Influence of Traffic on Local Air Quality in Boston, MA: A Community-University Partnership

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Introduction

- In urban areas, exposure to traffic-related air pollutants is an important issue
- Living near truck routes or major roadways has been associated with increased rates of asthma and hospitalizations; this is greater among low-income individuals
- Traffic-related exposure can be an environmental justice issue because urban low-income populations frequently live near major roadways
- Concentrations decrease rapidly as a function of distance from roadway

Specific Aims

- Evaluate spatial and temporal patterns of traffic related air pollutants in an urban environment
- Determine which traffic parameters relate to elevated concentrations of air pollutants
- Inform environmental justice concerns and transportation planning in the neighborhood

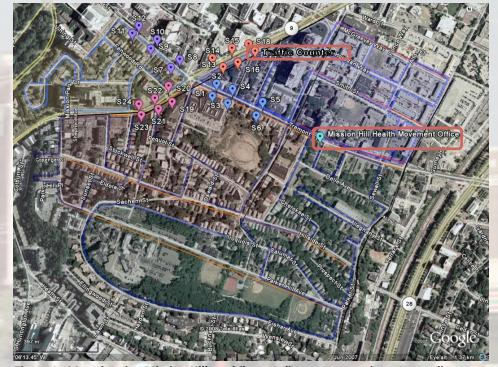


Figure 1: Map showing Mission Hill, mobile sampling routes, stationary sampling sites, traffic counters, and the Mission Hill Health Movement (MHHM) Office.

Methods

Fixed Site

- Air monitoring equipment at MHHM Office on Tremont St.
  - $PM_{2.5}$, ultrafine particles, black carbon (BC), PAHs, and nitric oxide
  - Wind speed & direction, temperature, relative humidity
- Traffic counters
  - One on Tremont St. at MHHM collecting volume, axle type, and speed in both directions
  - One on Huntington Ave. collecting volume traveling from intersection of Tremont and Huntington

Mobile Monitoring

- Three teams of two high school students with GPS devices continuously monitoring $PM_{2.5}$, ultrafine particles, and PAHs, doing source characterization for two 2-hour shifts per day (morning, afternoon)
  - Each shift: one hour stationary, one hour mobile
- Mobile monitoring – forward and reverse on 4 routes through neighborhood, and on 3 sets of parallel routes
  - Laying GPS waypoints for idling vehicles, smokers, and recording abnormal activity
- Stationary monitoring at 25 sites (Figure 1)
  - Idling vehicles, traffic backups, traffic flow, diesel/non-diesel counts, smokers, and abnormal activity

Statistical Methods

- Fixed-site concentrations regressed against available traffic variables, temperature/RH, wind speed/direction relative to roadways
- Mobile/stationary concentration models: above terms + distance from each of two major roads (Huntington, Tremont/Francis)

Results and Discussion

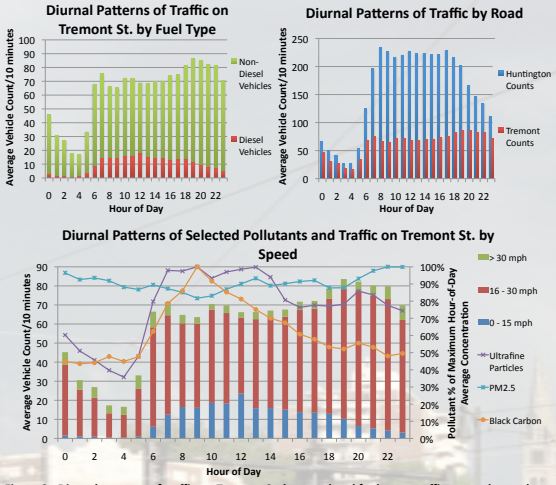


Figure 2: Diurnal patterns of traffic on Tremont St. by speed and fuel type, traffic counts by road, and diurnal patterns of ultrafine PM, $PM_{2.5}$, and BC. Pollutants are represented as percent-of-maximum hourly concentrations to show relative trends.

Fixed Site

- Significant diurnal variability of ultrafine PM, BC, and all traffic parameters
  - Atypical traffic pattern with midday plateaus in slow-moving cars and diesel vehicles, total vehicle counts steady mid-day and highest in evening
  - Mid-morning peak in BC
  - Mid-day peak in ultrafine PM with slight increase with evening rush hour
  - Little diurnal variability in $PM_{2.5}$
- Concentrations of pollutants were significantly related to traffic parameters, with different parameters influencing different pollutants (Table 1)
- Regression model results unchanged by use of AR1 correlation structure
- Concentrations of BC and ultrafine PM, but not $PM_{2.5}$, significantly higher under downwind conditions for all models

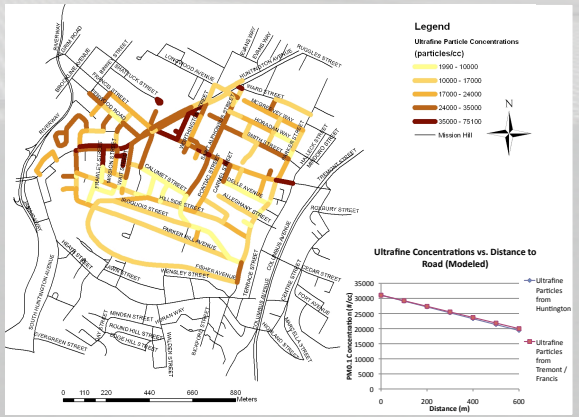
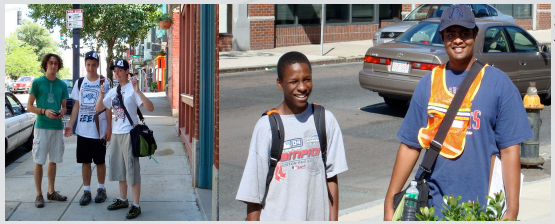


Figure 3: Map showing mean ultrafine particle concentrations by road segment throughout Mission Hill, along with the application of the regression model in Table 1 to illustrate the relationship between ultrafine particle concentrations and distance from roadway.



Sampling team on a typical day of sampling

Table 1: Results of regression models showing traffic parameters with significant positive effects on the various pollutants. Fixed site models were adjusted for temperature, humidity, wind direction and wind speed. Stationary models were adjusted for temperature, humidity, and distance to the other road. The mobile model was adjusted for temperature and humidity.

		Ultrafine Particles (#/cc)		$PM_{2.5}$ (mg/m³)		Black Carbon (ng/m³)	
Fixed Site Models							
		Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Mission Hill Health Movement Office	Vehicles 0 - 15 mph	93.2	<0.001			29.0	<0.001
	Vehicles > 16 mph			5.9E-05	0.0021		
	Vehicle Count	8.7	0.032	4.1E-05	0.0215		
	Diesel Vehicle Count	97.0	<0.001			39.8	<0.001
	Non-Diesel Vehicle Count			5.4E-05	0.0182		
Stationary Monitoring Models							
		Ultrafine Particles (#/cc)		$PM_{2.5}$ (mg/m³)		PAHs (ng/m³)	
		Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Huntington	Traffic Flow						
	Diesel Count			3.1E-03	<0.001		
	Non-Diesel Count	310.0	0.0045				
	Total Count	329.0	0.0015				
	Traffic backup to sampling site						
	Presence of idling vehicle						
Tremont/ Francis	Traffic Flow						
	Diesel Count	5607.8	0.0015				
	Non-Diesel Count			4.2E-04	<0.001	3.9	<0.001
	Total Count	369.0	0.048	4.2E-04	<0.001	2.7	<0.001
	Traffic backup to sampling site	5702.8	0.0026				
	Presence of idling vehicle	9229.9	0.010				
Mobile Monitoring Model							
Distance	Distance from Tremont/Francis	-18.5	< 0.001				
	Distance from Huntington	-19.5	< 0.001				
	Significant and positive relationship	No relationship or negative relationship					

Mobile Monitoring

- Concentrations of ultrafine particles decrease as distance from each major road increases (approximately 1000 particles/cc per 50 m); $PM_{2.5}$ showed no significant gradient
- Total vehicle count was predictive of an ultrafine particle concentration increase on both roads. Traffic backups and idling vehicles were predictive of increases only on Tremont/Francis St., and traffic flow characterization was not predictive.
- Terms for wind speed/direction in mobile models lacked statistical significance and interpretability and were not included

Environmental Justice

- Community-based monitoring using high school students as the field staff was successful and produced scientifically viable results, illustrating potential "hot spots" within an urban community
- The Mission Hill community was informed of the study and its findings through multiple outreach efforts
- The results can be used to inform transportation planning and help Mission Hill Health Movement with advocacy efforts

Acknowledgements

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