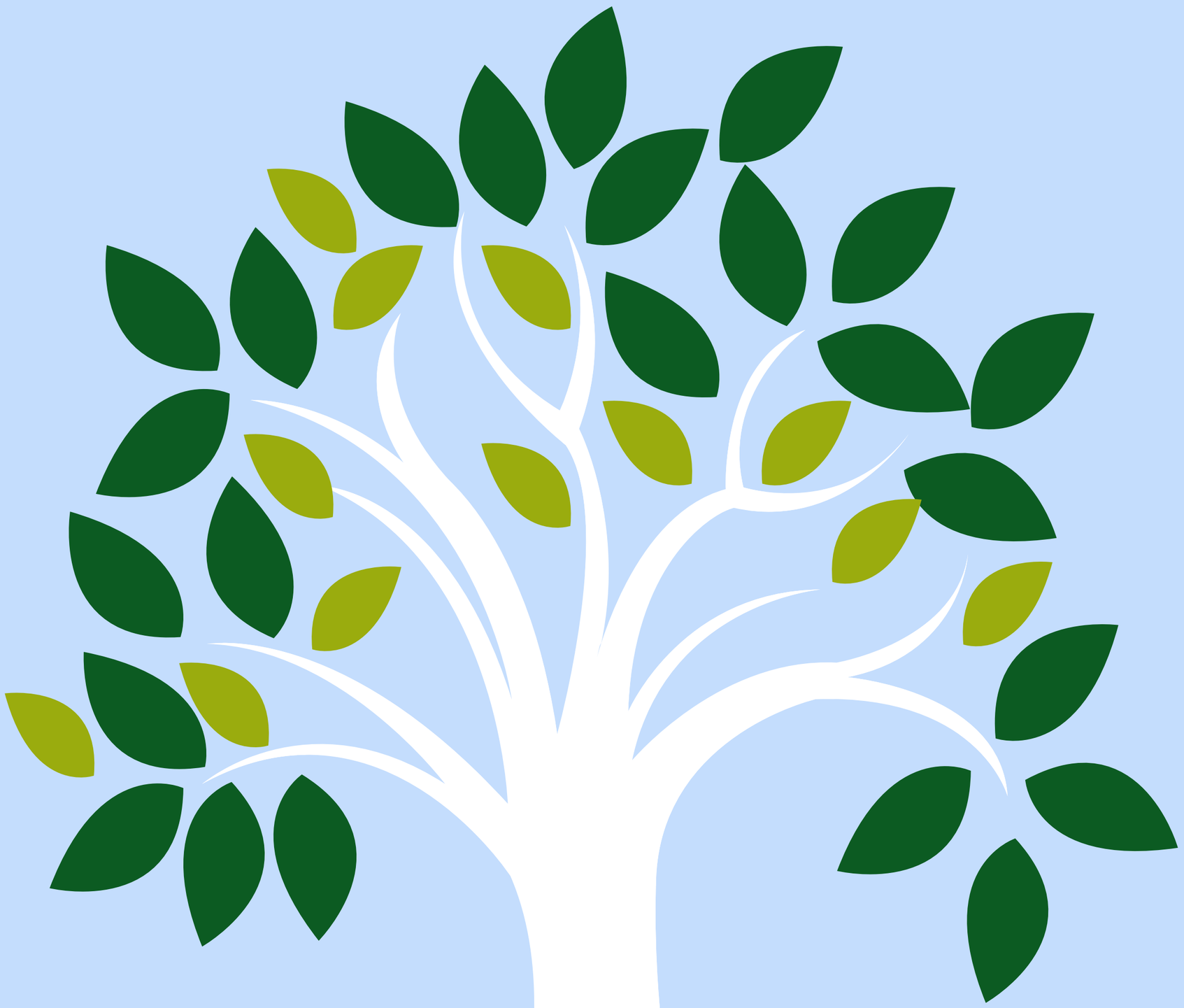
BREATHE EASY 2021

Findings from a citizen science project monitoring air quality in Ottawa



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Acknowledgements

Completing a community-led air quality monitoring project would not have been possible without Ecology Ottawa's **exceptional volunteers**. Over 100 volunteers signed up to be trained for air quality monitoring, while five more were involved in the data management, analysis and mapping effort. After long years of pandemic restrictions, this project was an opportunity to revive the sense of community within the city, through the dedication and commitment of our volunteers.

A special acknowledgement is due to **Dr. Robbie Venis**, an Environmental Engineer affiliated with Carleton University during this project, who guided the experimental design and data monitoring, led the data analysis for this project and authored parts of this report.

Succession's community partner **Sierra Club Canada Foundation** worked alongside us this year on a similar air quality monitoring project, sharing knowledge and solutions to problems that could occur during the study. The Foundation also helped organize two public webinars with air quality experts.

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Our funders, the **Trottier Foundation**, made this project possible.

Policy Proposals

1 Increase Granularity of Air Quality Monitoring

The city's air quality needs to be monitored on a regular basis, at a scale and level of detail that allows for specific identification of issues related to spikes in pollutant levels. We should monitor air quality in more locations than the single one currently used. The province needs to look at geographic heterogeneity and not assume the entire city is the same. It is only by studying the issues that we may find solutions, and the more that studies are detailed and specific, the more we can find appropriate solutions.

2 Re-evaluate Zoning/Routing By-Laws With Environmental Lens

We need to look at zoning through an environmental lens, with demographic data included in analysis, as well as their adjacencies. Indeed, zoning has been shown to have an impact on certain people rather than others. Therefore we should look at re-evaluating approval protocols that consider demographic factors to work towards equity in relation to the following, as these are all shown to impact air quality:

- trucking routes;
- new industrial development; and
- environmental protection

3 Explore Increasing Affordable Housing Supply across City

There is currently a 20% correlation between low-income prevalence and transportation zoning. This shows how lower income people are exposed to more contaminants in areas where it is cheapest to live. During this campaign, we also realized that median income was a major correlated factor with air quality, which was also related to trucking routes and industrialization. That is why more affordable housing in more neighbourhoods would reduce the concentration of lower income individuals in areas with higher rates of pollution.

4 Explore Expansion of Environmentally Protected Areas

Environmental protection has been shown to have a significant impact on air quality. Protecting more space and preserving green spaces are fundamentally important for air quality and environmental health. More protection can lead to better health and ecosystem outcomes that will increase equity within the city.

Introduction

Air pollution is one of the most significant environmental challenges impacting public health, and one of the most avoidable causes of death and disease globally. It is now estimated that 4.5 million people die prematurely from outdoor air pollution every year. The Government of Canada estimates that air pollution from fine particulate matter, nitrogen dioxide and ozone, causes 14,600 premature deaths every year in Canada. Air pollution leads to disease, increased hospitalizations, and premature death from stroke, heart disease, chronic obstructive pulmonary disease, lung cancer and acute respiratory infections.

Breathe Easy is a community-led project measuring the air quality across Ottawa, over 2020 and 2021. Before Ecology Ottawa's 2020 Breathe Easy campaign, there was no regular collection of localized air quality information across Ottawa's neighbourhoods. In fact, the single provincial air quality monitoring location downtown sits within a park.

In 2020, Ecology Ottawa carried out the Breathe Easy air quality monitoring project in neighbourhoods across Ottawa, producing a report with findings from across the city. Despite this campaign, there still remains a gap in public understanding of localized air pollution effects.

The 2021 project sought to expand on the previous campaign by increasing monitoring locations and examining sociodemographic indicators in an attempt to understand the drivers behind variable air quality in different neighbourhoods.

Methodology

In 2021, over 100 volunteers reached out to our coordinators to help monitor Ottawa's air quality. These volunteers were trained to operate an easy-to-use portable air monitoring device and went to sites across the city to measure the levels of Particulate Matter 2.5, Nitrogen Dioxide and Ozone.

Particulate Matter (PM), is not just one contaminant or pollutant, but a range of particles of dust, dirt, and liquids that become suspended in the air. Some of these are large enough to see, like smoke, smog, or soot, but the most harmful are smaller, invisible particles. These can get into your lungs and your bloodstream. Numerous studies have linked PM to aggravated cardiac and respiratory diseases such as asthma, bronchitis and emphysema and to various forms of heart disease. PM can also have adverse effects on vegetation and structures, and contributes to visibility deterioration and regional haze. Our analysis focuses primarily on PM, as the pollutant harmful to human health which could be most accurately measured by our monitors.

During Breathe Easy 2021, we decided to increase the number of sites monitored, and ensure that they were spread more widely across the city, gaining a more robust geospatial representation across the city and applying an analysis with more of a socio-economic lens to the data in order to understand the drivers of those differences in air quality across the city.

As a result, measurements were taken at 46 different sites across the city, which were spaced equally apart to create a grid for residents to see the air quality close to their neighbourhood. Each site was monitored three times over the course of the summer; half were monitored during the morning and half were monitored during the afternoon to maximize the comparability of measurements taken in each location. A number of these sites were specifically chosen to be near to child care centres, schools, hospitals and senior residences to assess the air quality close to areas where vulnerable populations congregate.

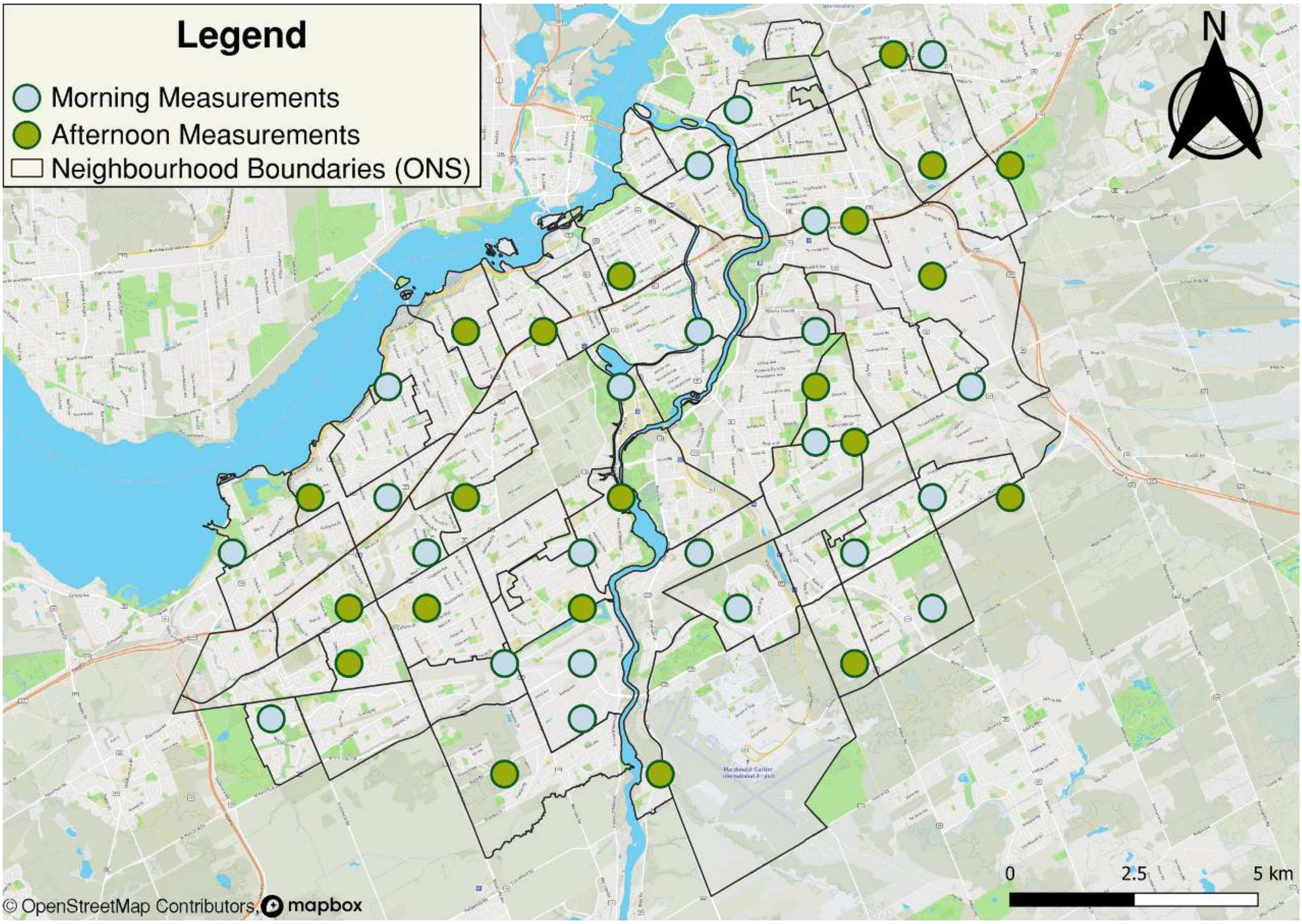
The air quality data, averaged over the three monitoring sessions and matched with GPS coordinates, was uploaded into a map of the city after analysis. This allows residents to identify both good and bad air quality areas in their neighbourhoods. Identifying 'hot spots' across the city for air pollution is an important first step in sparking community dialogue around neighbourhood-level solutions designed to improve air quality and ultimately, quality of life. Then looking with a socio-economic lens we can attempt to improve our understanding of how city zoning and organization can impact air quality.

46 Sites Across the City

The table below and the map on the following page show the locations across Ottawa where air quality was monitored over the course of the summer of 2021. The monitoring sites were spread evenly across the city (within the greenbelt) for good geographic spacing and each site was monitored three times, either in the morning (8am-12pm, in blue) or in the afternoon (4pm-8pm, in green). The neighbourhood boundaries reflect those chosen by Ottawa Neighbourhood Study for socio-economic analysis against their data, as well as against data from Open Ottawa.

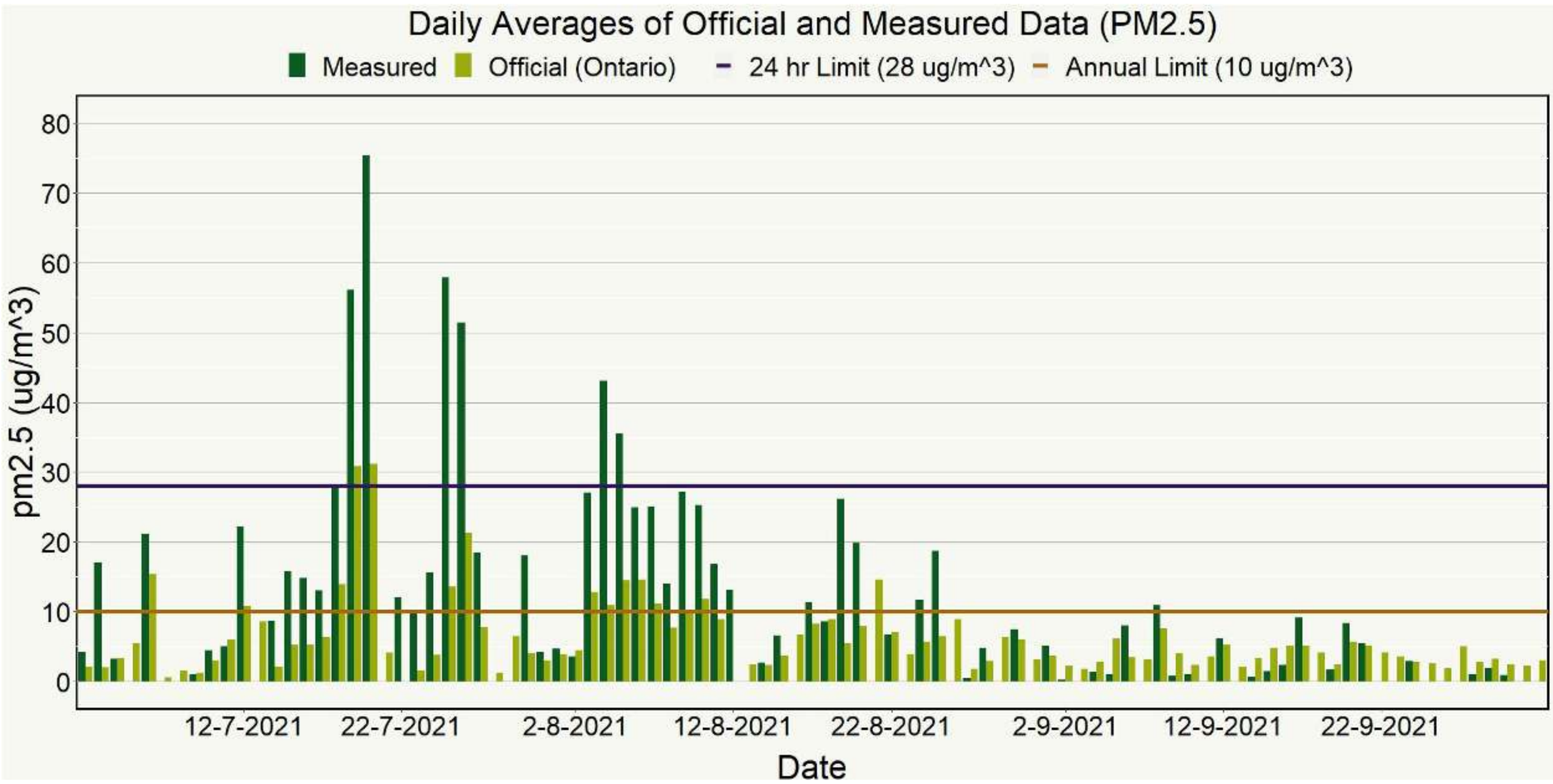
Morning	Afternoon
Vanier North	Carlington
Nepean/Tanglewood	Parkwood/Borden Farm
Nepean/Pineglen	Nepean/Merivale
The Glebe/Lansdowne	Industrial Park
Emerald Woods/Sawmill Creek	Nepean near Airport
Riverside/Windsor Park	Champlain Park/Wellington Village
Carleton Heights/Rideauview	Civic Hospital area
Alta Vista/Guildwood Estates	Centretown
Hunt Club	Hogs Back
Fairfield Heights	Alta Vista
Centrepointe/Pinecrest	Greenboro
Rothwell Heights	Ryan Farm/Meadowlands
South Keys	Kenson Park
Westboro	Emerald Woods/Blossom Park
Riverside	St. Laurent/Eastway Gardens
Sandy Hill	Viscount Alexander
Bel Air Heights/Copeland Park	Beacon Hill/Cyrville
Glabar Park	Alta Vista/Riverside Hospital
Hawthorne Meadows	Woodpark/Whitehaven
Faircrest/Ottawa Hospital	Centrepointe
Hurdman/Overbrook	Pineview
Sheahan/Arlington	Manor Park
Nepean	The Arboretum

46 Sites Across the City



Data Reliability

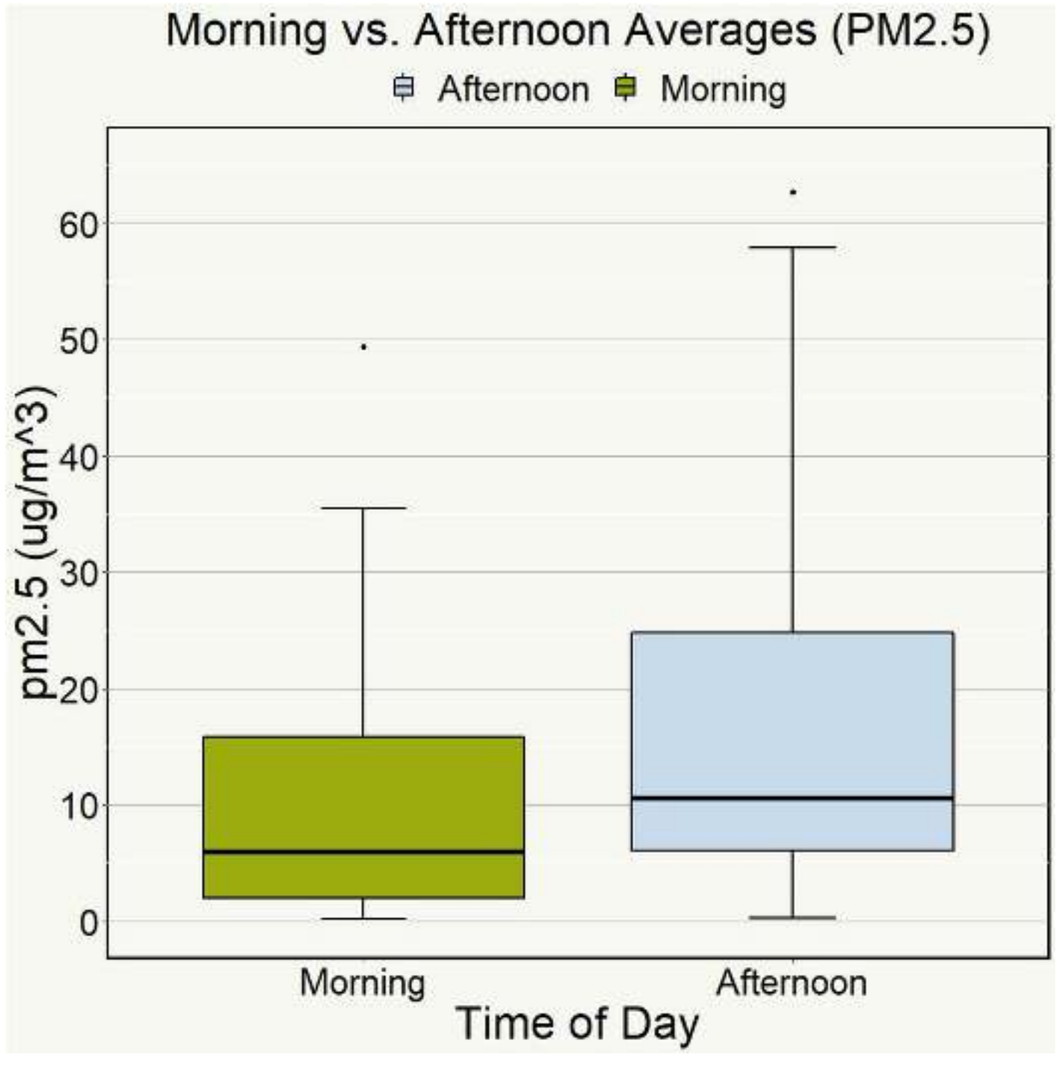
Our analysis focuses on Particulate Matter 2.5 (PM2.5), as a pollutant harmful to human health which can be reliably measured with our monitors. The graph below sets out the daily average levels of PM2.5 as measured by volunteers in the Breathe Easy campaign over the summer of 2021 (in dark green) and compared with official estimates taken by Ontario's Ministry of the Environment, Conservation and Parks (in light green). The averages follow the same trend, indicating a high level of reliability in the data collected in the Breathe Easy campaign.



The PM2.5 concentrations measured in the Breathe Easy campaign were, however, a lot higher as compared with official measurements taken by the province. This is potentially indicative of a number of factors, including that our volunteers were taking measurements closer to the ground, meaning closer to the point where we consume them, but also closer to vehicle exhausts where we would anticipate air quality to be reduced; it could also be indicative of the variability of the locations between where we took measurements and the single location where the province takes measurements, reinforcing the inadequacy of the province's current air quality monitoring, which fails to take account of geographic variability of air quality across the city.

Data Reliability

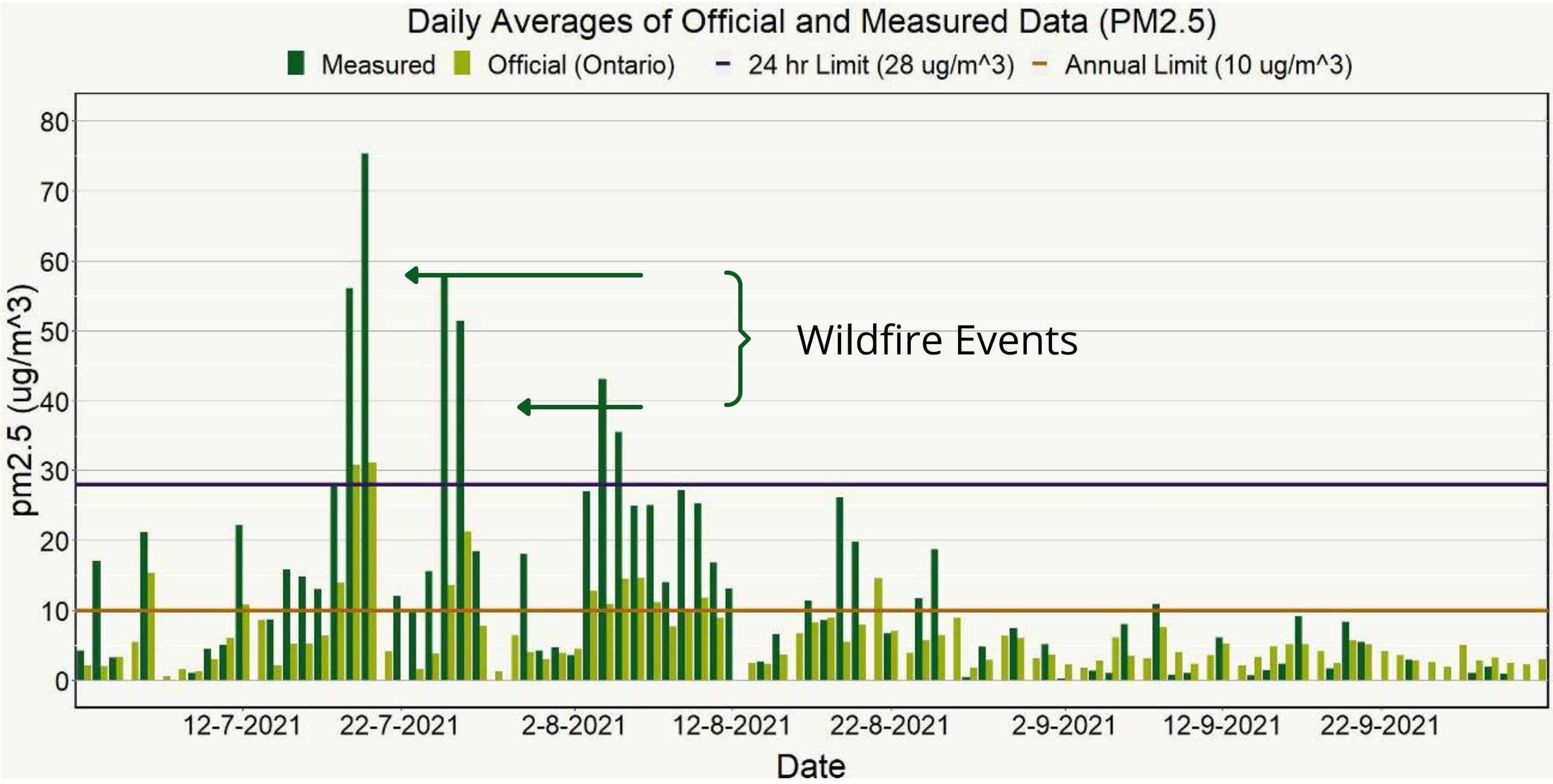
Another interesting observation was the significant difference between the air quality in the morning and the afternoon, with the quality being significantly reduced in the afternoon. This aligns with the theory and previous studies showing that air pollutants accumulate over time. In the afternoon there are more likely to be more vehicles driving, more businesses open, more buildings being heated or cooled. By contrast, overnight pollutants can settle, fall into the water and wash away and be blown away with the wind. This was another quality assurance, indicating that our data collected was representative of trends found in official air quality monitoring and therefore reliable.



The only official air quality monitoring in downtown Ottawa is carried out by Ontario's Ministry of the Environment, Conservation and Parks. The station is located in MacDonald Gardens Park on Wurtemburg Street at an elevation of four metres. The air quality measurements taken there can be anticipated to show reduced pollutants from their location in greenspace as well as their elevation (rather than being taken at the height of human consumption).

It is important that we invest in higher quality data collection, that takes samples for longer periods of time and accesses that granularity that we have captured in this monitoring program.

Wildfire Events



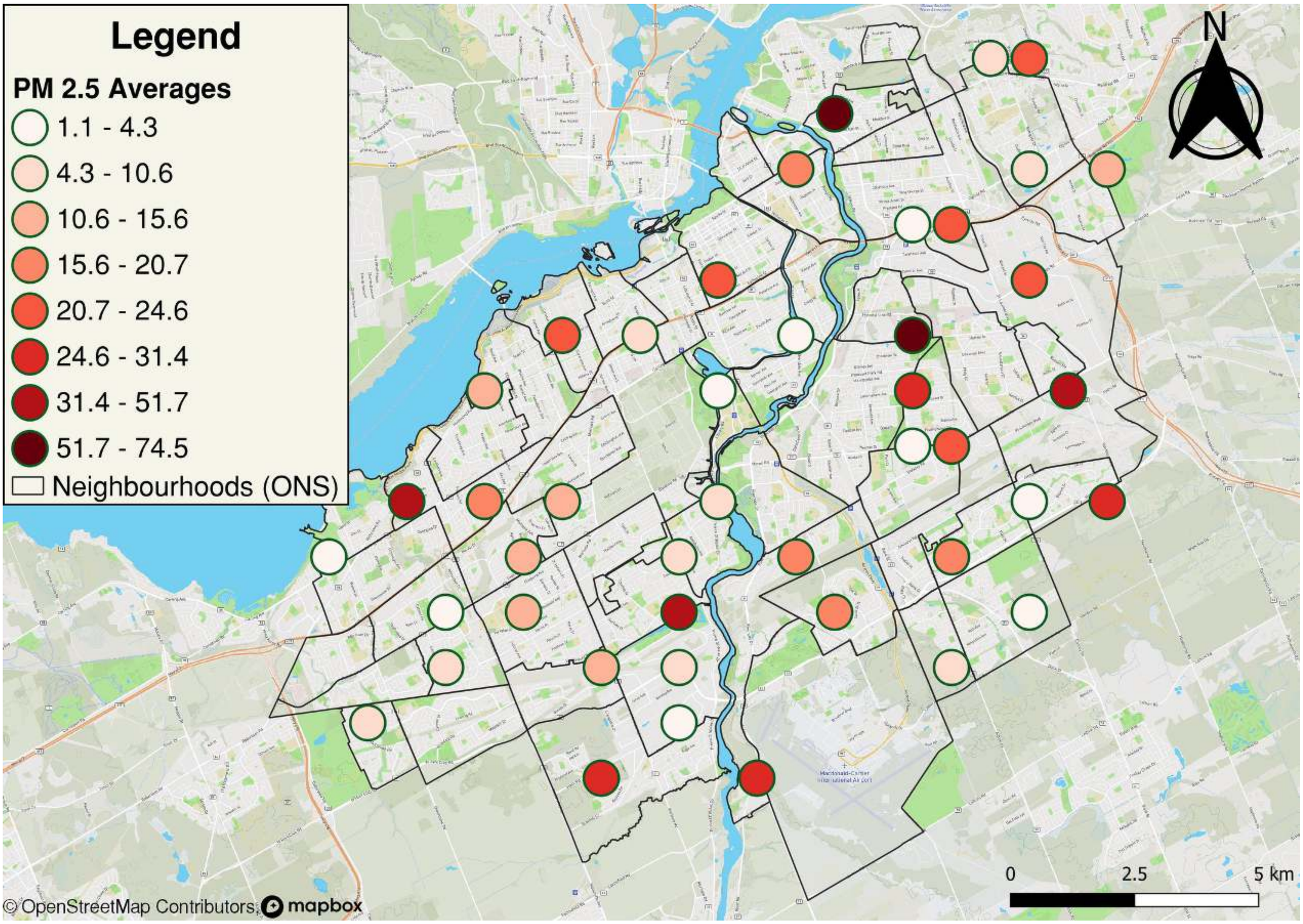
Our team of volunteers was able to capture the wildfire events experienced in Northern Ontario over the summer of 2021, the smoke from which was carried to Ottawa. Those days show significantly elevated concentrations of PM2.5 and demonstrate the influence on the air quality across the city, despite occurring hundreds of kilometres away. These events caused spikes in air pollution which exceeded the province's recommended 24 hour limit of PM2.5 exposure (dark line). As climate change continues to increase the frequency and intensity of such wildfire events (as well as storms, flooding and intense heat) we can anticipate an increase of days where the province's air pollution guidelines are exceeded in the future.

Note that the data from these four days were removed from the geospatial analysis on the following pages to ensure the findings were not skewed by these events.

“As climate change continues to increase the frequency and intensity of such wildfire events (as well as storms, flooding and intense heat) we can anticipate an increase of days where the province's air pollution guidelines are exceeded in the future.

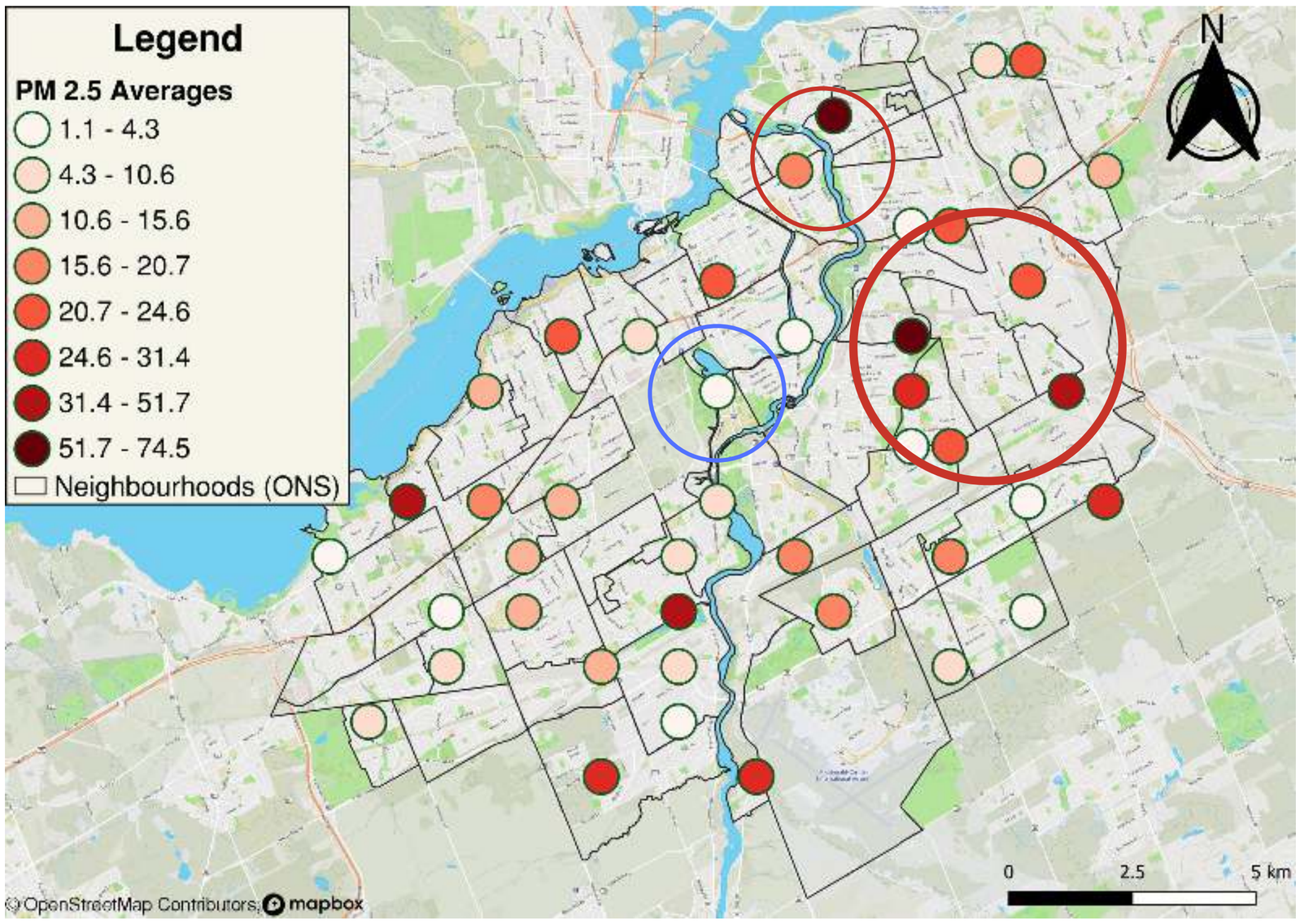
Results

Mapping the data collected across the city provides a great indication of the variability across Ottawa, further demonstrating the dire need for greater granularity in official air quality data collection. Our data measurements ranged from 1 part per billion, to 75, which is three times higher than the provincial guideline.



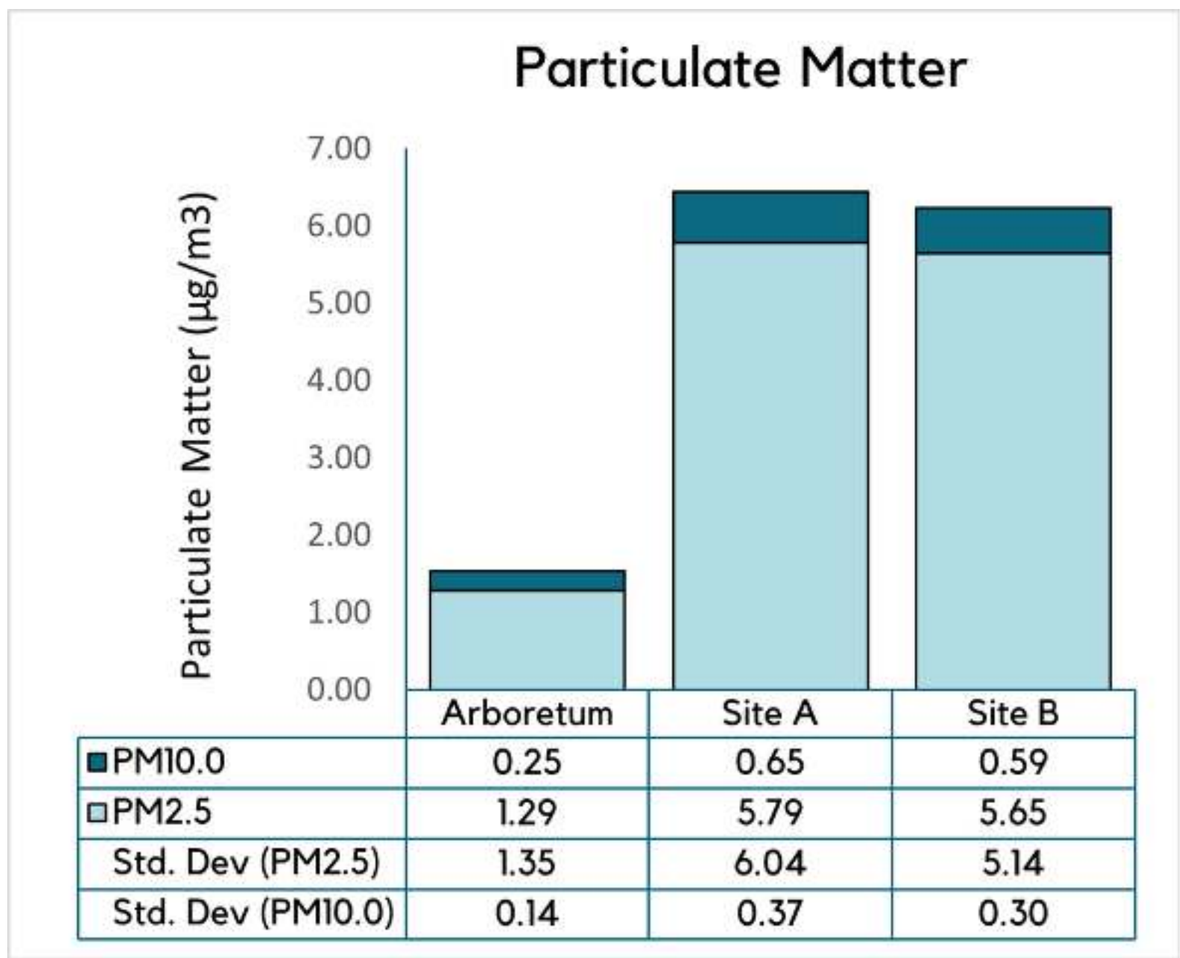
Results

We can also see clustering when we transpose the data onto the map of the city, (the large red circle) showing a high levels of pollution of the South Vanier/Heron area as well as in the Lowertown and Byward Market area (the smaller red circle).



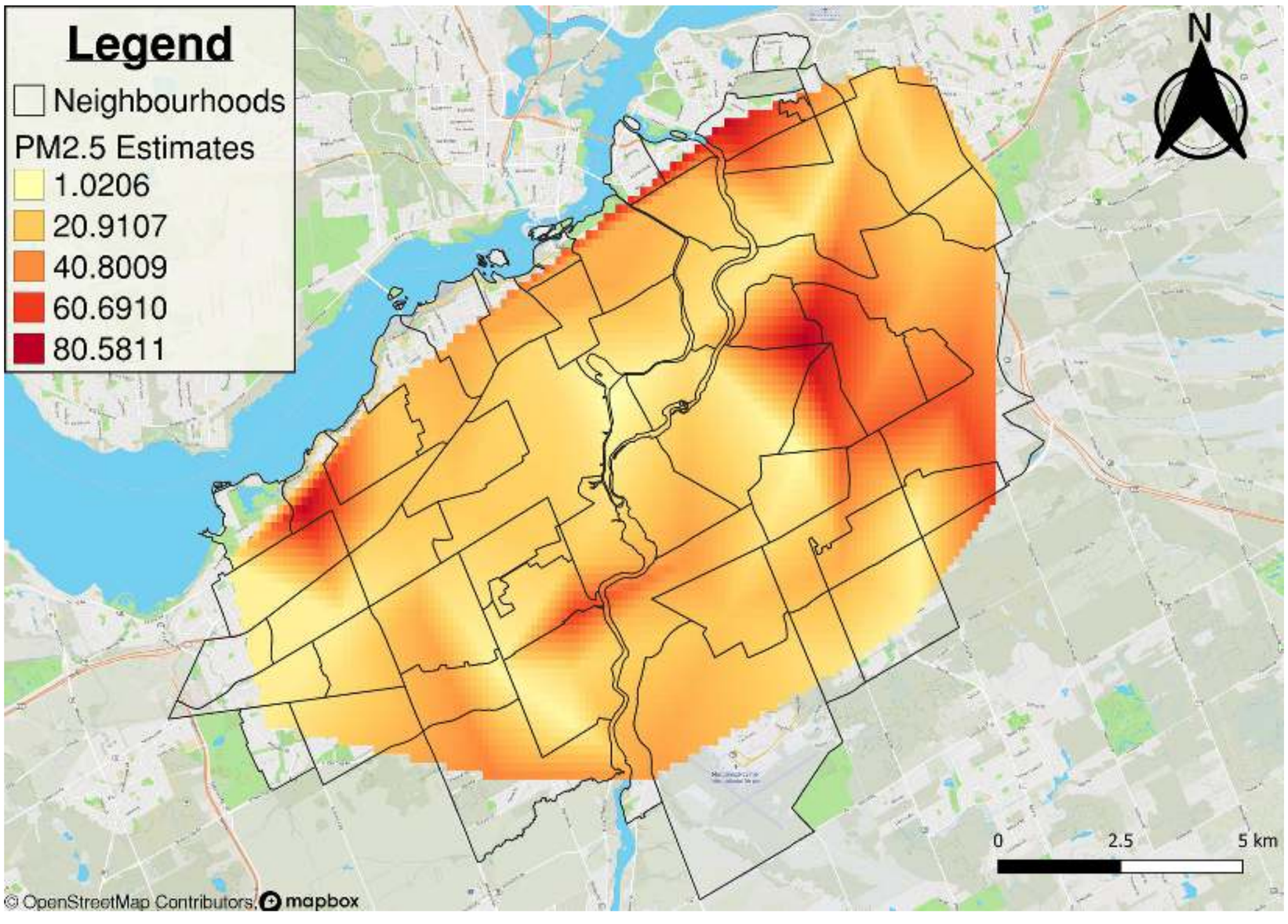
By contrast, when we look at the Arboretum (circled in blue), it has the best air quality or lowest contamination across the city, which supports our findings from 2020, showing that the arboretum has a demonstrative impact on our city's air quality because of the beneficial impact of the greenspace it offers.

Results from Breathe Easy 2020

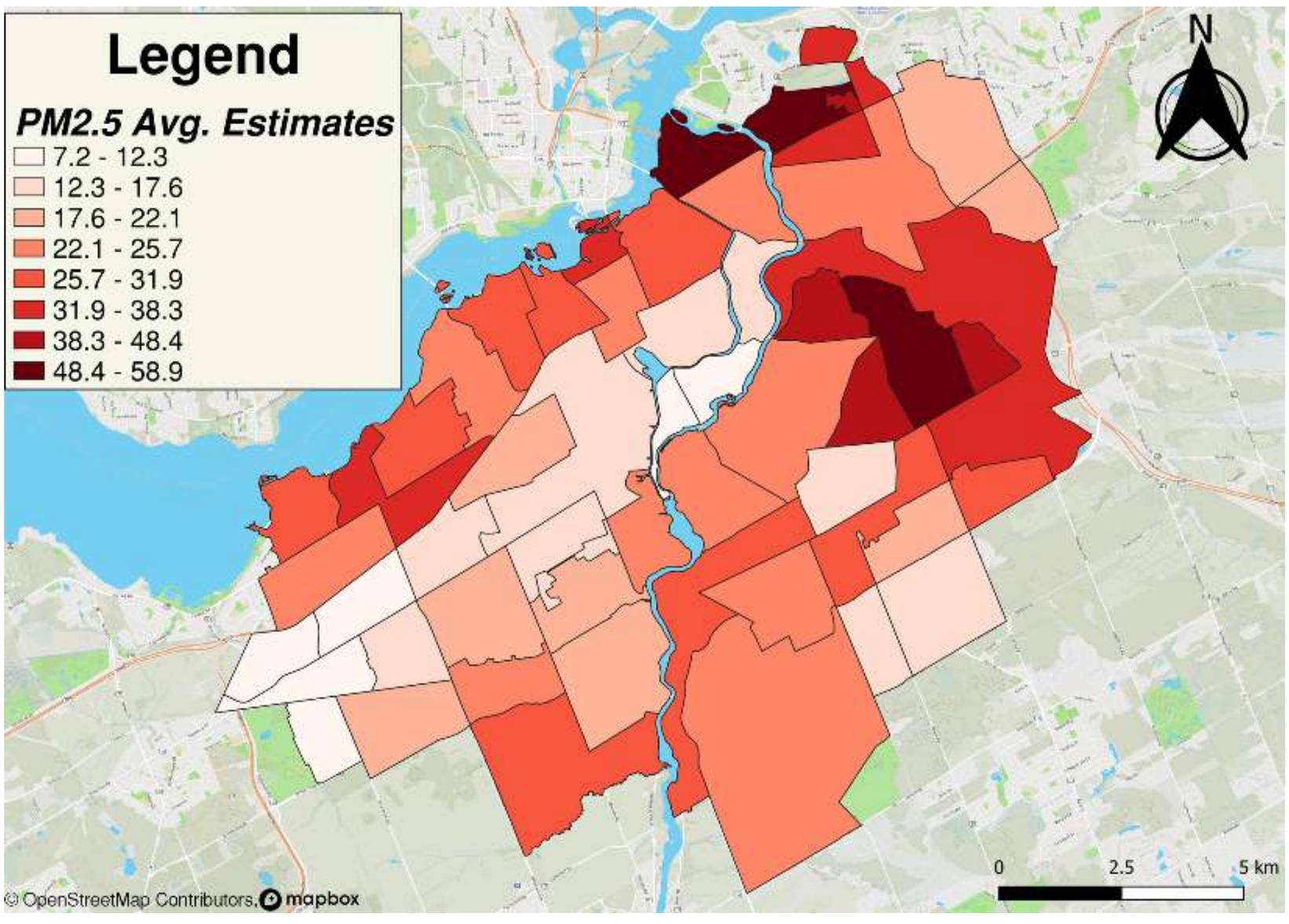


	Arboretum	Site A	Site B
PM10.0	0.25	0.65	0.59
PM2.5	1.29	5.79	5.65
Std. Dev (PM2.5)	1.35	6.04	5.14
Std. Dev (PM10.0)	0.14	0.37	0.30

Results

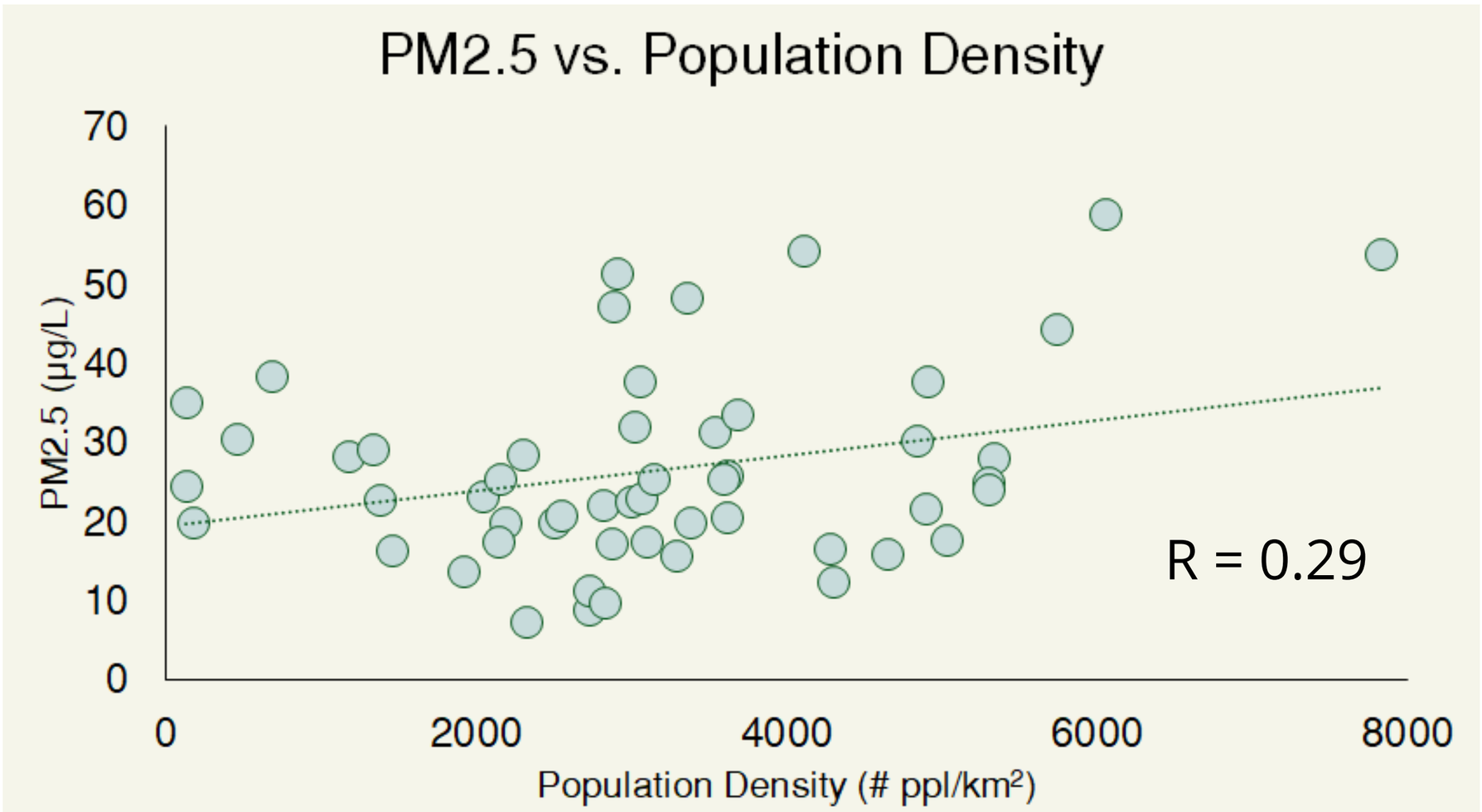


Taking all of the data collected across the city, we interpolated the results between data points to produce a coverage map (above). We then took each of the data points within the boundaries of each of the neighbourhoods to come up with the neighbourhood estimates across the highest decile (meaning the top ten percent of measurements) (below). We then used this neighbourhood estimate to evaluate the data against various demographic indicators taken from the Ottawa Neighbourhood Study (ONS).

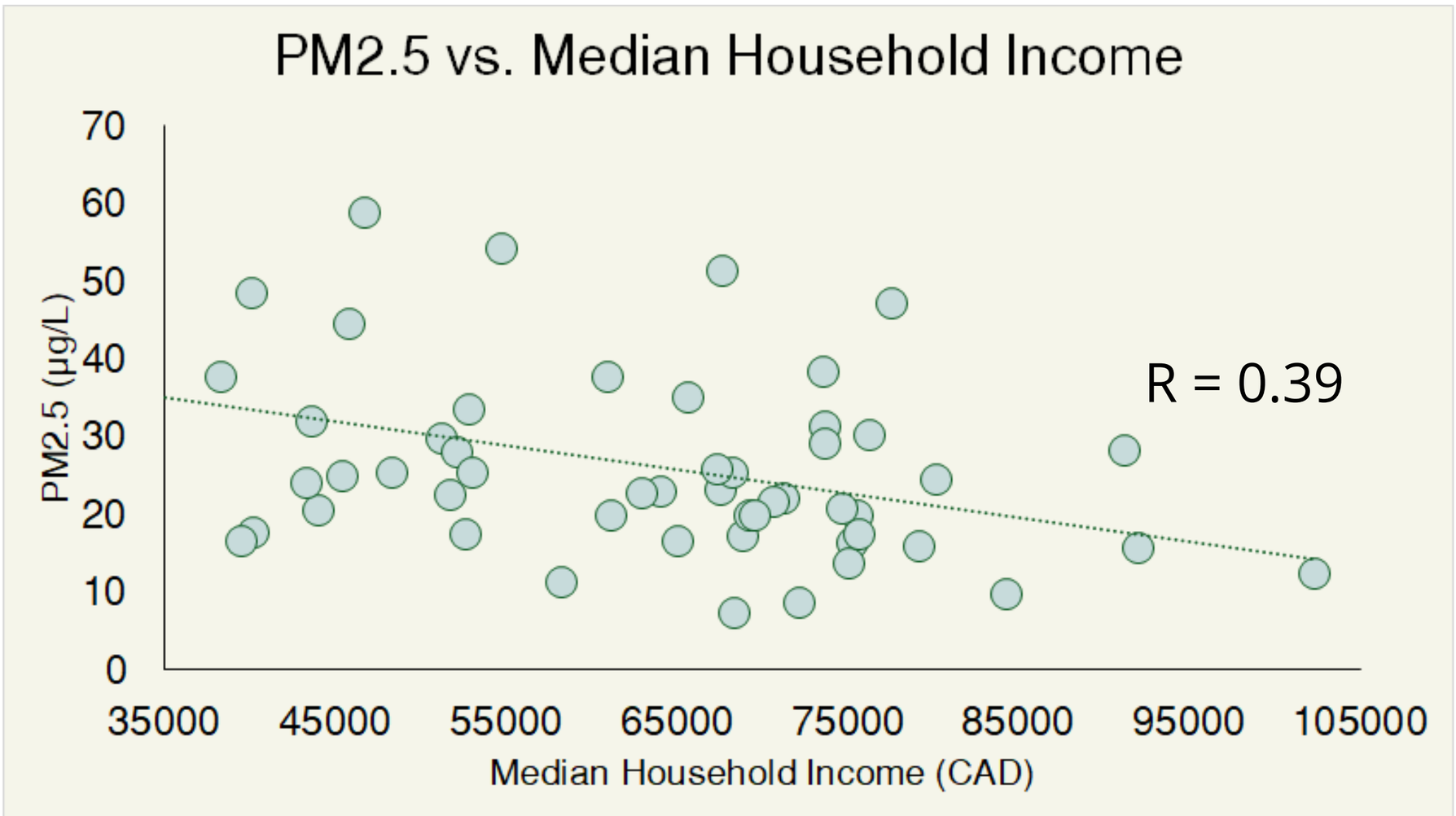


Demographics: Population Density

The first demographic indicator evaluated was population density within each neighbourhood. We see a significant (29%) positive correlation between population density and the PM2.5 measured, demonstrating that as higher numbers of people are congregating together, there is a higher release of PM2.5.

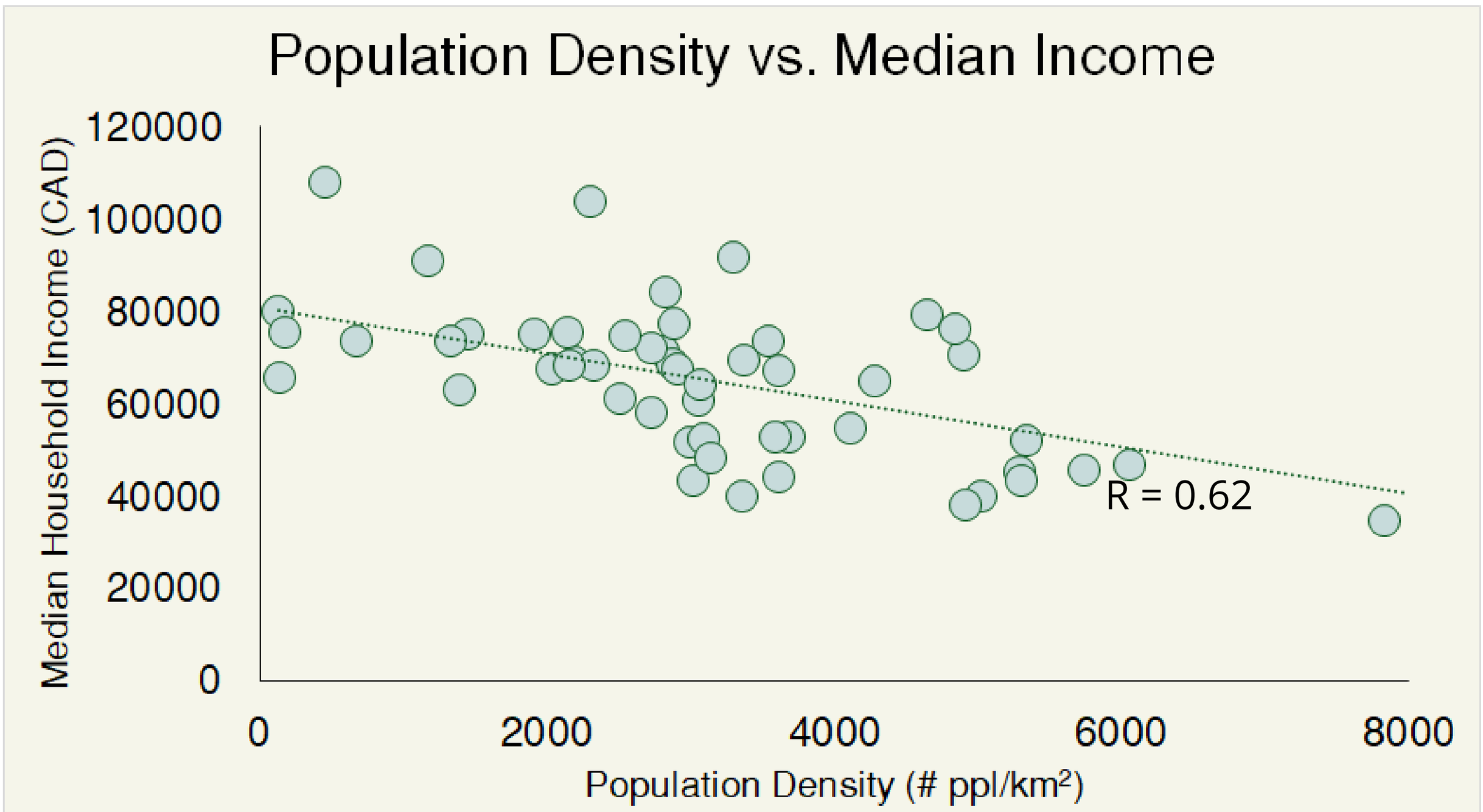


A second important observation was that where we correlated the data with median household income for each of the neighbourhoods, we see a significant relationship (almost 40%), meaning that about 40% of this data is explained by the median household income, demonstrating that **populations in lower income neighbourhoods tend to be those subject to elevated levels of contaminant concentrations and therefore elevated levels of environmental health risk. Air quality worsens with income in a more significant way than any other factor. This is a clear demonstration of environmental inequity within the city.**



Demographics: Household Income

Taken together, this information is also indicative of the fact that lower income populations tend to be those living more densely populated. So **lower income communities have more people living together, correlating with observed increases of environmental health risk. This means that the two previous observations are compounding and that the city is creating higher health risks for the most vulnerable people in the city.**



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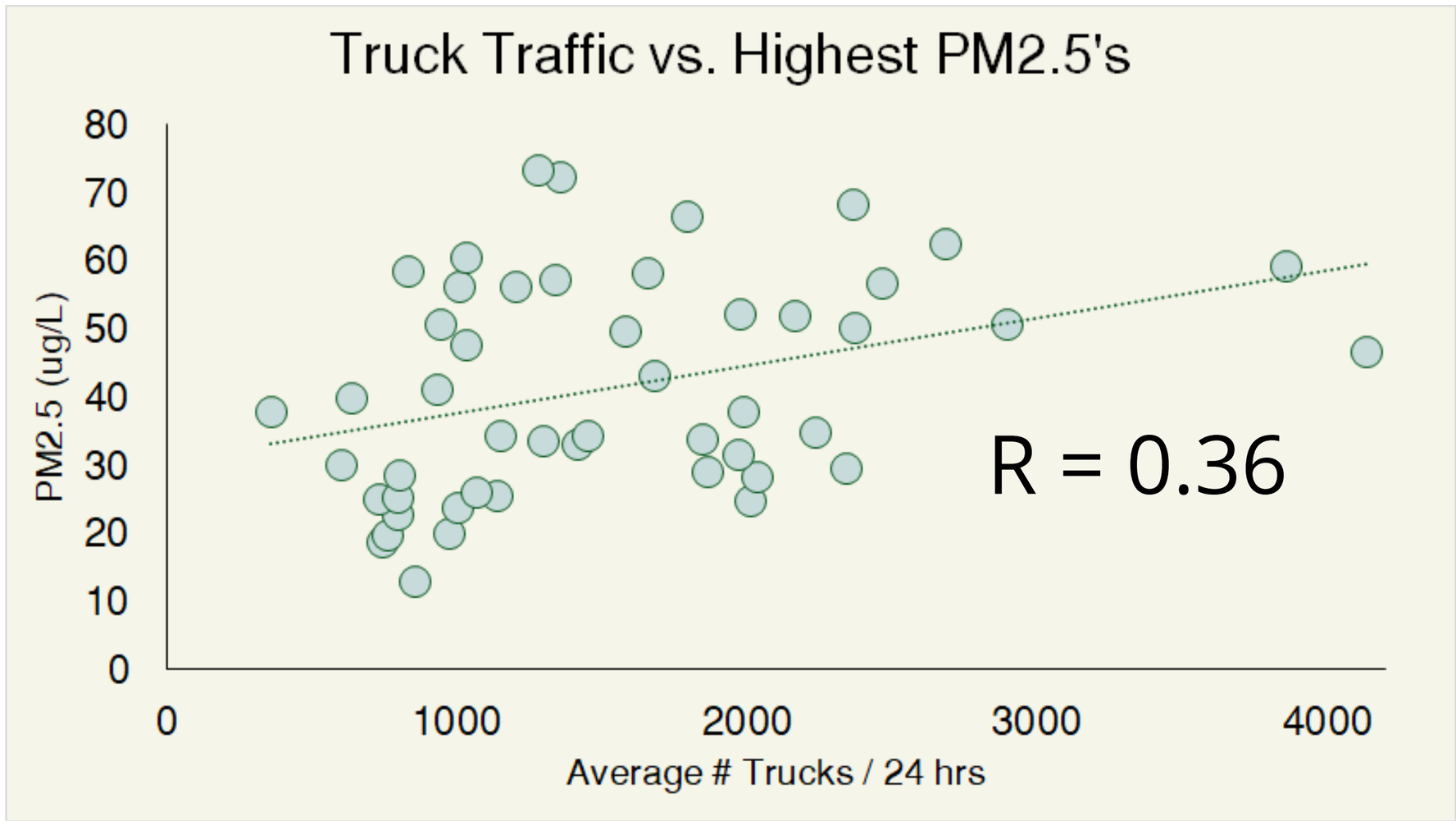
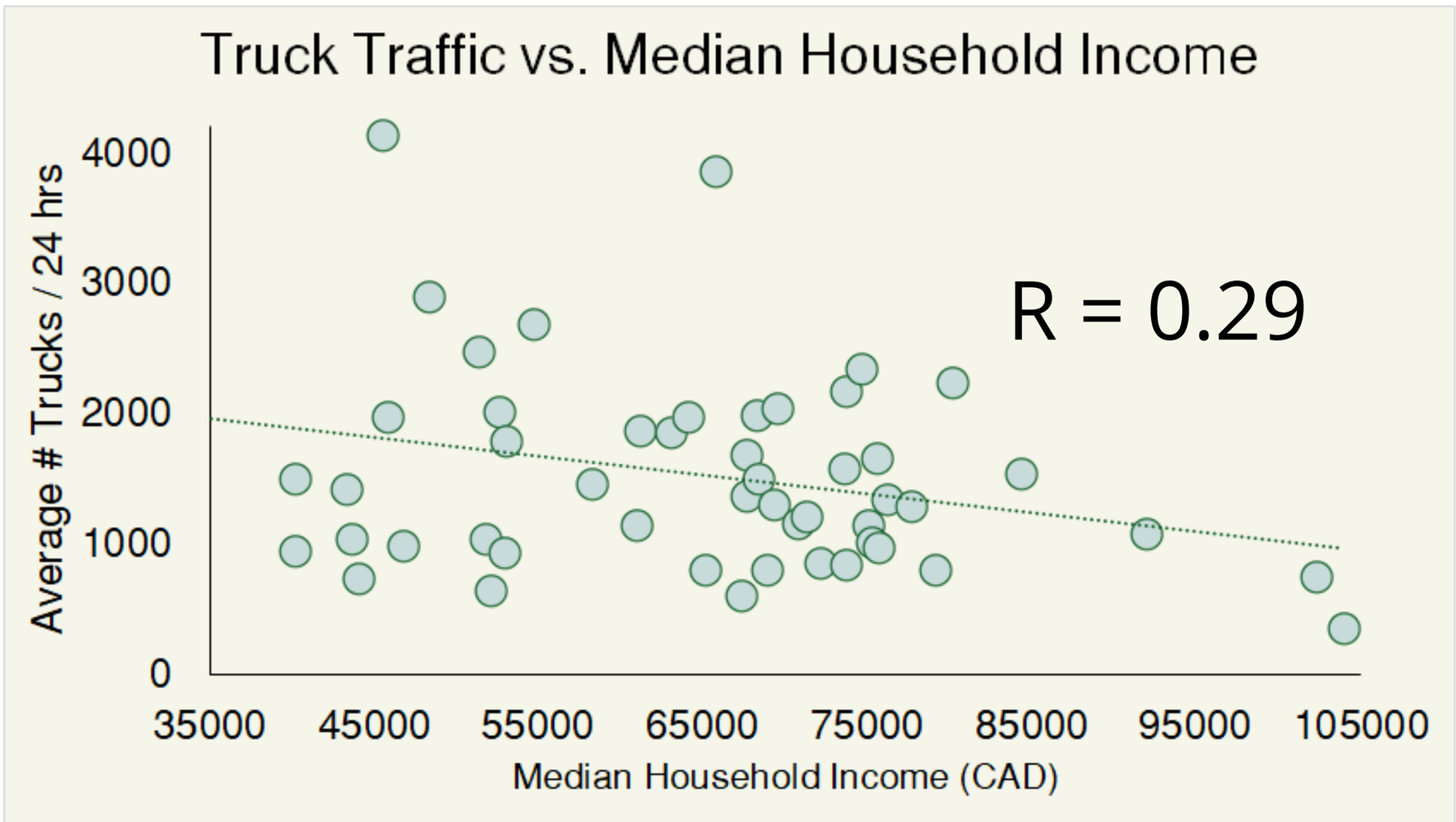
Zoning: Truck Traffic



Taking the top decile of data from the dataset demonstrates a linear correlation (of 36%) between the highest concentrations of PM2.5 and truck traffic. Where more trucks drive through specific neighbourhoods, we see increases in the highest concentrations of pollutants.

Again, lower income populations are those experiencing the higher number of trucks driving through their neighbourhood (with a 29% correlation), demonstrating that trucking routes are currently oriented towards or concentrating in neighbourhoods where lower income communities are living. This is showing that **neighbourhoods with the lowest income in Ottawa are being placed in circumstances that contribute to worse pollution and negative associated health outcomes.**



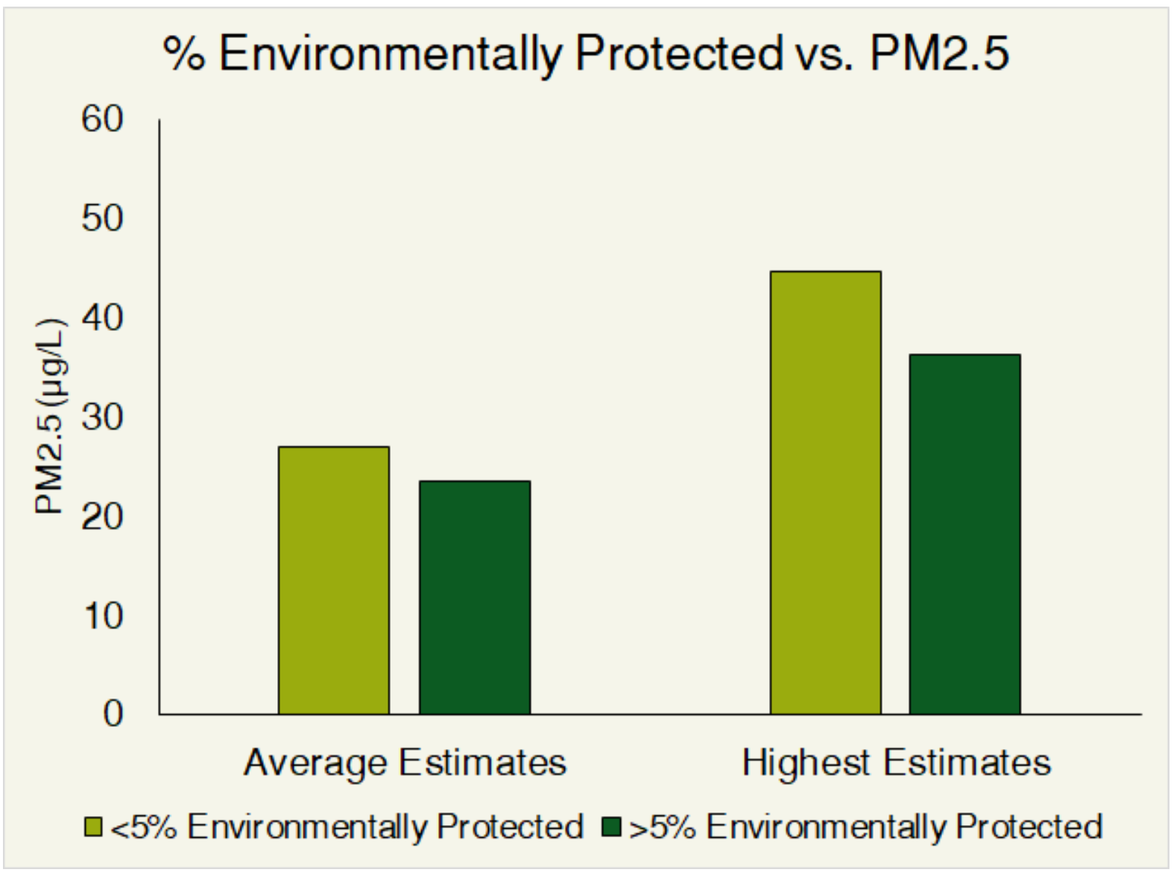
Zoning: Industrialization, greenspace

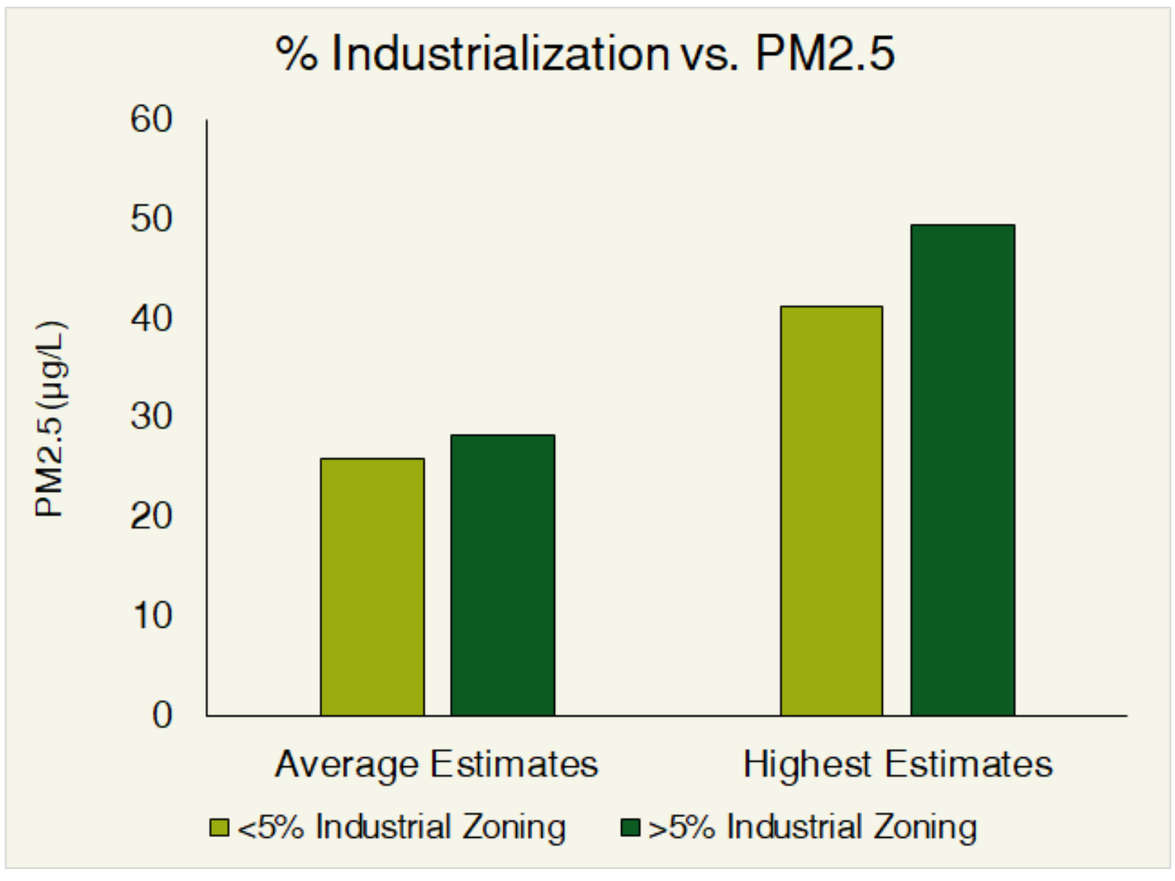
Looking at industrialization (such as manufacturing facilities, warehouses) across the city, if we take the average, with less than 5% of industrialization in the lighter green and more than 5% industrialization in the darker green, we can see that on average there is a difference, where less industrialization results in less concentration of PM.

When we translate that to the top decile, the top ten percent of measurements that we took, that difference increases even more. **Higher industrialization in a neighbourhood, correlated with those areas having the highest measurements of air pollution that we took during the campaign.**

Conversely, there is an opposite effect when we look at environmental protection. Where we compare the average estimates for areas with less than 5% (as defined by the City of Ottawa) of environmental protection (in light green) and areas which are more than 5% environmentally protected (in dark green), when there is less protection, there is a higher concentration of contaminants.

When we translate that to the highest decile of pollutants measured, that difference becomes even more significant, suggesting that **environmental protection and greenspaces are really critical to managing air quality within our neighbourhoods. Environmental protection safeguards against the worst levels of pollution that we measured.**





Conclusion

The air quality data collected by our team of volunteers across the city paints a vivid picture of clusters of high concentrations of contaminants in areas such as South Vanier, Lowertown and Byward Market and then beneficial air quality in areas with areas with extensive greenspaces such as the Arboretum. When mapped and analysed against socio-economic demographic data, the measurements give a rare insight into significant environmental health inequities in our city.

Lower-income populations are subject to elevated environmental health risk

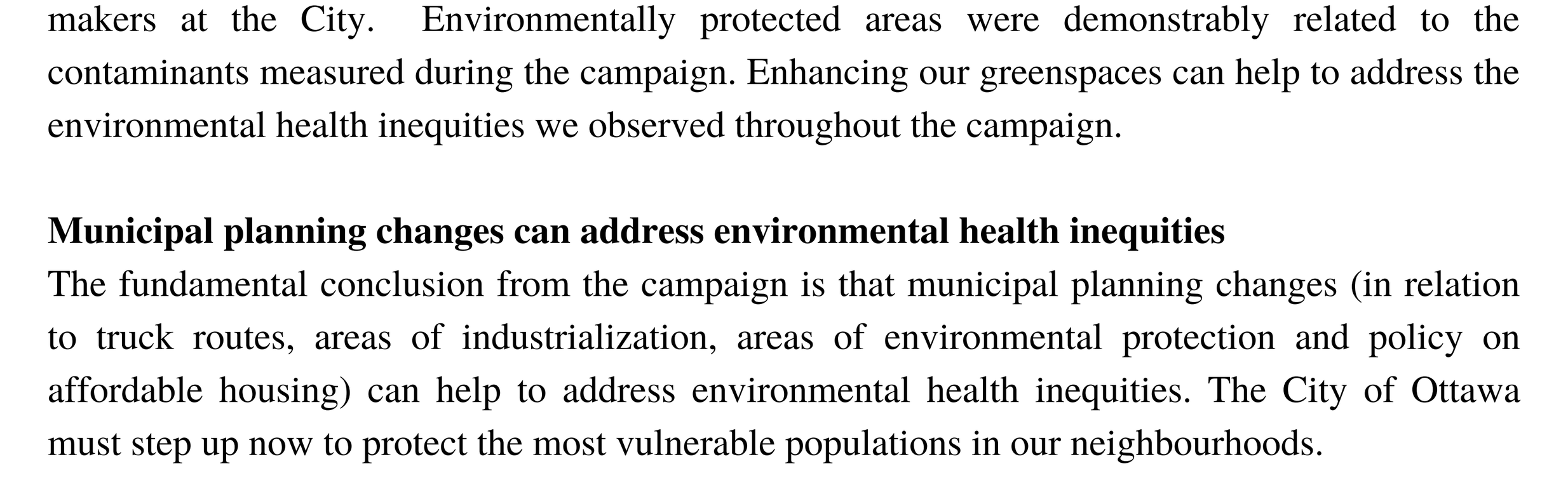
Our data is suggesting that lower income populations are subject to elevated environmental health risk than higher income populations within the study area. This means that there is a disproportionate environmental health risk factor that can be traced linearly with median household income within the neighbourhoods.

Commercial vehicle traffic, industrialization and greenspaces each contribute to air quality

The contribution to air quality of commercial vehicle traffic and trucks can be seen in the data upon analysis. Increased industrialization within neighbourhoods also correlated with increased contaminants. These major factors should be considered and looked at in more detail by policy-makers at the City. Environmentally protected areas were demonstrably related to the contaminants measured during the campaign. Enhancing our greenspaces can help to address the environmental health inequities we observed throughout the campaign.

Municipal planning changes can address environmental health inequities

The fundamental conclusion from the campaign is that municipal planning changes (in relation to truck routes, areas of industrialization, areas of environmental protection and policy on affordable housing) can help to address environmental health inequities. The City of Ottawa must step up now to protect the most vulnerable populations in our neighbourhoods.



Thank you!

Thank you again to our devoted team of citizen science volunteers!

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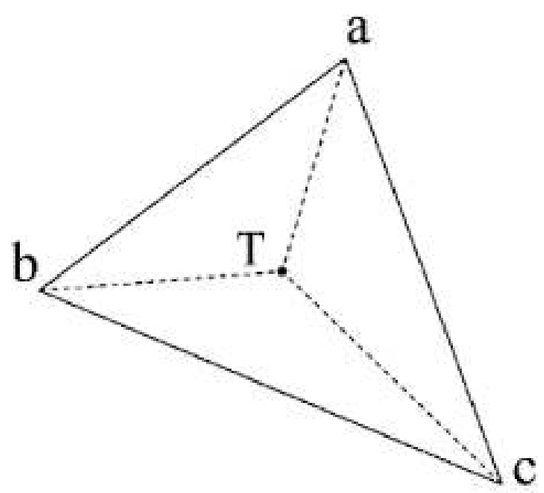
Annex: Data Analysis

As with our Breathe Easy 2020 campaign, all data were evaluated by comparisons to international guidelines for particulate matter established by the World Health Organization for average contaminant level intake over one hour. This is to say that usually, a location is monitored for one entire hour, and the average of this hour is analyzed. Considering the scope of the study, we did not ask volunteers to remain at each location for an hour. As such, data were not collected for long enough time periods to establish a truly comparable average. This analysis should therefore be read as suggestive of the air quality at a given location during our "snapshot" readings.

Air quality data collected from the volunteers at every site was consolidated into a single file before analysis. Calibration cleaning was then carried out on the data. Monitors need to stabilize before readings are considered accurate, which does not always happen by the time volunteers get to the site. Data was removed if the measured value was more than 1 standard deviation different from the previous minute's estimate. This was therefore done iteratively until only relatively similar data was compiled. Too much data did not meet this requirement for ozone measurements so no analysis was done on this measure. Also, no analysis was done on Nitrogen Dioxide because the portable air quality monitors did not collect measurements properly over a sufficient period of the campaign.

When mapping the data across each of the neighbourhoods in Ottawa, we used what is called Triangular Irregular Network (TIN) interpolation. A 100x100 matrix of data points was created across the entire map. Each point estimated particulate matter based on the three nearest measured data points (a, b and c below) and produced an estimate on point location (T), given its distance to those measurements. This modelling was used to estimate neighbourhood values.

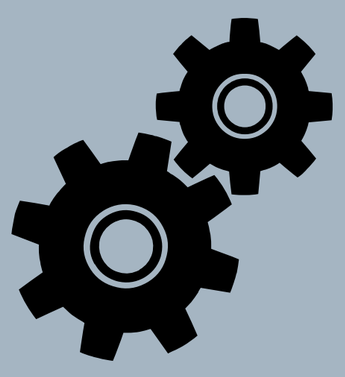
Some limitations of this method include assumption of linear change with distance (even though it is weighted) and data does not fully capture the full picture of air quality at each location as there were only three measurements taken. The air quality estimates here should therefore be taken as suggestive of the air quality within neighbourhoods across Ottawa, rather than descriptive.



Annex: Study Limitations

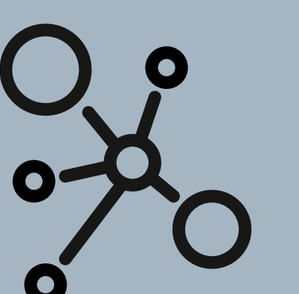
Time

- Sampling times range from 2-20 minutes
- Sampling across seasons and few times



Resources

- Only 2 AQ Monitors
- AQ Monitors are mobile and data reliability imperfect



Model

- TIN assumes linear change
- Doesn't capture buildings, wind, etc.

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