Quantifying the Impacts of Vegetation on Air Quality and Health

Air quality measurements to support:

Green Heart Louisville

Louisville Superfund Research Program

Pradeep Prathibha and Jay Turner

Department of Energy, Environmental and Chemical Engineering

Washington University in St. Louis

St. Louis, Missouri, USA

St. Louis Area Monitoring Agencies Meeting

St. Louis University

May 23, 2018

Three Synergistic Projects

Green for Good / St. Margaret Mary (SMM) School (PI: Turner)

Quantify pollutant removal by a near-road engineered vegetative buffer (continuation of FHWA/DOT through 08/18)

Green Heart Louisville (PI: Bhatnagar)

Assess impact of increasing neighborhood greenspaces on cardiovascular health

Louisville Superfund Research Program (PI: Srivastava)

Project 4: Characterizing Urban- and Finer-Scale Spatial Variability for Select VOC Superfund Compounds (PI: Turner)

Green for Good (G4G)/SMM Pilot Study

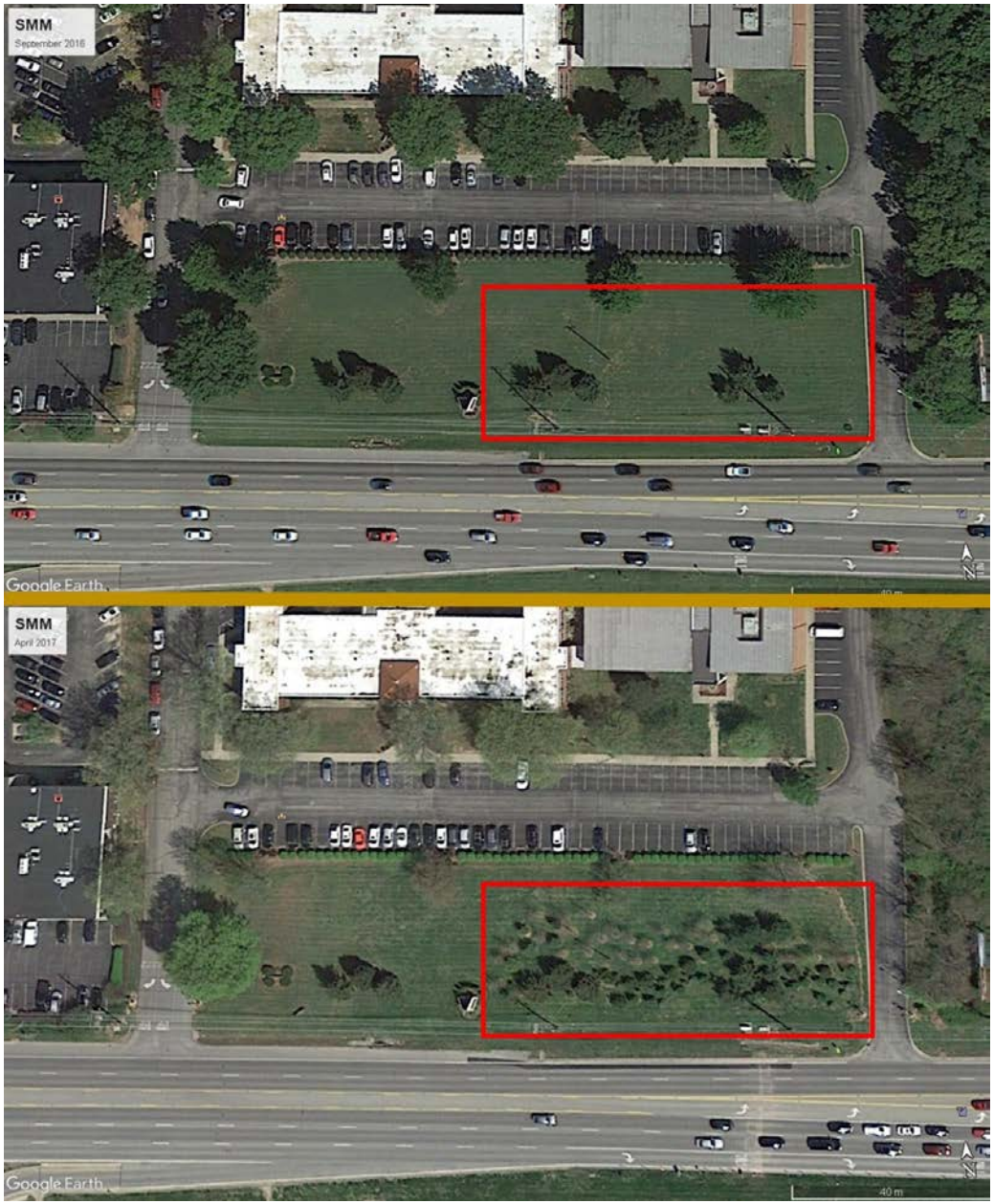
Objective: Quantify pollutant removal by near-road engineered vegetative buffer

Passive sampling: Two-week monitoring (monthly)

Simultaneous ultrafine particle (UFP) measurements at multiple sites

High-fidelity computational fluid dynamics (CFD) modeling (Max Zhang group, Cornell U.)

Engineered vegetative buffer - Installed Fall 2016



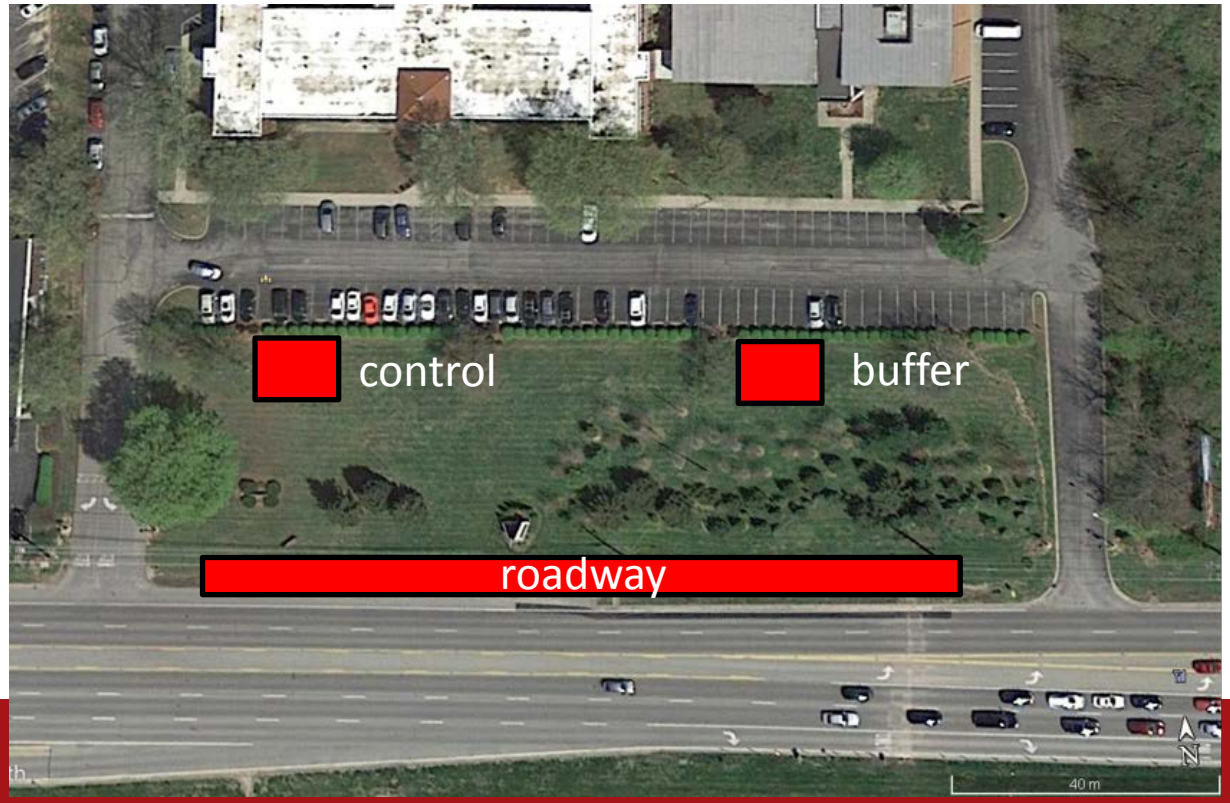
Passive sampling: Oxides of Nitrogen (NO_x)

- Pilot Study (through Summer 2017)

  Periodic, nominally one-week integrated samples

- Oct. 2017 – Aug. 2017

  Two-week integrated samples collected once a month



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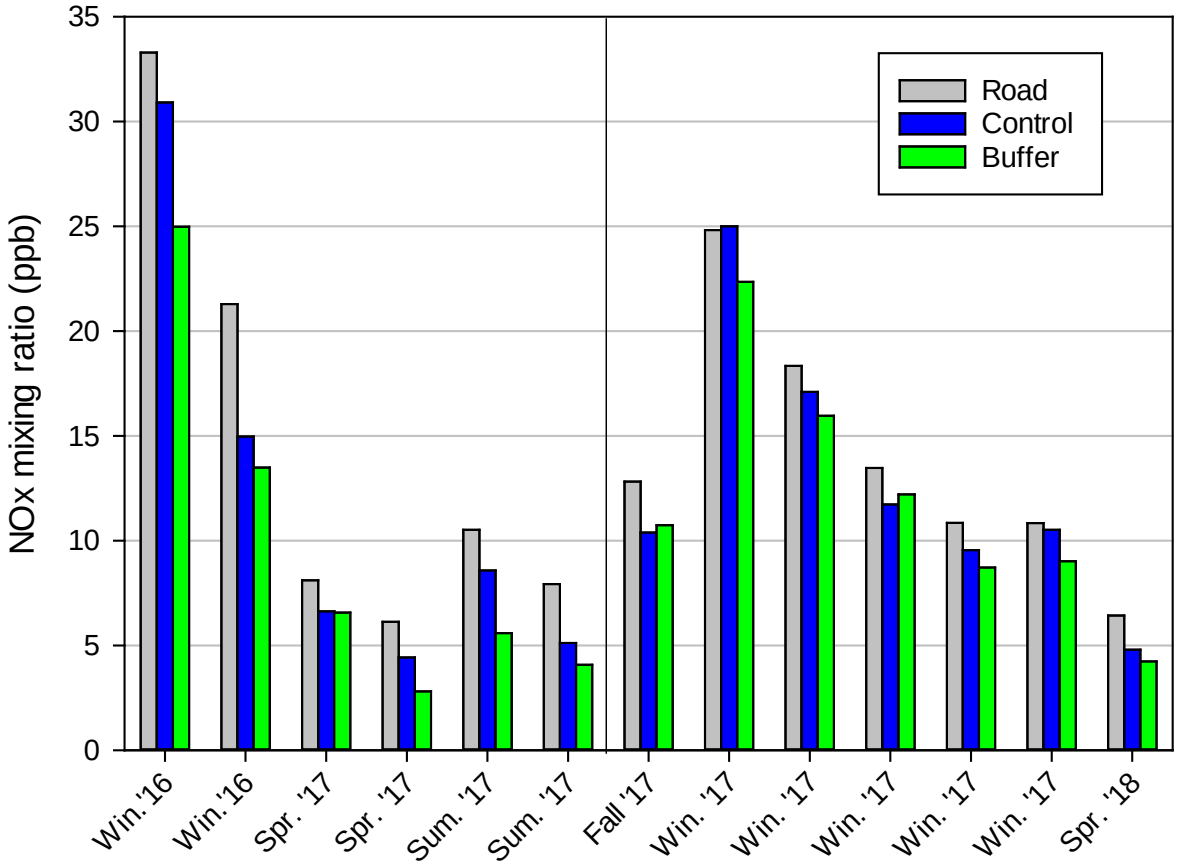


- Monotonic decrease: Road > Control > Buffer (8/13)
- Control > Buffer (11/13)

Passive sampling: Oxides of Nitrogen (NO_x)

Seasonality of reduction

Winter	Spring/Summer
Roadside NO_x: 22 ppb	Roadside NO_x: 6 ppb
Mean: +9% (N = 6)	Mean: +23% (N = 4)
Mean reduction: 1.9 ppb	Mean reduction: 1.5 ppb

- Similar pattern for NO_2

Passive sampling: Oxides of Nitrogen (NO_x)

Implications: Evidence suggests buffer removes oxides of nitrogen

- NO_x – percentage reduction highest in summer
  – absolute reduction highest in winter
- NO_2 – reduction < 1 ppb at this site

NOTE

- Measurements are conducted a few meters behind the buffer
- Reductions will diminish with increasing distance

Green for Good (G4G)/SMM Pilot Study

Next:

- Continue passive sampling through Aug. 2018
  - Run-to-run differences

- Three multi-day high time-resolution sampling
  - Simultaneous UFP measurements
  - Aerodyne Arisense AQ Sensor Systems

    NO_x, CO, total oxidants, CO_2, PM (0.4 – 17 microns)

- CFD modeling of the buffer by Zhang Group (Cornell U.)
  - Current: Developing methods to develop leaf area density

Green Heart Louisville

GREEN HEART PROJECT

University of Louisville
The Nature Conservancy
Institute for Healthy Air, Water, and Soil
City of Louisville (various agencies)

Cornell University
Hyphae Design Lab
US Forest Service
Washington University in St. Louis

Green Heart Louisville

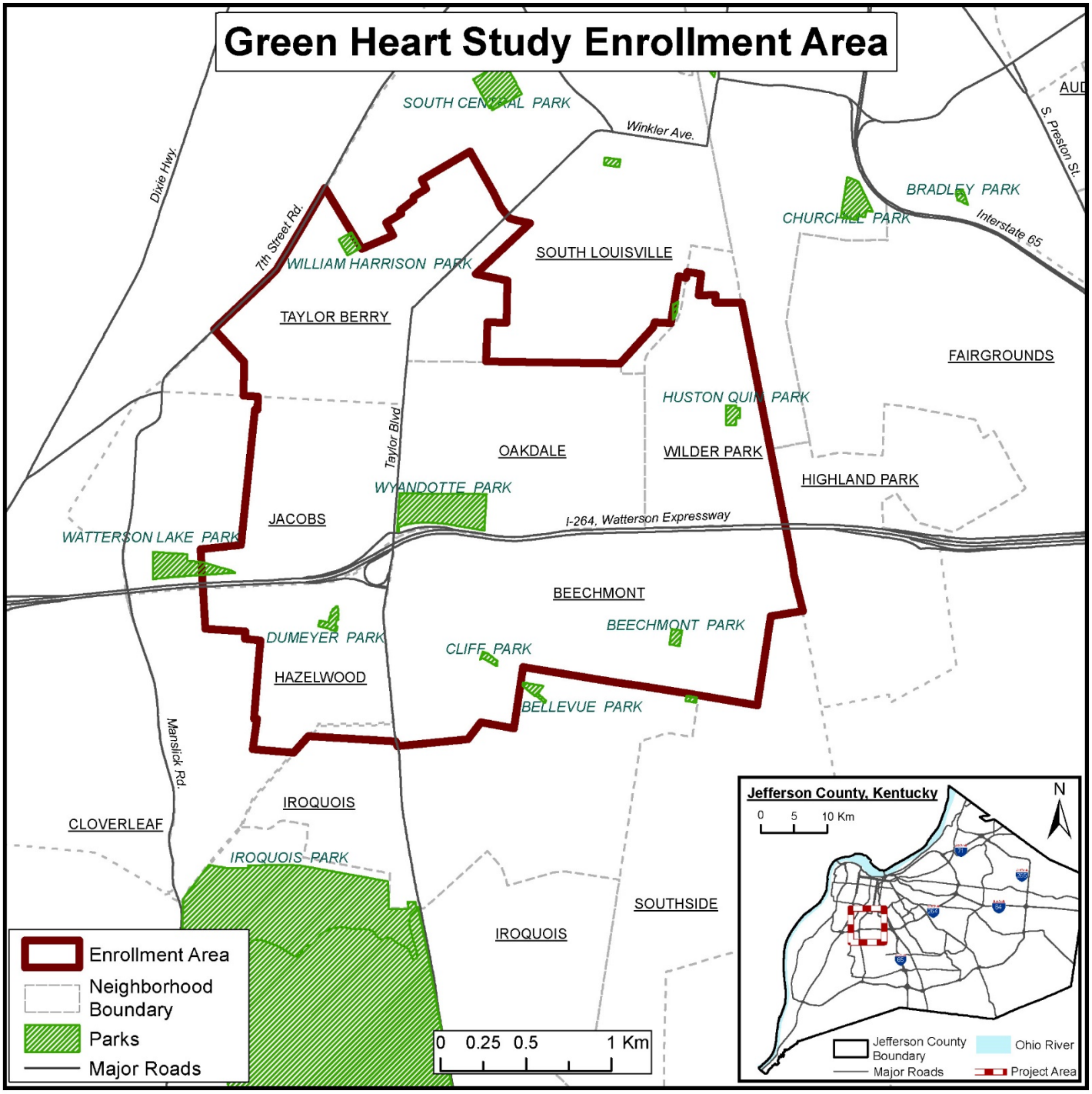
Objective: Examine linkages between vegetation exposure and cardiovascular (CVD) health

Mediators include air quality and psychosocial factors

HYPOTHESIS

Exposure to neighborhood greenery diminishes CVD risk by decreasing levels of local air pollution

Green Heart Study Enrollment Area



Specific Aims

1. Evaluate baseline cardiovascular health in neighborhoods with sparse greenspaces
2. Determine how increasing greenspaces affects neighborhood characteristics

   Air Quality, Demographics, Hospital admissions/mortality, changes to built environments
3. Assess the impact of increasing neighborhood greenspaces on CVD

INNOVATION: LARGE-SCALE INTERVENTION (GREENING)

Health and wellness – Beyond CVD

Recruit 700 individuals from study area

- Health status
- Stress levels
- Social cohesion
- Disease risk (obesity, diabetes, heart disease)

1. Before intervention: Baseline measurements
2. After intervention: Repeated biennially

Overall Monitoring Strategy

Control before intervention	Control after intervention
Planted area before intervention	Planted area after intervention

space

time

Air Pollutant Measurement Objectives

1. Assess efficacy of vegetation to reduce air pollution
- Near-road
- Neighborhood-scale

2. Exposure estimates to support the health effects studies
- Measurements to drive and validate land use regression modeling (LUR) for residential-level pollutant estimates

Pollutant Spatiotemporal Variability

Multi-pronged measurement strategy

1. Passive sampling
2. Mobile platform measurements
3. Fixed-site monitoring
4. Residential (indoor) monitoring (~40 homes)

Passive Sampling

Two-week integrated sampling at 60 sites

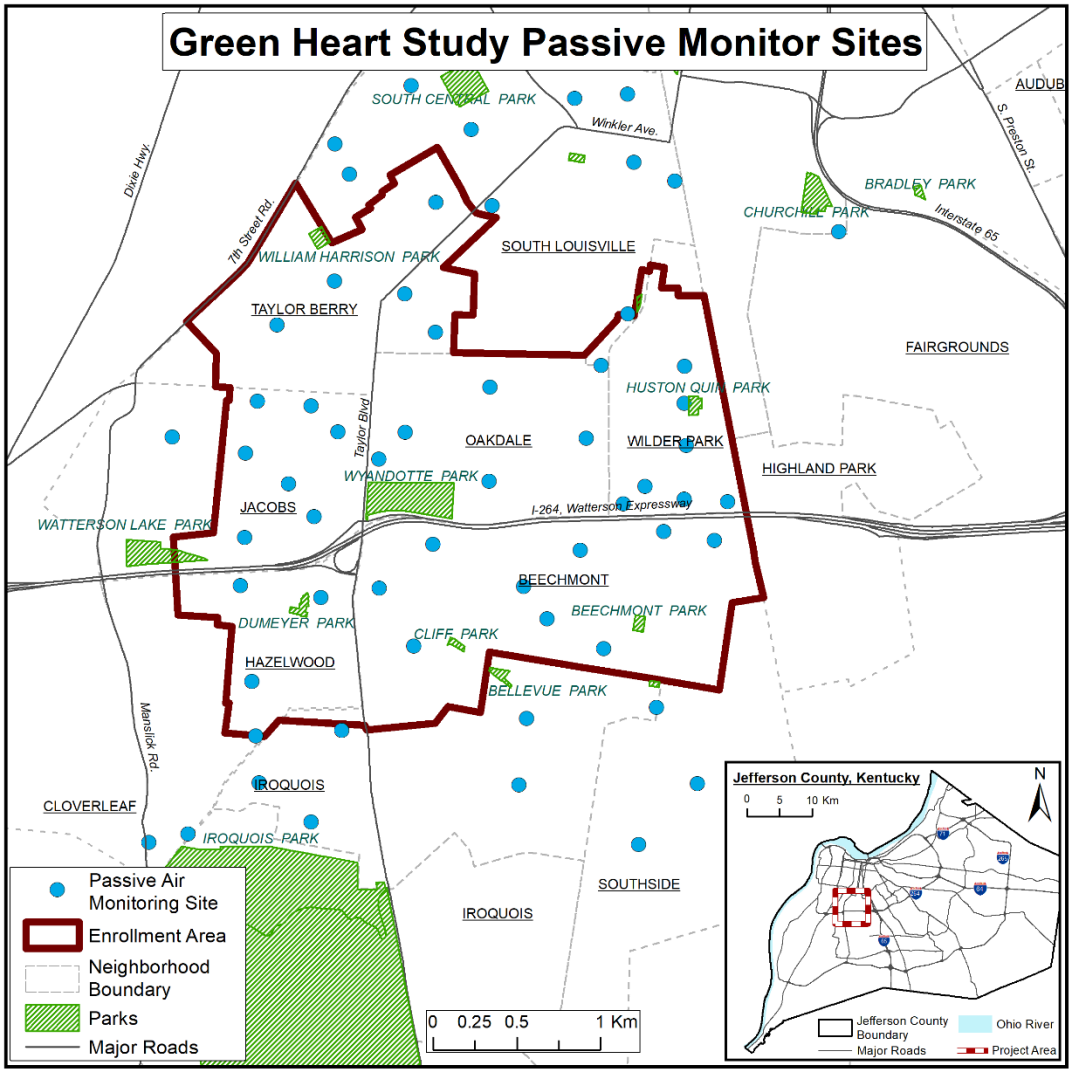
(Jason Su, UC Berkeley)

Currently: NO_x

Next: Ozone

VOCs

Noise (10 sites)



Mobile Platform and Fixed Site Monitoring

1. Mobile platform driving circuits across study area
2. Fixed monitoring to measure urban- and larger-scale background:
   - Adjust mobile platform data for within-run variability
   - Quantify temporal variability

Wind speed, direction	NO/NO_x
Temperature	O_3
Noise	CO_2
UFP	Speciated VOC monitor

Mobile Platform - Pilot Studies

1. Series of short-term (2-4 hrs) runs with ultrafine particle (UFP) counter

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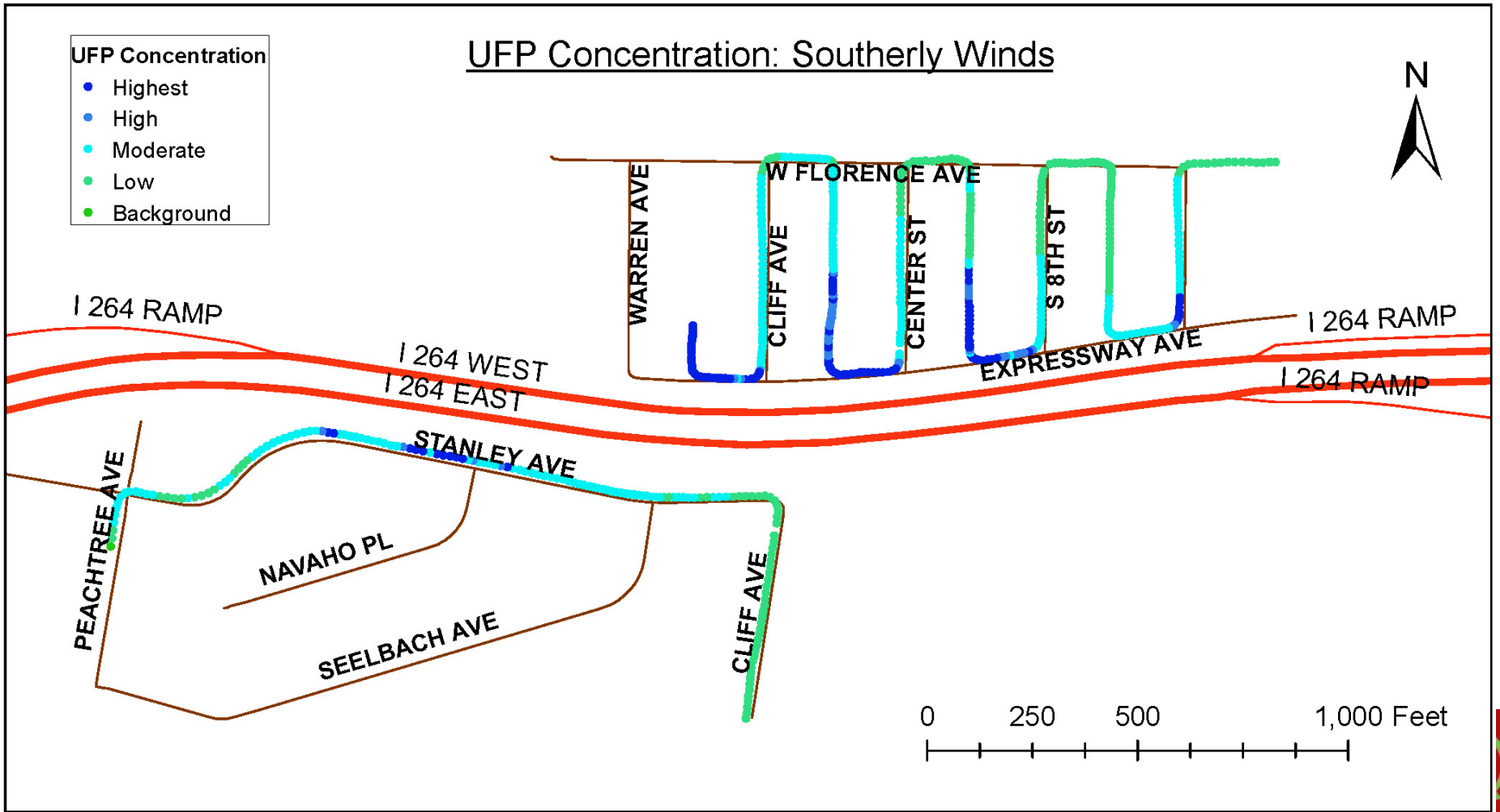
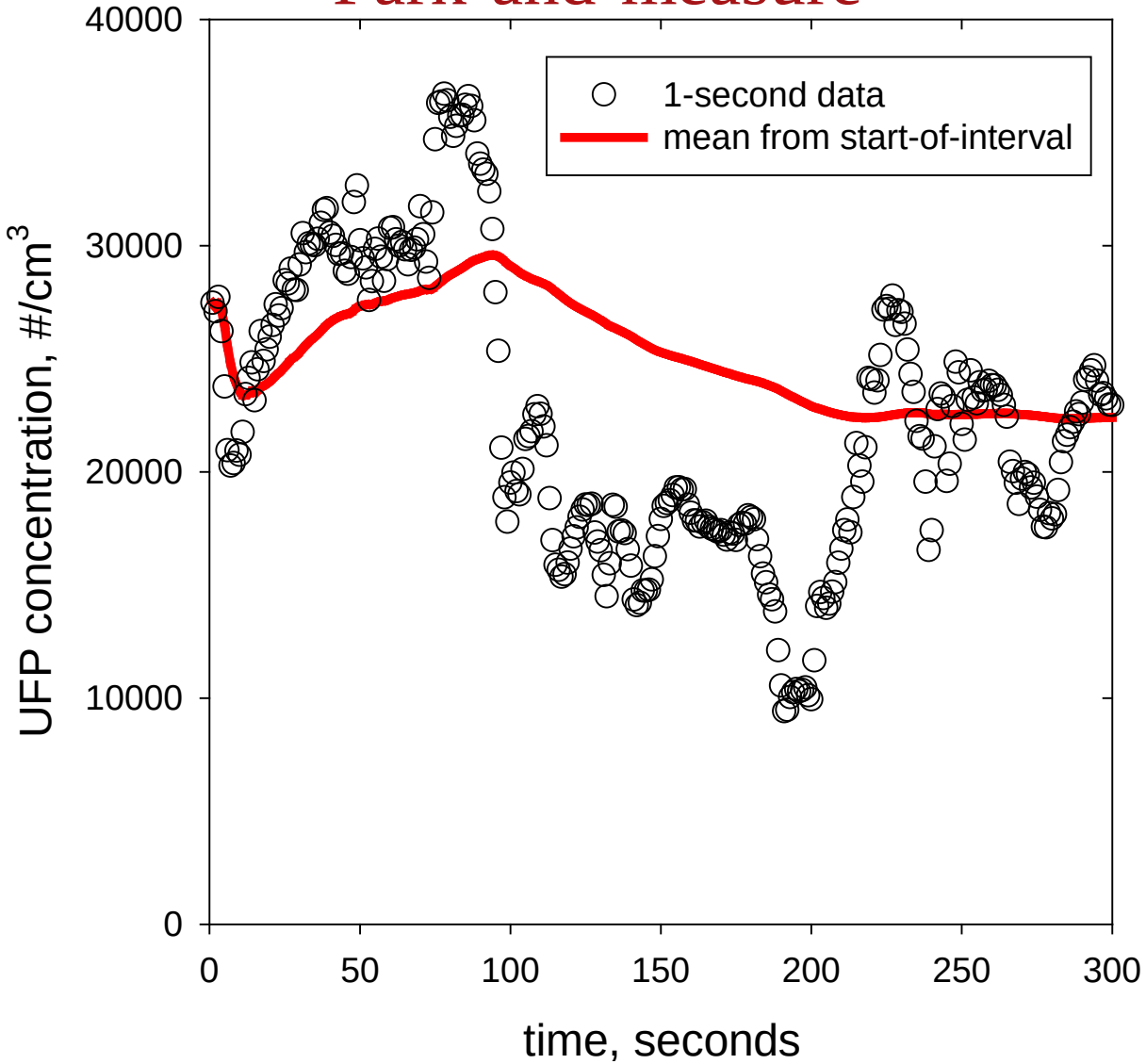


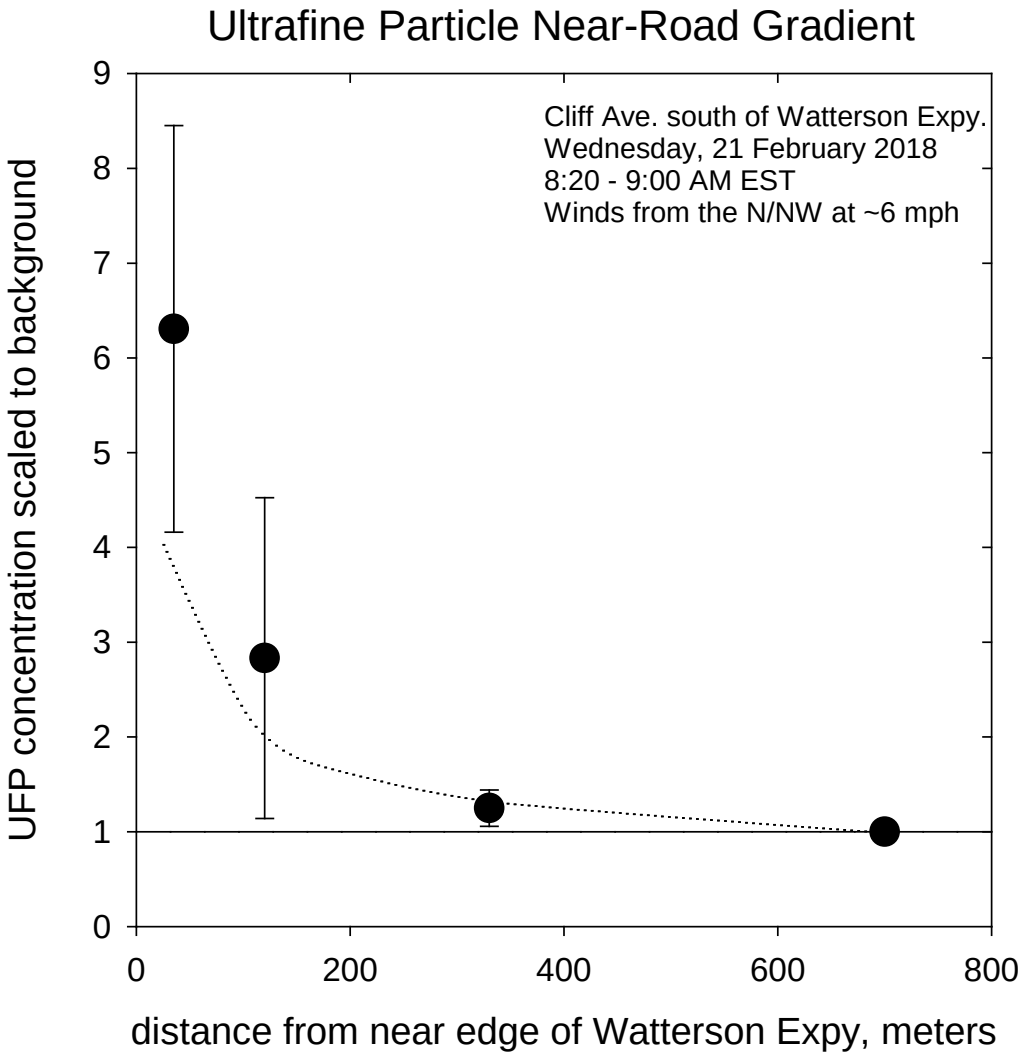
Mobile Platform - Pilot Studies

1. Series of short-term (2-4 hr) runs with ultrafine particle (UFP) counter
2. Measure throughout study domain with emphasis on UFP gradients near Watterson Expressway
3. **Refine measurement plan and inform greening plan**

Continuously drive in near-road conditions
Park-and-measure



UFP 5-Minute Park-and-Measure Study (Feb. 21, 2018)



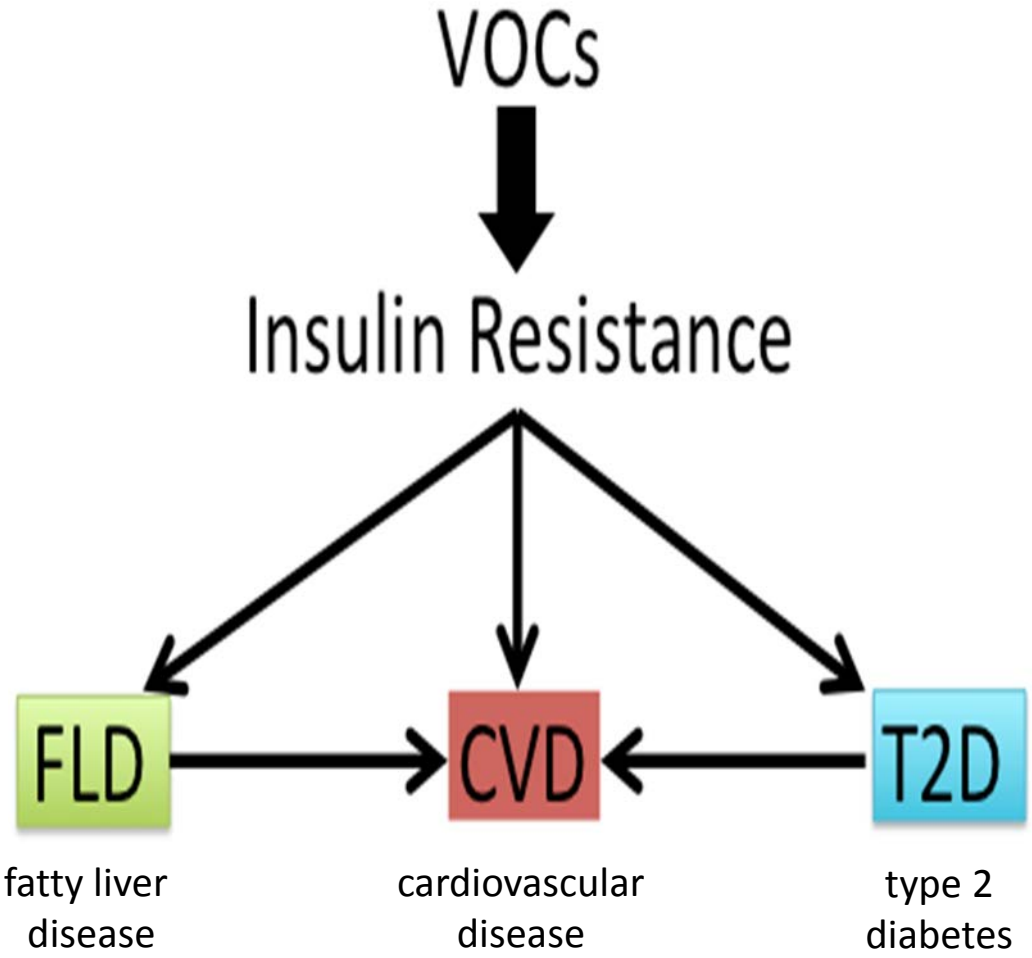
Louisville Superfund Research Center

Objective: Characterize select VOC Superfund Chemicals across an urban landscape

HYPOTHESIS

VOC Superfund Chemicals exhibit high spatial variability in urban, and possibly neighborhood, scales because of differential patterns in emission sources and their zones of influence

Louisville Superfund Research Program



Project 4 Team

Instrument Development – Brent Williams Group (WashU)

- Nathan Kreisberg (Aerosol Dynamics, Inc.)

Study Design, Deployment, Data Analysis – Turner Group

- Russ Barnett, Rick Strehl, Ray Yeager (UofL)
- Jason Su (UC Berkeley)
- Steve Hankey (Virginia Tech)

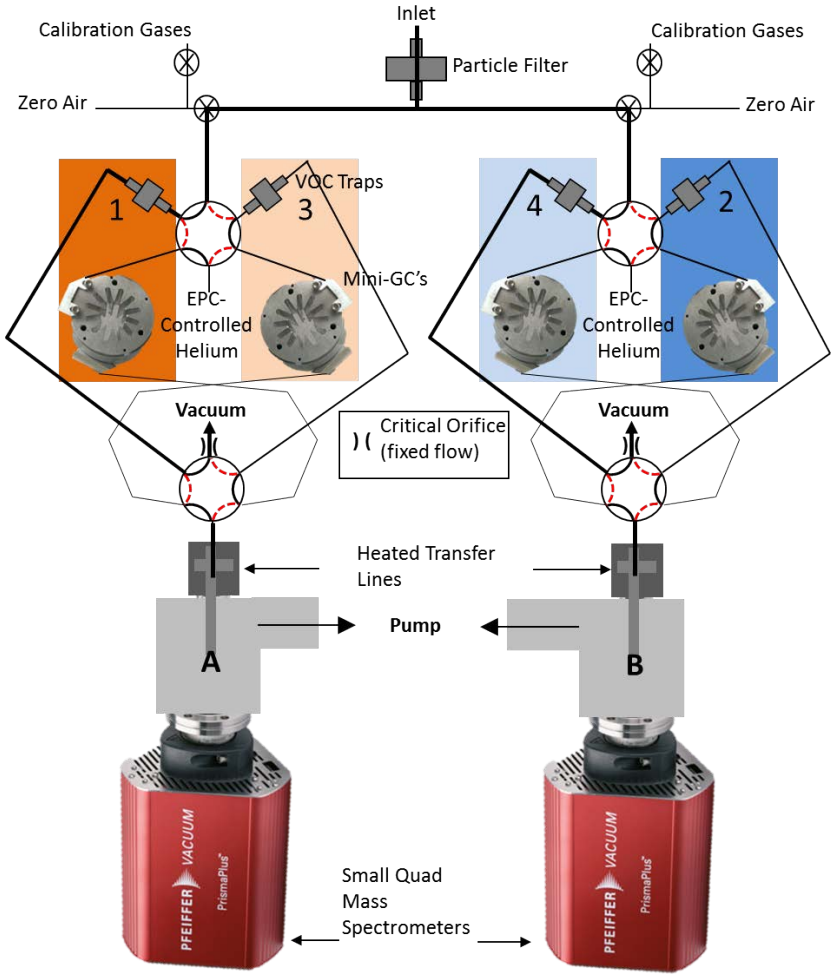
Aims

Instrument Development– Brent Williams Group (WashU)

Design, construct, and validate a portable field gas chromatograph (GC) suitable for mobile monitoring (5-min resolution)

Instrument Design

- Parallel sample collection and analysis
- Continuous monitoring
- High spatial resolution



Aims

Instrument Development– Brent Williams Group (WashU)

Design, construct, and validate a portable field gas chromatograph (GC) suitable for mobile monitoring (5-min resolution)

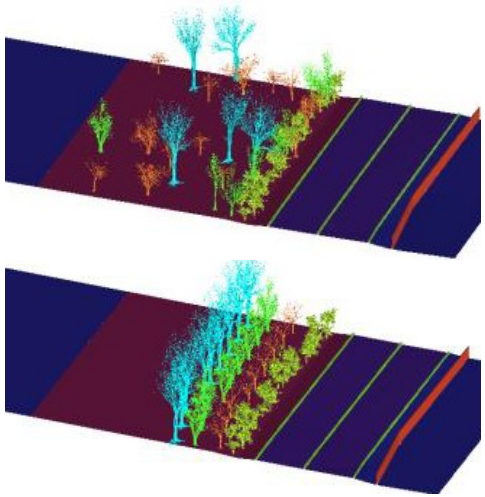
Study Design, Deployment, Data Analysis – Turner Group

1. Conduct mobile monitoring of select VOC Superfund Chemicals in geographic clusters
2. Construct LUR model to quantify small-area variation in ambient VOC
3. **Predict residential level outdoor VOC exposures using LUR**

Greening Strategies

- Neighborhood scale
- Near-road (middle scale)

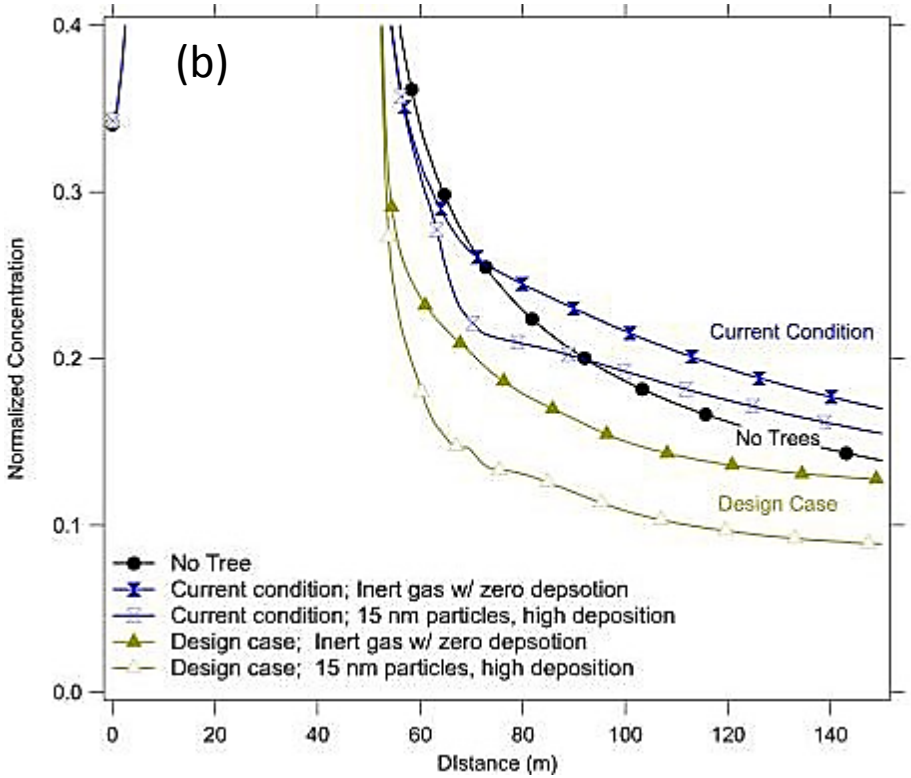
(a)



Current

Design

(b)



(a) Comparison between the current conditions of vegetation near Wyandotte Park and a hypothetical design case;

(b) Preliminary simulation results comparing the effect of vegetation on downwind concentrations of inert gas species and 15 nm particles for the current condition, design case and no-tree case.