Assessing the Co-Burdens of Air Quality and Noise Pollution in Providence, Rhode Island

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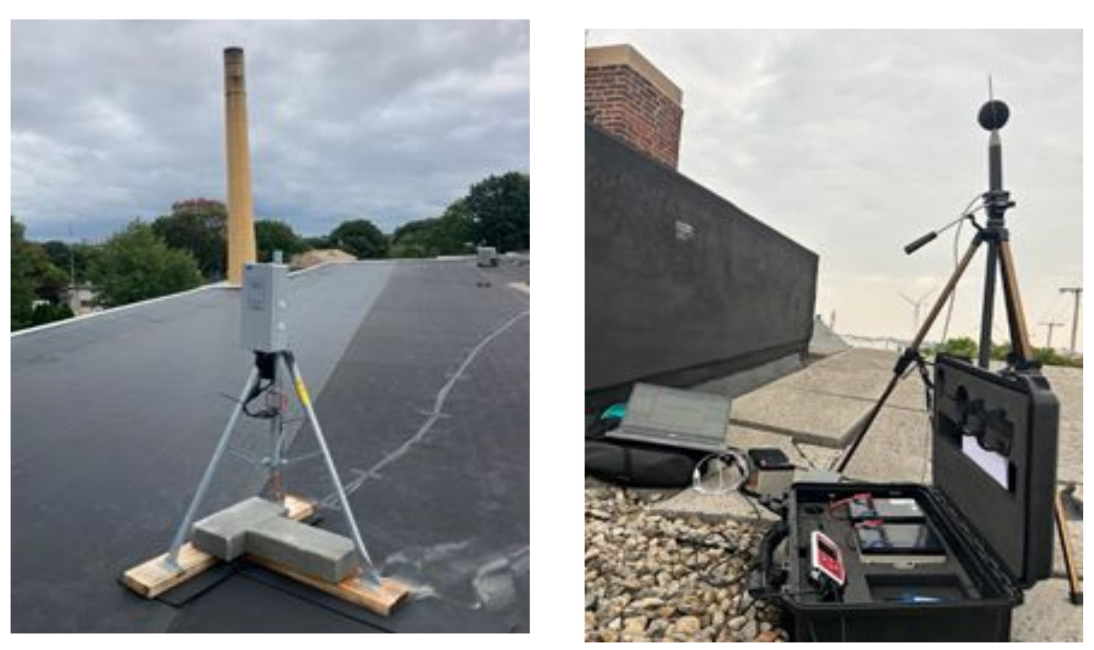
INTRODUCTION

Children and adults encounter a wide range of environmental stressors on a daily basis, including noise and air pollution. This exposure can result in acute and chronic effects on health; outdoor air pollution can lead to cardiovascular diseases, including stroke, chronic obstructive pulmonary disease (COPD), and lung cancer. Noise pollution can cause stress related illnesses, high blood pressure, hearing loss, and sleep disruption. Despite noise and air pollution's shared sources in cities, current research on their correlations is limited and somewhat inconsistent. Yet, understanding the interplay between noise and air pollution is critical for designing appropriate and effective interventions, especially in areas where these co-burdens are high.

The Breathe Providence project is a network of 25 low-cost air quality monitors in Providence, Rhode Island. The sensors are preferentially distributed in communities vulnerable to poor air quality and related health outcomes. The instrumentation, supplied by UC Berkeley's BEACO2N team, measures Carbon Dioxide (CO_2), Nitrogen Oxides (NO_x), Ozone (O_3), Carbon Monoxide (CO), and aerosols ($PM_{2.5}$). at 5-second intervals. **In collaboration with the Community Noise Lab in the School of Public Health, we co-located equipment for 3 months to examine the temporal and spatial distribution of air pollutants and noise at a high resolution.**



Above: Breathe Providence's BEACO2N monitors (left) and the Community Noise Lab's Optimus + Red Class 1 sound level meters (right)

OBJECTIVES

Our research takes a combined environmental and epidemiologic approach to investigate the spatio-temporal relationships between air pollution and noise in Providence neighborhoods. **This intra-city method aims to better understand local environmental co-burdens at a more granular level than government-operated air quality monitoring.**

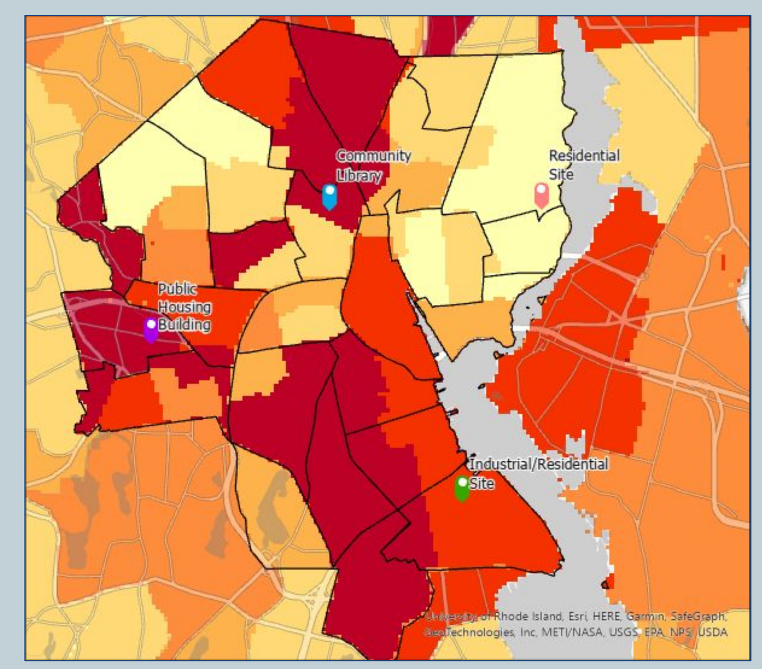
Between May 30th to June 7th, 2023 much of the Northeast was impacted by poor air quality due to transport of smoke from the Canadian wildfires. **The impact of the wildfires is used as a case study to compare "baseline" trends of air quality and noise with a disruptive, network-wide air pollution event.**

METHODS

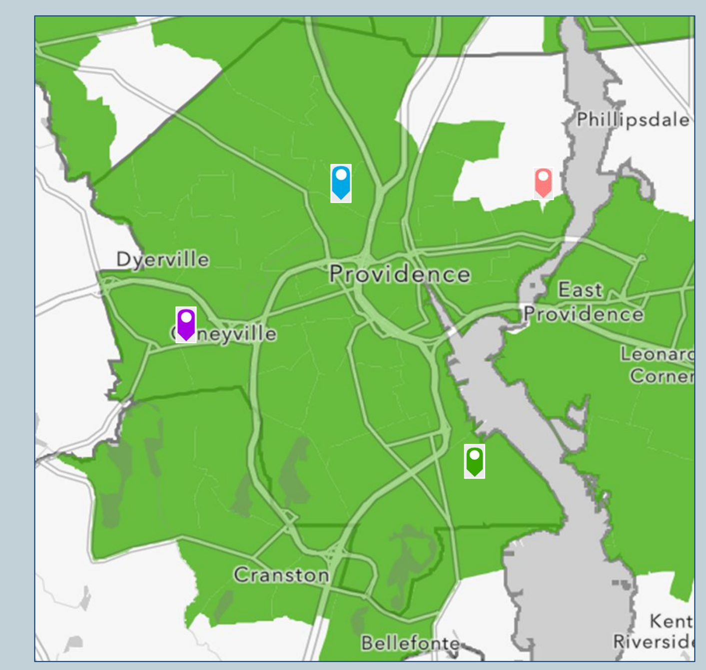
Optimus + Red Class 1 sound level meters were set up along with a BEACO2N node continuously measuring CO_2, NO_x, O_3, CO and $PM_{2.5}$ at four Breathe Providence monitoring sites. Each site had characteristic differences in neighborhood type (industrial, commercial, residential), road proximity to throughfares, and highway proximity.

SITE SELECTION

AQVI Map with Co-located Measurements



EJ Focus Areas with Co-located Measurements

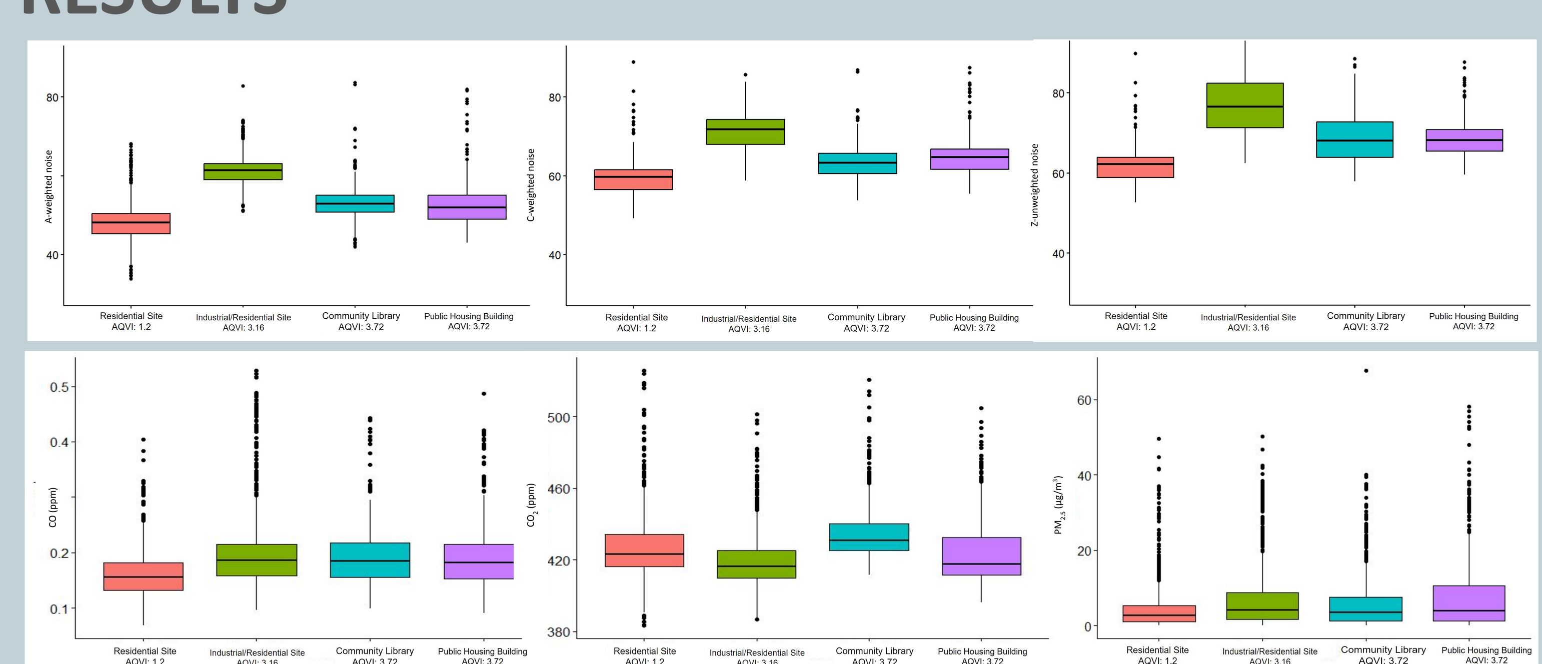


Berg et al., in prepTo inform site selection, we utilized an Air Quality Vulnerability Index (AQVI) (). The index ranks areas from 1-4 based on socioeconomic status, minority status, and household characteristics. We incorporated previously collected noise and air quality data into the ArcGIS Pro ModelBuilder to guide identification of neighborhoods that are most vulnerable to high levels of noise and poor air quality.

Environmental Justice Focus Areas, as defined by the Rhode Island Department of Environmental Management (RIDEM) are census tracts that meet one or more of the following criteria:

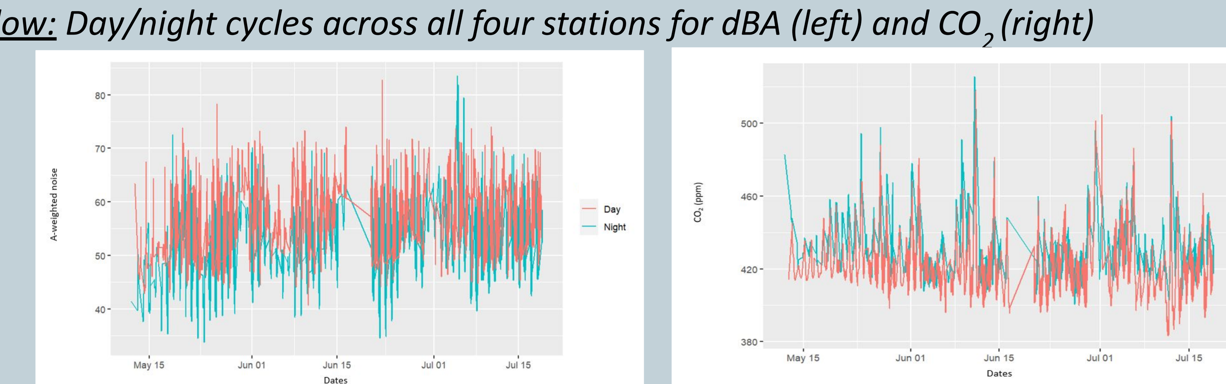
- Annual median household income is <65% of the statewide income;
- Minority population is >40% of the population;
- >25% of the households lack English language proficiency; or
- Minorities comprise >25% of the population and the annual median household income of the municipality in the proposed area does not exceed 150% of the statewide annual median household income.

RESULTS

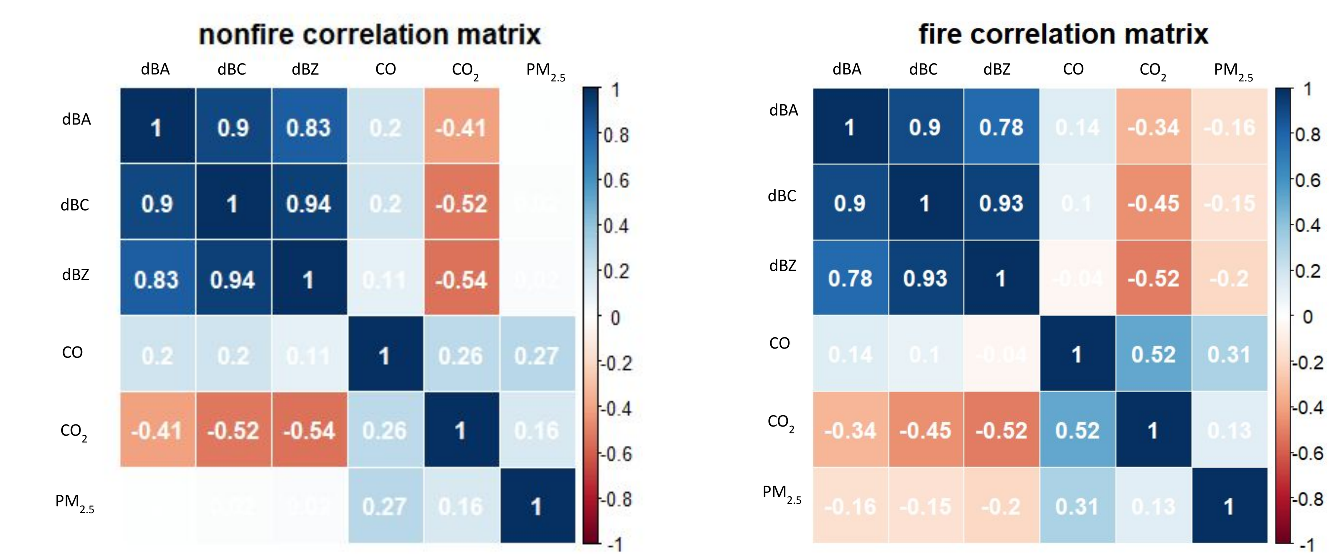


Above: Boxplots showing overall noise and air quality metrics levels across each site with marked 25th, 50th, and 75th percentiles

Below: Day/night cycles across all four stations for dBA (left) and CO_2 (right)

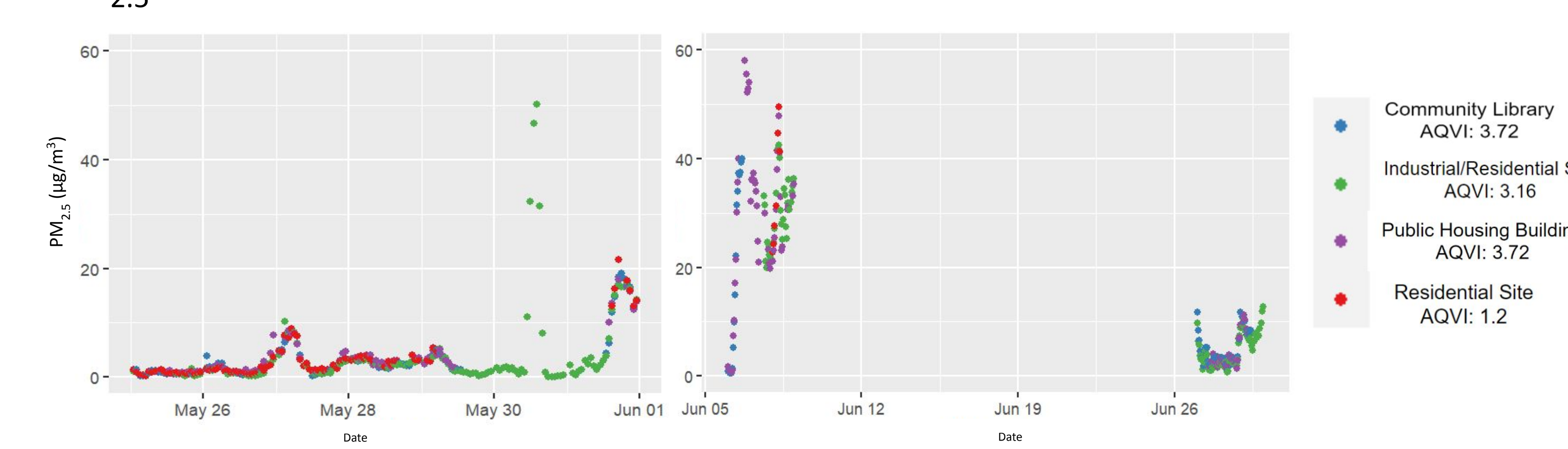


CASE STUDY: CANADIAN WILDFIRES



Above: Correlation matrices for noise and air quality during pre-fire and fire periods

- We see a strong, positive correlation (0.78 to 0.94) between the noise levels and a moderate, positive correlation (.16 to .52) between air pollutants
- During the wildfire period, we see a more dampened relationship between CO and CO_2 with noise, but a slightly stronger negative correlation between $PM_{2.5}$ and the noise metrics.



Above: $PM_{2.5}$ concentrations during pre-fire (left) and fire (right) periods across sites

- Comparing nonfire impacted days to fire impacted days across each of the four sites, we saw
  - little change (roughly +/- 1 db) in magnitude of the three noise metrics
  - significant increases in CO and $PM_{2.5}$ concentrations across all sites
  - decreases in CO_2 across three vulnerable sites (high AQVI) but an increase at the least vulnerable site (low AQVI)
- Overall, the industrial/residential site generally had higher noise and $PM_{2.5}$ levels prior to the wildfires. However, during the fire period, the residential site exhibited more elevated air pollution levels, while still remaining the site least affected by noise pollution.

NEXT STEPS

Moving forward, we would be interested to:

- Incorporate other air pollutants, particularly O_3 and NO_x
- Contextualize noise data in broader framework of air quality data
- Understand additional co-burdens in defined EJ Zones
- Examine peaks and variability in the data from a health perspective

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