	0.8	0.7	-0.03
Brooklyn	Bay Ridge and Dyker Heights (CD10)	310	1	1	1	1	0.9	0.9	0.8	-0.03
Queens	Bayside and Little Neck (CD11)	411	1	1	1	0.9	0.9	0.9	0.8	-0.03
Brooklyn	Greenpoint and Williamsburg (CD1)	301	1.5	1.4	1.4	1.4	1.3	1.3	1.3	-0.03
Manhattan	East Harlem (CD11)	111	1.4	1.4	1.4	1.3	1.3	1.3	1.2	-0.03
Manhattan	Financial District (CD1)	101	1.4	1.4	1.4	1.3	1.3	1.3	1.2	-0.03
Manhattan	Midtown (CD5)	105	1.9	1.8	1.9	1.8	1.7	1.8	1.7	-0.03
Queens	Jamaica and Hollis (CD12)	412	0.9	1	0.9	0.9	0.8	0.8	0.8	-0.03
Queens	Rockaway and Broad Channel (CD14)	414	0.6	0.7	0.7	0.6	0.6	0.5	0.5	-0.03
Manhattan	Clinton and Chelsea (CD4)	104	1.7	1.6	1.6	1.6	1.5	1.6	1.5	-0.03

Table A3-6: Community district, summertime average O_3 and per-year change in levels

Borough	Geography	ID	Annual Average 2009	Annual Average 2010	Annual Average 2011	Annual Average 2012	Annual Average 2013	Annual Average 2014	Annual Average 2015	Slope (per year decline)
Bronx	Williamsbridge and Baychester (CD12)	212	26.6	33.8	33.2	35	31.6	31.4	29.8	0.11
Queens	Rockaway and Broad Channel (CD14)	414	33.7	39.1	39.1	40.4	36.9	36.3	37.5	0.13
Brooklyn	Coney Island (CD13)	313	30.6	37.4	37.5	37.9	34.6	33.2	35.8	0.15
Bronx	Throgs Neck and Co-op City (CD10)	210	27.8	35	34.9	36	32.6	32.5	31.7	0.16
Brooklyn	Sheepshead Bay (CD15)	315	29.3	36.2	36.2	36.8	33.6	32.4	34.8	0.22
Staten Island	South Beach and Willowbrook (CD2)	502	27	35.2	34.1	33.7	31.3	31.6	32.5	0.23
Bronx	Morris Park and Bronxdale (CD11)	211	26.1	33.7	33.5	35	31.6	31.4	30.5	0.24
Staten Island	Tottenville and Great Kills (CD3)	503	27.6	36.5	35.9	35.3	32.6	31.9	34.1	0.25
Brooklyn	Bensonhurst (CD11)	311	27.4	34.9	34.5	34.9	32	31.5	33.4	0.31
Queens	Woodside and Sunnyside (CD2)	402	26.4	33.3	32.8	33.8	30.7	30.9	31.6	0.31
Staten Island	St. George and Stapleton (CD1)	501	24.9	33	31.5	31.5	29.2	30.3	30.4	0.31
Brooklyn	Flatlands and Canarsie (CD18)	318	28.9	36.1	35.9	36.6	33.6	33.1	34.7	0.33
Queens	Long Island City and Astoria (CD1)	401	26.3	33.5	33.3	34.5	31.2	31.1	31.8	0.34
Bronx	Parkchester and Soundview (CD9)	209	25.6	33.5	33.6	34.9	31.5	31.3	31.2	0.37
Queens	Flushing and Whitestone (CD7)	407	26.3	34	34	34.5	31.5	32	31.9	0.37
Queens	Bayside and Little Neck (CD11)	411	26.3	33.6	33.1	33.9	30.8	32.3	31.4	0.37
Queens	Jackson Heights (CD3)	403	25.5	33.1	33.1	33.7	30.7	30.8	31.5	0.39
Brooklyn	Bay Ridge and Dyker Heights (CD10)	310	25.6	33.4	32.5	33	30.3	30.7	31.8	0.39
Brooklyn	Greenpoint and Williamsburg (CD1)	301	25.4	32.5	31.6	32.7	29.8	30.5	31	0.39
Queens	Queens Village (CD13)	413	27.8	34.4	33.7	35	31.9	33.7	32.6	0.40
Queens	Ridgewood and Maspeth (CD5)	405	26.1	33.7	33.3	33.7	31.1	31.5	32.1	0.41
Bronx	Riverdale and Fieldston (CD8)	208	23.7	32	31.3	33.8	30.4	30.5	28.8	0.41
Queens	Elmhurst and Corona (CD4)	404	24.9	32.7	32.6	32.9	30.2	30.5	31.2	0.43
Bronx	Kingsbridge Heights and Bedford (CD7)	207	23.6	31.9	31.4	33.5	30.3	30.3	29.2	0.45
Brooklyn	East New York and Starrett City (CD5)	305	26.7	34.3	33.9	34.4	31.9	32.3	32.9	0.45
Queens	South Ozone Park and Howard Beach (CD10)	410	27.2	34.6	34.2	34.8	32.3	33	33.1	0.45
Brooklyn	Flatbush and Midwood (CD14)	314	25.6	33.4	32.8	33.5	30.8	30.7	32.3	0.45
Brooklyn	Borough Park (CD12)	312	25.3	33.2	32.4	33.1	30.4	30.6	32	0.46
Bronx	Hunts Point and Longwood (CD2)	202	25.5	33.6	33.8	35.3	31.9	31.6	31.8	0.46
Brooklyn	East Flatbush (CD17)	317	25.7	33.6	33	33.6	31	31.2	32.4	0.48
Brooklyn	Bushwick (CD4)	304	25.3	33	32.3	32.9	30.4	31	31.7	0.48

Borough	Geography	ID	Annual Average 2009	Annual Average 2010	Annual Average 2011	Annual Average 2012	Annual Average 2013	Annual Average 2014	Annual Average 2015	Slope (per year decline)
Bronx	Belmont and East Tremont (CD6)	206	23.7	32.1	31.9	33.8	30.5	30.3	29.8	0.48
Queens	Hillcrest and Fresh Meadows (CD8)	408	25.2	32.9	32.5	33	30.4	31.7	31.3	0.49
Queens	Rego Park and Forest Hills (CD6)	406	24.5	32.5	32.2	32.5	30	30.6	31.1	0.49
Brooklyn	Brownsville (CD16)	316	25.4	33.3	32.6	33.2	30.7	31.2	32.1	0.50
Queens	Jamaica and Hollis (CD12)	412	26.4	33.6	33	33.9	31.3	32.8	32.2	0.50
Queens	Kew Gardens and Woodhaven (CD9)	409	25.4	33.2	32.8	33.2	30.8	31.7	31.8	0.51
Brooklyn	Sunset Park (CD7)	307	24.5	32.6	31.4	32.2	29.6	30.6	31.2	0.51
Brooklyn	Bedford Stuyvesant (CD3)	303	23.9	31.8	30.8	31.6	29.1	29.9	30.6	0.52
Manhattan	Lower East Side and Chinatown (CD3)	103	21.6	28.8	27.4	28.8	26.1	27.3	28	0.53
Brooklyn	Park Slope and Carroll Gardens (CD6)	306	23.4	31.3	29.9	31	28.4	29.7	30	0.54
Brooklyn	South Crown Heights and Lefferts Gardens (CD9)	309	24.2	32.3	31.4	32.1	29.6	30.3	31.2	0.54
Brooklyn	Fort Greene and Brooklyn Heights (CD2)	302	22.7	30.5	29.1	30.2	27.6	28.9	29.4	0.55
Bronx	Mott Haven and Melrose (CD1)	201	24	32.1	32.1	34	30.6	30.5	30.8	0.56
Bronx	Morrisania and Crotona (CD3)	203	23.4	31.9	31.9	33.7	30.4	30.3	30.2	0.56
Brooklyn	Crown Heights and Prospect Heights (CD8)	308	23.6	31.7	30.7	31.5	29	29.8	30.7	0.56
Manhattan	East Harlem (CD11)	111	22.8	30.6	30.3	32.3	28.9	29	29.6	0.56
Manhattan	Upper West Side (CD7)	107	21.4	28.7	27.9	30.2	26.9	27.4	28.1	0.59
Manhattan	Greenwich Village and Soho (CD2)	102	20.5	27.7	26.1	27.7	25.1	26.5	27.2	0.60
Bronx	Fordham and University Heights (CD5)	205	22.2	31	30.7	32.9	29.7	29.7	29.1	0.61
Manhattan	Clinton and Chelsea (CD4)	104	20.3	27.3	25.9	27.9	25.1	26.1	27.1	0.61
Manhattan	Upper East Side (CD8)	108	20.8	28.1	27.4	29.2	26.2	26.6	28	0.62
Manhattan	Washington Heights and Inwood (CD12)	112	21.9	30.7	30.3	32.8	29.5	29.7	28.9	0.65
Bronx	Highbridge and Concourse (CD4)	204	22.3	31	30.8	33	29.7	29.8	29.7	0.67
Manhattan	Central Harlem (CD10)	110	21.6	29.8	29.5	31.8	28.5	28.6	29.1	0.68
Manhattan	Morningside Heights and Hamilton Heights (CD9)	109	21.3	29.6	29.2	31.6	28.3	28.5	28.8	0.69
Manhattan	Stuyvesant Town and Turtle Bay (CD6)	106	17.8	25.3	24	25.5	23.1	24.1	25.8	0.74
Manhattan	Financial District (CD1)	101	19.1	27	25.2	26.6	24.4	26.1	27.1	0.76
Manhattan	Midtown (CD5)	105	14.4	22.5	21	22.5	20.7	21.8	24.3	1.00

NYC Health