

# *AIR QUALITY MONITORING IN THE CITY OF HAMILTON*

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Oct 2023

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**RESEARCH STUDY  
GOALS**

## Primary Questions

- How does air pollution vary across Hamilton?
- Are socioeconomic variables correlated with pollution concentrations?

## Secondary Objectives

- Understand the spatial variation in BTEX.
- Identify regions of the city that are well-monitored with existing MOECP monitors.

# POLLUTANTS MEASURED

- Nitrogen dioxide, Nitric oxide & Nitrogen oxides ( $\text{NO}_2 + \text{NO}_x$ )
- Ozone
- Sulphur dioxide
- Benzene
- PAHs
- Length of Study: All seasons
- Total Number of Sites: 67

# POLLUTANTS MEASURED EACH SEASON

Pollutants being measured:

- Nitrogen dioxide
  - Nitric oxide
  - Nitrogen oxides ( $\text{NO}_2 + \text{NO}_x$ )
  - Ozone
  - Sulphur dioxide
- 
- Benzene

Number of Sites: 67

Ogawa



SKC ULTRA



# POLLUTANTS MEASURED IN WINTER AND SUMMER

Pollutants being measured:

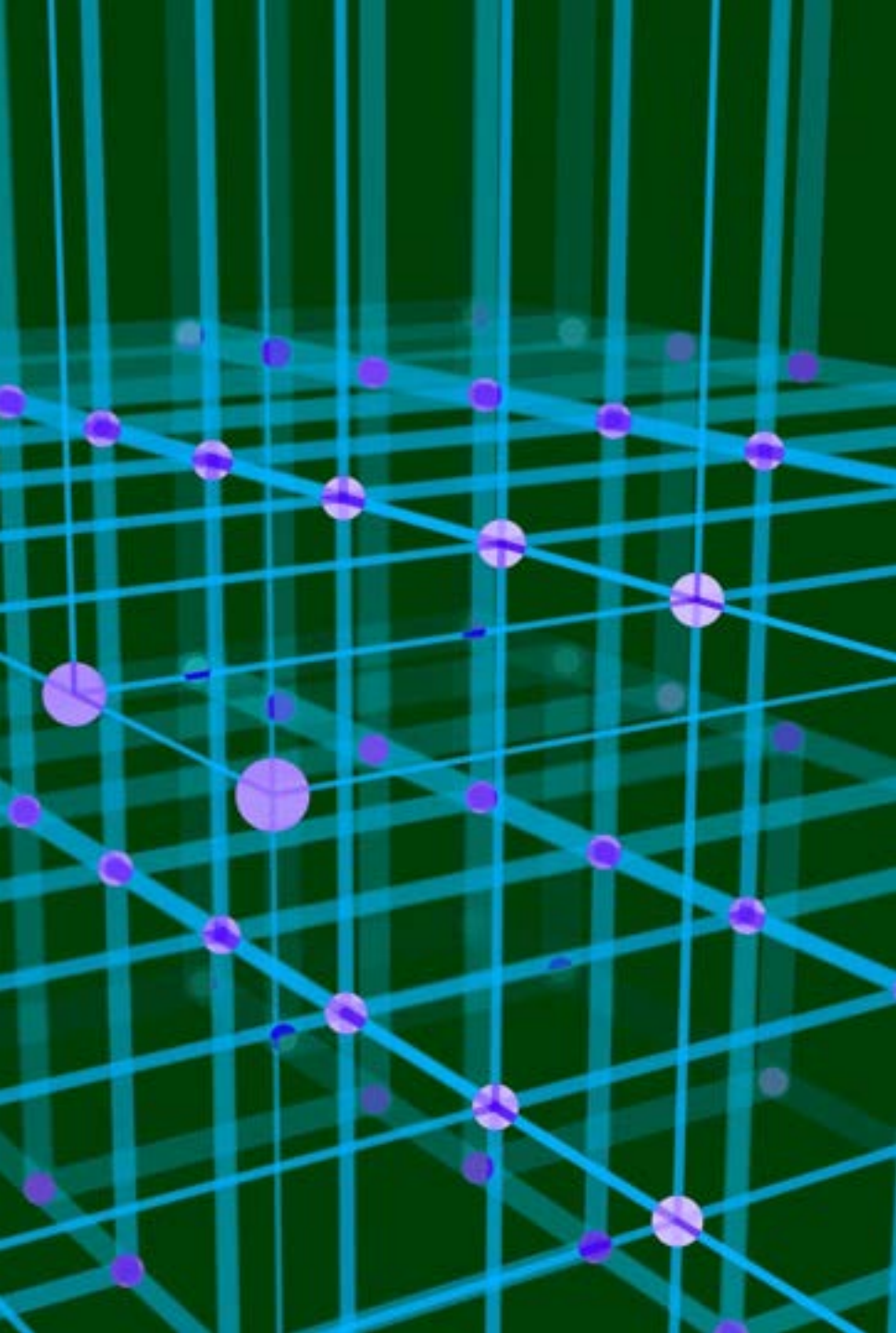
- PAHs
  - Benzo[a]pyrene is of high interest to Hamilton
- PUF-Pas
  - Global Atmospheric Passive Sampling (GAPS) Network
- Passive air samplers equipped with polyurethane foam

Number of Sites: 29



# PAH LIST

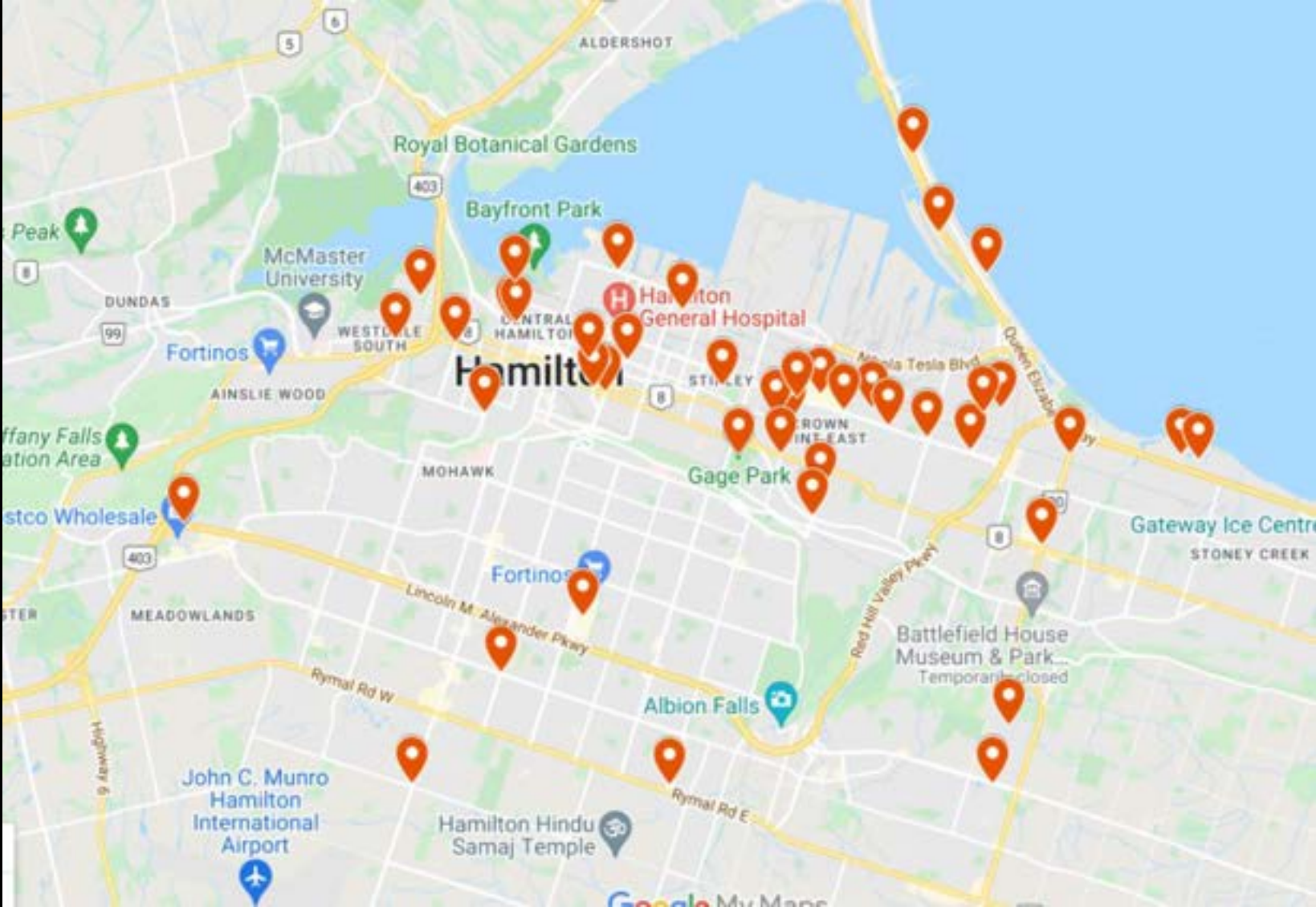
- Acenaphthene
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- Anthracene
- Benzo[a]anthracene
- Benzo[a]pyrene
- Benzo[b]fluoranthene
- Benzo[e]pyrene
- Benzo[g,h,i]perylene
- Benzo[k]fluoranthene
- Chrysene
- Dibenzo[a,h]anthracene
- Dibenzothiophene
- Fluoranthene
- Fluorene
- Indeno[1,2,3-c,d]pyrene
- Perylene
- Phenanthrene
- Pyrene
- Retene



# SITE SELECTION



# COMMUNITY INTEREST POINTS





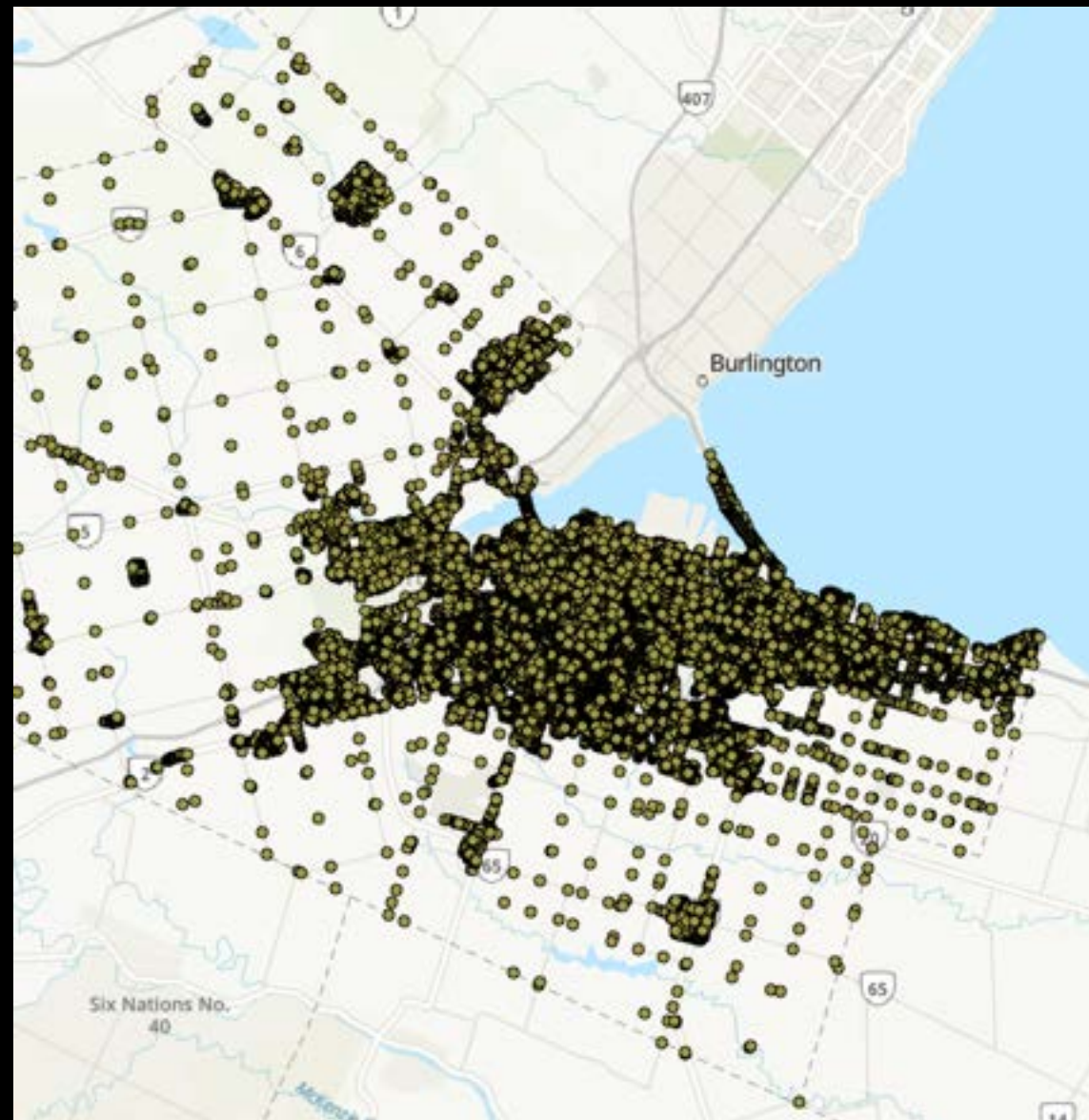
# SITE SELECTION:

# SITES COLLOCATED WITH ACTIVE MONITORS

Seven sites were selected for quality assurance/quality control purposes with the seven sites in the city with live monitoring of nitrogen dioxide, nitrogen oxide, ozone, and sulphur dioxide.



# POTENTIAL LOCATIONS



# SITE SELECTION: 15 WARD- REPRESENT ATIVE SITE

The location with average land use conditions for each ward was selected, based on land uses (Commercial, Gov/Ind, Open Area, Parks and Rec , Res, Industrial and Waterbody) within a 150-metre buffer around each streetlight.



**SITE**

**SELECTION:**

**45**

**POPULATION**

**-LEVEL**

**SITES**

1. Each streetlight was assigned with variables:
  - Distance from highways, water, industrial land, and open land.
  - Population density
  - Four marginalization indices from Public Health Ontario
    - Residential instability, material deprivation, dependency, and ethnic concentration
2. K-means clustering ( $K = 45$ ) applied, centroid of each cluster selected
3. Each set (5000 iterations) the nearest distance to each community area of concern
  - We selected the set of locations with the small sum of distances

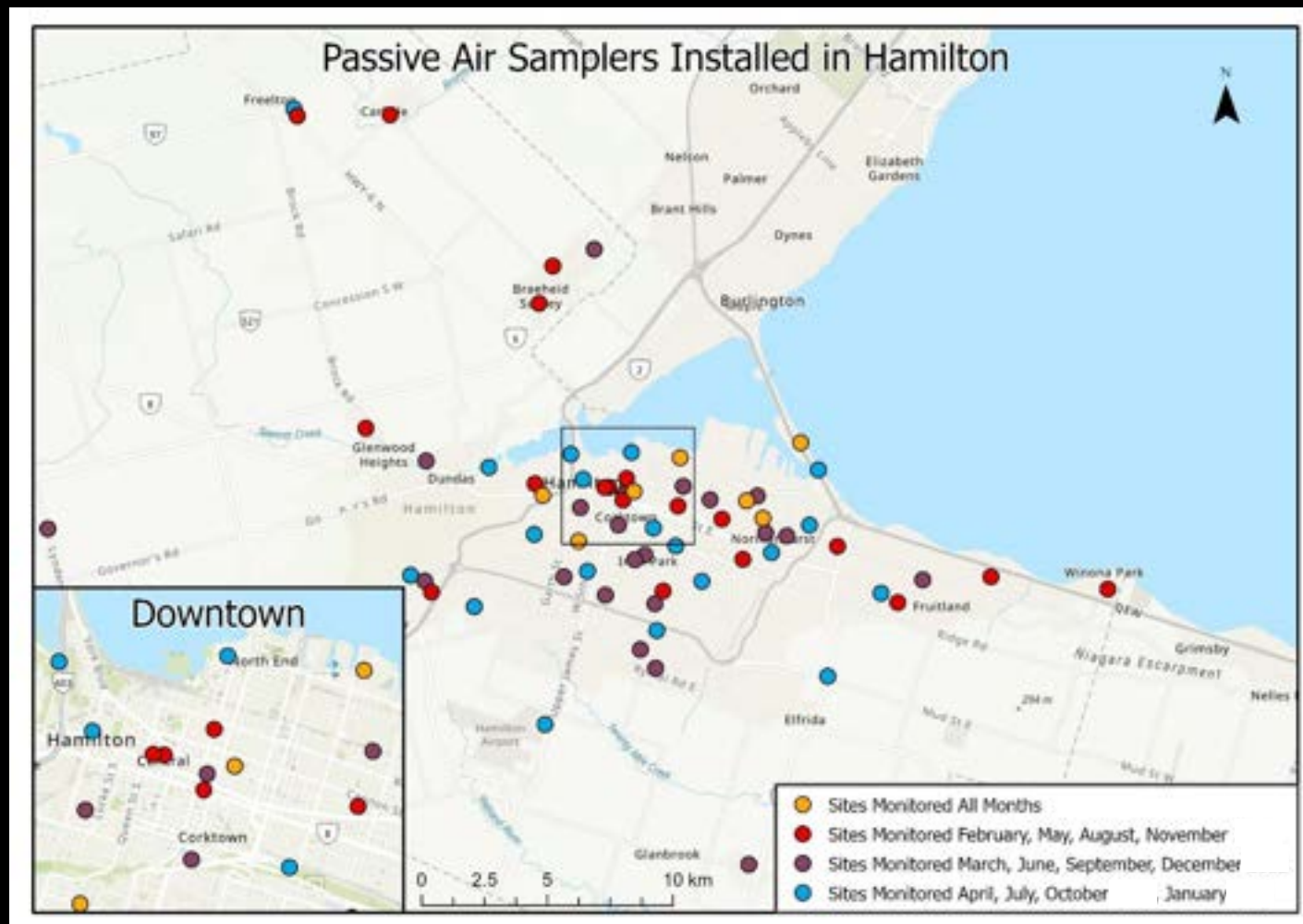




- One-third of sites are sampled every month
- Collocated sites which are always sampled
- Air monitors installed for two-week periods (PAH two months)

# SITE SELECTION: TIMING

SITES WILL BE  
MONITORED AT LEAST  
ONCE PER SEASON FOR  
AN ENTIRE YEAR.





A person wearing a dark suit is shown from the waist down, holding a blue folder or stack of papers. The background is a blurred outdoor setting, possibly a public square or park, with trees and a paved area. The overall image has a dark, semi-transparent overlay.

# **FIELD WORK AND LOCAL COMMUNICATION**



Hamilton

# Science is happening in your neighbourhood.

Passive air samplers were installed nearby  
to help study air pollution across the city.

## What is being measured?

Criteria air pollutants including nitrogen dioxide, nitric oxide, sulphur dioxide, ozone, and benzene are being sampled in order to get a better understanding of local differences in pollution exposure across the city.

## How can I learn more?

To learn more about projects like this or attend a public information session, visit:

[www.environmenthamilton.org/air\\_quality\\_monitoring](http://www.environmenthamilton.org/air_quality_monitoring)

## Who can I contact about questions and concerns?

Professor Matthew Adams  
University of Toronto Mississauga  
Email: [md.adams@utoronto.ca](mailto:md.adams@utoronto.ca)  
Phone: 905-569-4761



Passive monitors like the one above are being installed onto streetlights across the city. They are completely passive, meaning they are not electrically powered and can not communicate or record.

## Partners



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Environment  
Hamilton



# Science is happening in your neighbourhood.

Passive air samplers were installed on this streetlight to help study air pollution across the city.



Hamilton



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**Environment  
Hamilton**





# Results

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# Duplicates – Criteria Air Contaminates

Pollutant	Mean Difference Between Duplicates (ppb)	RMSE of duplicate error (ppb)	Mean Value
NO <sub>2</sub>	1.06	1.73	7.13
NO	1.66	2.24	55.21
NO <sub>x</sub>	1.07	1.54	12.34
SO <sub>2</sub>	0.45	0.77	1.01
O <sub>3</sub>	1.25	1.55*	27.53

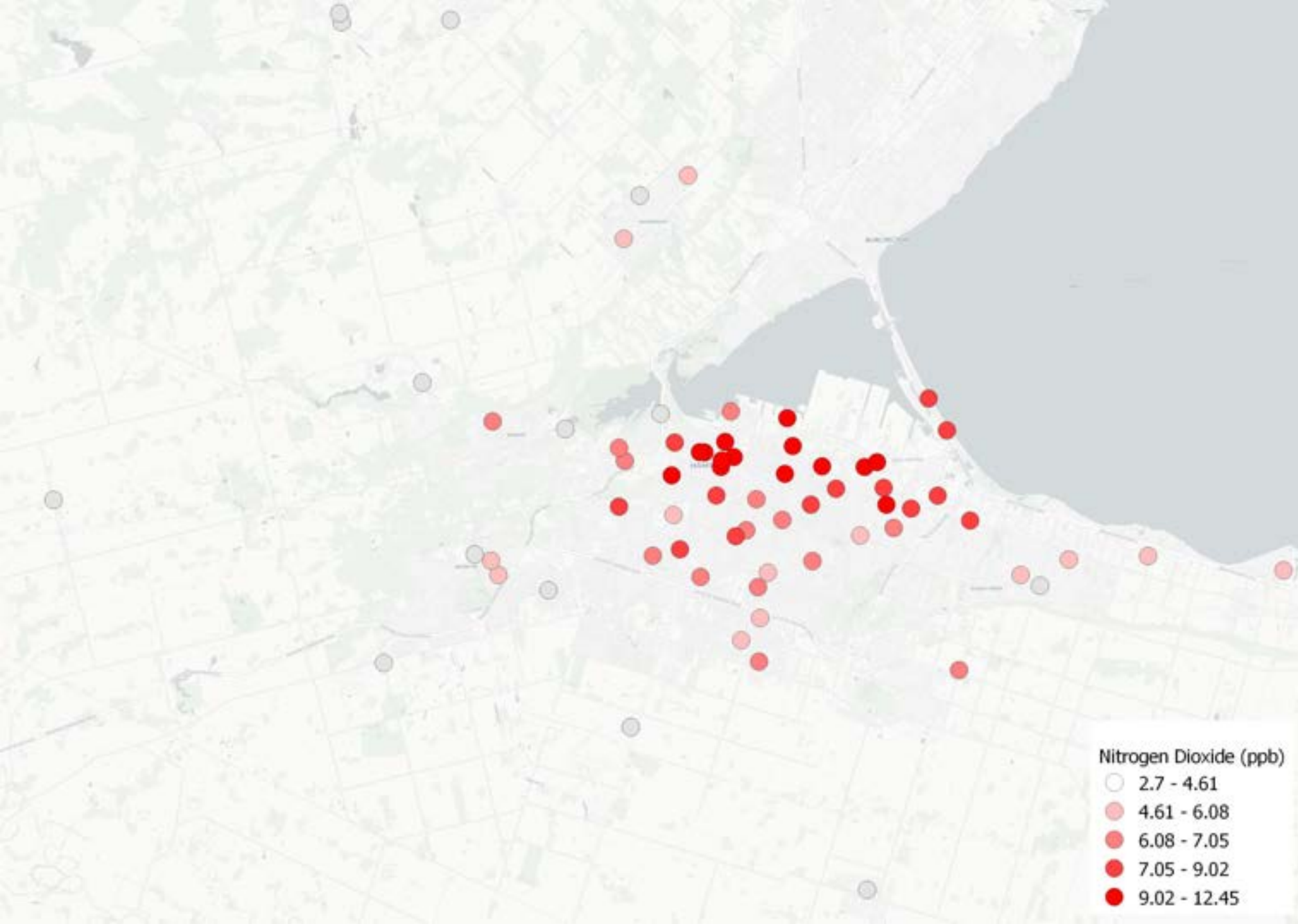


# Collocation

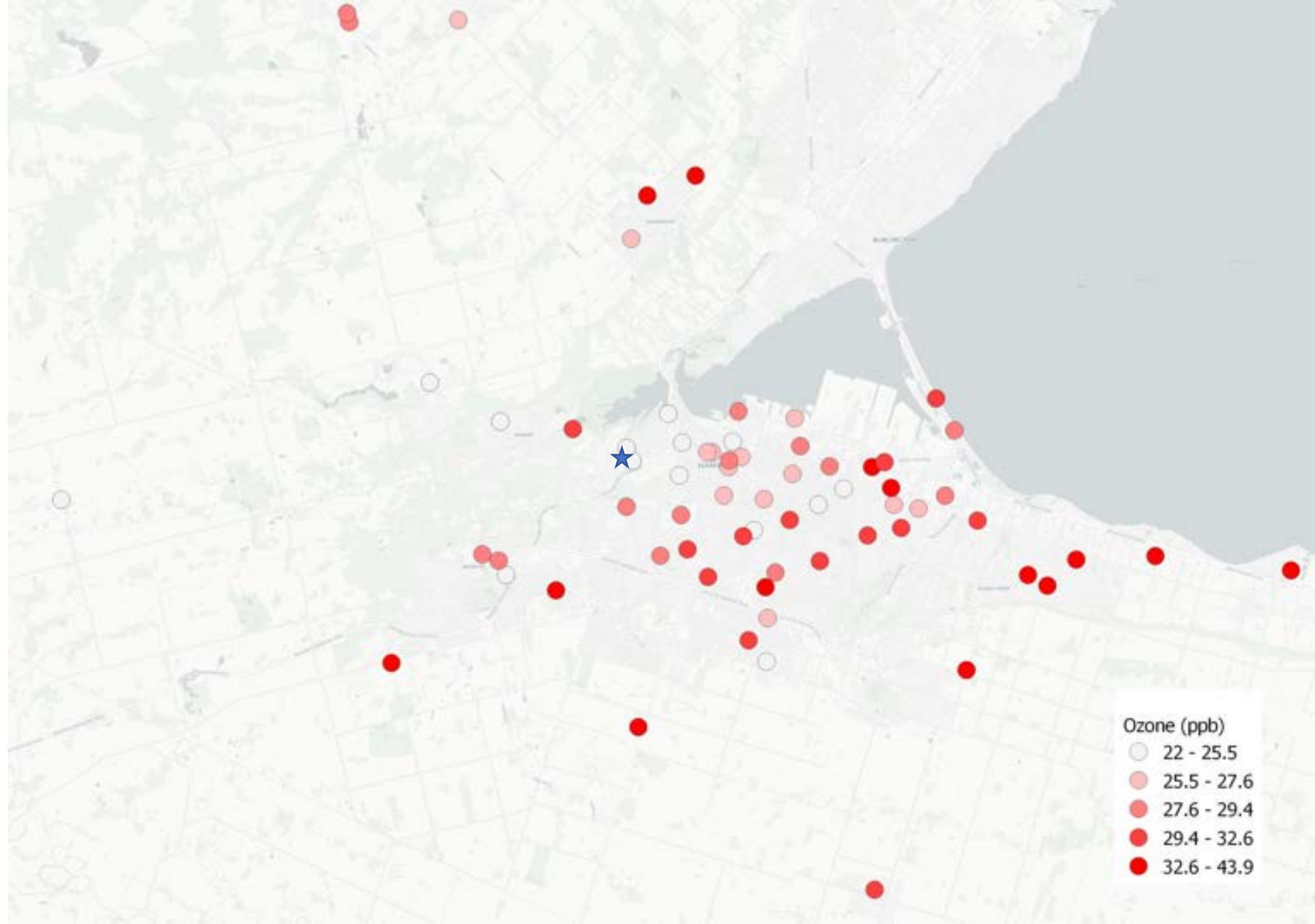
Pollutant	Mean Difference Between Active and Passive Samplers	RMSE when temp <10C	RMSE when temp >10C	Mean Value of Pollutant
NO <sub>2</sub>	2	1.8	1.6	7
NO	3	2.4	1.9	5
NO <sub>x</sub>	3	3.2	2.5	12
SO <sub>2</sub>	1	1.4	0.73	1
O <sub>3</sub>	3	3.4	2.5	28

# Nitrogen Dioxide

Canadian Ambient  
Air Quality  
Standards: 12 ppb



★ Hamilton West 2021  
Annual Average: 25 ppb



★ STN29102  
Beach Blvd:  
5.9 ppb  
(2022 Annual)



# Benzene

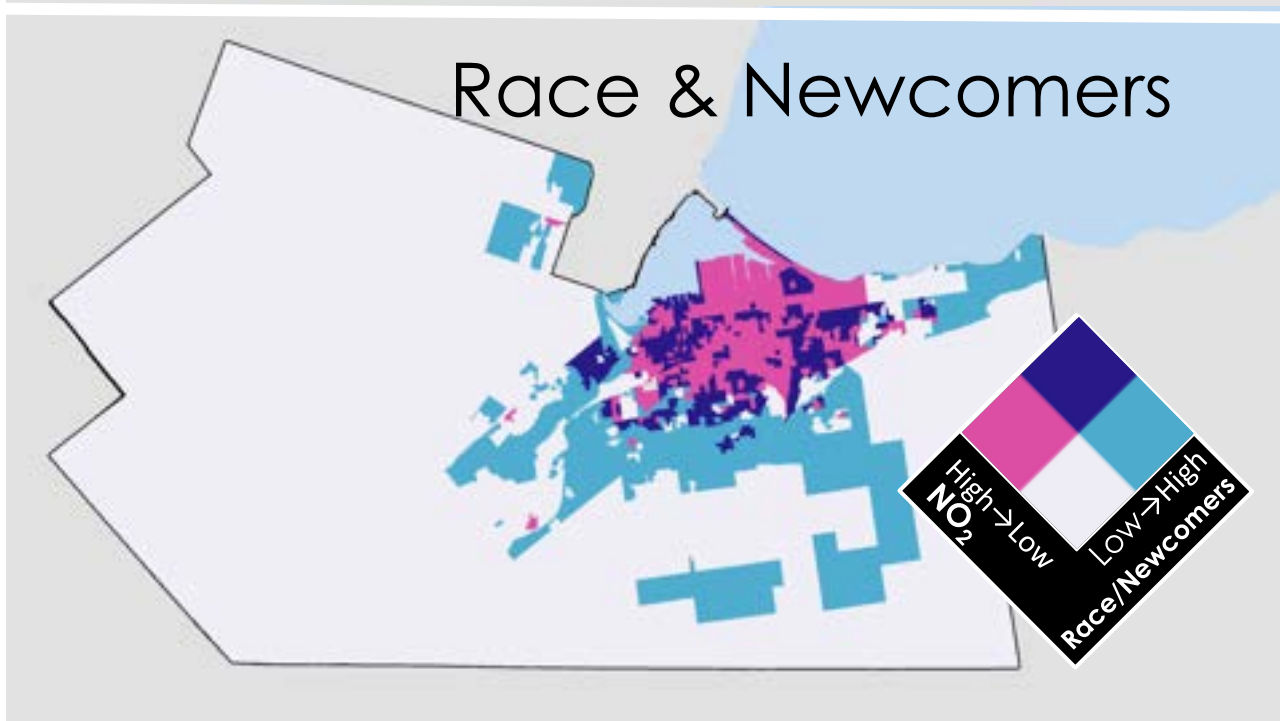
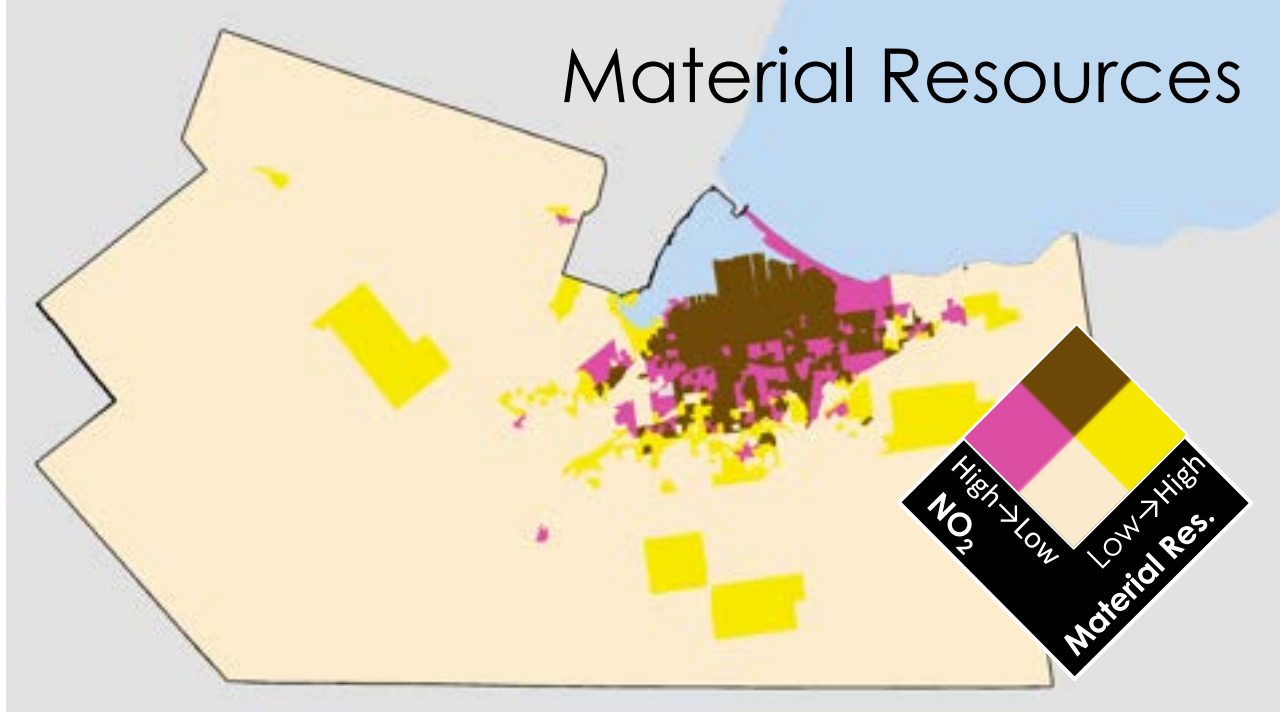
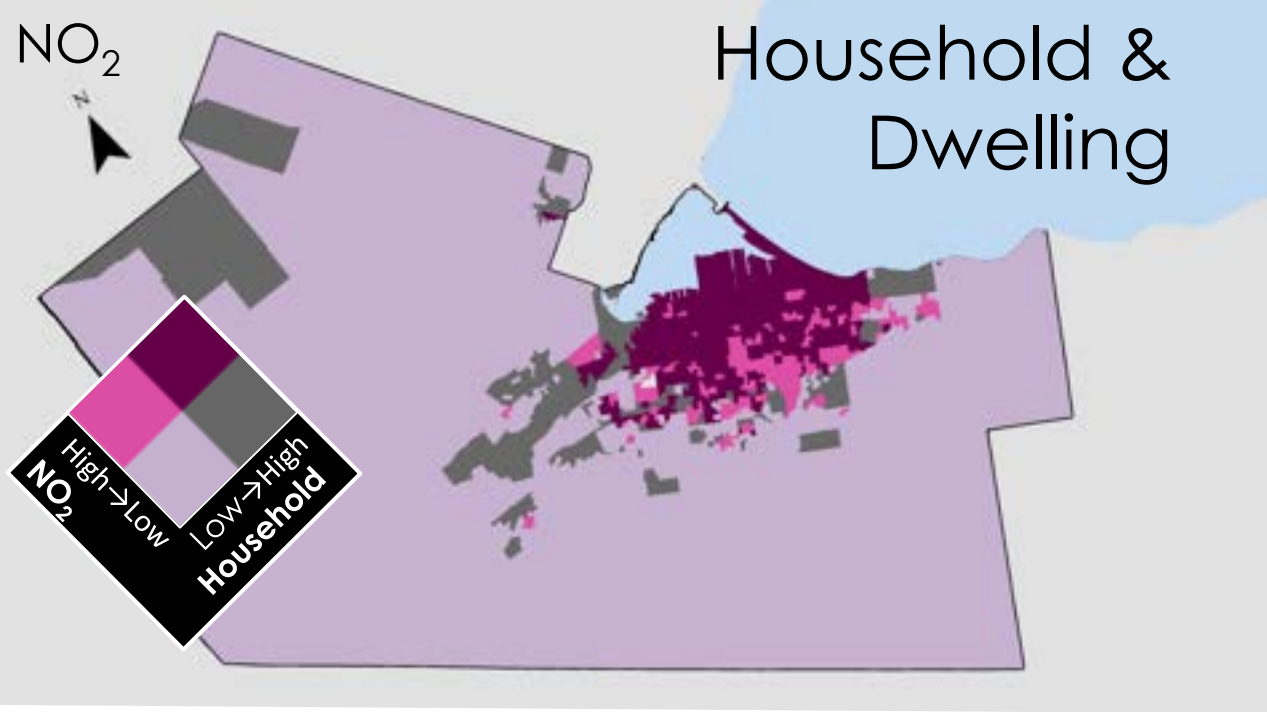
- ▶ Passive sampling technique demonstrated significant internal inconsistencies.
- ▶ Most concentrations observed were within the existing range of measured concentrations in Hamilton
- ▶ Poor confidence in the results.

# Marginalization Index

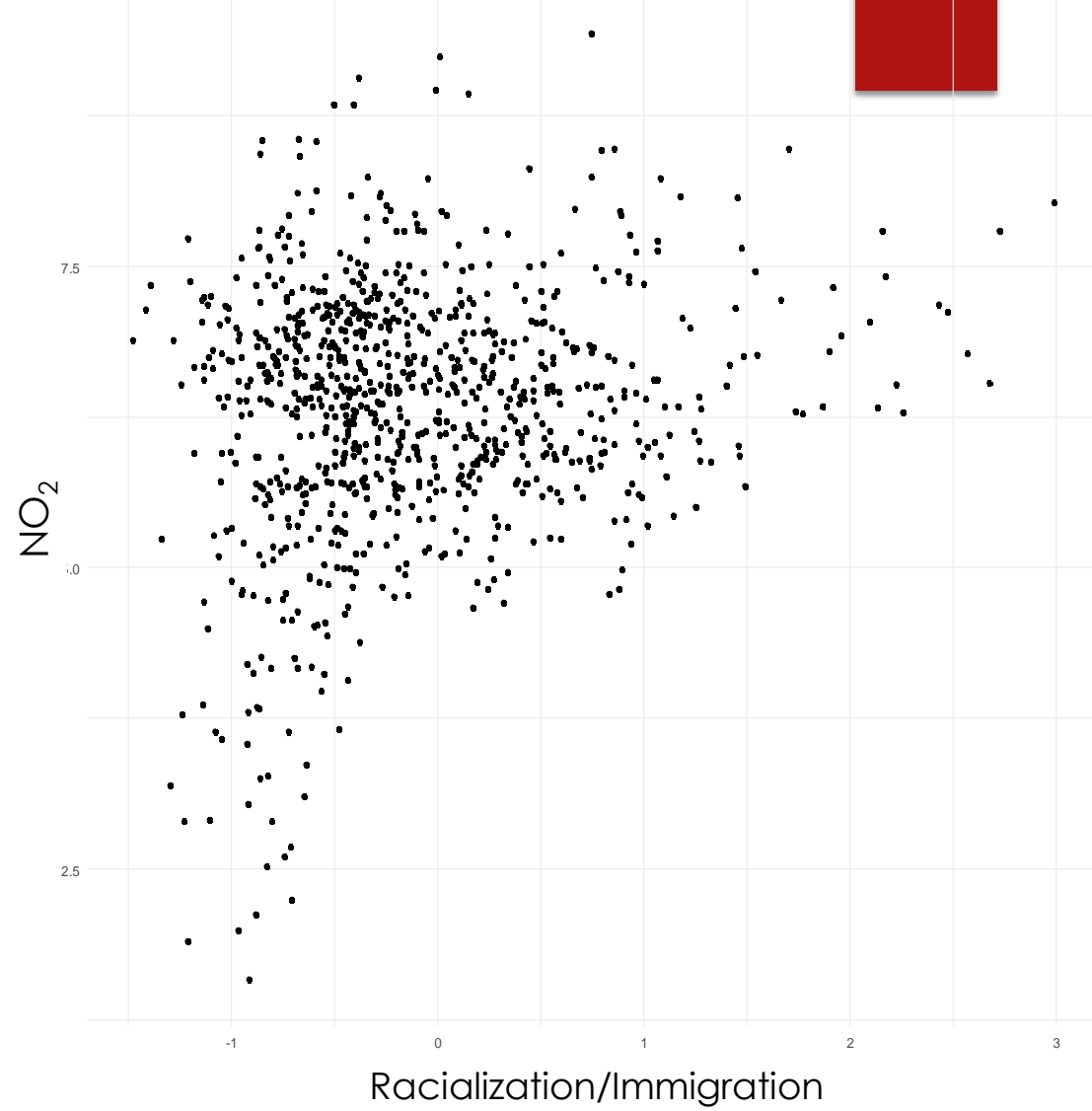
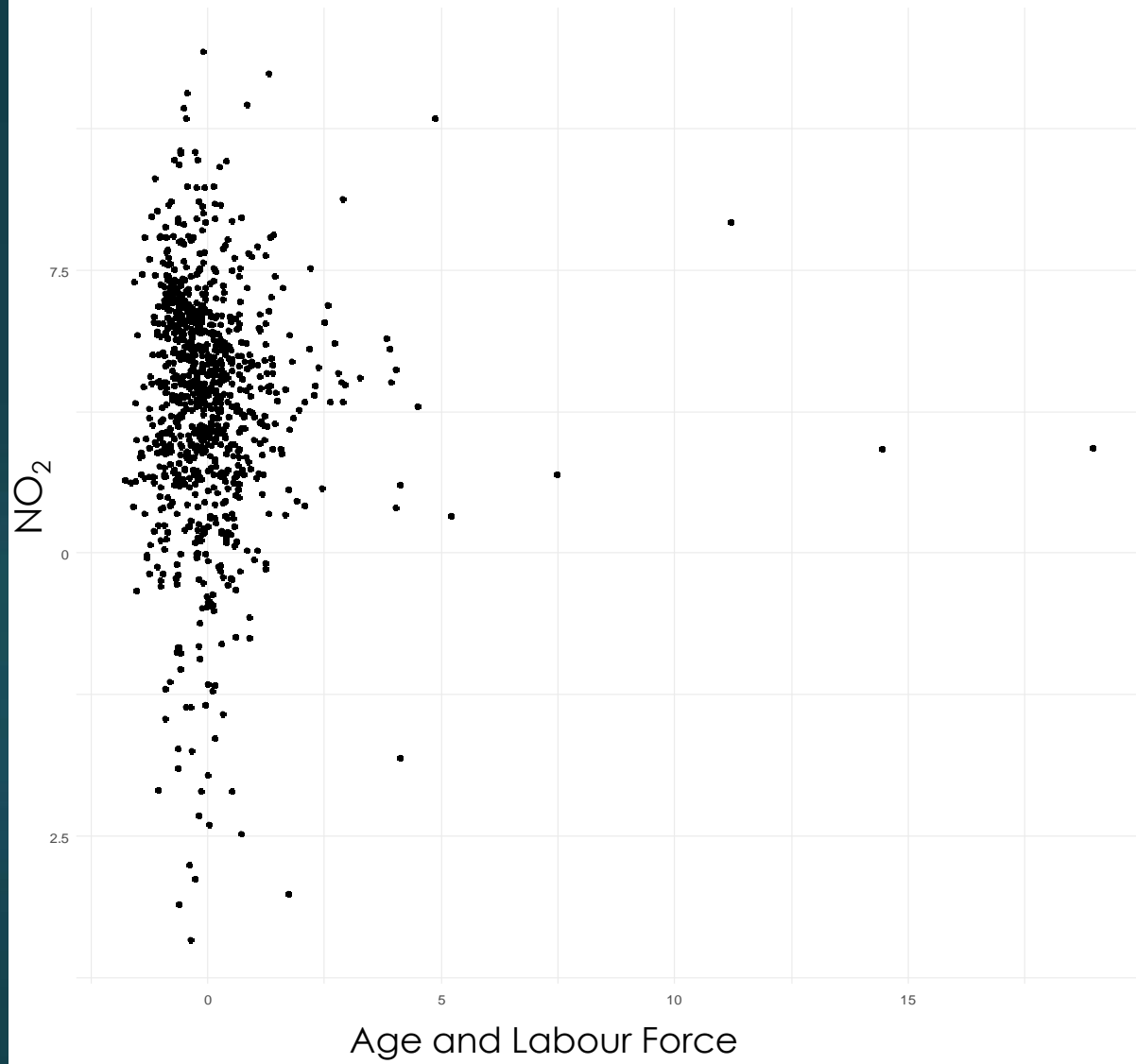
- **Households and dwellings** (previously called 'Residential instability')
  - ▶ Types and density of residential accommodations, and certain family structure characteristics, such as % living alone and % dwellings not owned.
- **Material resources** (previously called 'Material deprivation')
  - ▶ Access to and attainment of basic material needs, such as % unemployment and % without a high school degree.
- **Age and labour force** (previously called 'Dependency')
  - ▶ Describe % seniors (65+), the dependency ratio (the ratio of seniors and children to the population 15-64) and % not participating in the labour force.
- **Racialized and newcomer populations** (previously called 'Ethnic concentration')
  - ▶ Describe % recent immigrants and % who self-identify as a 'visible minority' (as defined by Statistics Canada).



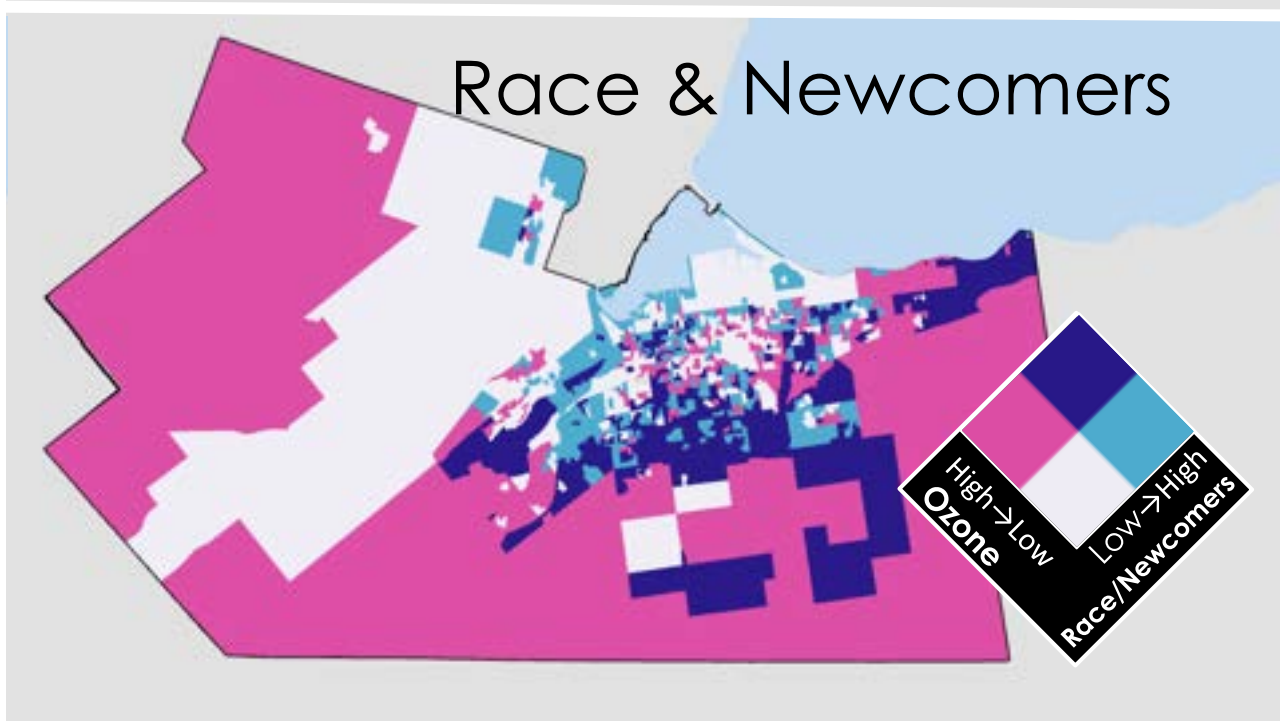
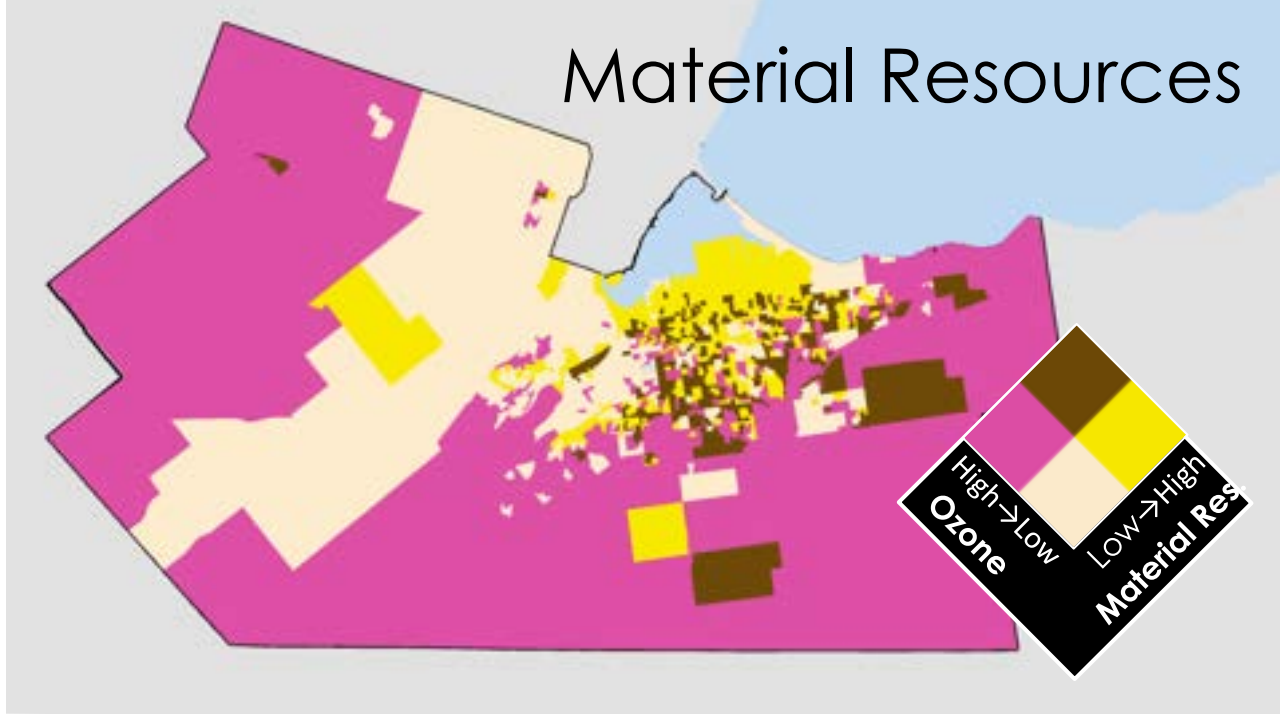
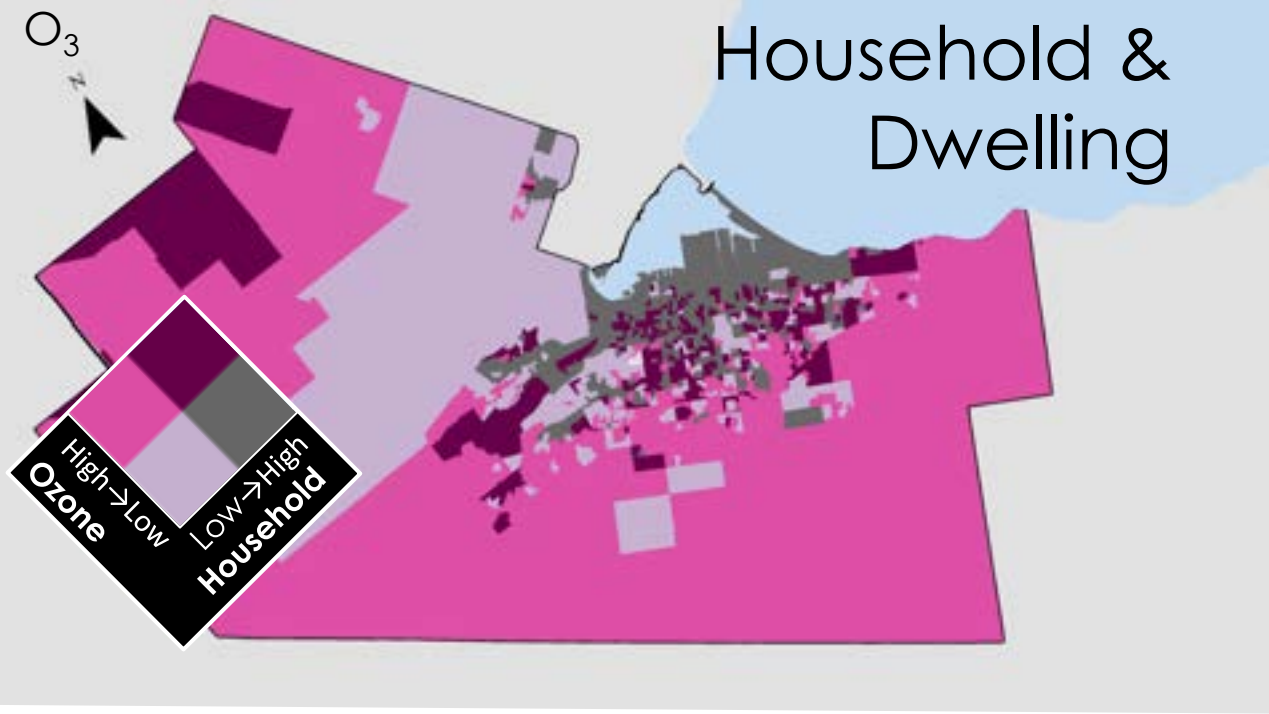
Households and dwellings	Material resources	Age and labour force	Racialized and newcomer populations
Population Living Alone [Proportion of]	Population Without A High School Diploma [Proportion of]	Population Who Are Aged 65+ [Proportion of]	Population Who Are Recent Immigrants [Proportion of]
Population Who Are Not Youth [Proportion of ]	Families With Lone Parents [Proportion of]	Dependency ratio of the population (65+/ 15-64)	Population Who Identify As A Visible Minority [Proportion of]
Persons Per Dwelling [Number of]	Total Income From Government Transfer [Proportion of]	Population Not Participating In Labour Force [Proportion of]	
Apartment Buildings [Proportion of]	population who are unemployed [Proportion of]		
Single/ Divorced Or Widowed Individuals [Proportion of]	Population Who Are Considered Low Income [Proportion of]		
Dwellings That Are Not Owned [Proportion of]	Population Who Live In Dwellings In Need Of Repair [Proportion of]		
Population Who Moved In The Last 5 Years [Proportion of]			MAP Centre for Urban Solutions at St. Michael's Hospital (Unity Health Toronto) and Public Health Ontario.

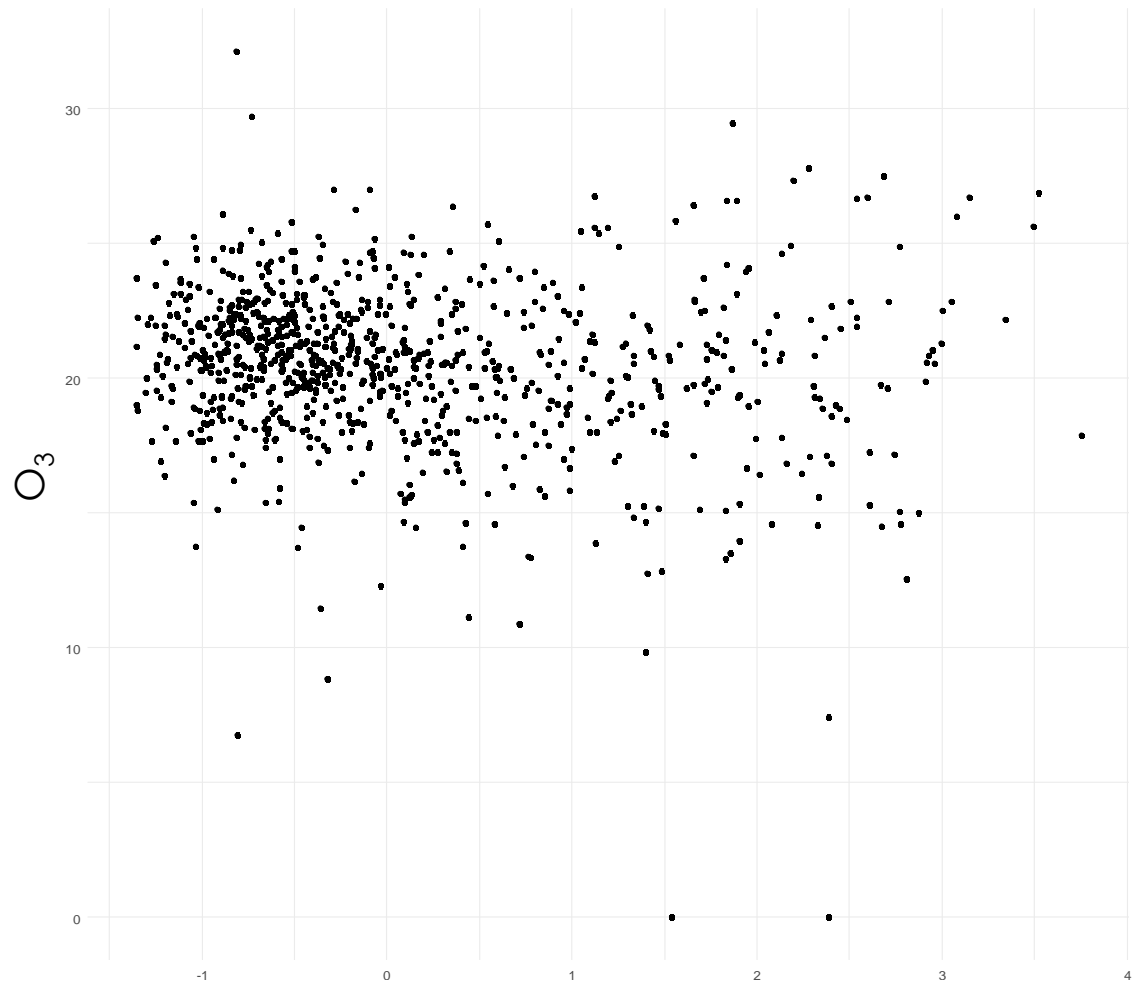




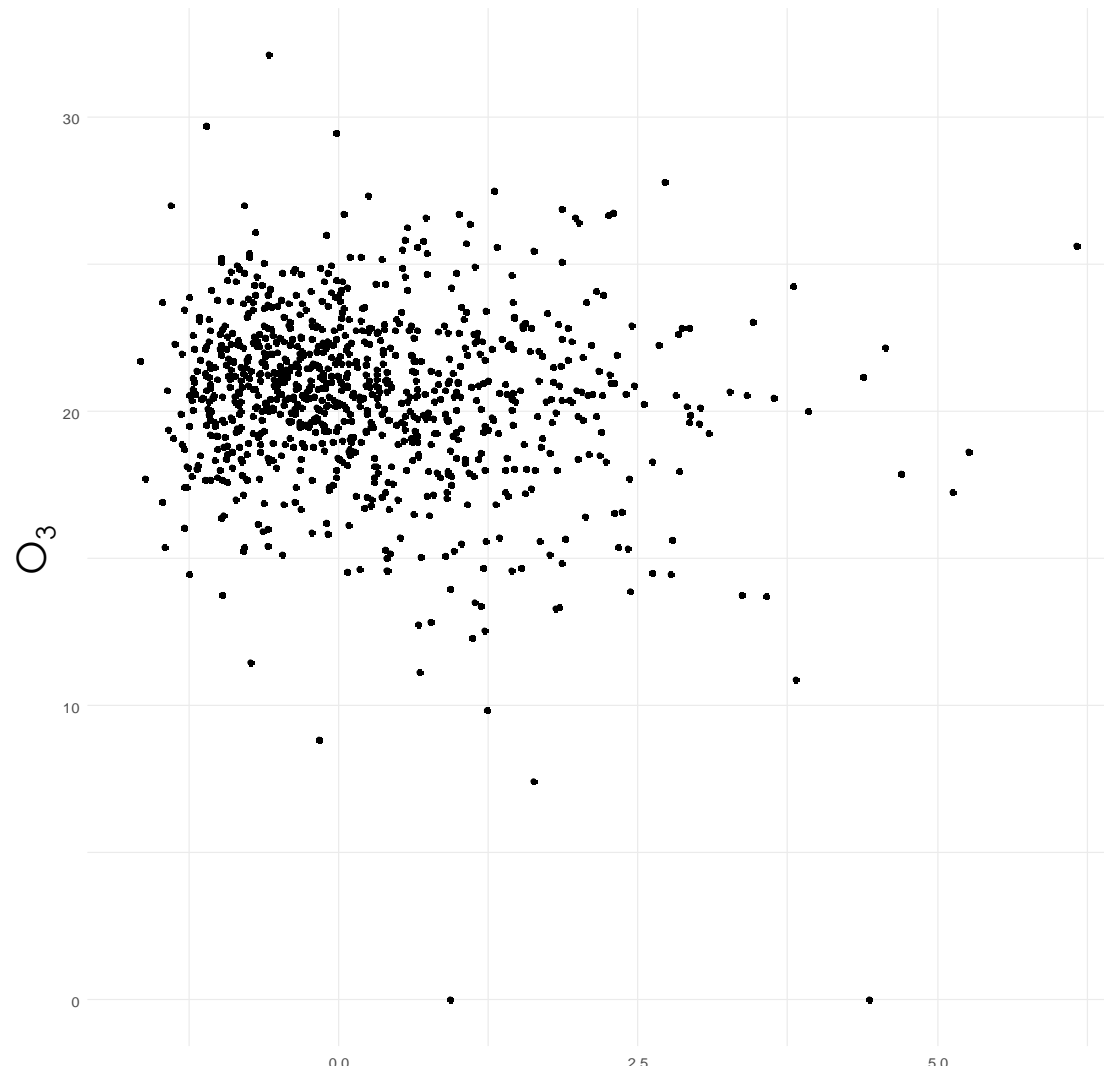






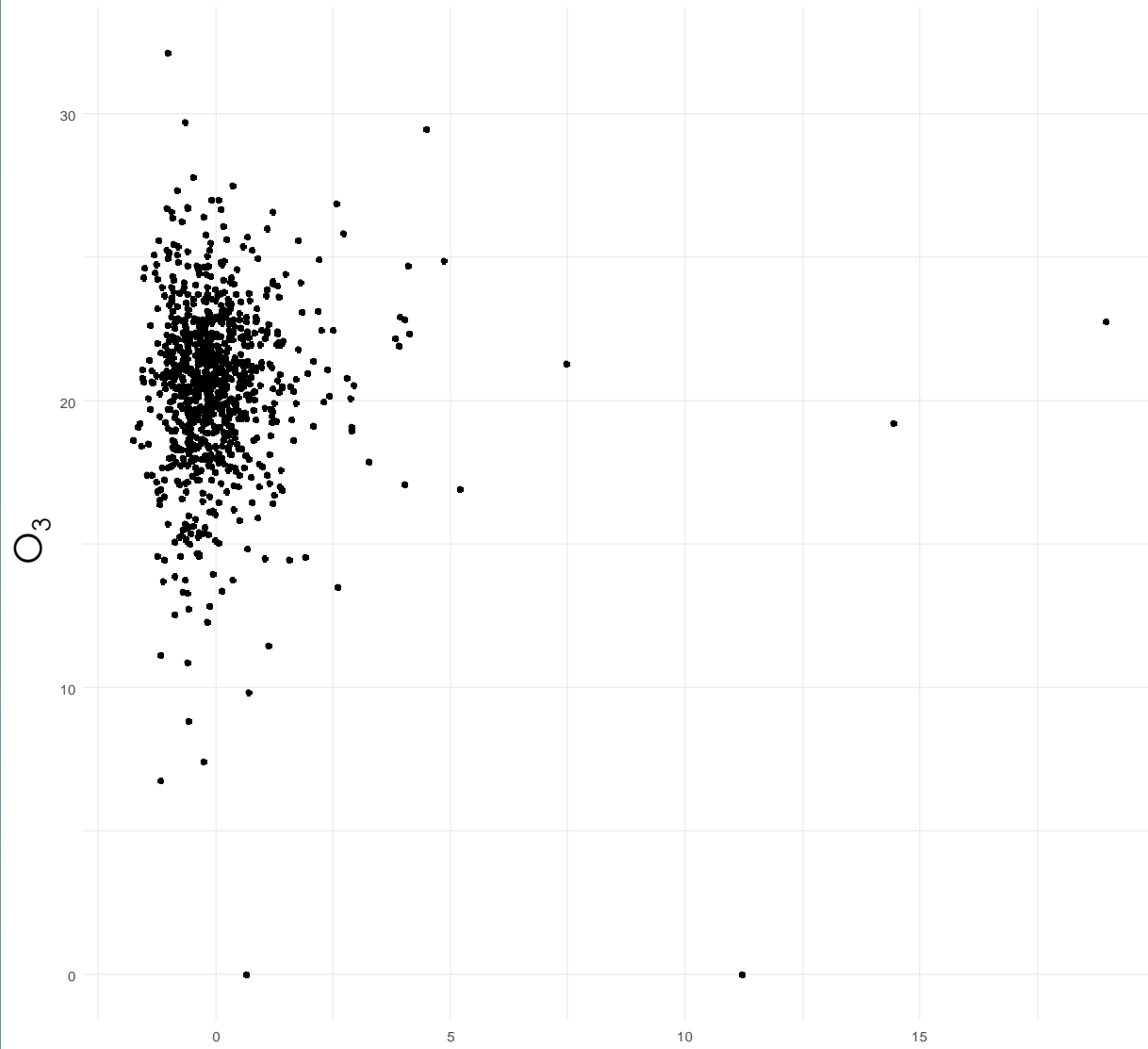


Households and Dwellings

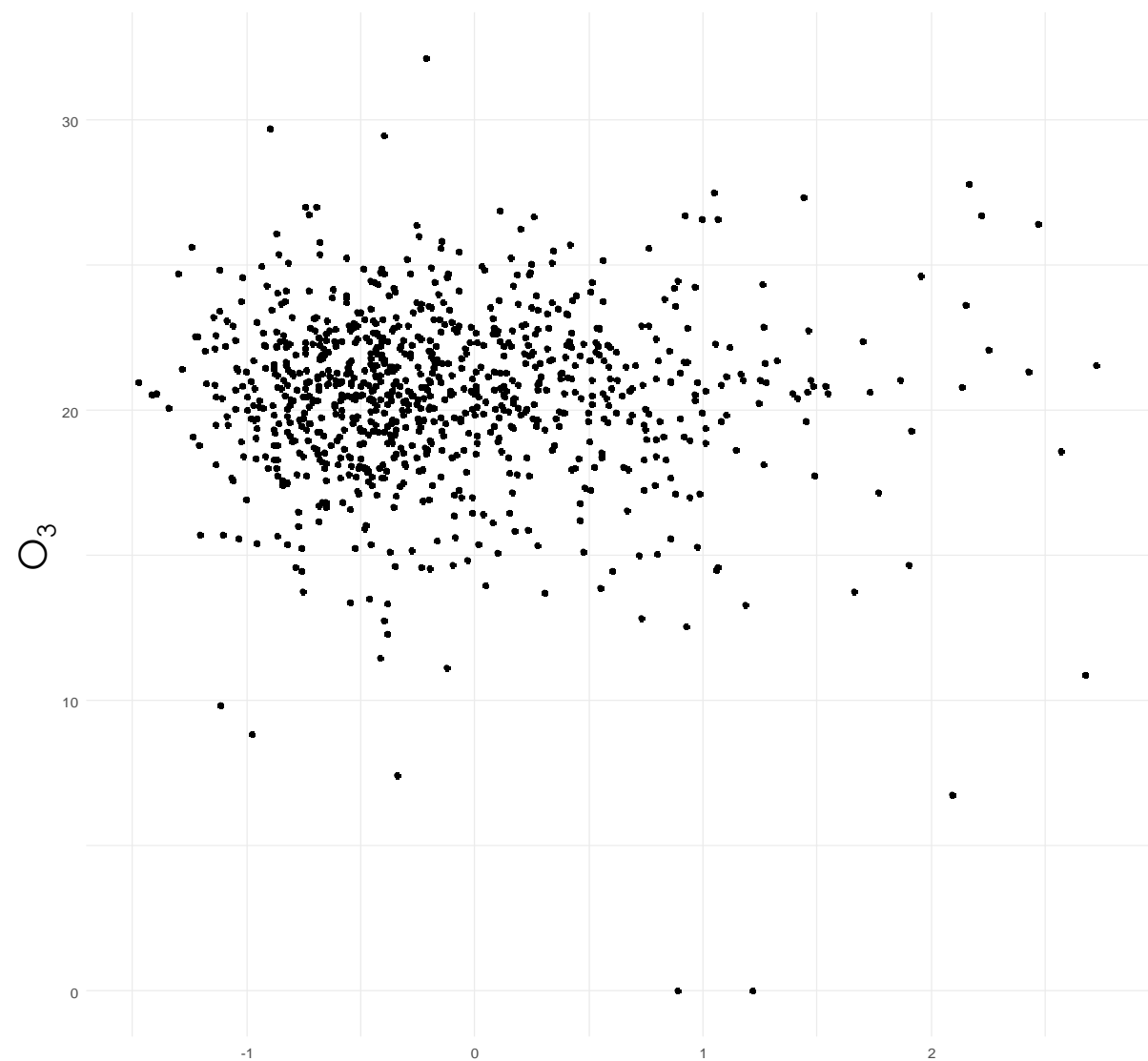


Material Resources





Age and Labour Force



Racialization/Immigration

# Collocated PAH Research

Pollutants being measured:

- PAHs
  - Benzo[a]pyrene is of high interest to Hamilton
- PUF-Pas
  - Global Atmospheric Passive Sampling (GAPS) Network
  - Dr. Tom Harner's Group at Environment Canada
- Passive air samplers equipped with polyurethane foam

Number of Sites: 29

\*\*Collocation Study with Dr. Angelos Anastasopoulos  
- Winter sampling

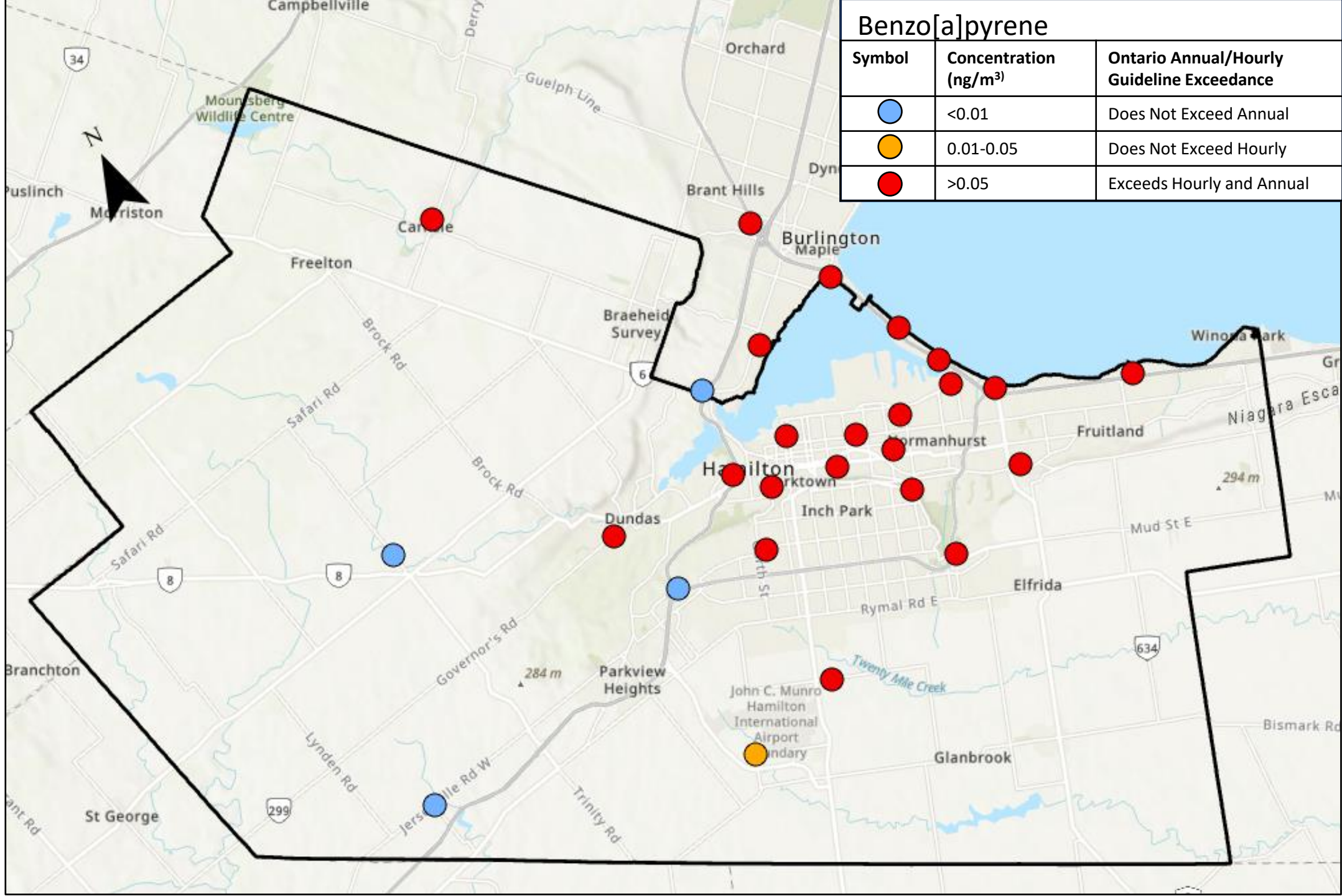


# PAH List

- ▶ **Acenaphthene**
- ▶ **Acenaphthylene**
- ▶ **Anthracene**
- ▶ **Benzo[a]anthracene**
- ▶ **Benzo[a]pyrene**
- ▶ **Benzo[b]fluoranthene**
- ▶ Benzo[e]pyrene
- ▶ **Benzo[g,h,i]perylene**
- ▶ **Benzo[k]fluoranthene**
- **Chrysene**
- **Dibenzo[a,h]anthracene**
- Dibenzothiophene
- **Fluoranthene**
- **Fluorene**
- **Indeno[1,2,3-c,d]pyrene**
- Perylene
- **Phenanthrene**
- **Pyrene**
- Retene

Summer  
Only

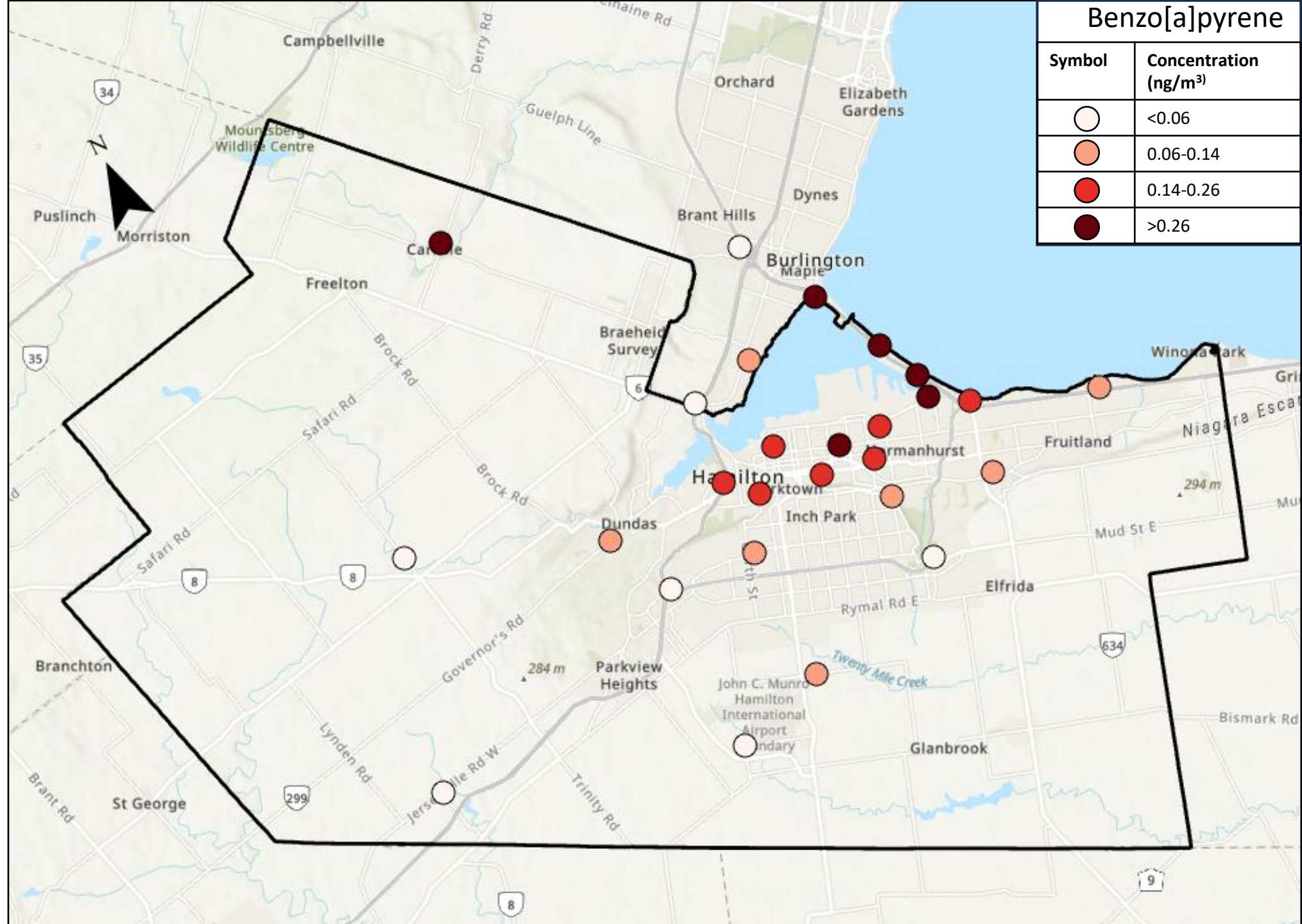
July 18, 2022 to  
Sept 19, 2022





Summer  
Only

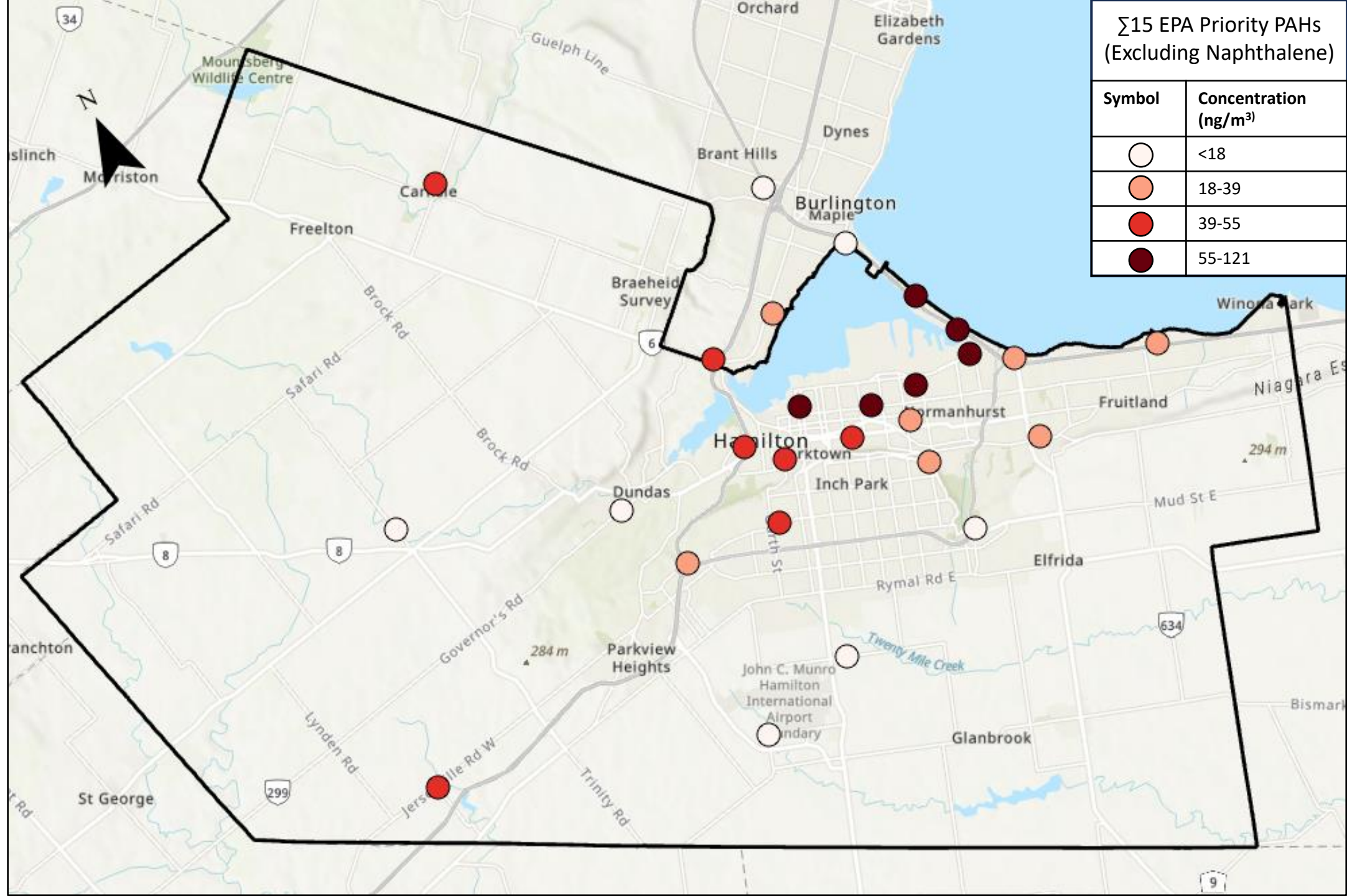
July 18, 2022 to  
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Σ15 EPA Priority PAHs  
(Excluding Naphthalene)

Symbol	Concentration (ng/m <sup>3</sup> )
○	<18
○	18-39
●	39-55
●	55-121



Summer  
Only

July 18, 2022 to  
Sept 19, 2022

## BaP as an Indicator

- ▶ Toxic equivalency factors (TEFs) indicate BaP represents 50% of the toxicity
- ▶ Dibenzo[a,h]anthracene (6%)
- ▶ Benzo[a]anthracene (8%)
- ▶ Benzo[b]fluoranthene (23%)
  - ▶  $r = 0.95$

# Conclusions

- ▶ NO<sub>2</sub> and SO<sub>2</sub> highest around industrial region of city. NO<sub>2</sub> has more dispersal.
- ▶ Ozone is highest in the rural regions; concentrations in those regions are likely underestimated by existing monitoring network.
- ▶ Benzo[a]pyrene is elevated in all locations except rural areas of the city.