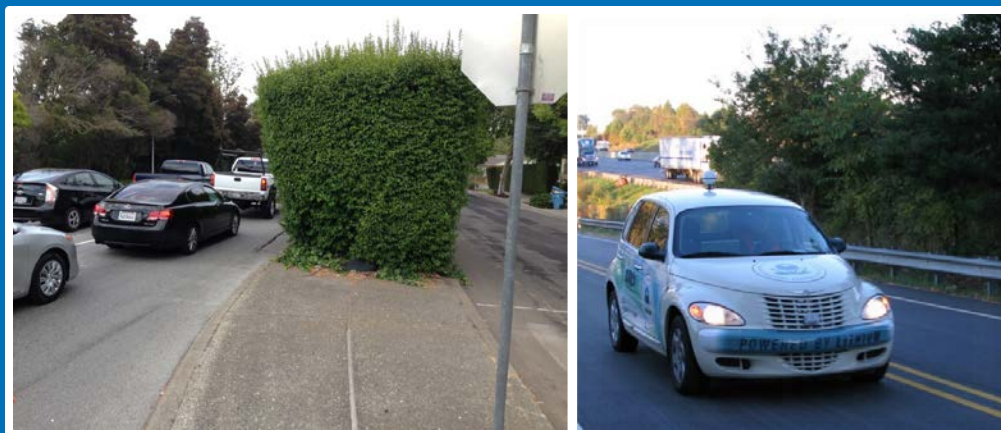


Air pollution abatement with green infrastructure : Reviews and Prospects

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Presentation Overview

- **Background**
 - Near-road health concerns
 - Roadside barrier air quality mitigation
- **Research on vegetation and air quality**
 - Impacts on near-road concentrations
 - Implications for human exposures
- **Summary and Recommendations**
- **Resources**
- **Conclusions**

Near-Road Health Concerns

People living, working and going to school near highways and large transportation facilities face increased health risks:

- Asthma and other respiratory diseases
- Cardiovascular effects
- Birth and developmental effects
- Premature mortality
- Cancer

Air pollution and exposures often highly elevated near these large transportation sources, especially within 200-300 meters

Large portion of the U.S. population exposed

- More than 50 million people estimated to live within 100 m of a large highway or other transportation facility (e.g. airport, rail yard)
- Over 4 million school children attend classes within 150 m of a major highway (1 in 11 schools; 1 in 5 new schools)

Near-Road Health Concerns

Mitigating these traffic emission exposures and health effects can be achieved by:

- Reducing emissions
- Reducing vehicle activity
- Creating development exclusion zones
- Using urban and transportation planning
 - Road location and configuration
 - Walk and bike options
 - Site design and layout
 - ***Roadside vegetation and noise barriers***

Why study roadside barriers?

Public wants to know what can be done now when near-road health concerns are raised for schools, daycares, etc.

Few other “short-term” mitigation options exist

- Emission standards can take long to implement
- Planning, zoning and large investments often needed for activity reduction programs
- Buffer/exclusion zones may not be feasible in urban areas



Why study roadside barriers?

Roadside barriers have other positive attributes with air quality only one of many potential benefits.

- Noise barriers reduce noise and can improve aesthetics
- Roadside vegetation can:
 - Reduce stormwater runoff/flooding
 - Improve water quality
 - Increase carbon sequestration
 - Reduce urban heat island effects
 - Improve aesthetics/property values
 - Enhance community livability
 - Generally improve public health

“Exposure to green space has been associated with better physical and mental health”

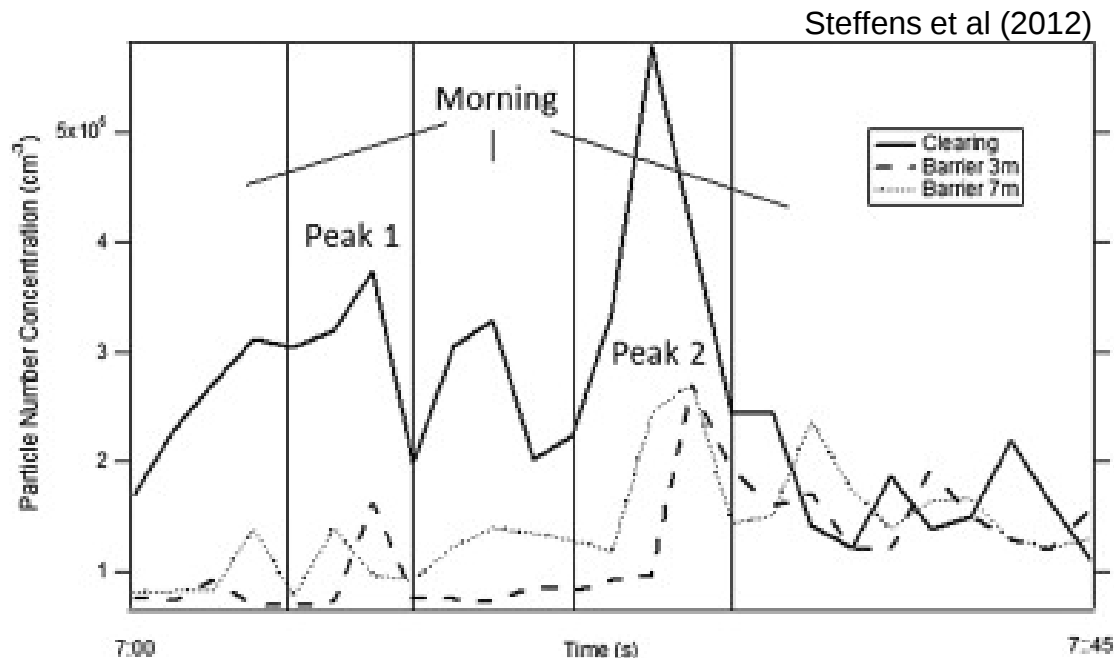
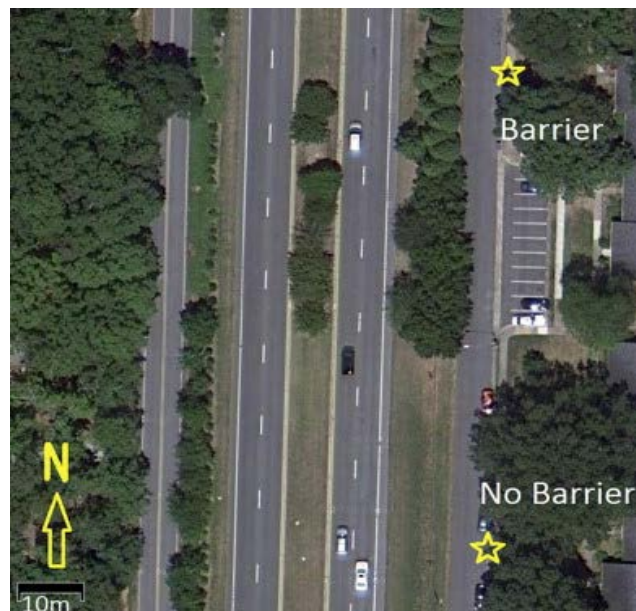


Roadside Vegetation Research Summary

Roadside vegetation can alter the transport and dispersion of air pollution from roads and other ground-level sources

- Reduces downwind pollutant concentrations by lofting the emission plume up and over vegetation
- Removes particulates and select gases by deposition onto leaf and branch surfaces
- Slows and stagnates wind allowing pollutants to pass through gaps or around edges which can lead to higher downwind pollutant concentrations

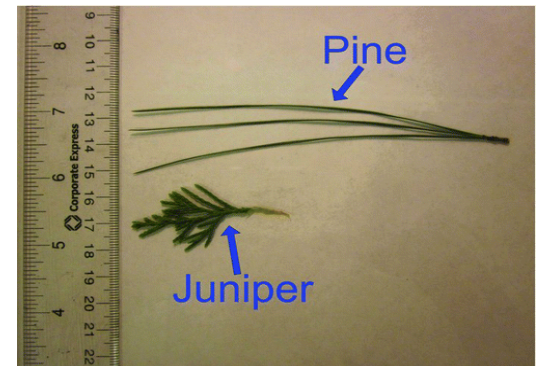
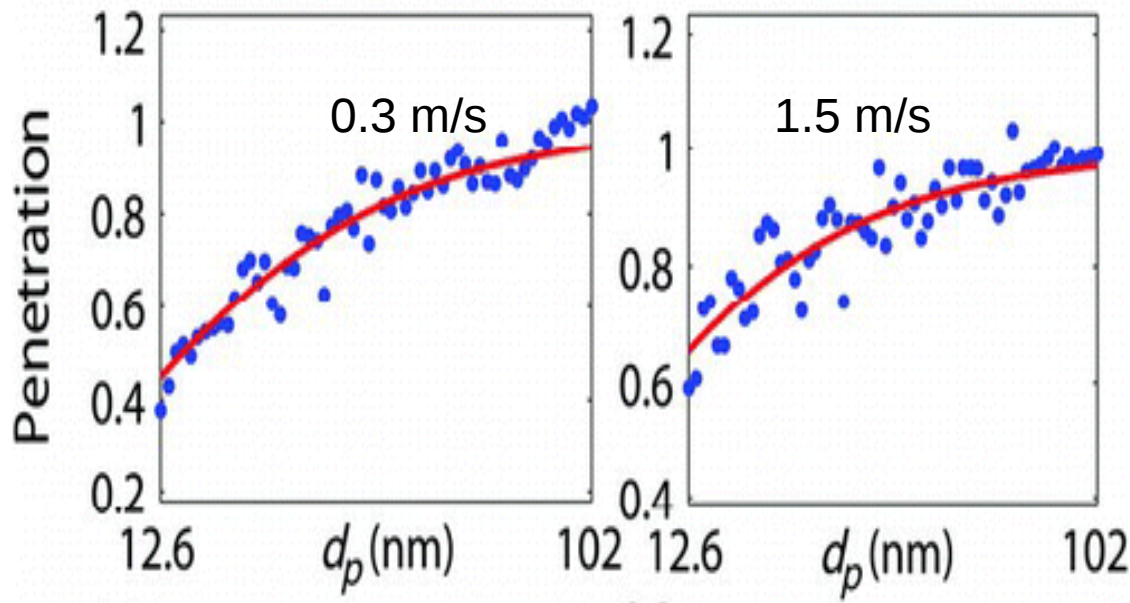
Roadside Vegetation Research



- Particulate matter generally reduced downwind of a vegetation stand
- Higher reductions occurred closer to ground-level
- Variable winds altered effects

Roadside Vegetation Effects

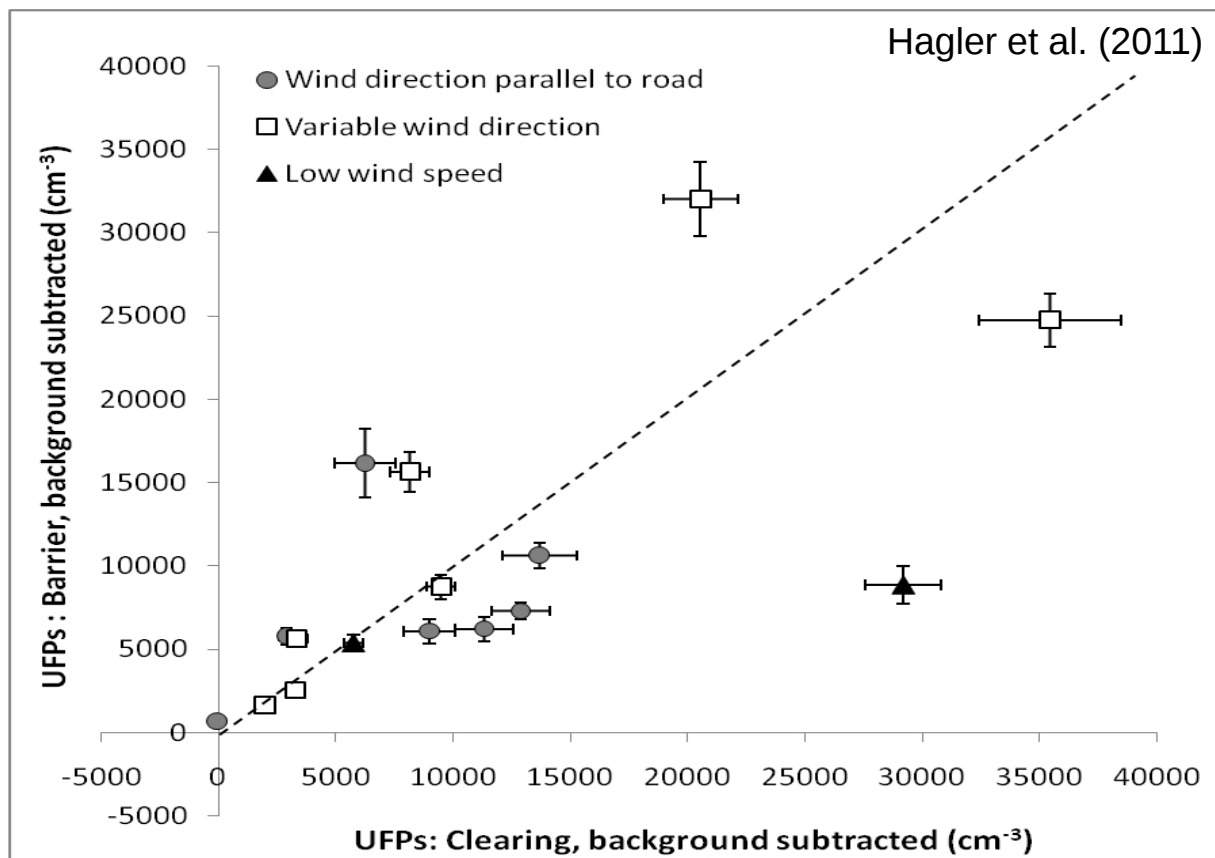
- Smaller size PM have higher removal rates
- Removal increases at lower wind velocities
- Branch/leaf shape and size affects removal



Cahill et al., (2010)

Vegetation Effects

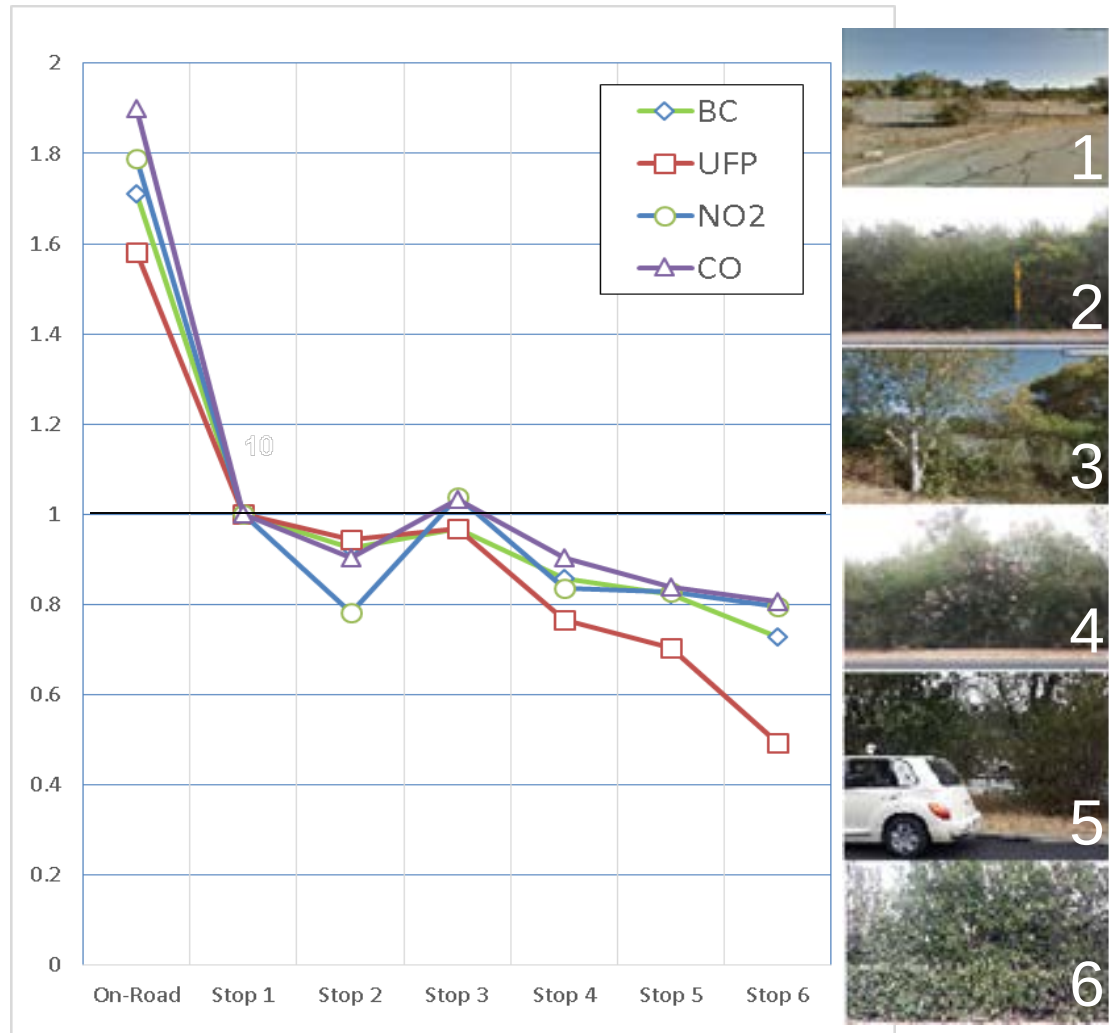
- For thin tree stands, variable results seen under changing wind conditions (e.g. parallel to road, low winds)
- Gaps/dead trees can lead to higher downwind concentrations



Roadside Vegetation Effects

Plant conditions affect downwind pollution

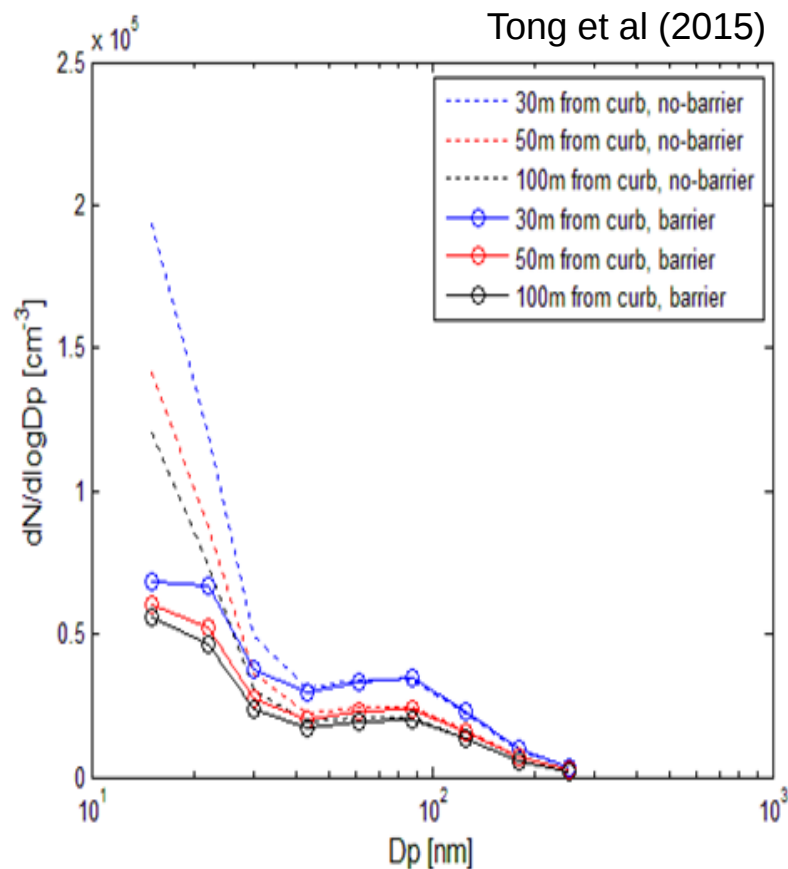
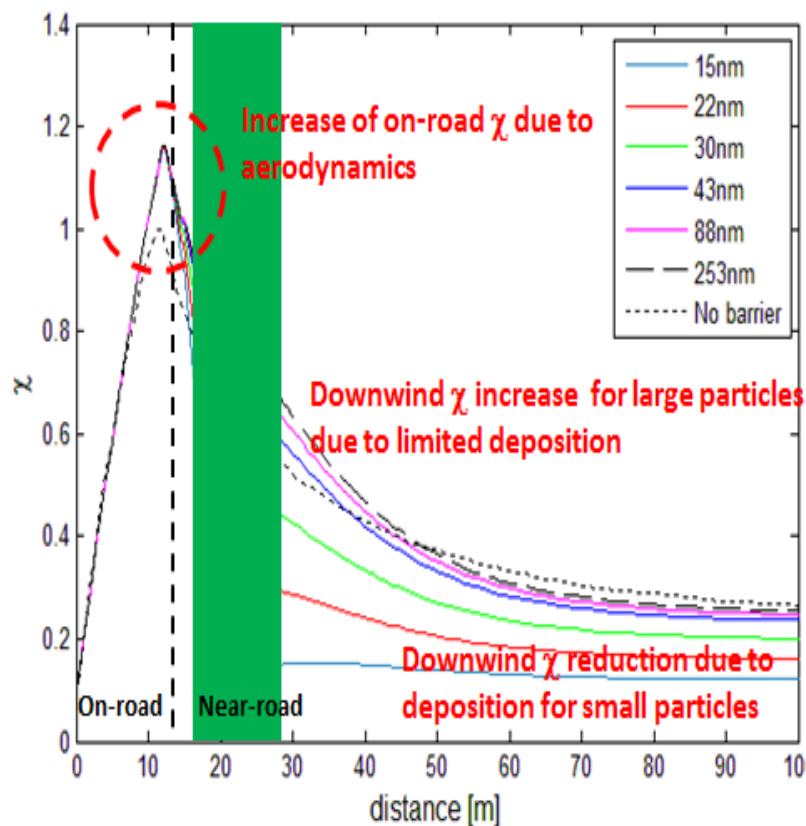
- Thick, tall and full coverage reduced pollution
- Gaps and porous vegetation led to higher levels



(Baldauf et al., *in press*)

Vegetation Model Algorithm

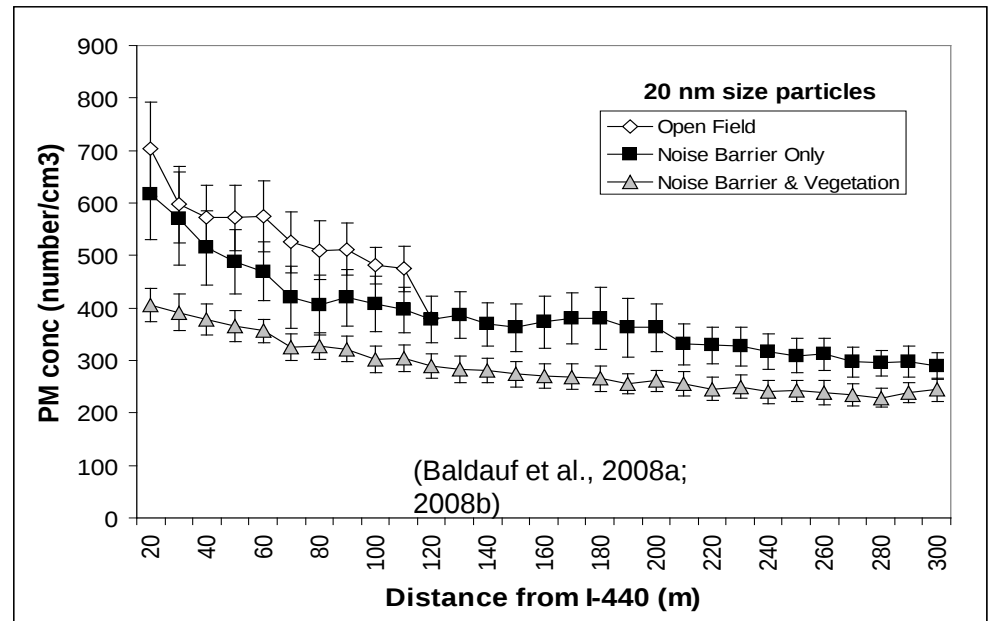
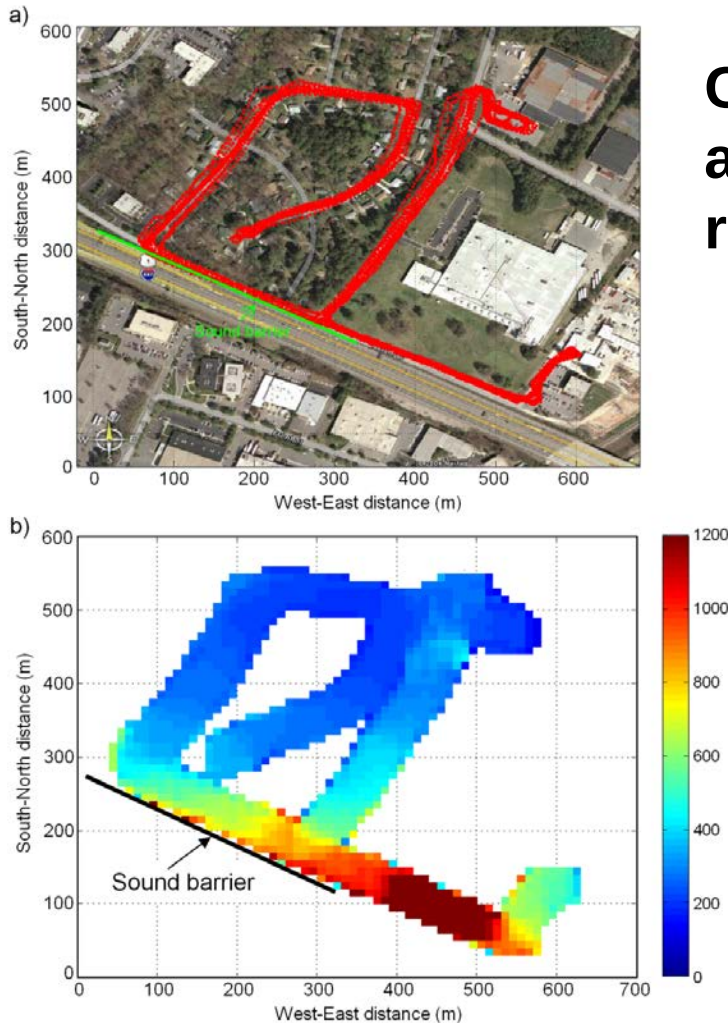
- CFD modeling highlights PM removal from vegetation, especially for smaller, ultrafine particles



Vegetation and Noise Barriers

Combinations of solid noise barriers and vegetation may provide greater reductions than either method alone

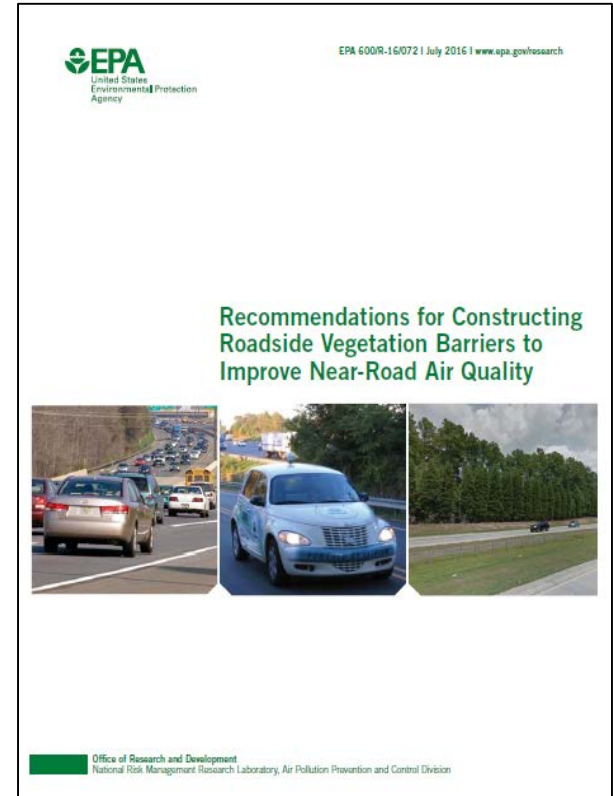
(Baldauf et al., 2008)



Vegetative Barrier Recommendations

EPA released recommendations for planting roadside vegetation

- Used to design planting projects in Oakland and Detroit
- Includes vegetation alone and combined with solid barriers
- Provides designs Intended to:
 - Maximize the potential for near-road air pollution reduction
 - Avoid unintended consequences and designs that may increase downwind concentrations and exposures



Vegetative Barrier Recommendations



Areas desired for reduced pollutant concentrations should avoid gaps and edge effects

- Complete coverage from the ground to the top of the canopy
- Thickness adequate to reduce porosity and avoid gaps

Pine/coniferous trees and thick bushes may be good choices

- No seasonal effects
- Complex, rough, waxy surfaces

Mix of species may increase coverage and robustness

Examples of full coverage, pine and bush barriers

Vegetative Barrier Recommendations



Pollutants can meander around edges or through gaps

- No spaces between or under trees
- No gaps from dead or dying plants; maintenance important



Examples of inadequate barriers due to gaps

Vegetative Barrier Recommendations

Combination of solid noise and vegetative barriers may have the most benefit

- Increases air pollutant dispersion and removal
- May be solid noise barrier with vegetation behind and/or in front
- Use of climbing vegetation on solid surfaces still uncertain



Examples of solid/vegetation barriers

Other Considerations

Vegetation characteristics:

- Species (e.g. native vs. non-native)
- Appropriateness for site
 - Drought/flood resistant
 - Road treatment tolerant (e.g. salt, sand)

Physical characteristics the barrier needs:

- Height, thickness, length and porosity
- Non-seasonal vegetation (conifers, bushes, etc.)
- Waxy leaf and branch surfaces for pollutant removal
- Low pollution/pollen emissions

Tools to help in the design process:

- USFS i-Tree model
- EPA EnviroAtlas

Additional Resources

The BBC reported on air quality benefits of roadside vegetation based on research by international partners following many of the recommendations outlined in the EPA report

6/7/2017 Cities need 'hedges as well as trees' for environment - BBC News

BBC

Home News Sport Weather Shop Earth Travel

Science & Environment

Cities need 'hedges as well as trees' for environment

By Roger Harrabin
BBC environment analyst

17 May 2017 | Science & Environment



Hedges are often better than trees at soaking up air pollution among tall buildings, research has suggested.

A paper in the journal *Atmospheric Environment* says tall trees are good at absorbing pollution in more open areas.

But hedges can trap toxins at exhaust pipe level, so reduce people's direct exposure to harmful pollutants.

<http://www.bbc.com/news/science-environment-39943197>

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Conclusions

- Roadside vegetation can provide significant reductions in local air pollution under certain conditions and design characteristics
- Recommendations have been developed to help design and maintain roadside vegetation for air quality benefits

For More Information:

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