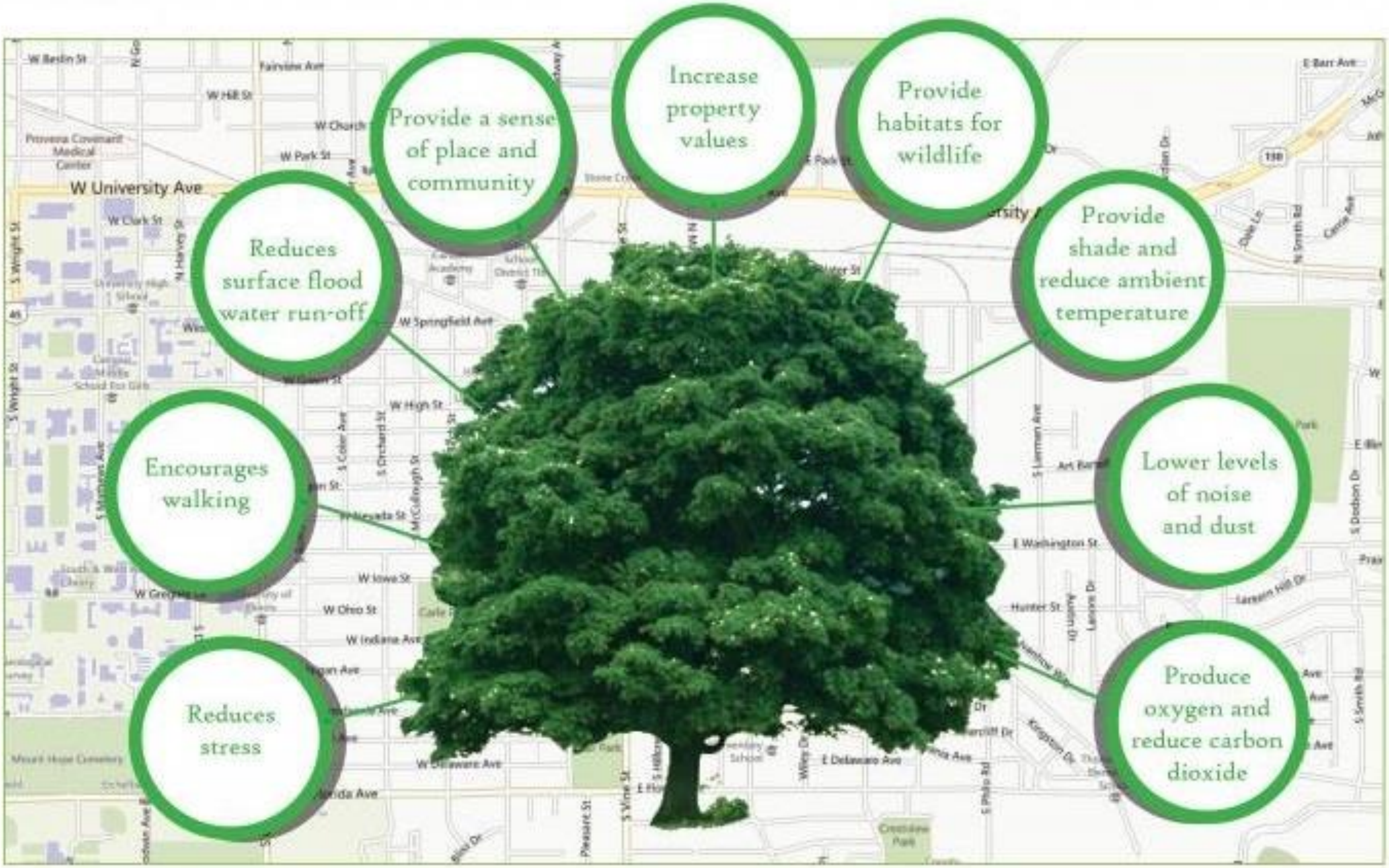
Evidence for Near-Road Air Pollution Abatement by Tree Cover

A Collaboration between EPA's **Air, Climate & Energy** and **Sustainable & Healthy Communities** Research Programs

Richard Baldauf, Gayle Hagler
Halley Brantley, and **Laura Jackson**
U.S. EPA Office of Research and Development
(with additional team members & partners)

The Conference for A Community on Ecosystem Services
December 18, 2014


W University Ave
Provide a sense of place and community
Increase property values
Provide habitats for wildlife
Reduces surface flood water run-off
Provide shade and reduce ambient temperature
Encourages walking
Lower levels of noise and dust
Reduces stress
Produce oxygen and reduce carbon dioxide

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Tree and forest effects on air quality and human health in the United States

David J. Nowak [a,*], Satoshi Hirabayashi [b], Allison Bodine [b], Eric Greenfield [a]

Available online at www.sciencedirect.com

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Urban Forestry & Urban Greening 4 (2006) 115–123

URBAN FORESTRY & URBAN GREENING

www.elsevier.de/ufug

Air pollution removal by urban trees and shrubs in the United States

David J. Nowak*, Daniel E. Crane, Jack C. Stevens

United States Department of Agriculture

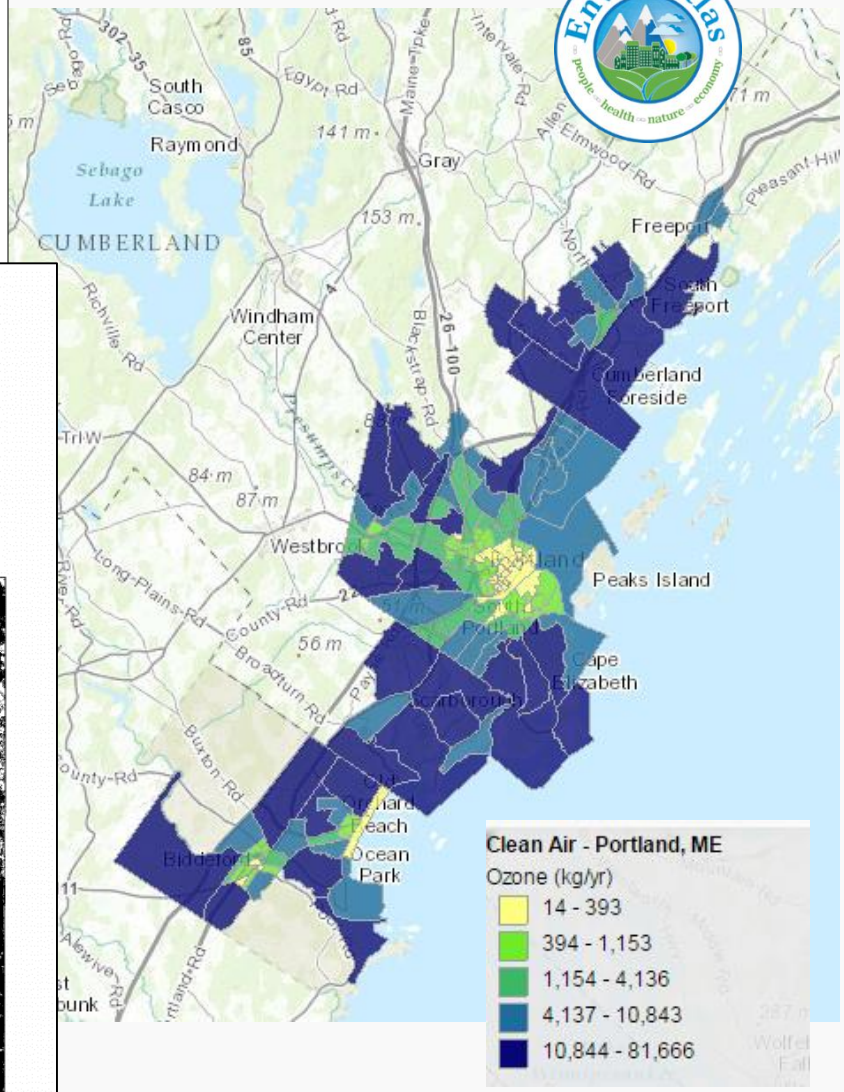
Forest Service

Northeastern Forest Experiment Station

General Technical Report NE-186

Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project

E. Gregory McPherson
David J. Nowak
Rowan A. Rowntree



What about Near-Road Air Quality?

Elevated pollutant concentrations have been measured near roads:

- NAAQS (CO, NO2, PM10, PM2.5)
- Particulate Matter constituents (e.g. ultrafine particles, black carbon, metals)
- Air Toxics (e.g. benzene, polycyclic aromatic hydrocarbons)

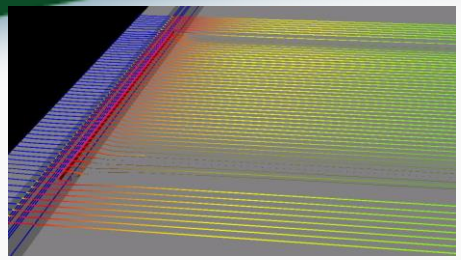
Living, working, or going to school near major roadways has been associated with numerous adverse health issues:

- Increased risk of adverse respiratory, cardiovascular, birth, cancer, and mortality effects
- International consensus on “public health concern”

A significant portion of U.S. pop. lives near large roads:

- 2007 American Housing Survey estimates >45 million people live within 100m of a major transportation facility, the majority of which are large roads.
- ~2 million children go to school near large roads; many also work in these areas.
- These residences and schools are disproportionately lower income.

Modeling Solid-Wall Barrier Effects

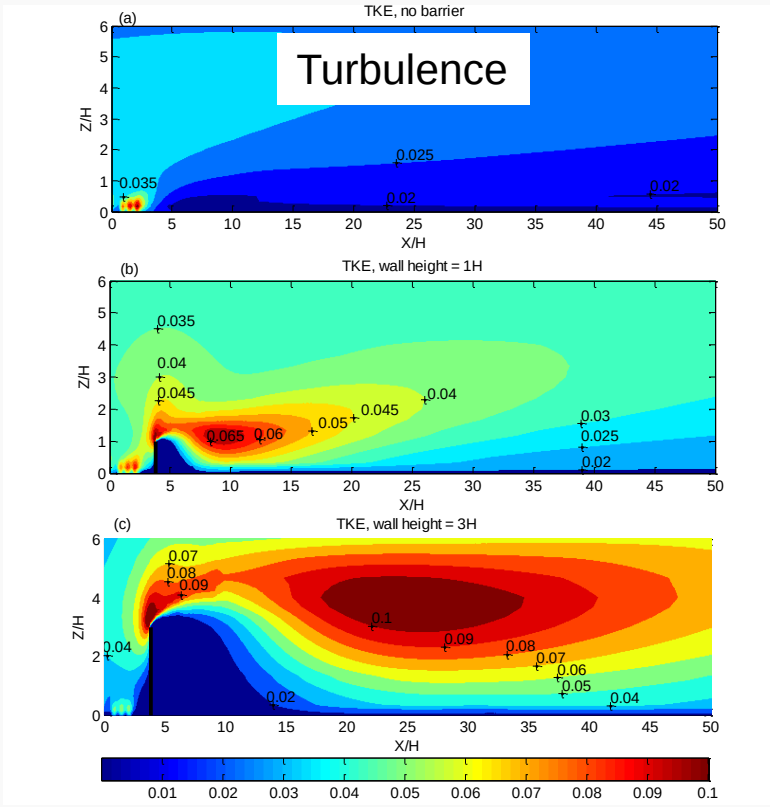


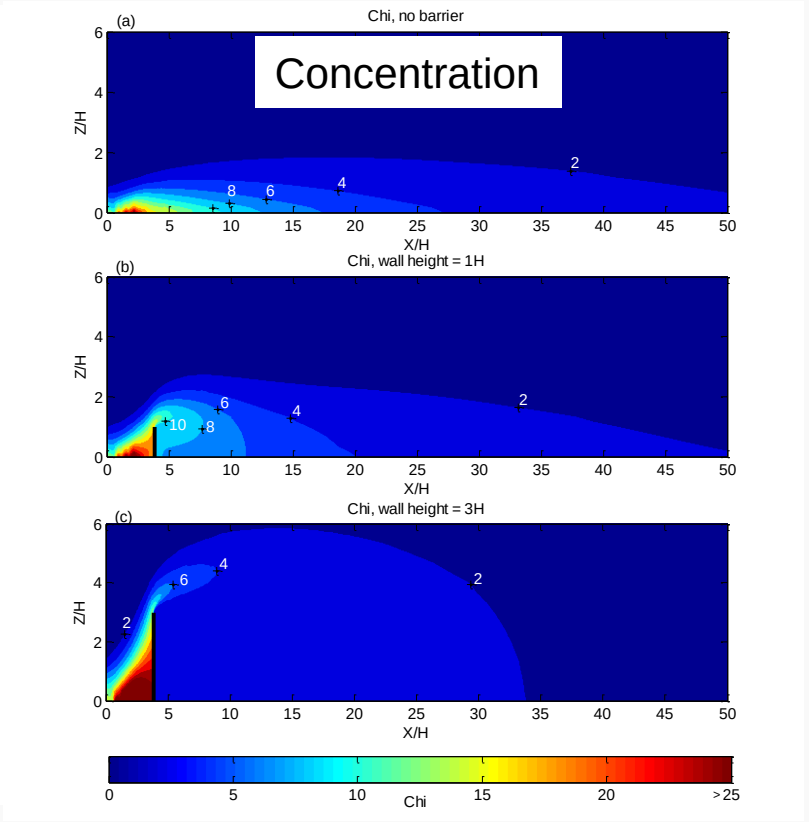
Computational Fluid Dynamics:

No barrier

6m barrier

18m barrier



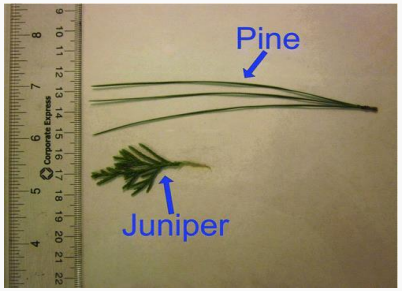


Hagler et al. 2011. Atmospheric Environment.

Presence of solid-wall barrier dramatically alters the dispersion of roadway emissions, leading to more vertical lofting of the plume and reducing ground-level concentrations behind the barrier. (On-road concentrations are modeled to increase with a barrier present.)

Wind Tunnel Simulations:
Needle and Broad-Leaf Evergreens

Aerosol Wind Tunnel facility, EPA-RTP, NC (Lin and Khlystov 2012)

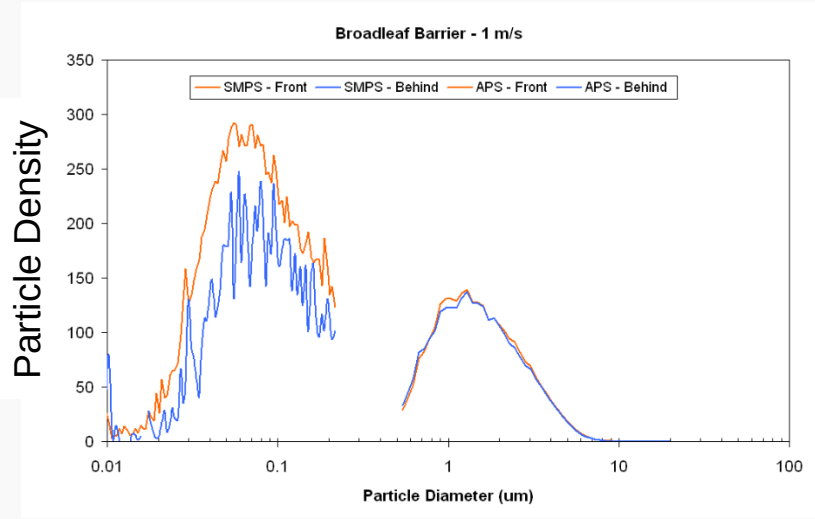


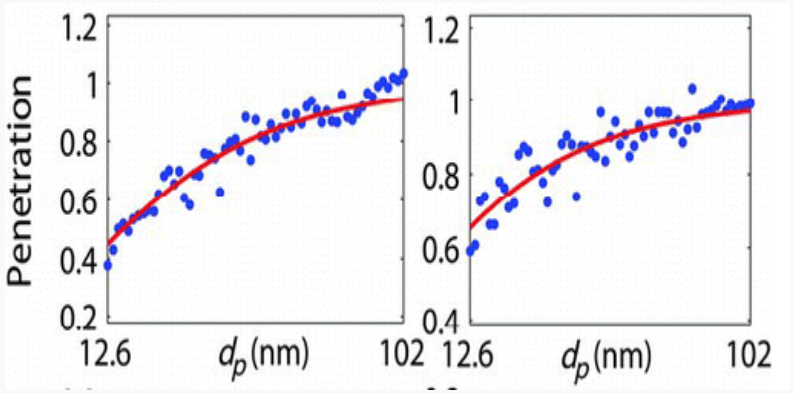
Mechanical Engineering Wind Tunnel, University of California-Davis (Cahill et al. 2010)

Findings:

Moderate reductions in ultrafine particles

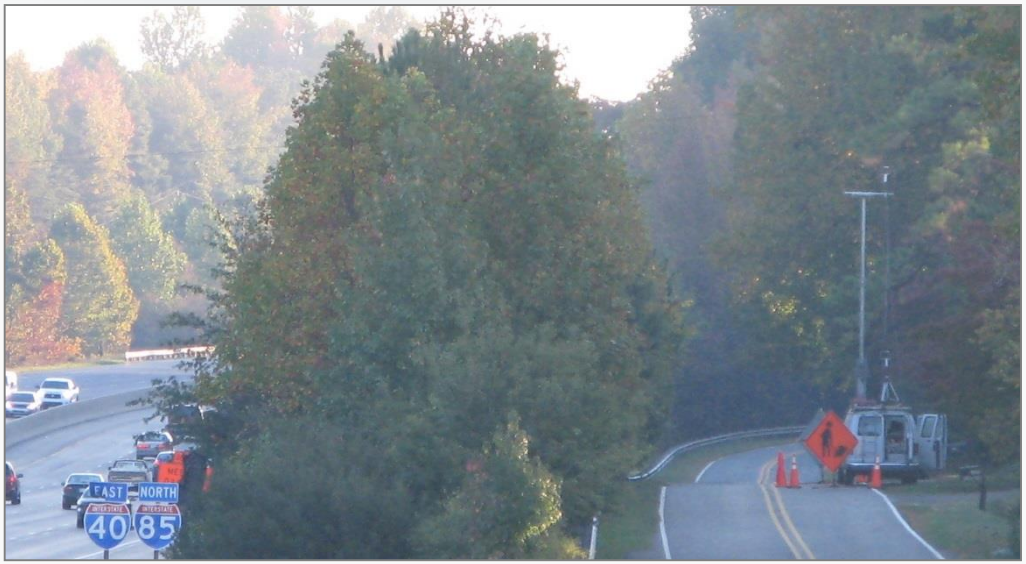
Larger particles unaffected

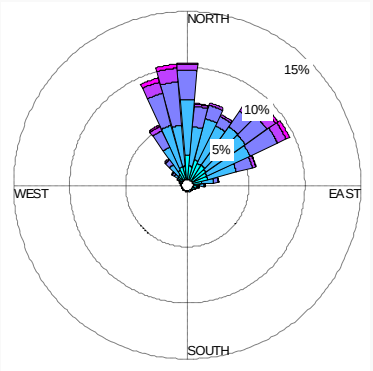


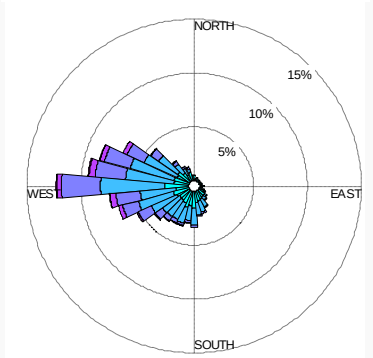


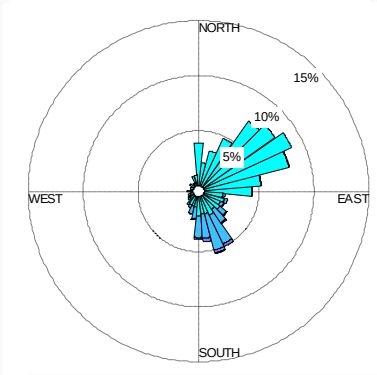
0.3 m/s 1.5 m/s

Field Studies…

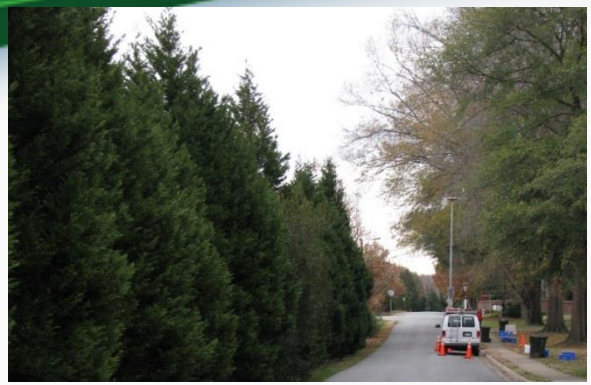


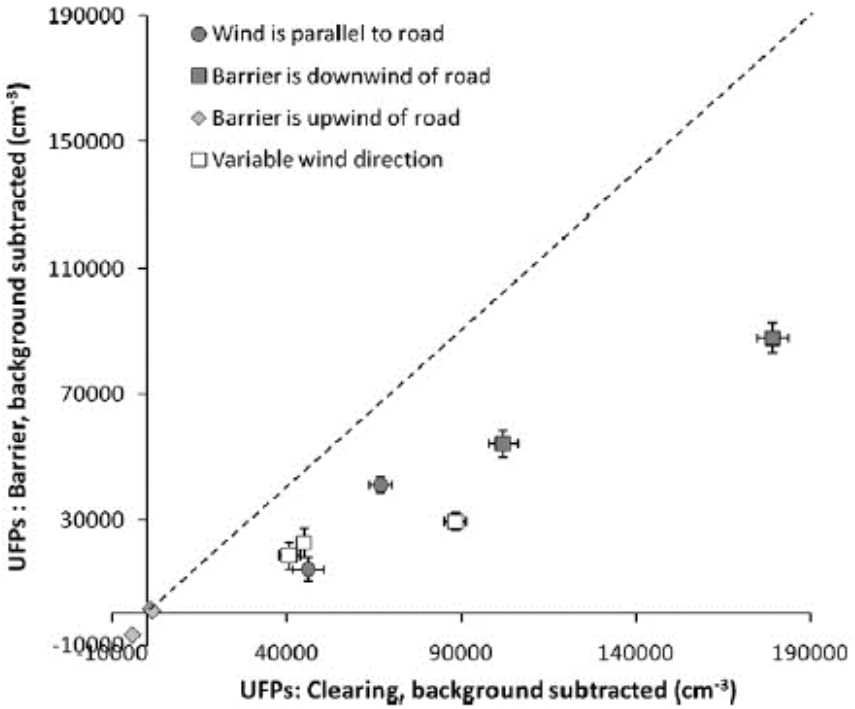


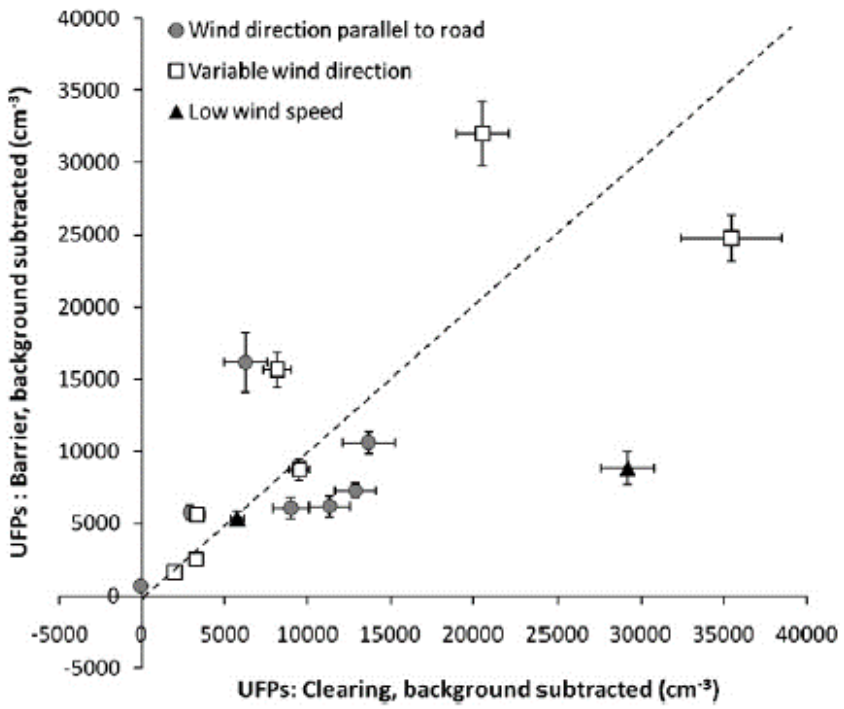




Effects on Ultrafine Particles





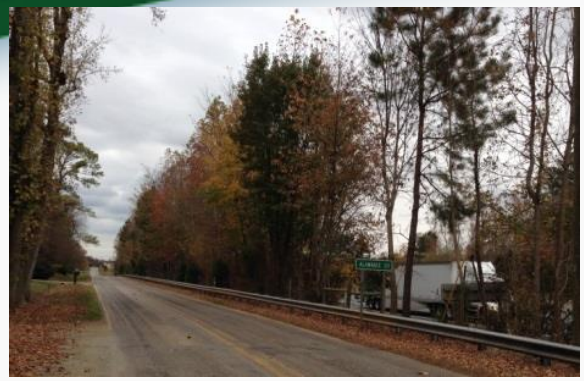


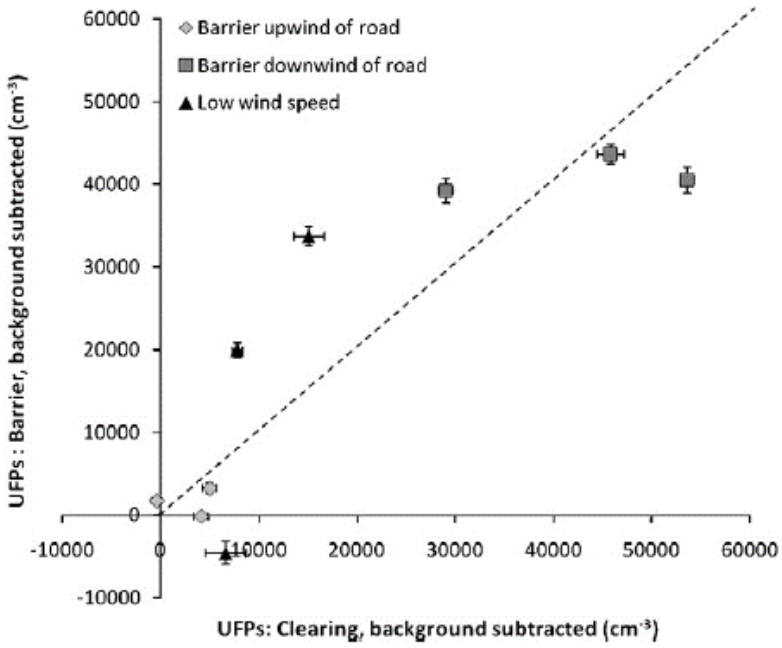
Solid-wall barrier (6m)
Raleigh, NC (10 sessions)

Evergreen tree barrier
Chapel Hill, NC (6 sessions)

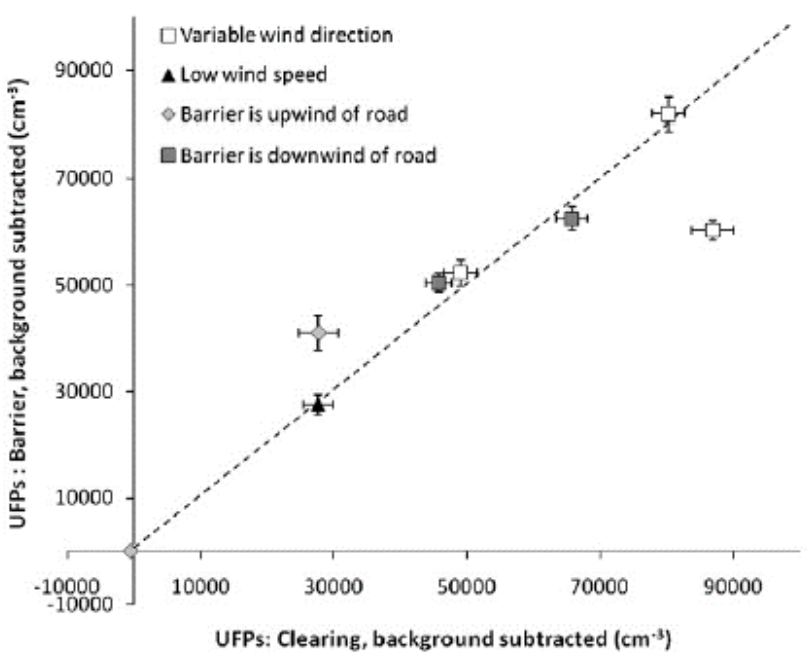
Hagler et al. 2012. Science of the Total Environment.

Deciduous effects





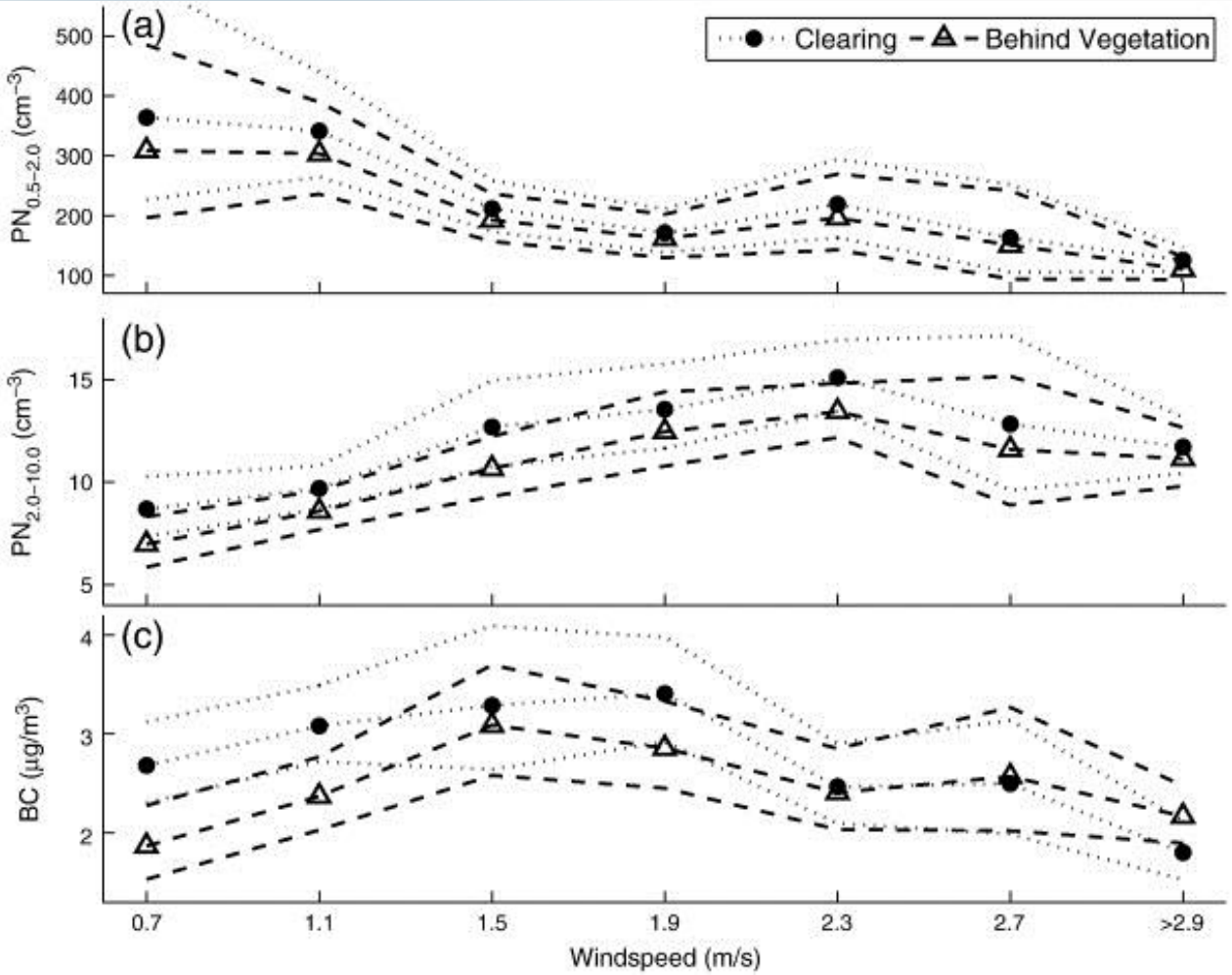
Deciduous tree barrier (early Fall)
Mebane, NC (9 sessions)



Deciduous tree barrier (winter)
Mebane, NC (8 sessions)

Hagler et al. 2012. Science of the Total Environment.

Effects on Black Carbon ultrafines (diesel indicator)



Detroit, MI Field Site
(continuous sampling for 28 days)

Brantley et al. 2014. Science of the Total Environment.

Research Impacts to date

EPA is incorporating roadside vegetation effects into research and voluntary recommendations:

- ✓ **Siting guidance for implementing the national near-road monitoring network**
- ✓ **Air quality modeling applications**
- ✓ **School siting and design guidelines for potential exposure mitigation**

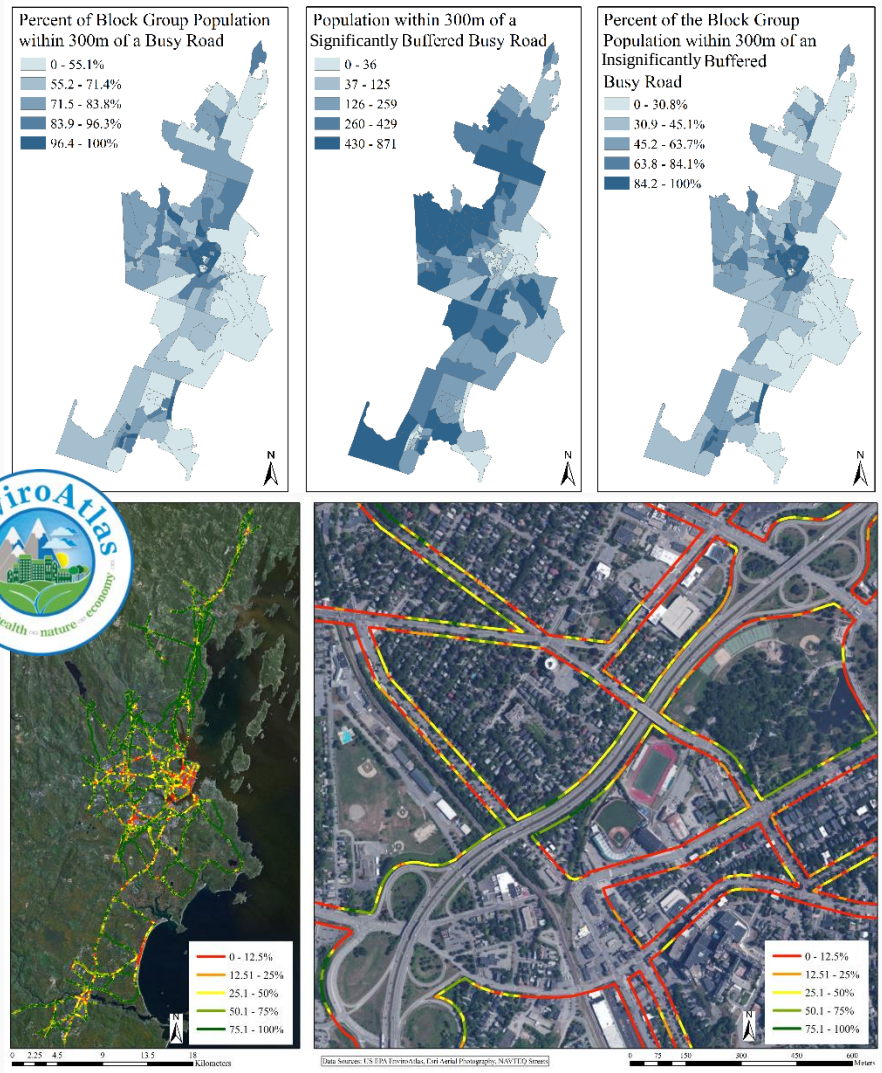
Other federal, state & local organizations are exploring roadside vegetation for mitigating near-road air quality impacts:

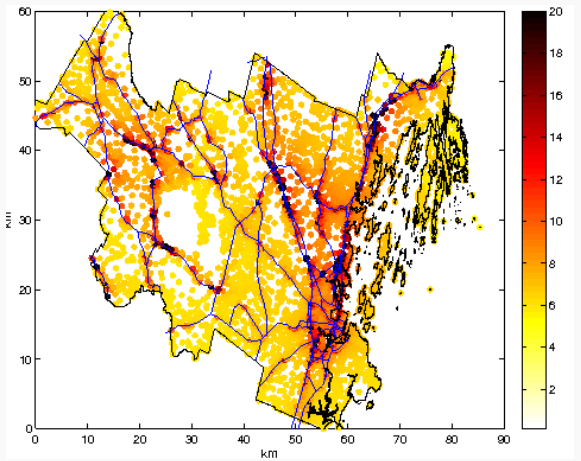
- ✓ **USDA Forest Service – *i-Tree* module**
- ✓ **Transportation Research Board**
- ✓ **California Air Resources Board**
- ✓ **School pilot in Atlanta**

Planned Research Synthesis may incorporate Eco-Epidemiology

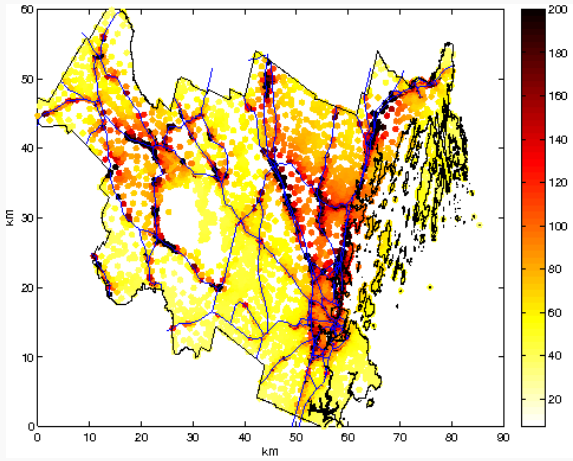
UNC INSTITUTE FOR THE ENVIRONMENT

Ex: Cumberland County, ME





$PM_{2.5}$



NOx

Annual Average Concentrations (μg/m^3) by Census Block-Group

Take-Home Messages

- **Models and fieldwork suggest that vegetation has the potential to improve near-road air quality.**
- **Research to date shows promise for ultrafines in particular.**
- **Results vary depending on wind speed, direction, seasonality, road design, and traffic conditions.**
- **Barrier type and configuration are critical (e.g., species, depth, gaps, and edge effects).**