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Assessing Exposures and Mitigation Opportunities for Traffic Emissions Near Roadways Using Measurements and Modeling

Rich Baldauf and Vlad Isakov,U.S, EPA

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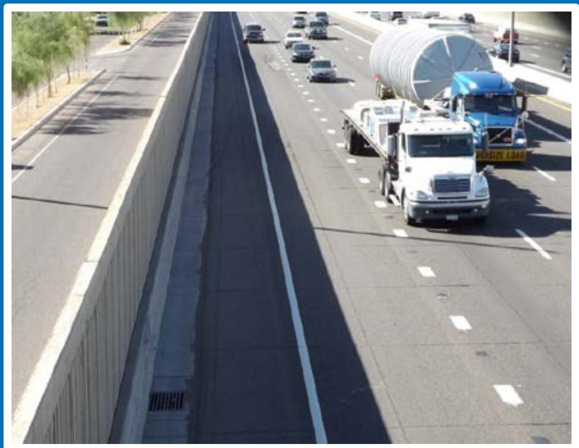

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Background

- Evidence of increased health risks for populations spending time near large roadways
- Elevated concentrations of many pollutants near large roads
- Public health concerns have raised interest in methods to understand and mitigate these traffic emission exposures
- Transportation and land use planning mitigation options include:
  - Vehicle emission standards and voluntary programs
  - Reducing vehicle activity/Vehicle Miles Travelled (VMT)
  - Buffer/exclusion zones
  - Use of roadway design and urban planning
    - Road location and configuration
    - Roadside structures and vegetation

Research Methodology

- EPA has initiated research to examine the role roadside features (noise barriers, vegetation) may play in affecting near-road air pollutant exposures
- Using modeling and monitoring to characterize the impact of roadway features on near-road air quality
  - Wind tunnel assessments
  - CFD modeling
  - Mobile monitoring field studies
- Developing new model algorithms for evaluating impacts of roadway features
  - Determine potential mitigation opportunities
  - Air quality characterization
  - Exposure assessment and characterization

Why study roadside features?

- Few other "short-term" mitigation options
  - Emission reductions take long to implement (fleet turnover required)
  - Planning and zoning involved in rerouting/VMT reduction programs
  - Buffer/exclusion zones may not be feasible
- Roadside features may already be present
- Roadside features often have other positive benefits

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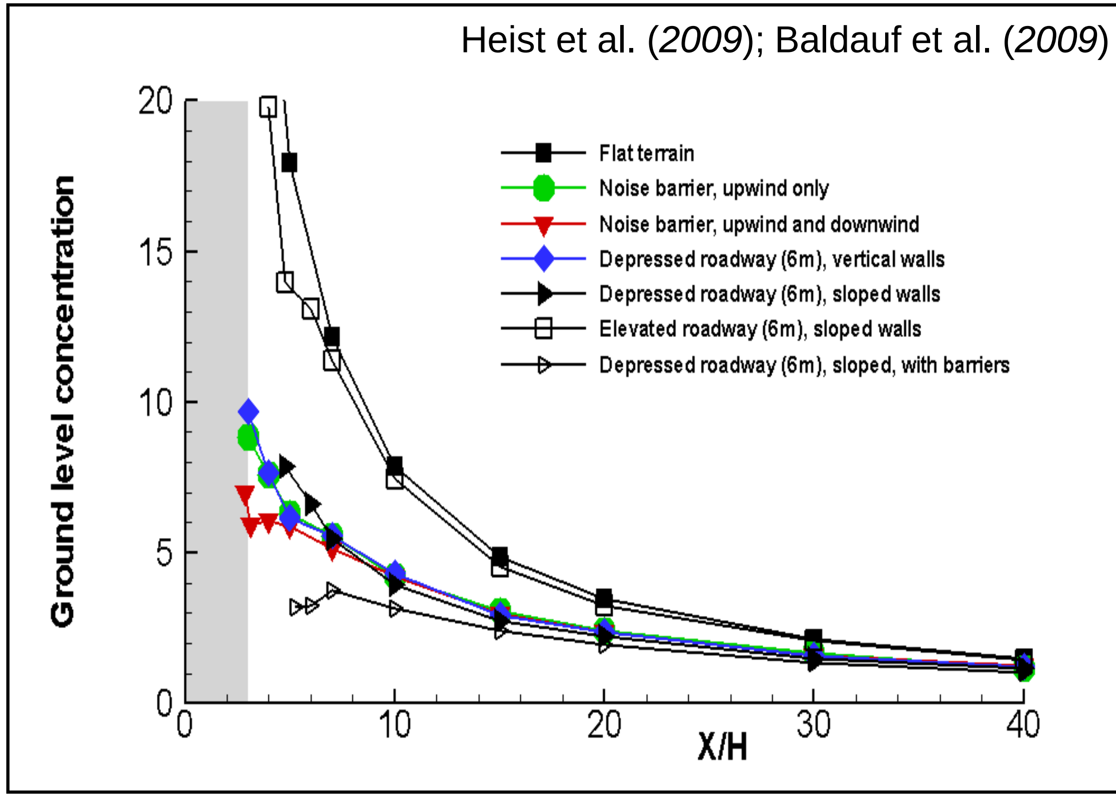
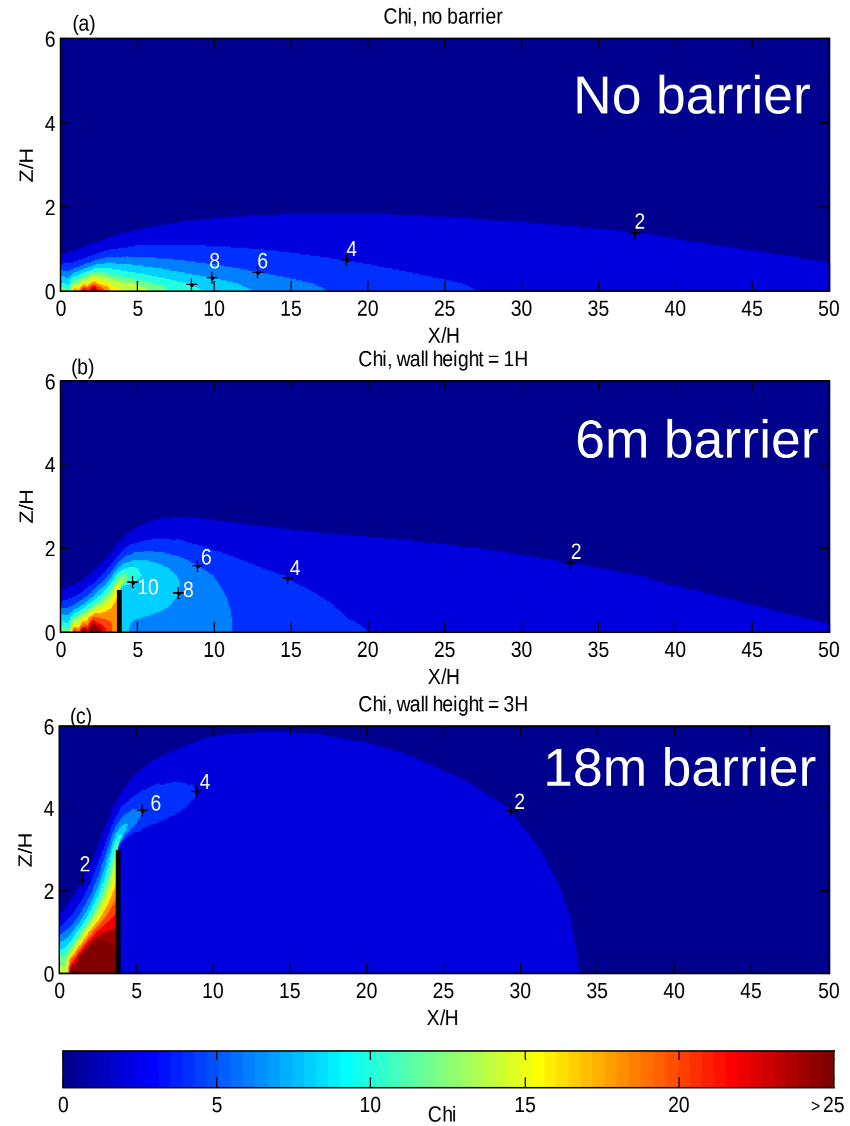
Roadway Configuration Effects



Wind tunnel simulations show roadway design effects on pollutant transport and dispersion. Highest levels occur with at-grade and elevated fill roads. Lowest levels occur with noise barriers and cut section roads

Noise Barriers

- CFD modeling suggest decreased concentrations downwind of barriers, but increased on-road concentrations
- Dispersion models being developed to quantify mitigation potential of barrier



(Hagler et al. 2011)

Noise Barrier Effects

Tracer studies also indicate noise barriers significantly reduced downwind air pollutant concentrations under all stability conditions

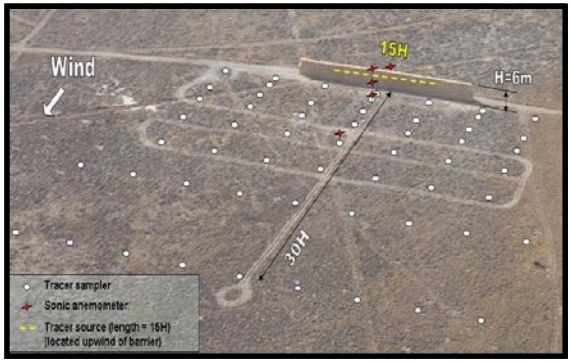
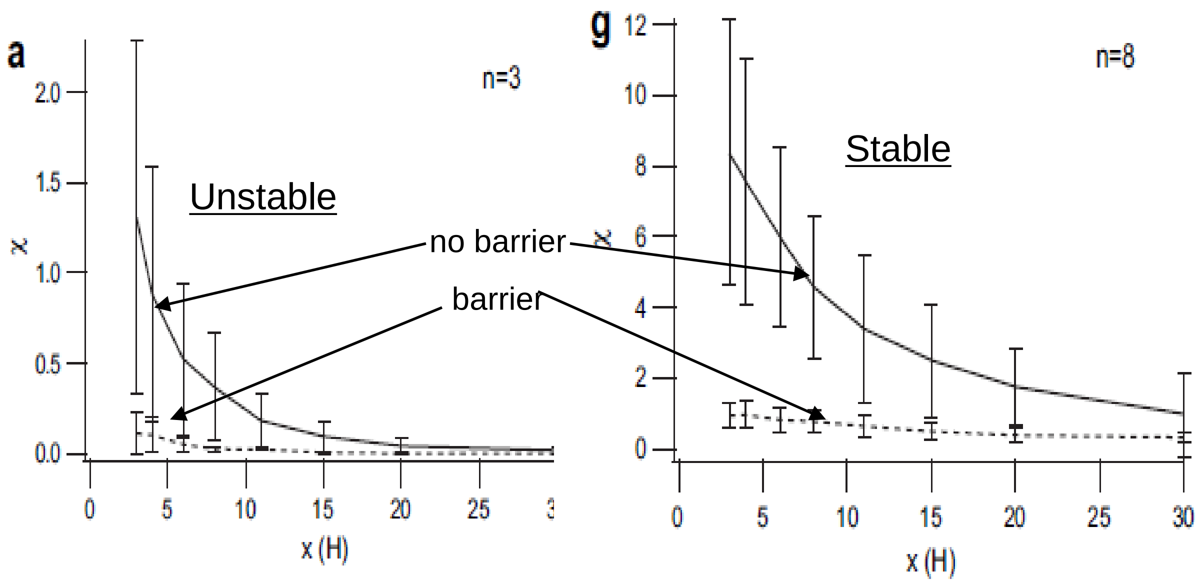


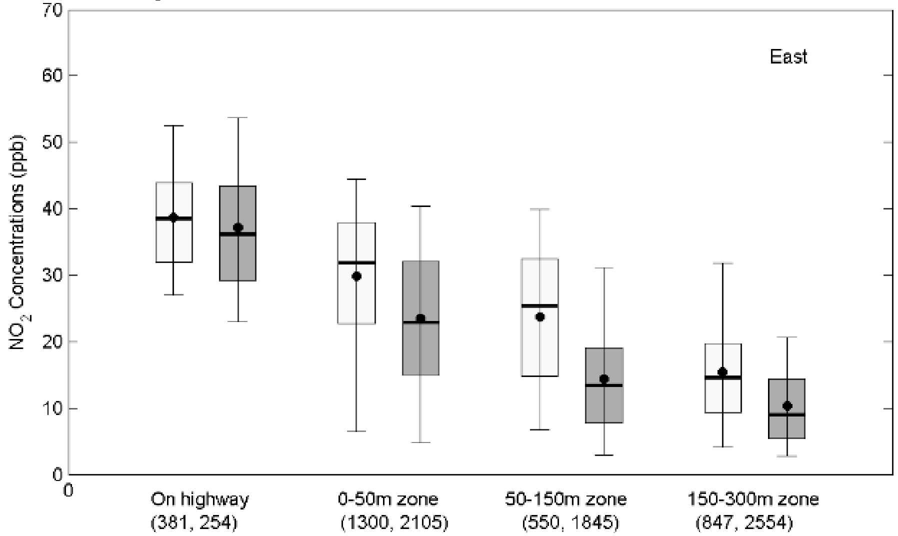
Fig. 1. Mock straw bale sound barrier, 6 m high and 90 m long.



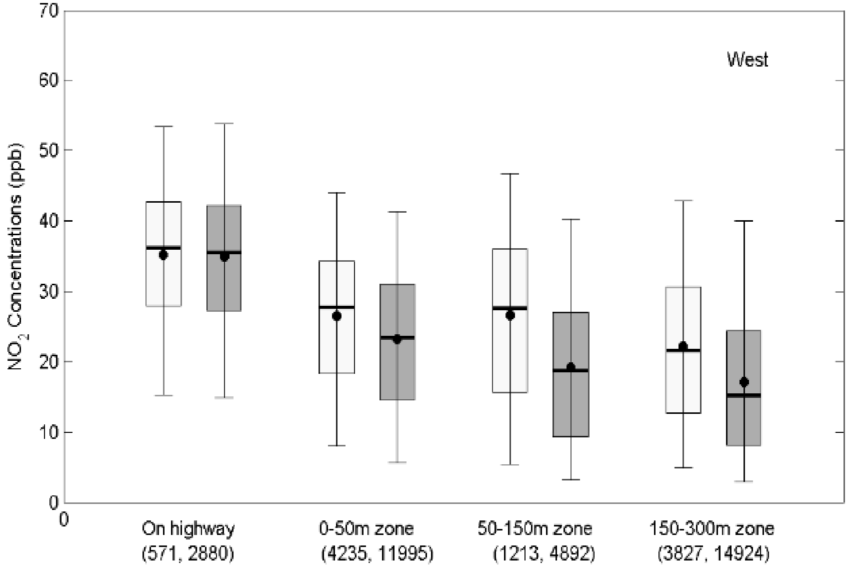
Finn et al., (2010)

Phoenix Study Results

NO_2 concentrations



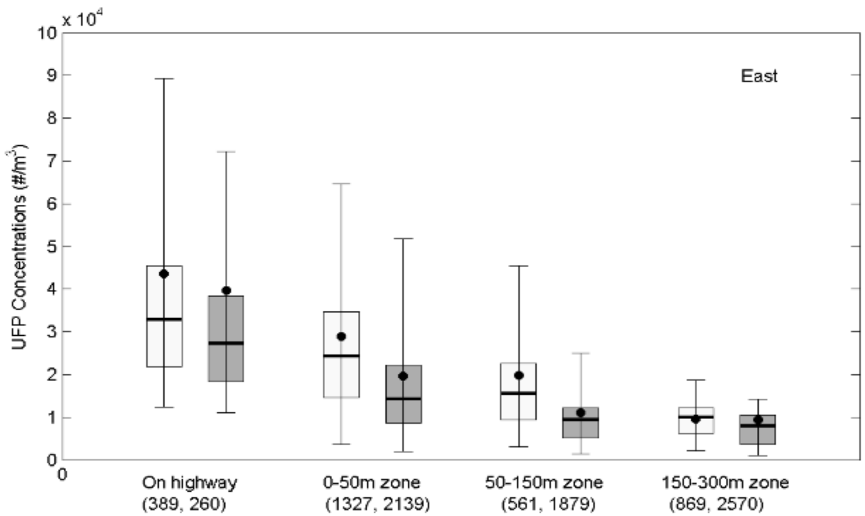
West Section (Morning)



East Section (Afternoon)

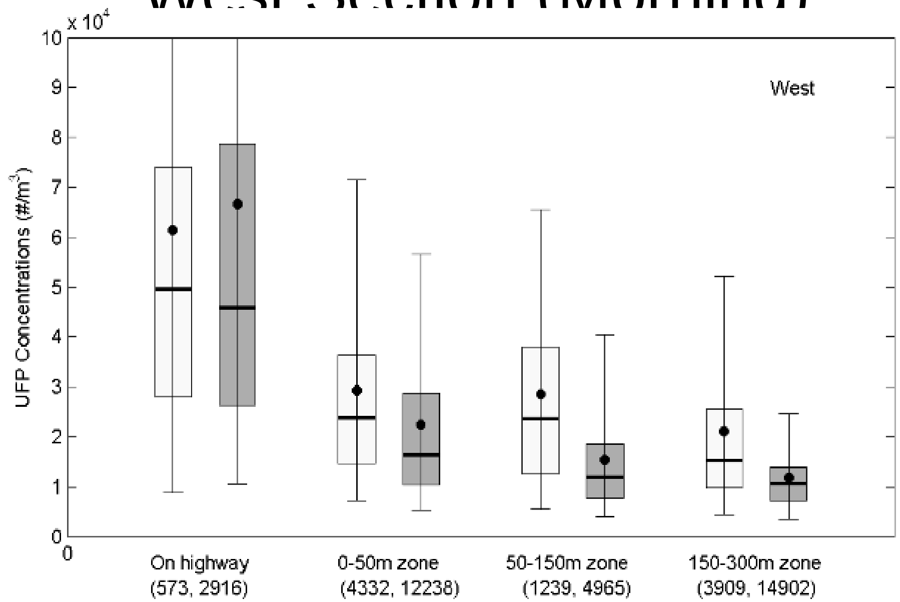
Phoenix Study Results

UFP concentrations

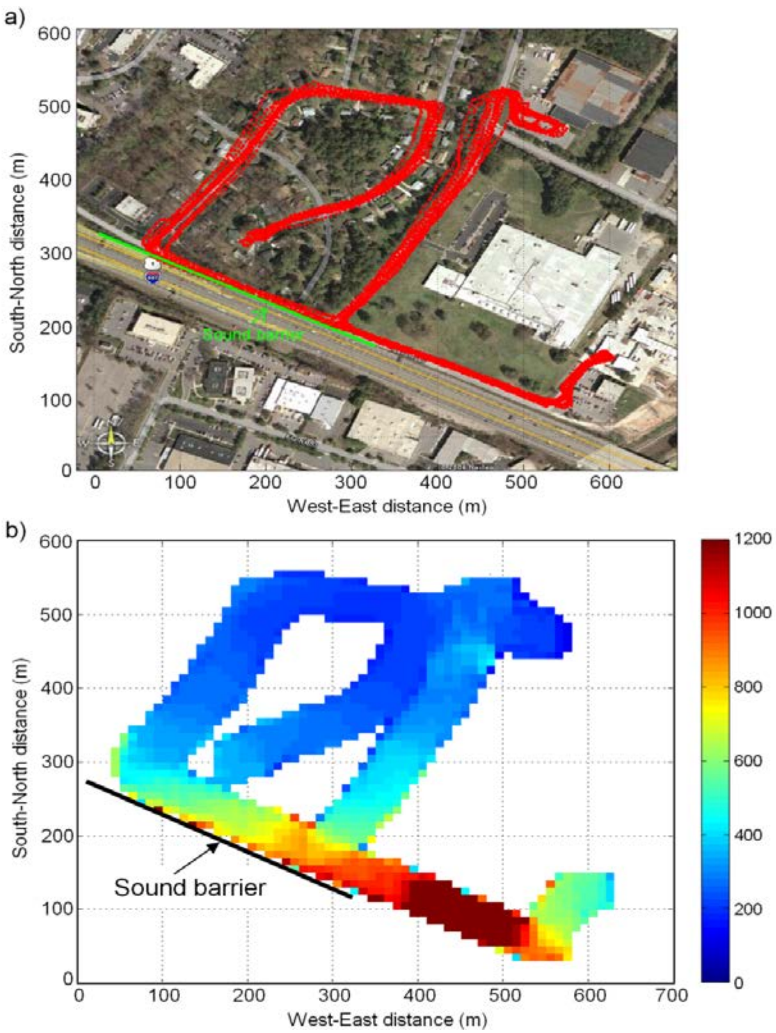


East Section (Afternoon)

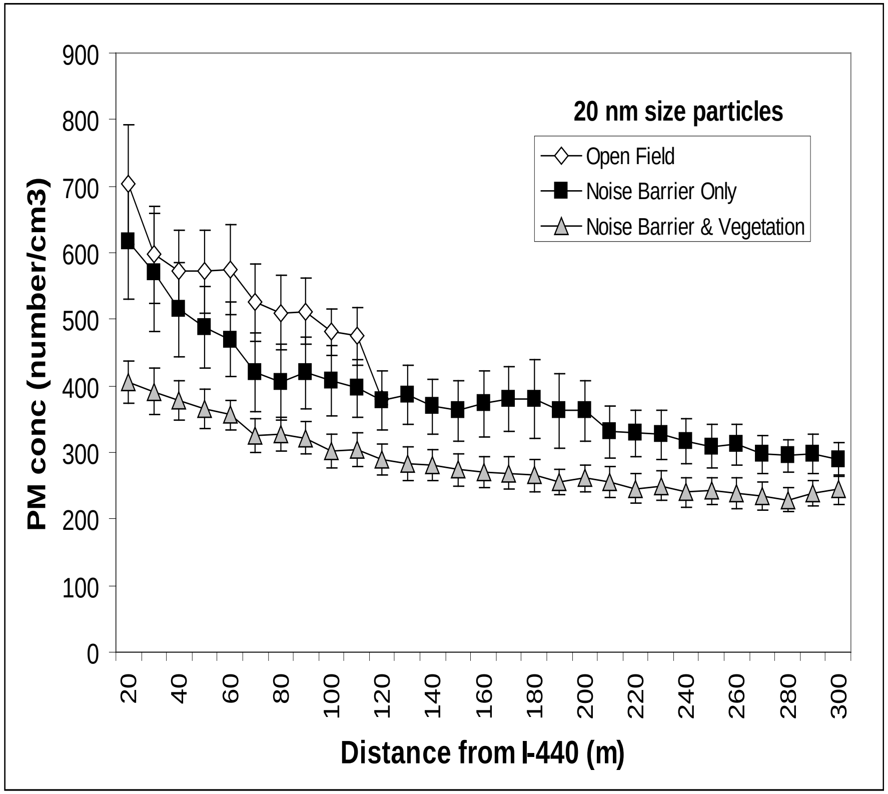
West Section (Morning)



Noise Barriers and Vegetation



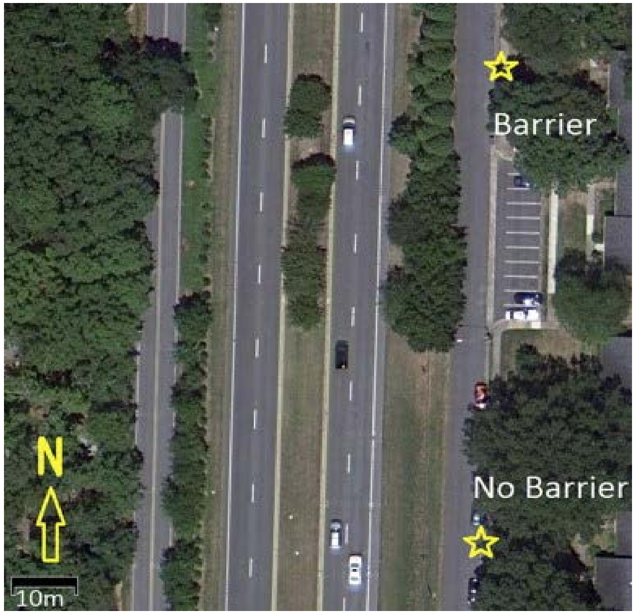
- Noise barriers reduced PM levels compared with a clearing
- Vegetation with noise barriers provided further PM reductions

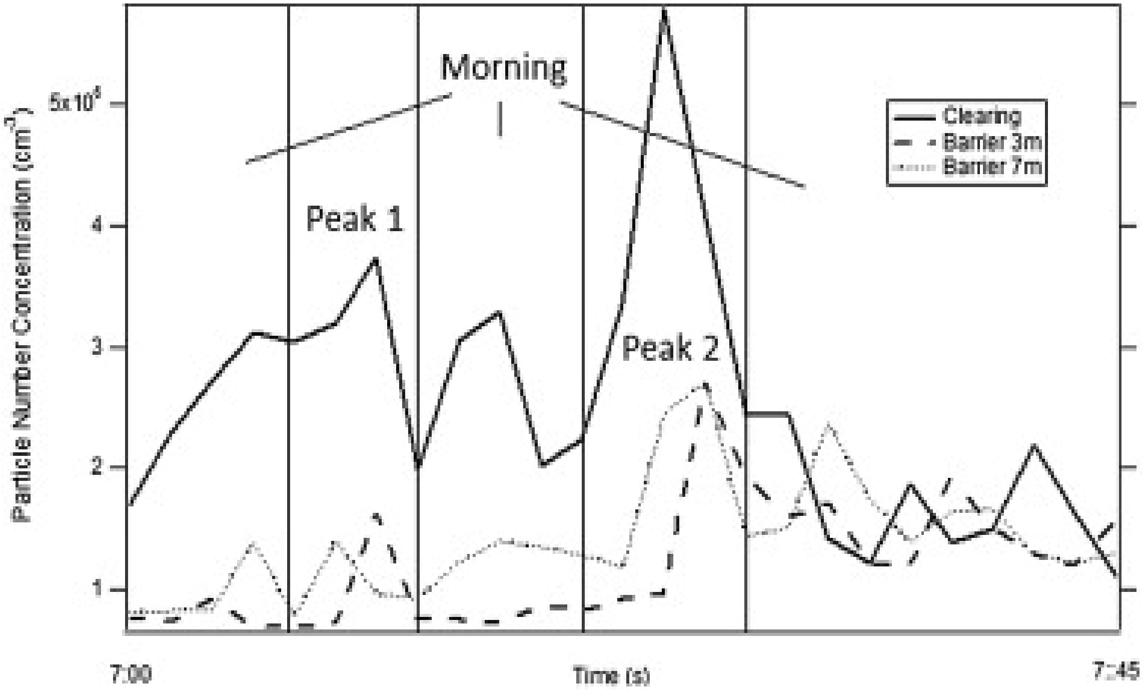


(Baldauf et al., 2008a; 2008b)

Vegetation Effects

Steffens et al. (2012)



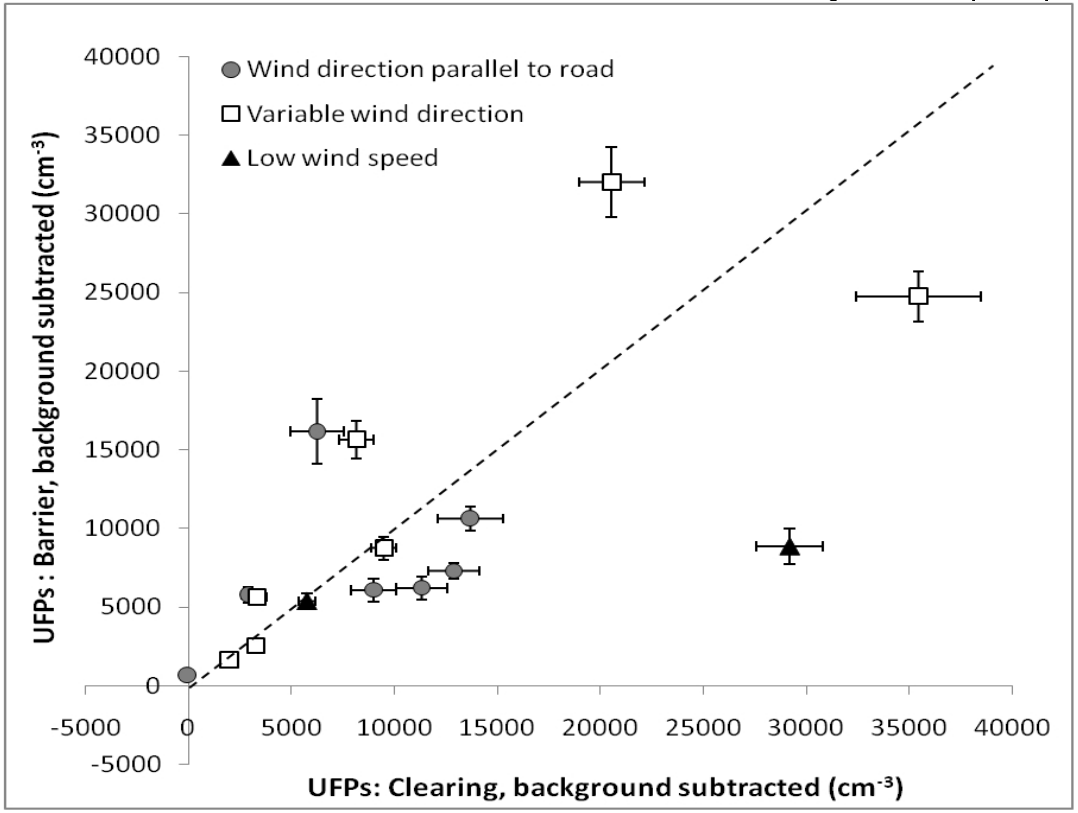


- Ultrafine PM number count generally reduced downwind of a vegetation stand
- Higher reductions most often occurred closer to ground-level
- Variable winds caused variable effects

Vegetation Effects

- For thin tree stands, variable results seen under changing wind conditions (e.g. parallel to road, low winds)
- Gaps/dead trees may have led to higher concentrations
- Future research looking into effects of lower porosity/wider tree stands

Hagler et al. (2011)



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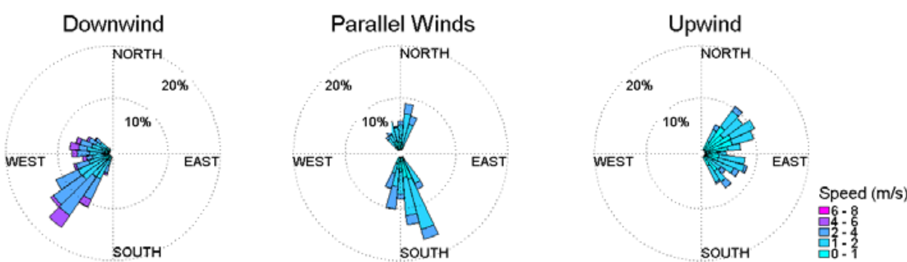
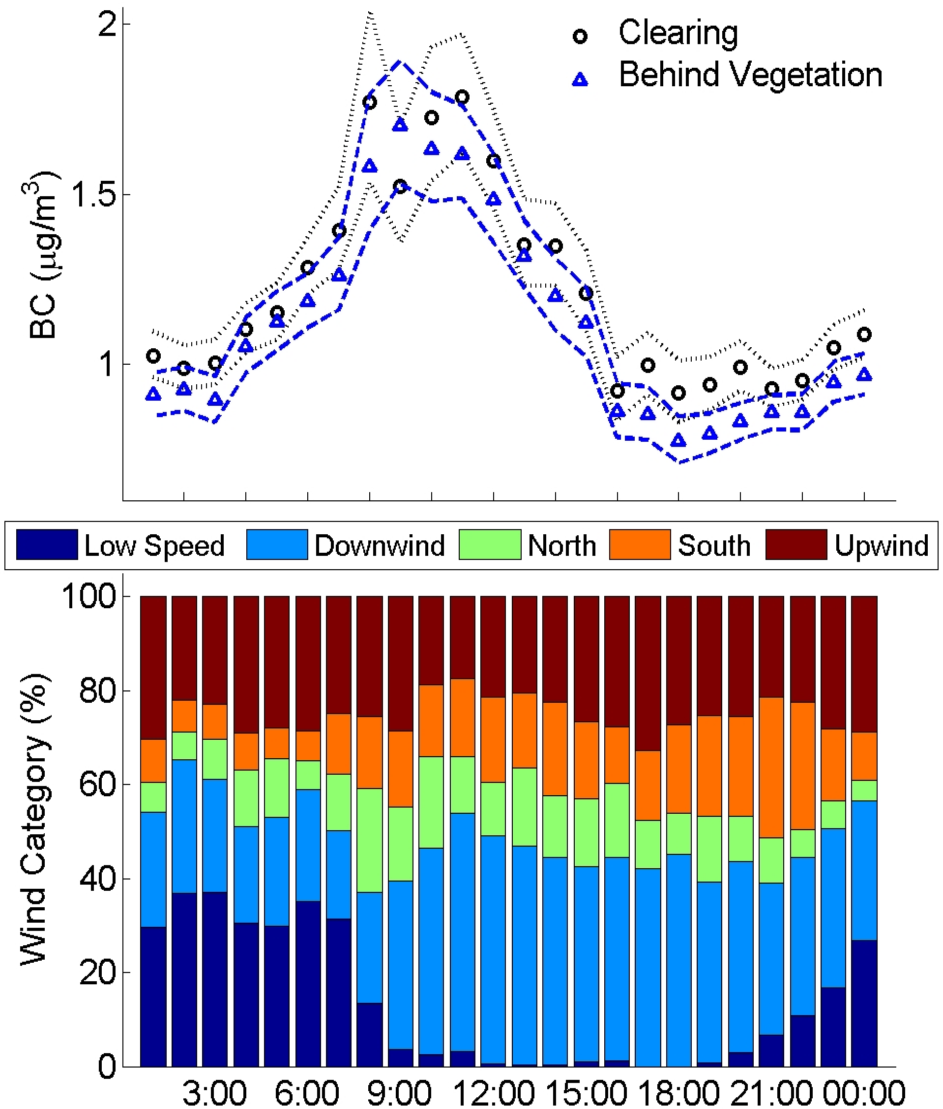
Vegetation Effects

Vegetation on average resulted in 15% lower BC levels compared to concentrations in a clearing



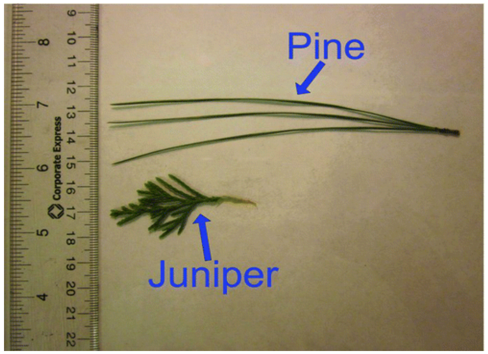


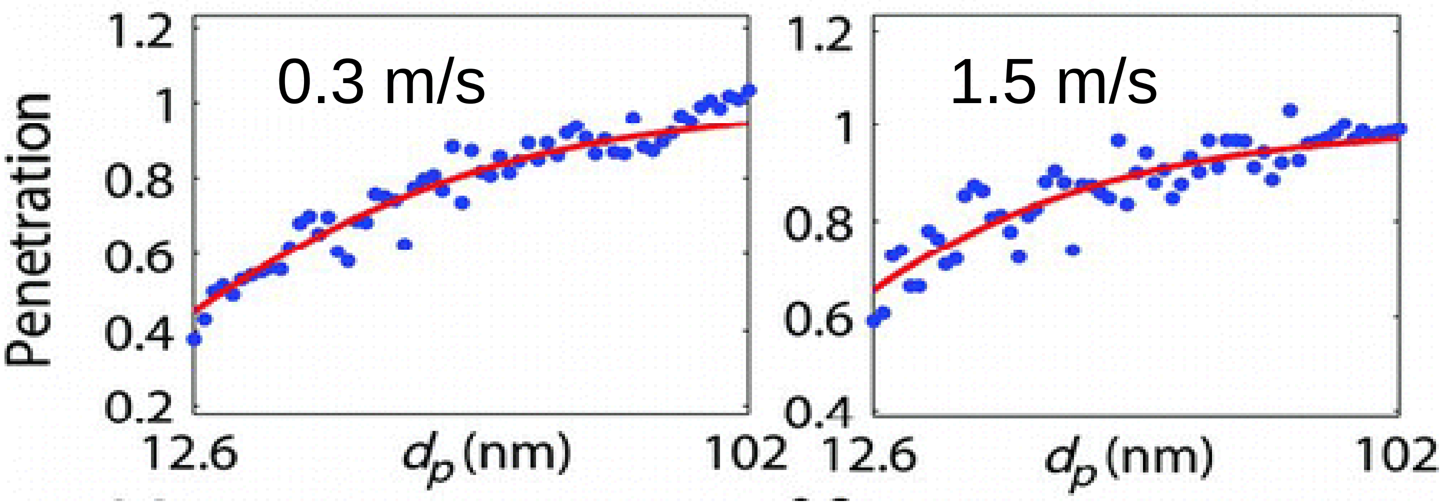
Brantley et al. (in prep)

Vegetation Effects

(Cahill et al., 2010)

- Smaller size fractions of PM have higher removal efficiency
- Removal increases at lower wind velocities
- Shape and size of branches/leaves affects removal





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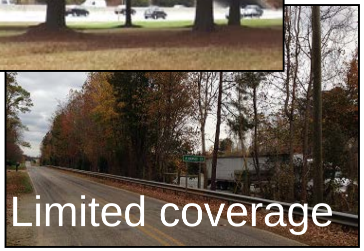
Summary

- As public health concerns increase, understanding near-road exposures is important in identifying and implementing effective mitigation strategies
- Roadway design and roadside features can greatly affect nearby population exposures
  - Road configuration can alter the transport and dispersion of traffic-emitted air pollutants
  - Roadside features like noise barriers and vegetation can also affect pollutant transport and dispersion
    - Reductions as high as 60% have been measured downwind of barriers and vegetation
    - Near-road pollutant levels can increase under certain conditions
- Models will be important in evaluating exposures and mitigation options

Summary – Noise Barriers

- Research shows noise barriers can reduce downwind pollutant levels
- Design considerations important:
  - Generally, the higher the barrier, the higher the pollution reduction
  - Pollutants can meander around edges (sides and top), so sensitive areas should avoid edge effects
  - Pollutant reductions measured when noise barrier close to the source; unknown when distance is increased
  - Pollutants can be trapped on the upwind side of the barrier
    - May lead to increased concentrations on the road, although data limited
    - "Upwind" sources in the area should be evaluated

Summary - Vegetation



- Research shows roadside vegetation can reduce downwind pollutant levels
- Design considerations important:
  - Generally, the higher and thicker the vegetation, the higher the reduction
  - Pollutants can meander around edges or through gaps, so sensitive areas should avoid edge effects
  - Vegetation should be appropriate for area:
    - Native plants and trees preferred
    - Mature vegetation – trees take time to grow
    - Reasonable water use; water runoff control
    - Limited seasonal effects for year-round benefits
    - Falling debris will not impact roadway

Summary – Combination Barriers

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- Noise with vegetation barriers may provide the highest reductions
  - Increase potential for pollutant dispersion and removal
  - May be solid barrier with vegetation behind and/or in front
  - Use of climbing vegetation and hedges with solid barrier may also provide additional benefits
    - Field study results mixed
    - Vegetation on solid wall should extend enough to allow air to flow through

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For More Information

- Websites:
  - http://www.epa.gov/nrmrl/appcd/nearroadway/workshop.html
  - http://www.epa.gov/ord/ca/quick-finder/roadway.htm
- References

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- Contact Information:

Rich Baldauf, PhD, P.E.
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina
919-541-4386
baldauf.richard@epa.gov