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Examining the Role of Vegetation in Mitigating Near-Road Air Pollution

Rich Baldauf

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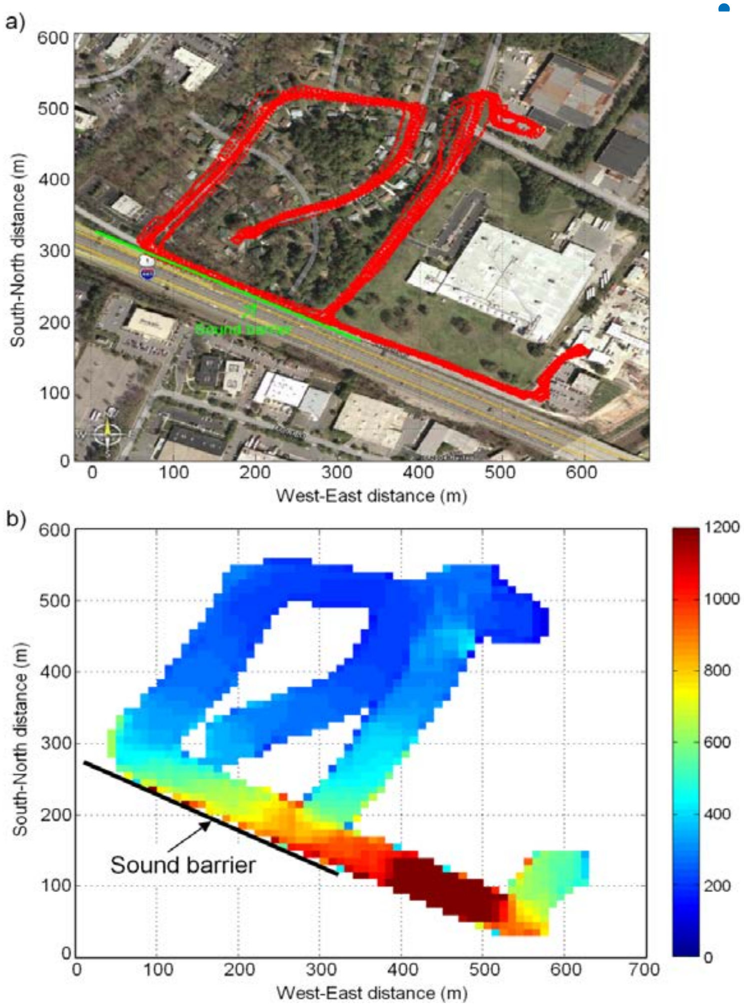
Sacramento, CA

Research Methodology

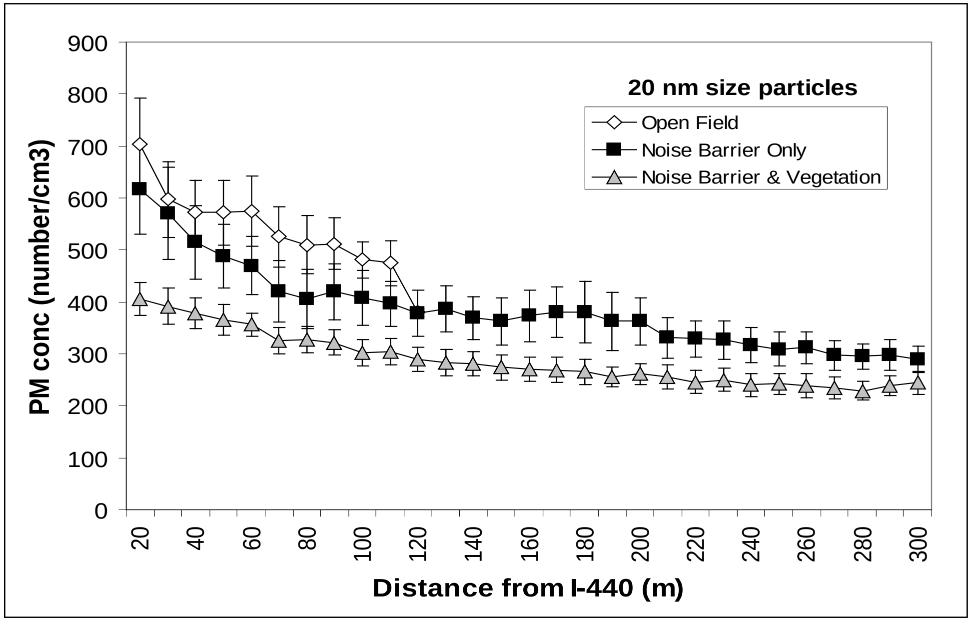
- EPA has initiated research to examine the role roadside vegetation may play in reducing near-road air pollution
  - Field studies
    - Research Triangle Park area (vegetation and noise barriers)
    - Detroit (vegetation)
    - San Francisco (vegetation)
  - Wind tunnel assessments
    - Vegetation removal processes
    - Site-specific configurations
  - Computational Fluid Dynamics (CFD) modeling
    - Generalized vegetative scenarios
    - Site-specific configurations

Noise Barrier & Vegetation Effects



- Noise barriers reduced PM levels compared with a clearing

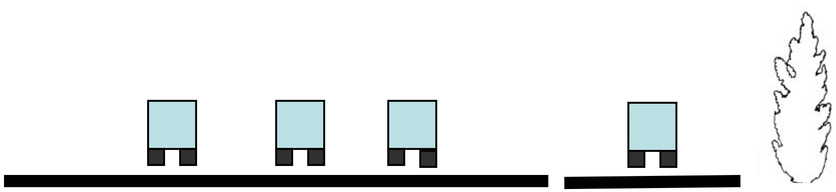
  Vegetation with noise barriers provided a further reduction of PM concentrations and gradients



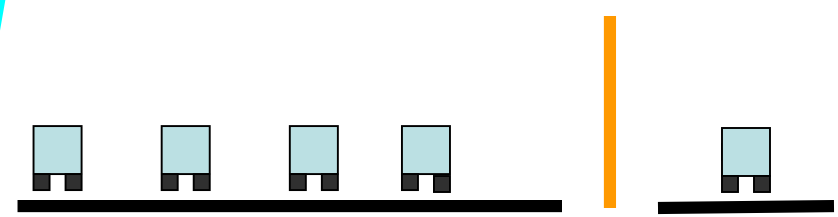
(Baldauf et al., 2008a; 2008b)

Noise Barrier & Vegetation Effects

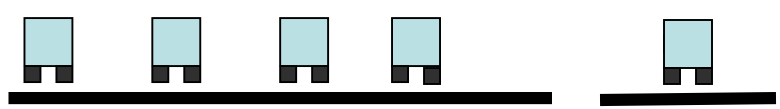
N1– hwy + access road + trees



N3, N4 – hwy + wall + access road

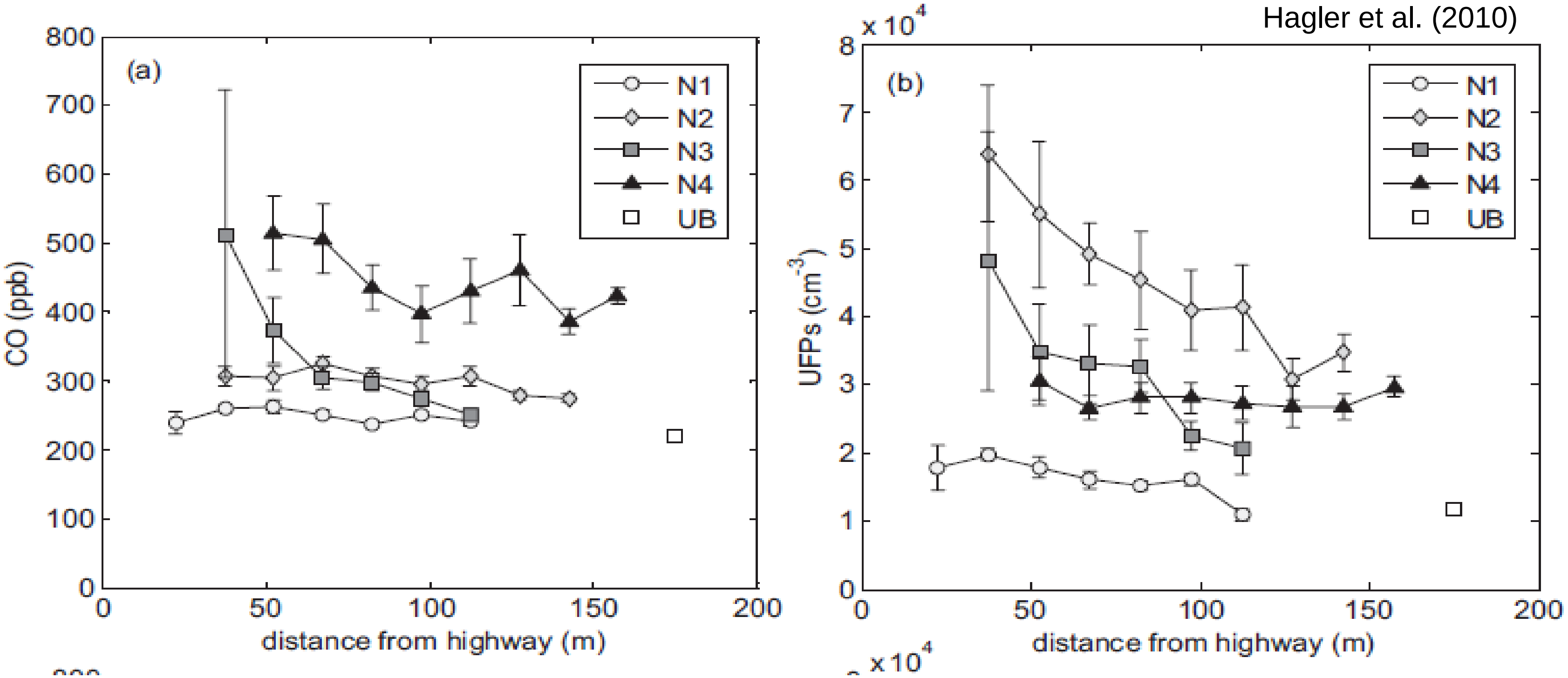


N2 –hwy + access road



Noise Barrier & Vegetation Effects

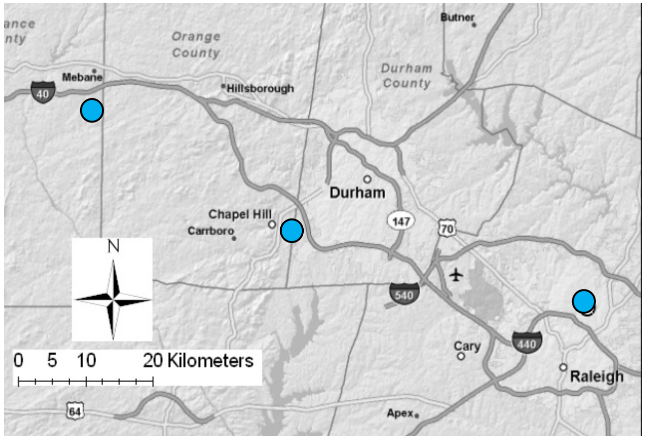
Hagler et al. (2010)

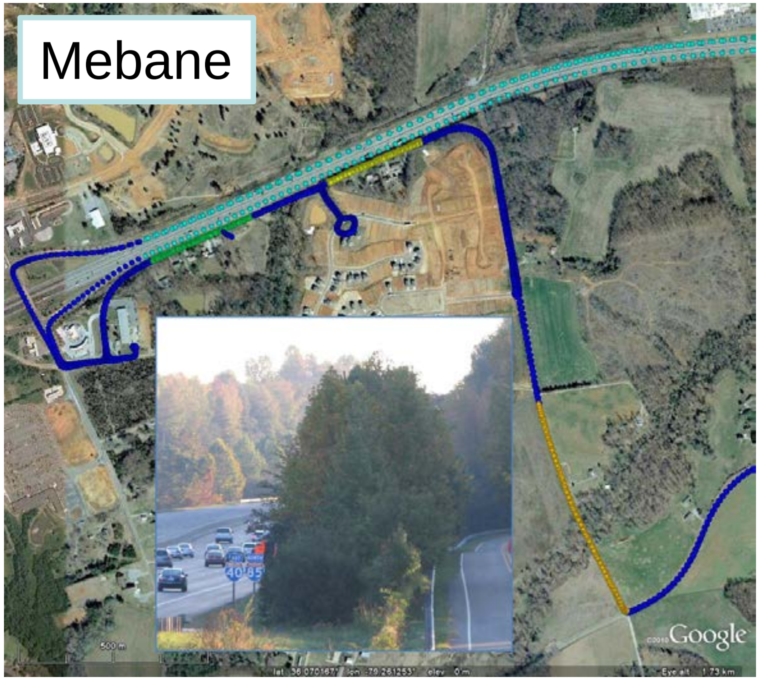


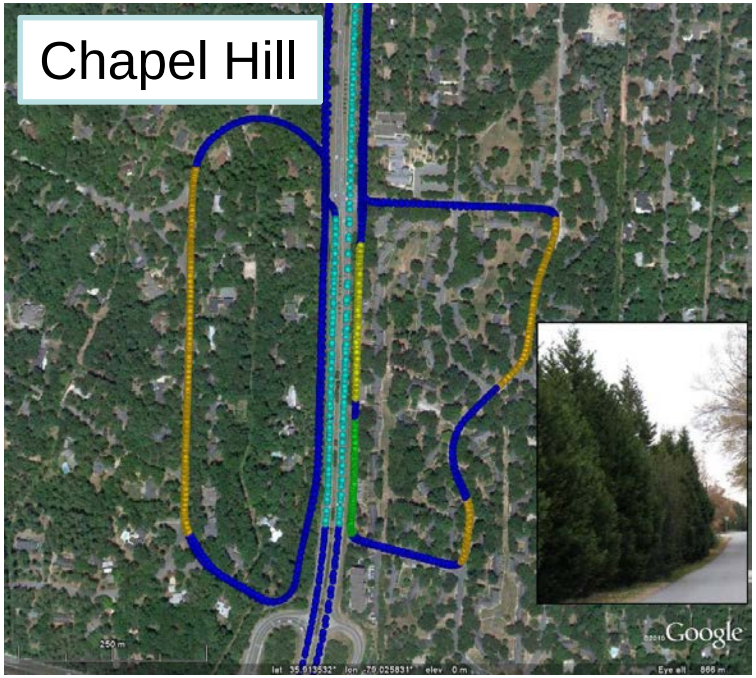
- Vegetation barriers had the lowest downwind pollutant concentrations (although traffic volumes also lower near this neighborhood)
- Access road behind noise barrier led to increased concentrations

Vegetation Effects

- Field data: Mobile and fixed site sampling study at two sites in North Carolina
  - One with primarily pine trees (Chapel Hill)
  - One with primarily hardwoods (Mebane)







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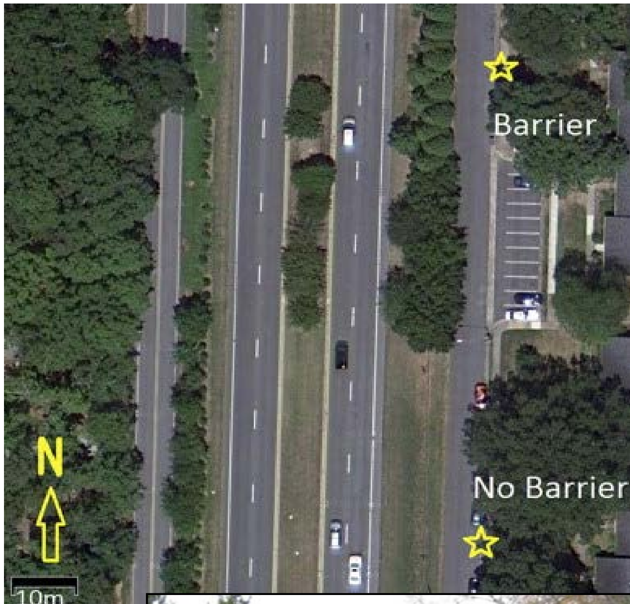
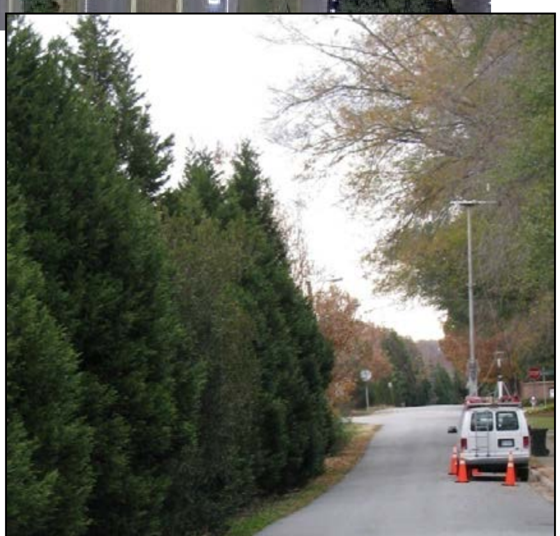
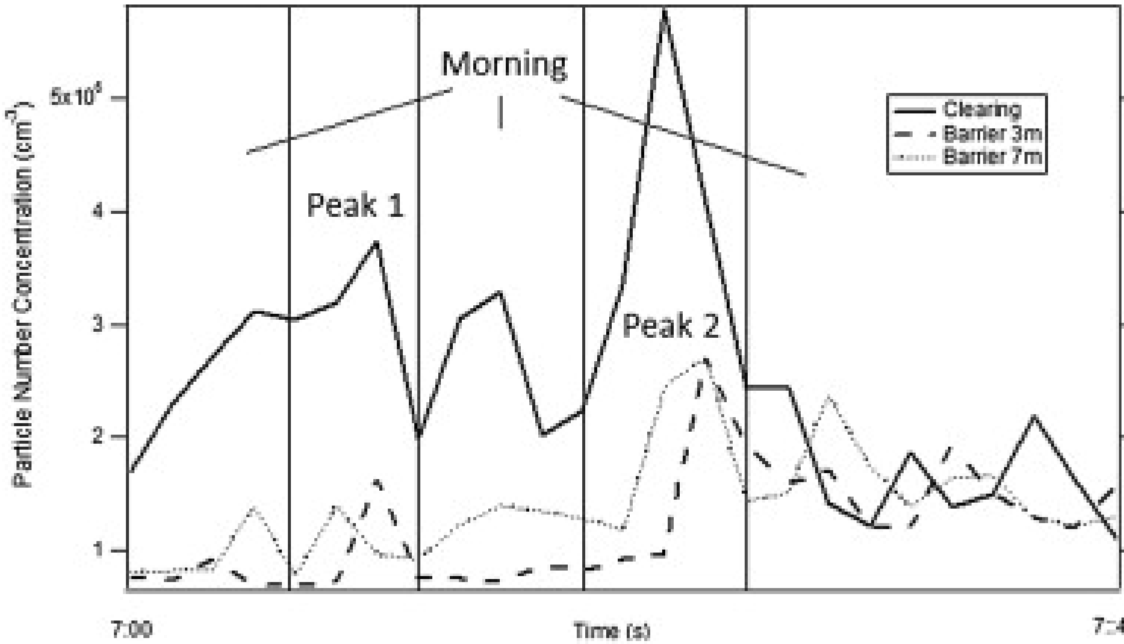
Vegetation Effects





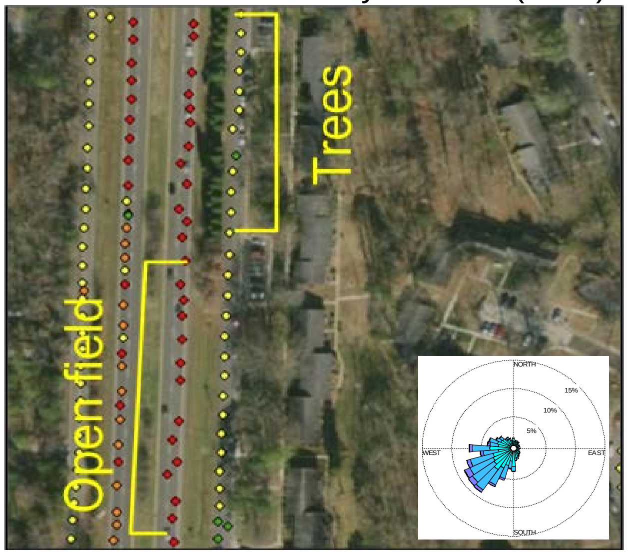
Steffans et al. (2011)

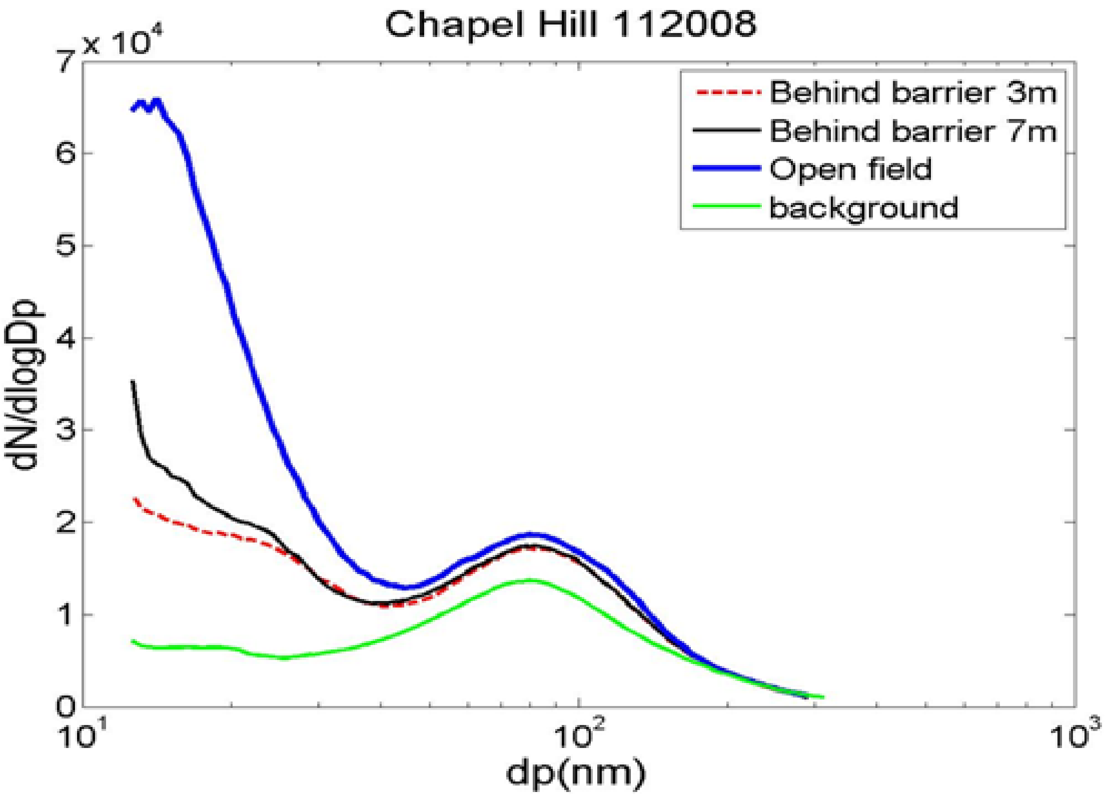


- Ultrafine PM number count generally reduced downwind of a vegetation stand
- Higher reductions most often occurred closer to ground-level
- Variable winds caused variable effects

Vegetation Effects

Khlystov et al (2012)

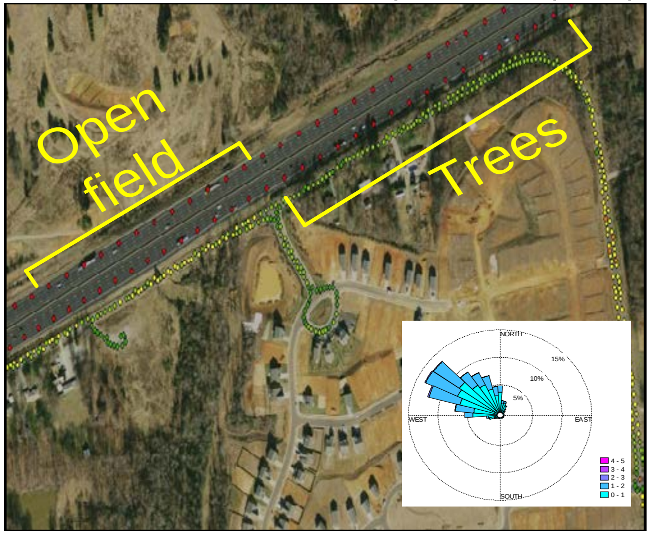


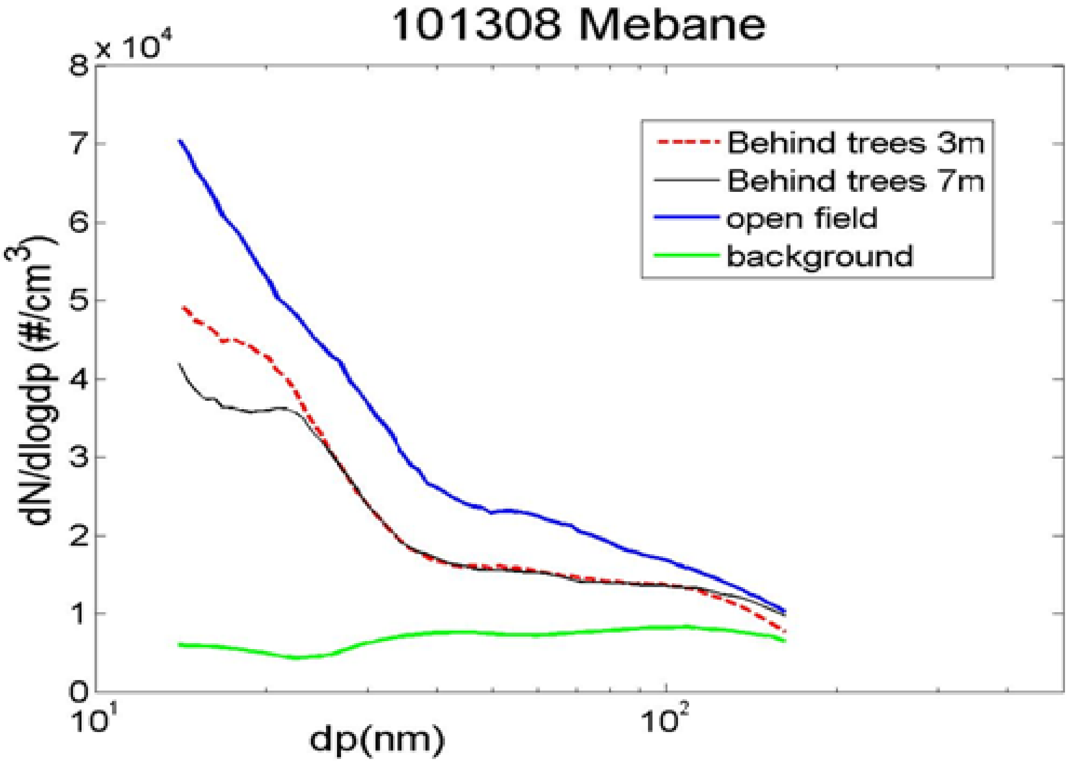


- Lower size fractions of PM most reduced downwind of the vegetation stand
- Effect most evident closer to ground-level

Vegetation Effects

Khlystov et al (2012)





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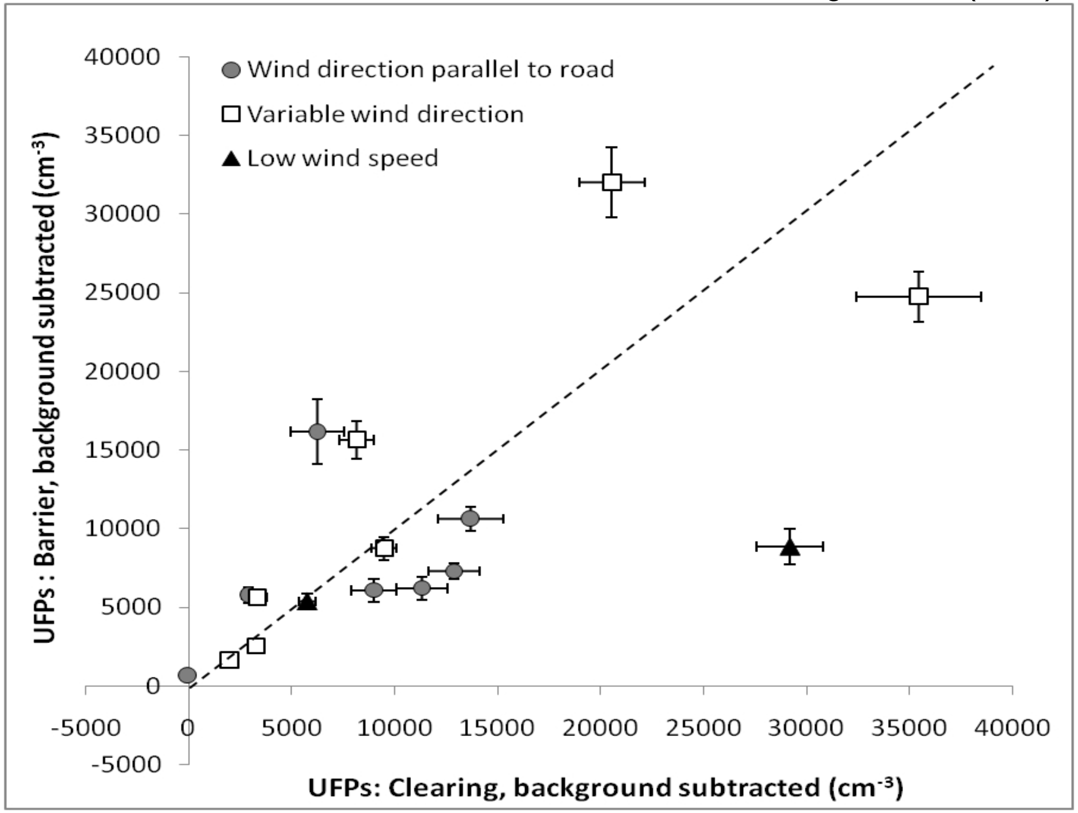
Vegetation Effects

- For thin tree stands, variable results seen under changing wind conditions (e.g. parallel to road, low winds) and larger spatial scales
- Future research looking into effects of lower porosity/wider tree stands

Hagler et al. (2011)



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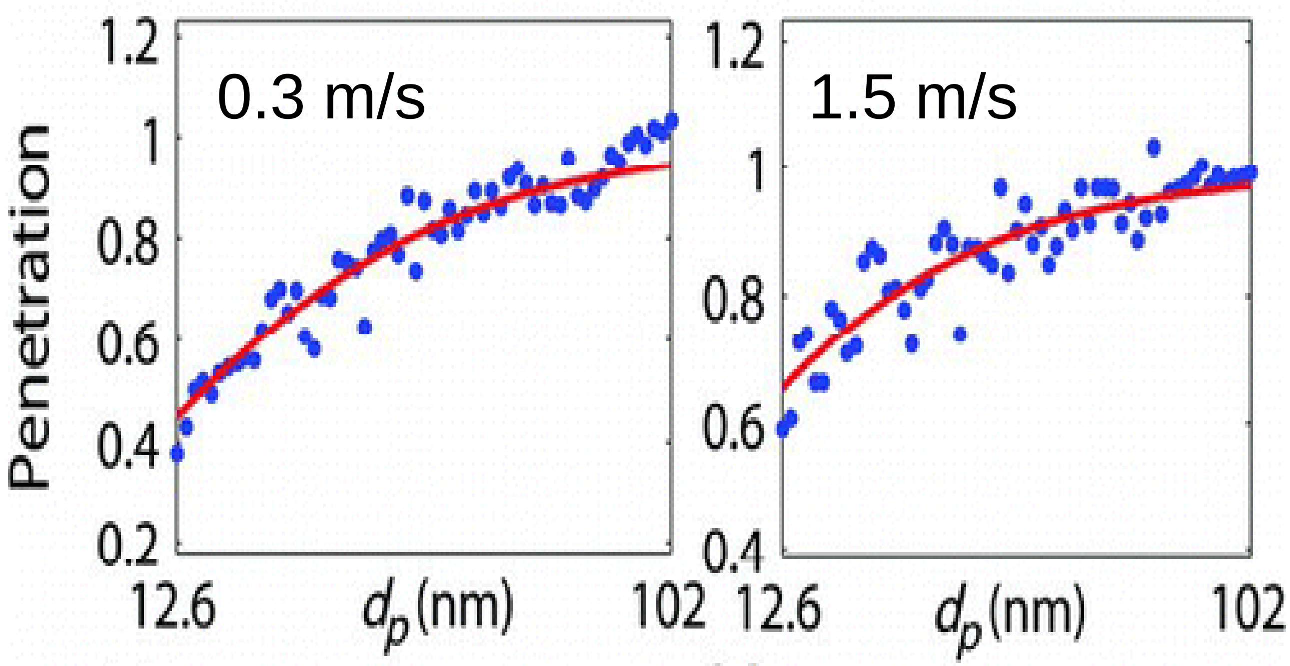
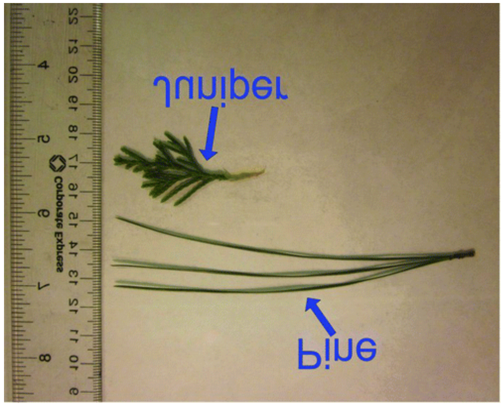
Vegetation Effects

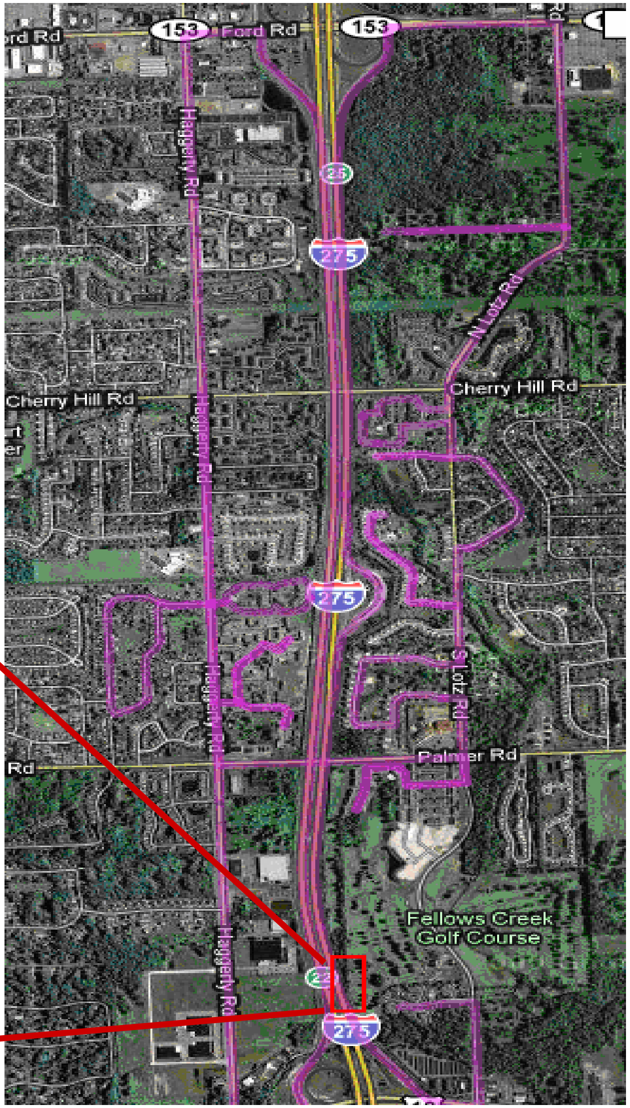
- Smaller size fractions of PM have higher removal efficiency
- Removal increases at lower wind velocities
- Shape and size of branches/leaves affects removal





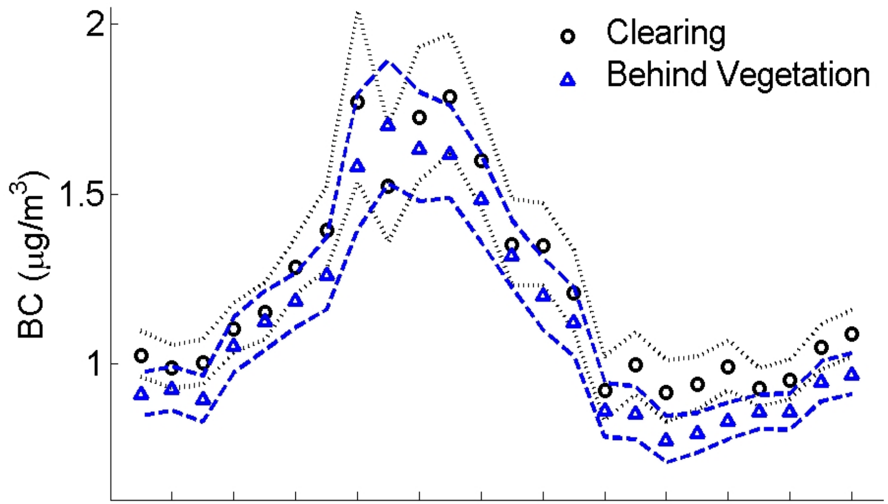
Detroit Vegetation Study

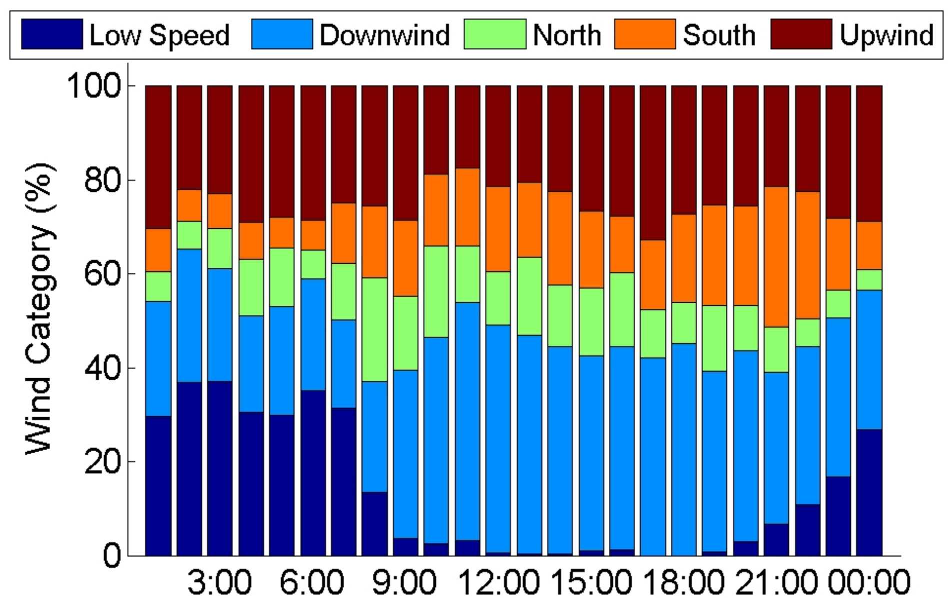
- On-road and near-road mobile monitoring with varying vegetation and neighborhood configurations
- Fixed and backpack monitoring for detailed vegetation assessment

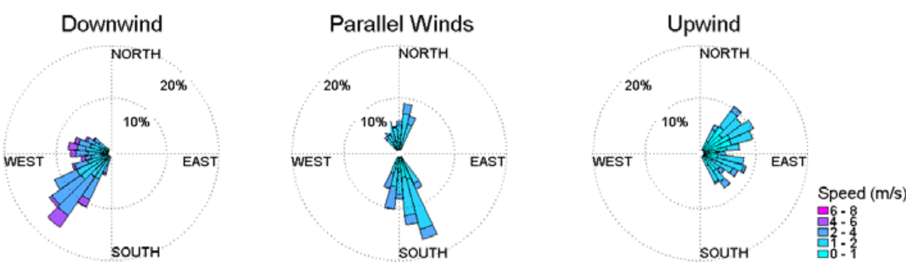


Vegetation Effects

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







Brantley et al. (in prep)

San Francisco Vegetation Study

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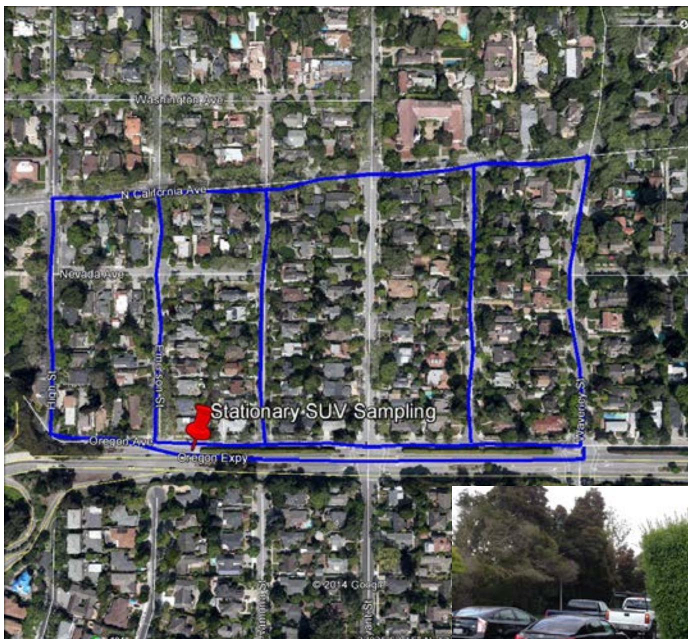
- On-road and near-road mobile and fixed monitoring with varying vegetation types
  - Bush/tree combinations with varying porosity
  - Manicured hedges



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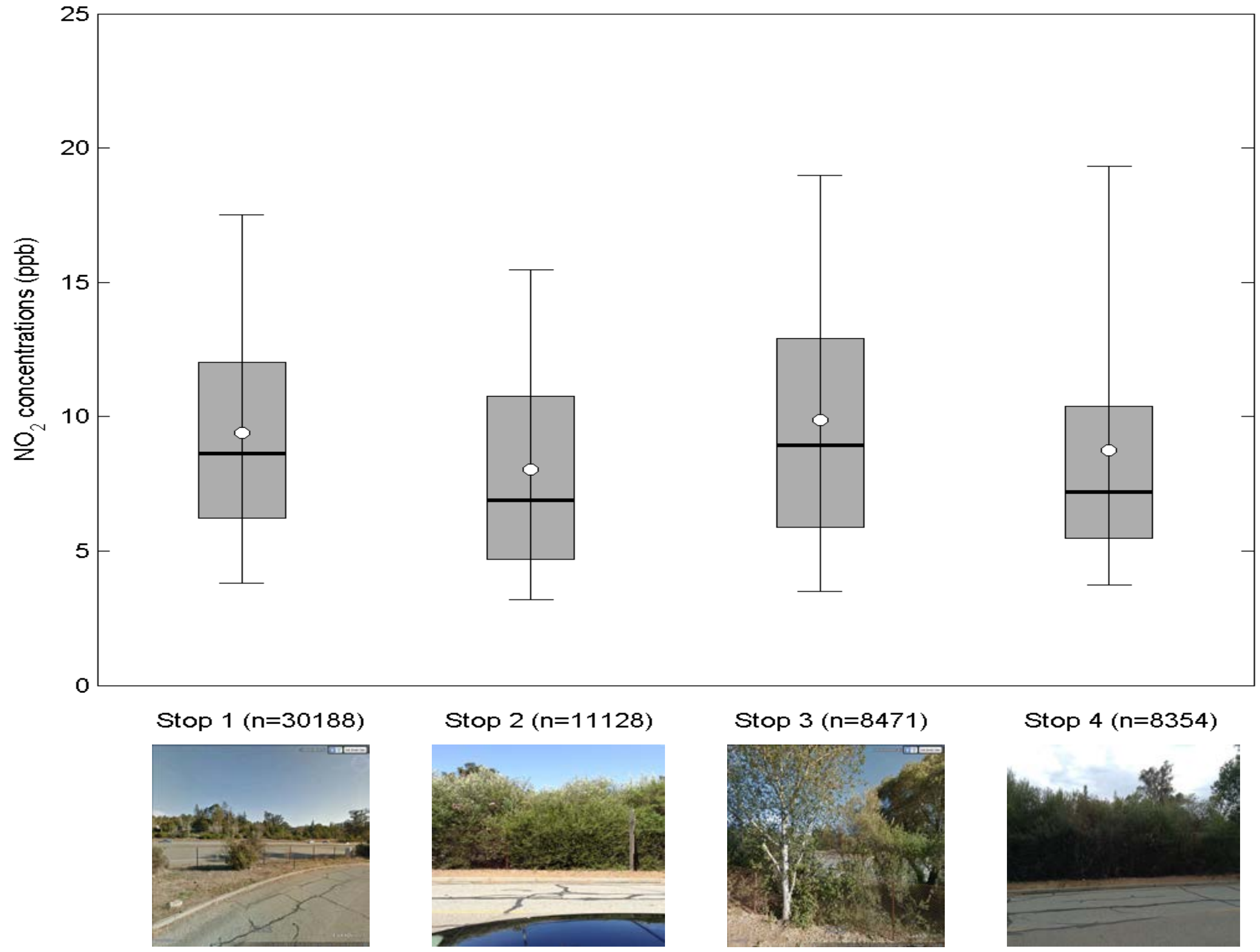
San Francisco Vegetation Study

- Initial results suggest the importance of thickness, porosity and full coverage



San Francisco Vegetation Study

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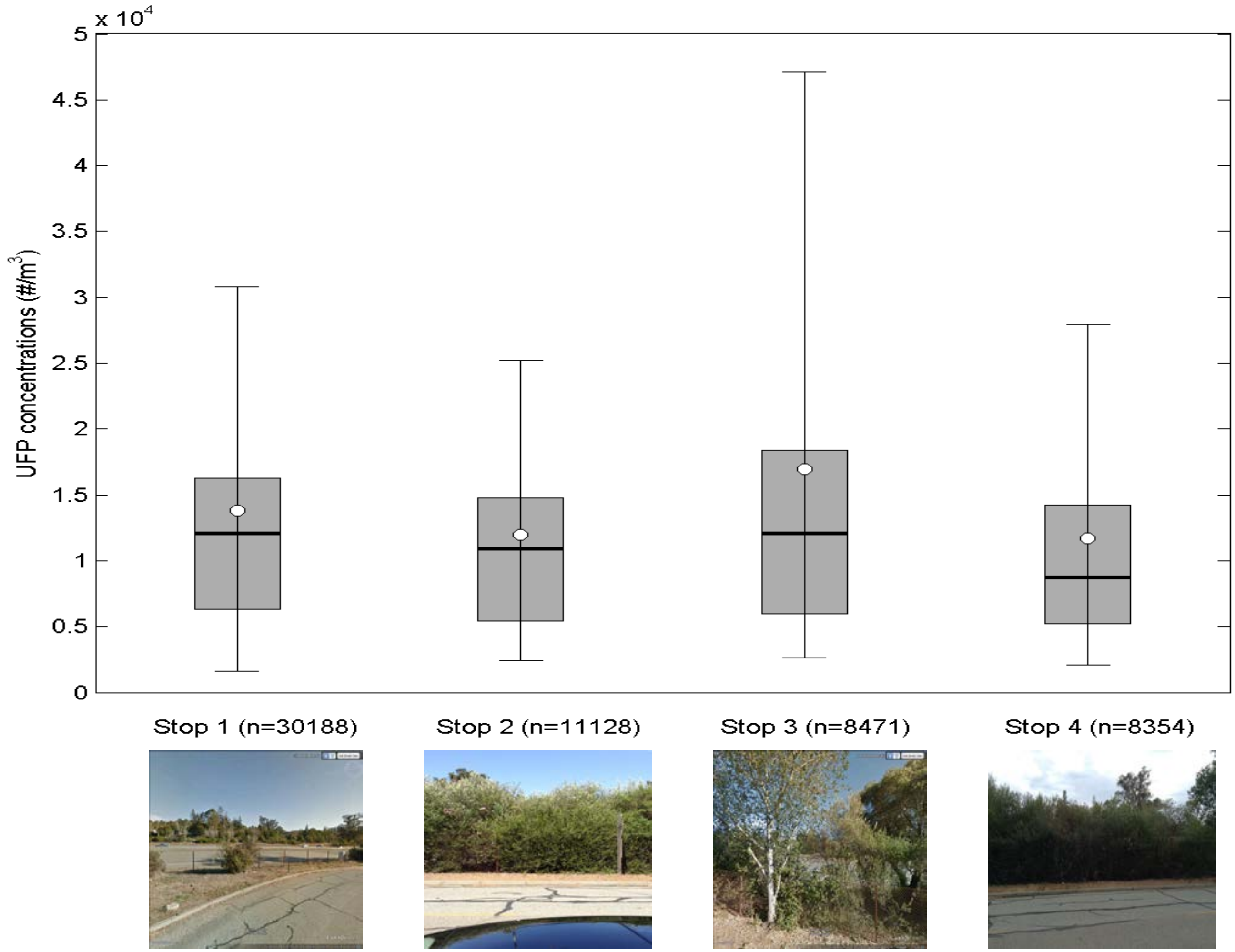


Summary - Vegetation

- Research shows the ability for roadside vegetation to reduce downwind pollutant concentrations near roads
- Design considerations are very important:
  - Generally, the higher and thicker the vegetation, the higher the pollution reduction
  - Pollutants can meander around edges or through gaps, so areas targeted for reductions should avoid edge effects
  - Vegetation should be appropriate for the location of use
    - Native plants and trees preferred
    - Mature vegetation – trees take time to grow
    - Reasonable water use; water runoff control
    - Limited seasonal effects to ensure operational barrier year-round
    - Falling debris will not impact roadway

Summary - Vegetation

- Areas desired for reduced concentrations should avoid edge effects
  - Vegetation barrier should provide coverage from the ground to the top of canopy
  - Barrier thickness should be adequate for complete coverage so gaps are avoided
- Pine/coniferous vegetation may be a good choice
  - No seasonal effects
  - Complex, rough, waxy surfaces

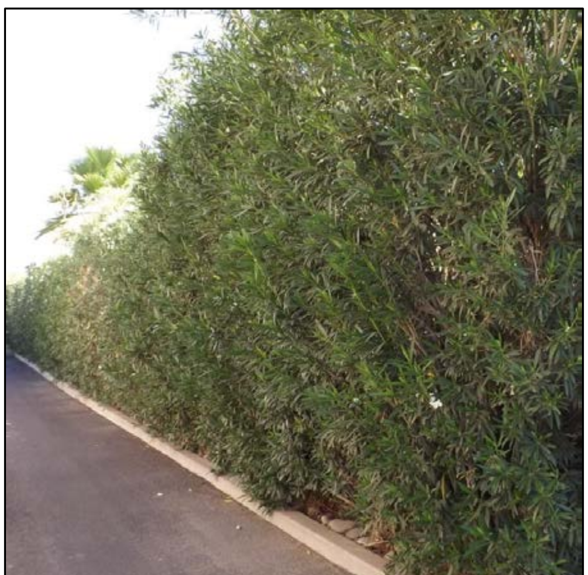
Examples of full coverage, pine barriers

Summary - Vegetation

- Pollutants can meander around edges or through gaps
- Barrier thickness should be adequate for complete coverage to avoid gaps
  - No spaces between or under trees
  - No gaps from dead or dying vegetation; maintenance important

Examples of inadequate barriers due to gaps

Summary - Barriers



- Combination of noise and vegetative barriers may provide the most benefits
  - 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

Examples of solid/vegetation barriers

Summary

- Multiple options exist to mitigate traffic emission impacts on near-road air quality and population exposures
  - Reducing emissions
  - Reducing exposures
- Ambient air mitigation options focus on exposure reduction although some techniques may also remove air pollutants
- Each mitigation option has advantages and disadvantages in both short- and long-term air quality improvement
- Implementing a strategy for reducing adverse health risks for near-road populations requires a combination of options
- Best practice guidance and case studies needed to fully evaluate potential effectiveness of roadside vegetation
- Models will be important in evaluating mitigation options and designing future research studies

Acknowledgements

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Kevin Black
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Adam Alexander

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Dennis Finn
Kirk Clawson

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