

# Vegetation Influences on Near-Road Air Quality

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*U.S. Environmental Protection Agency*

*2010 NTAQS Meeting*

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*Boston, Mass*



# Background

- Concerns regarding population exposures near large roadways
  - Elevated pollutant concentrations
  - Adverse health effects
  - Potentially large population exposed
- Interest in the role near-road vegetation may play in mitigating traffic emission impacts
  - Workshop held in North Carolina, April 27-28
  - Representatives from academia, state and local agencies, environmental advocacy groups, and government agencies,
  - Participant expertise included air quality, urban forestry, ecosystem services, and policy
  - Reviewed the current science and identified future activities and research needs

# Why are we concerned? Traffic Emissions

- More than 1,000 compounds have been identified in exhaust and evaporative emissions from mobile sources – many with known health implications
  - NAAQS Pollutants
  - Air Toxics
  - Particulate Matter
- Air quality measurements have indicated elevated pollutant concentrations near roads
  - CO and Pb the focus during the 70's
  - Recent studies reveal complex mixture of pollutants

# Why are we concerned?

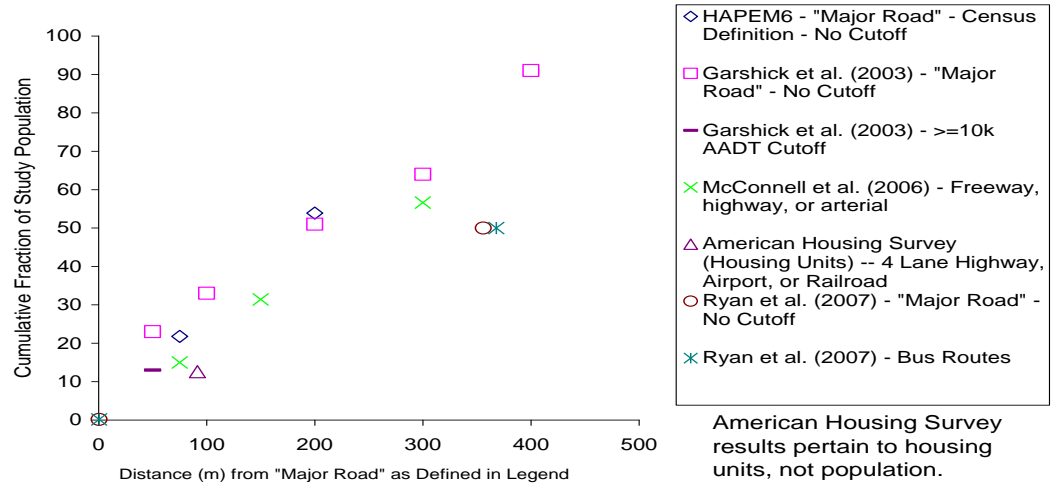
## Adverse Health Effects

- Living, working, or going to school near major roadways has been associated with numerous adverse health endpoints
  - Respiratory effects (e.g., asthma, bronchitis)
  - Cardiovascular effects
  - Adverse birth outcomes/developmental effects
  - Premature mortality
  - Cancer
- Hundreds of studies published this decade
  - Account for varying fleets, engine technologies, etc.
  - Health Effects Institute (HEI) summarized these findings, concluding that exposures to traffic emissions near roads are a “public health concern.”

# Why are we concerned? Population Exposures

- Significant portion of U.S. population lives near large roads or transportation system
  - 2007 American Housing Survey estimates >45 million people
  - Additional portion of population works or goes to school near large roads
  - High density traffic residences and schools disproportionately lower income

Cumulative Population Fraction within X Meters of "Major Roads"  
"Major Road" Definitions Shown in Legend



# One way to mitigate impacts: Roadway Design and Roadside Features?

**Flat, At-Grade**



**Vertical Road Cut**



**Sloped Road Cut**



**Noise Barriers**

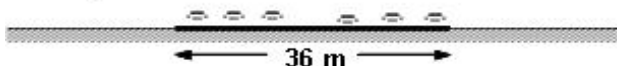


**Vegetation (porous) Barrier**



# Influence of Roadway Design and Roadside Features

Flat, At-Grade



Vertical R



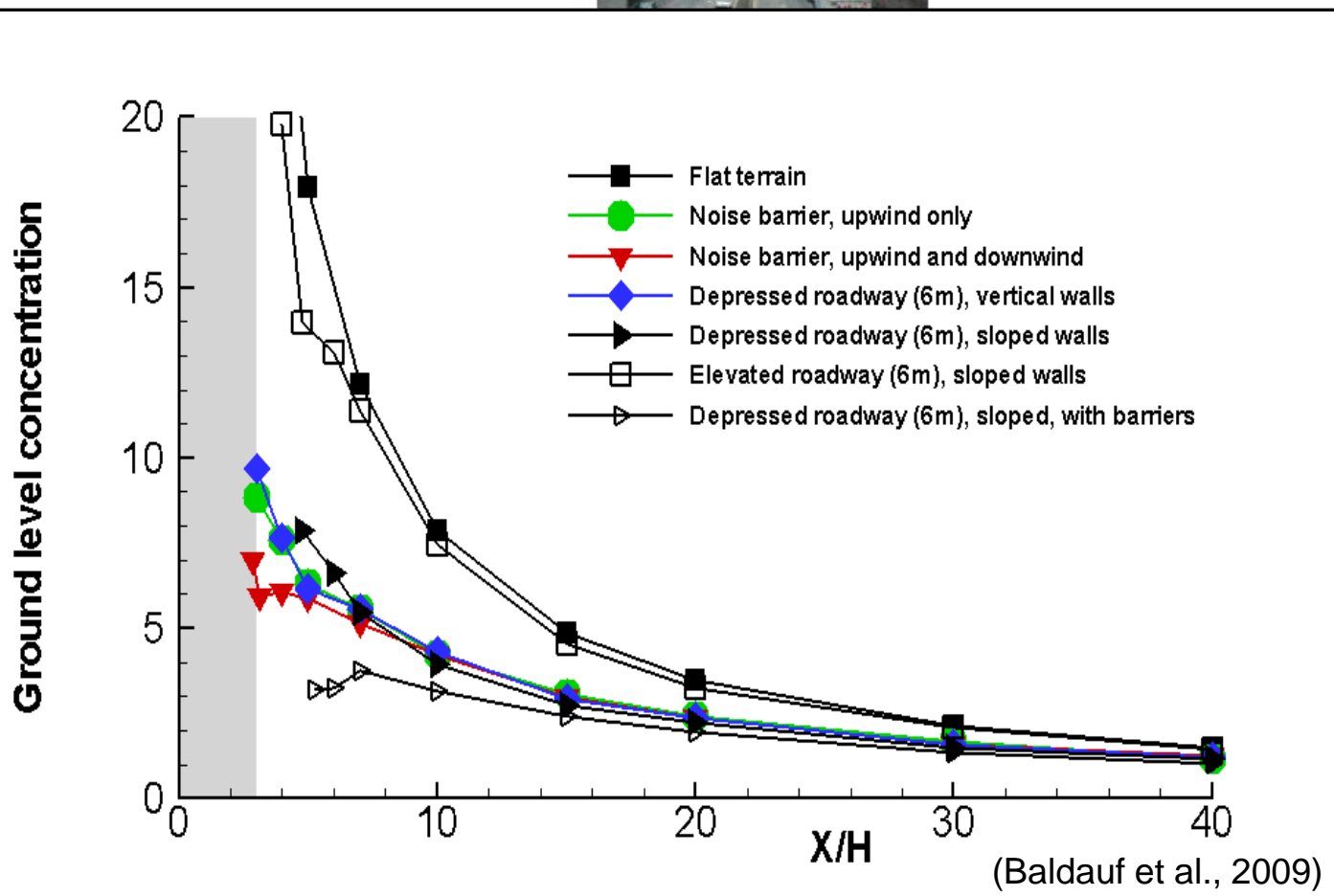
Sloped R



Noise Bar



Vegetation



# Influence of Roadway Design and Roadside Features

**Flat, At-Grade**



**Vertical Road Cut**



**Sloped Road Cut**



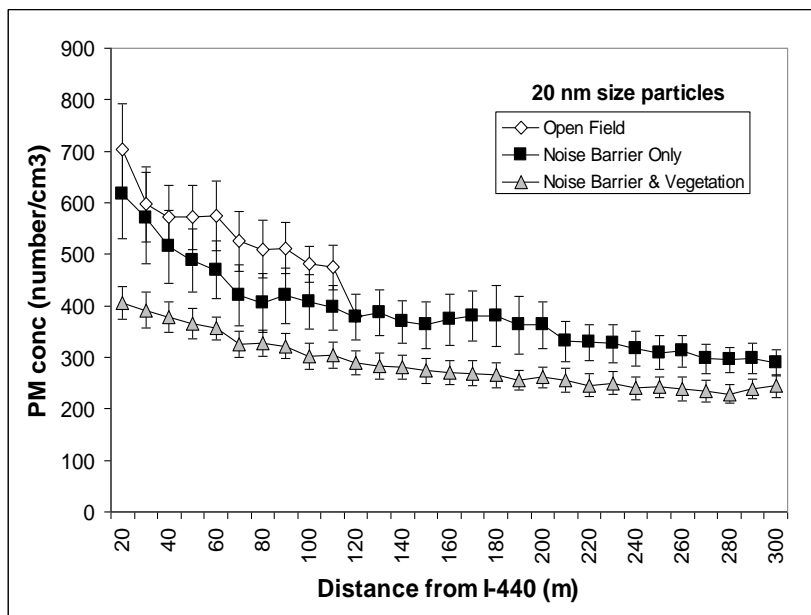
**Noise Barriers**



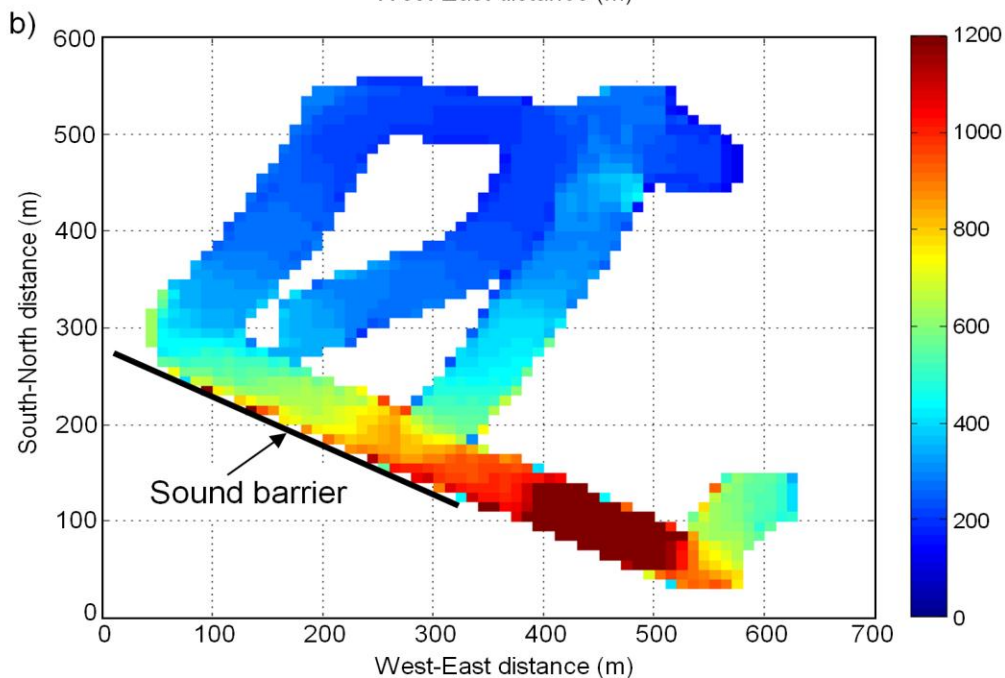
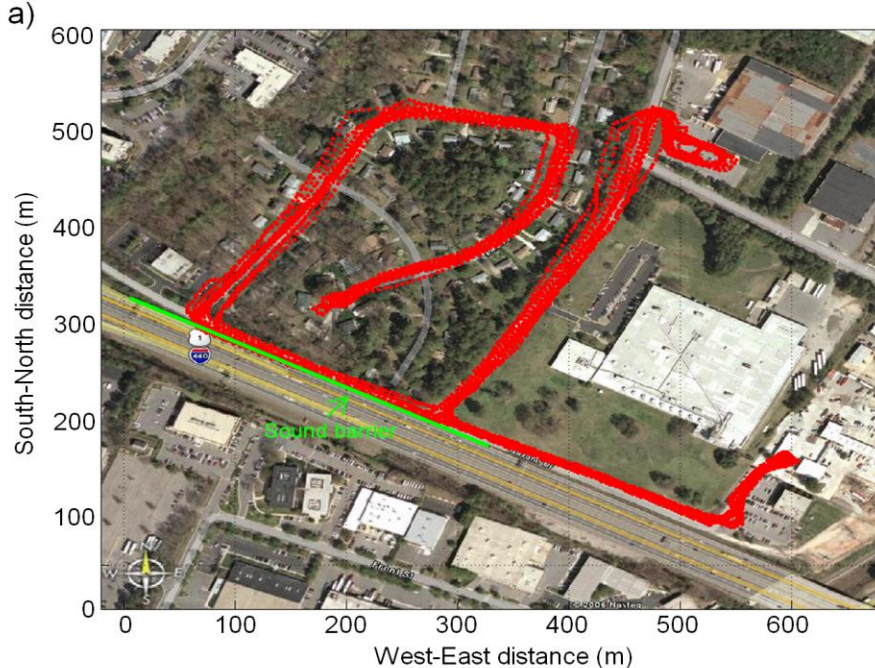
**Vegetation (porous) Barrier**



*Field studies showed the influence of noise barriers and vegetation on both pollutant concentrations and gradients*

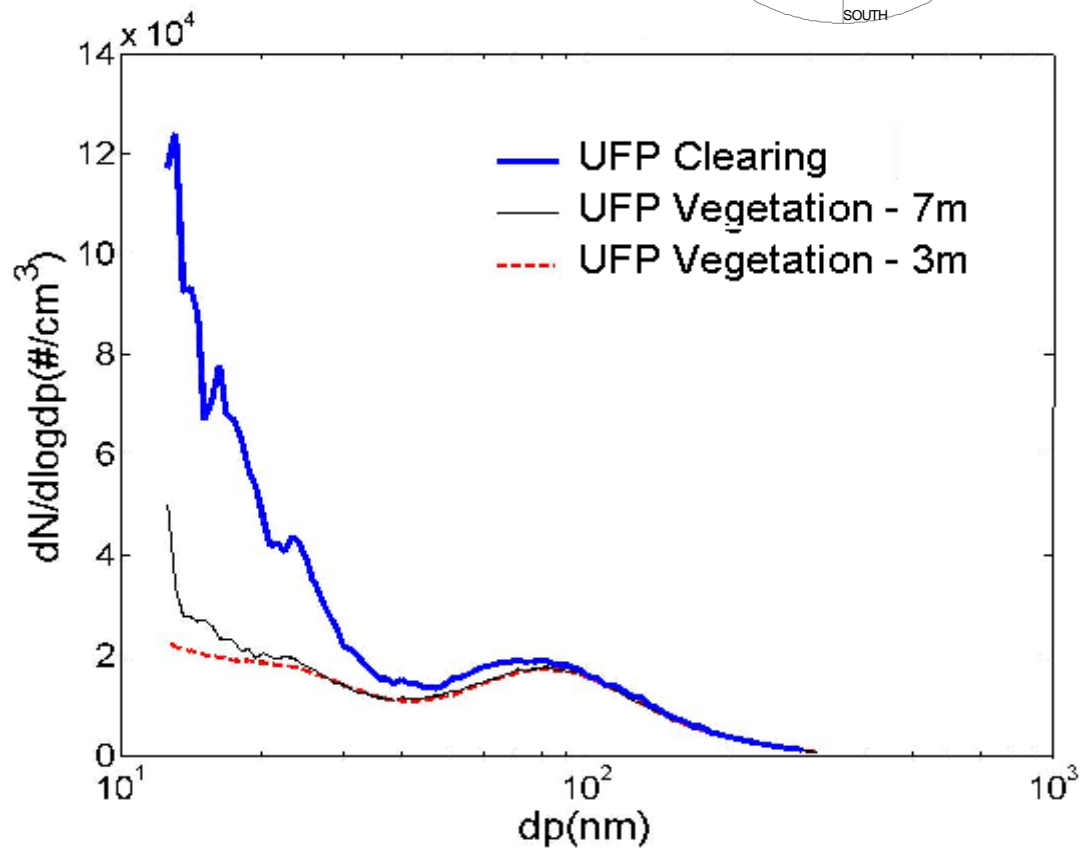
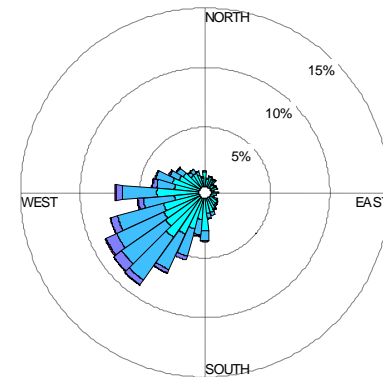


(Baldauf et al., 2008)



[from Baldauf, 2010 Vegetation Workshop]

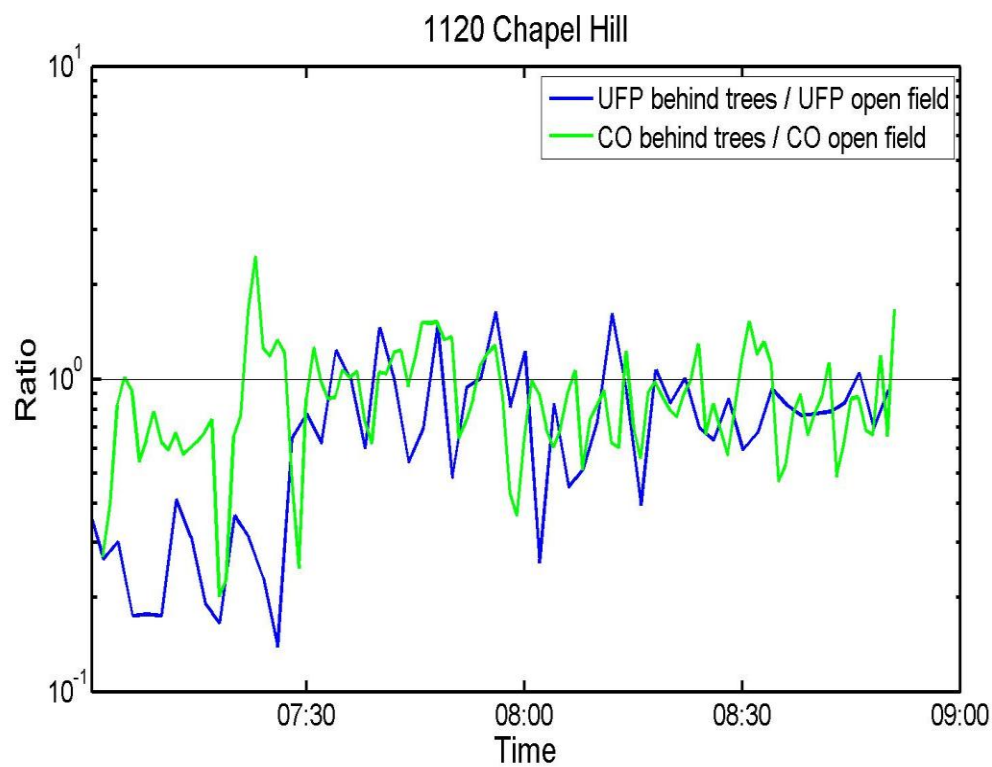
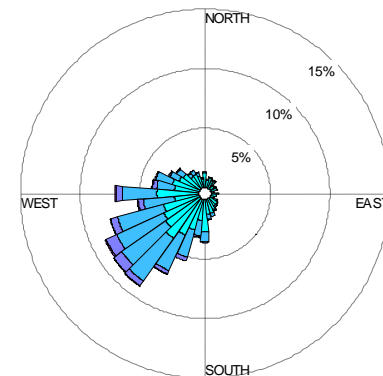
# Vegetation Effects



Khlystov et al., (Preliminary Data – do not cite, quote, or reference)

[from Hagler, 2010 Vegetation Workshop]

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# Factors Affecting Removal

- Crown texture (fine)
- Leaf complexity (pinnate)
- Leaf size (small)
- Leaf surface
  - Rough, resinous, hairy, sticky, etc.
- Leaf margins
  - Ciliate, serrulate, filamentous

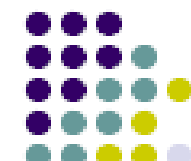


Figure 5-3. Scanning electron microscope micrograph of the adaxial surface of an 8-week-old London plane leaf. Spore, pollen, carbonaceous, angular, and aggregate particles are visible. Scale, 10  $\mu$ m.

(Smith, 1990)

Note: Vegetation can also increase mixing and dispersion

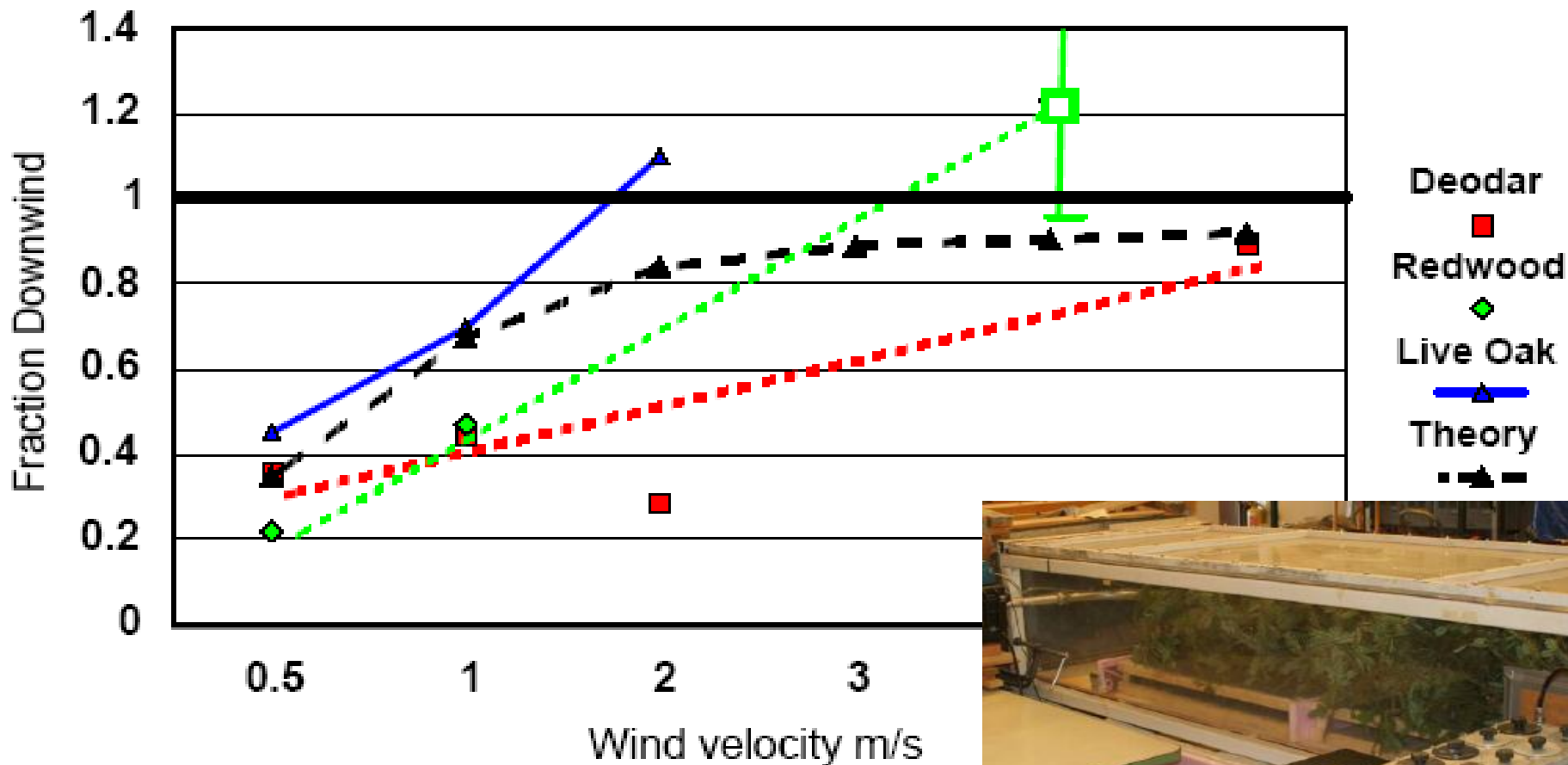
# Removal of very fine particles



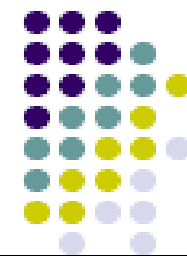
## BC/SET HETF/SMAQMD/UC Davis Wind Tunnel Vegetation Study

Fraction of particles  $0.26 > D_p > 0.09$  microns surviving after 2 m of branches

All S-XRF Sr data (red flare); Mean error in replicates  $\pm 15\%$



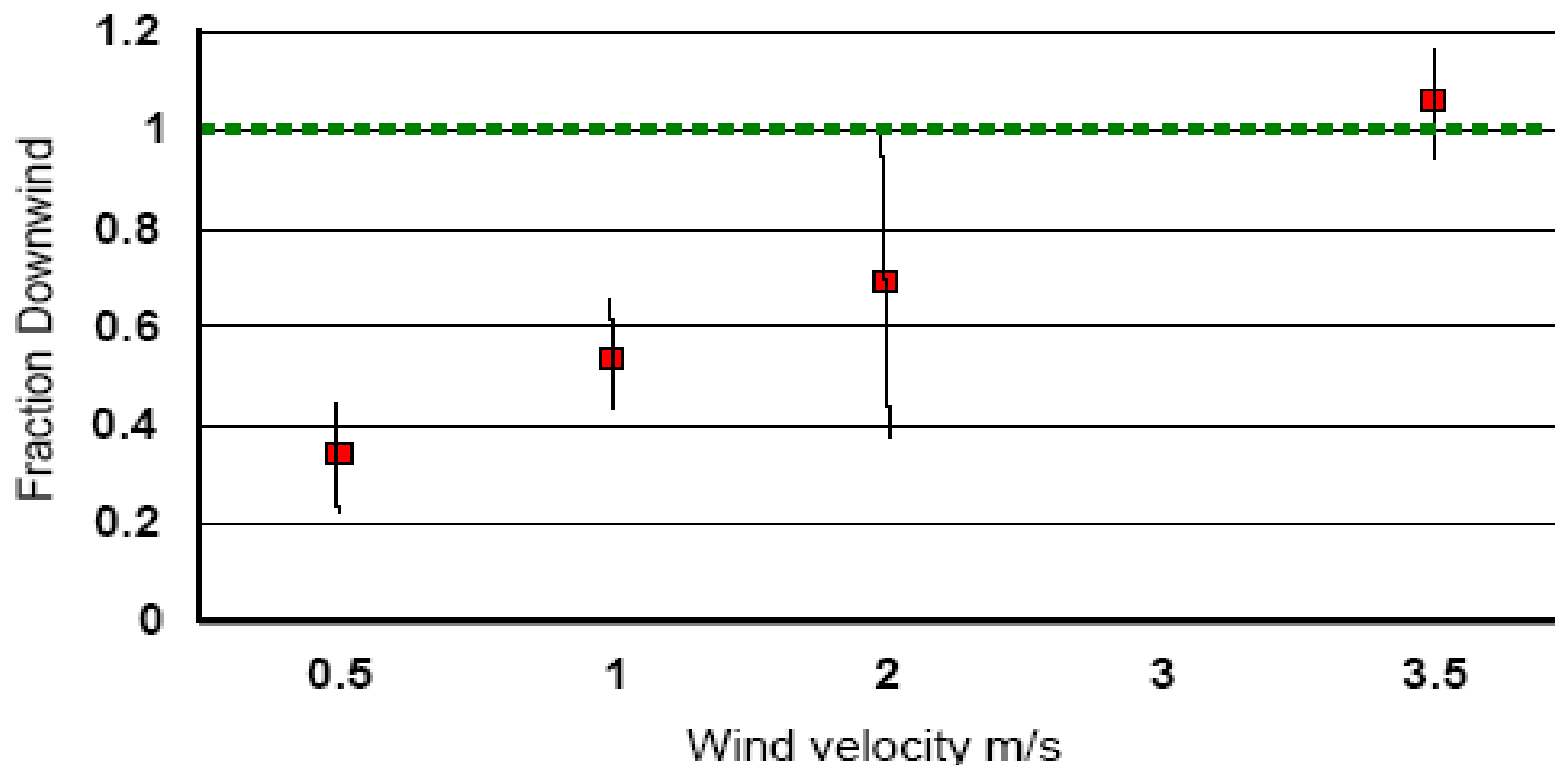
# Summary of all S-XRF analyses, all vegetation types



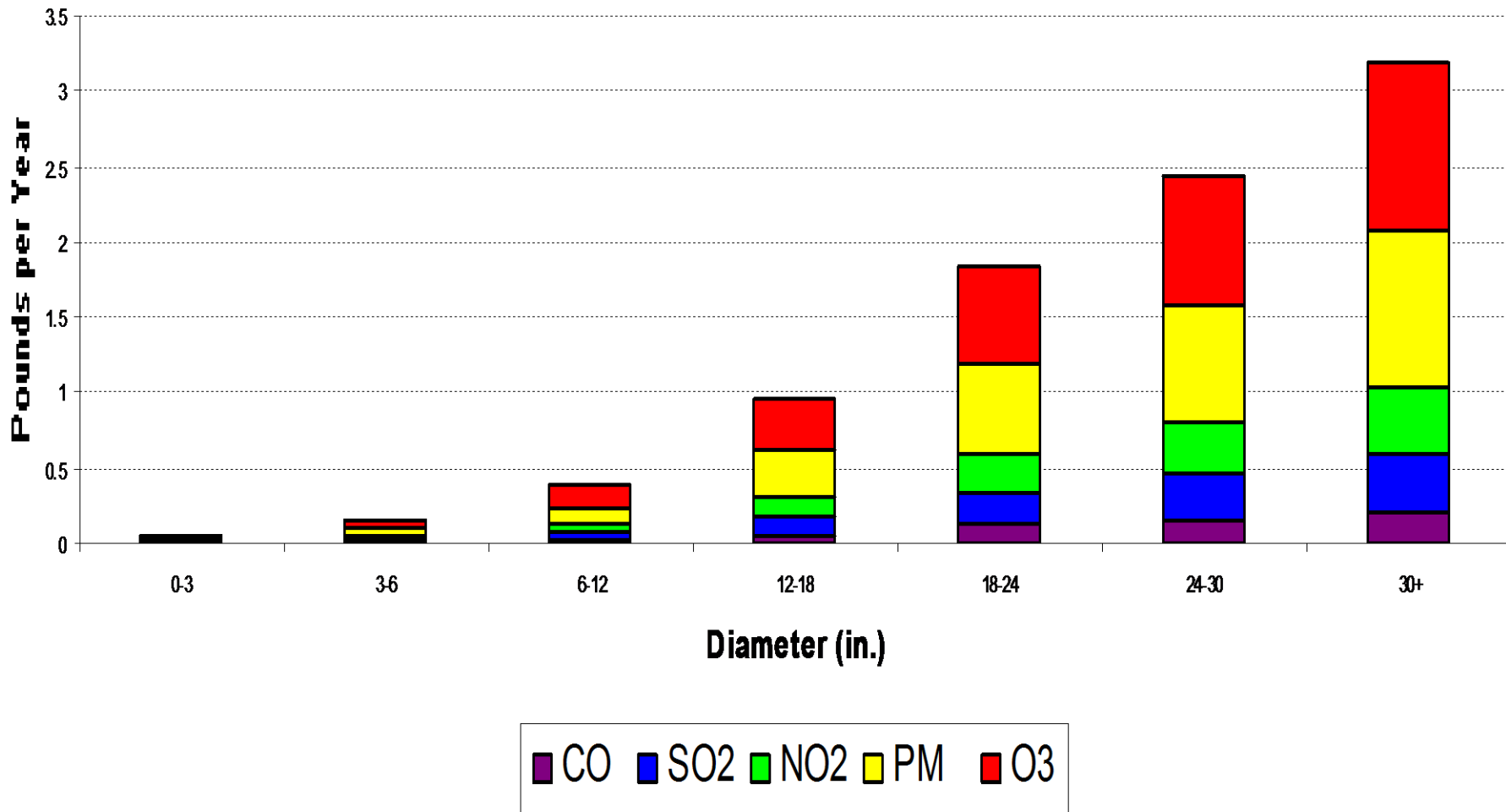
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# Pollution Removal by Trees



# Modeling Vegetation Effects

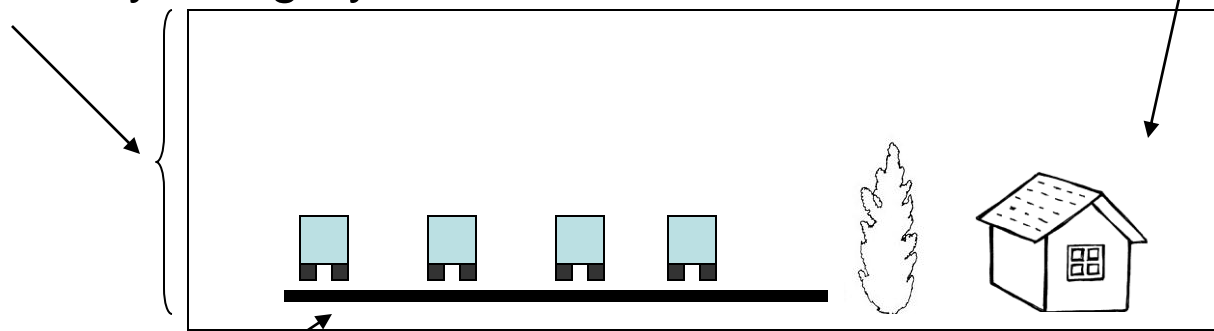
## Key Parameters: “Simple Scenario”

### Meteorology factors:

- Wind direction and speed
- Stability category

### Behind barrier factors

- Building height/location
- Any other pollution sources?



### On-road factors:

- Traffic activity/fleet mix
- Vehicle-induced turbulence
- Surface temperature of the road
- Emissions characteristics

### Vegetation factors:

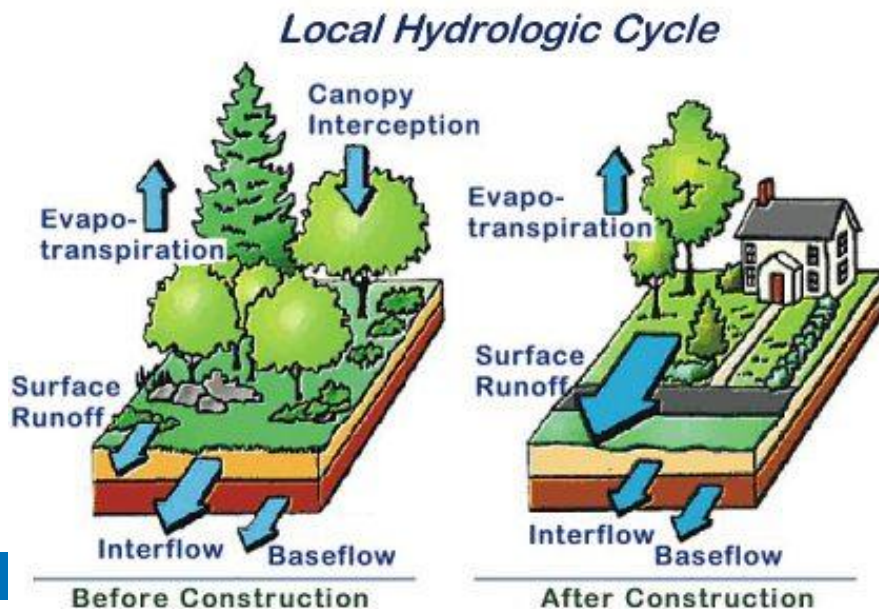
- Species
- Dimensions
- Porosity
- Location/Season

## **Beneficial Vegetation Characteristics**

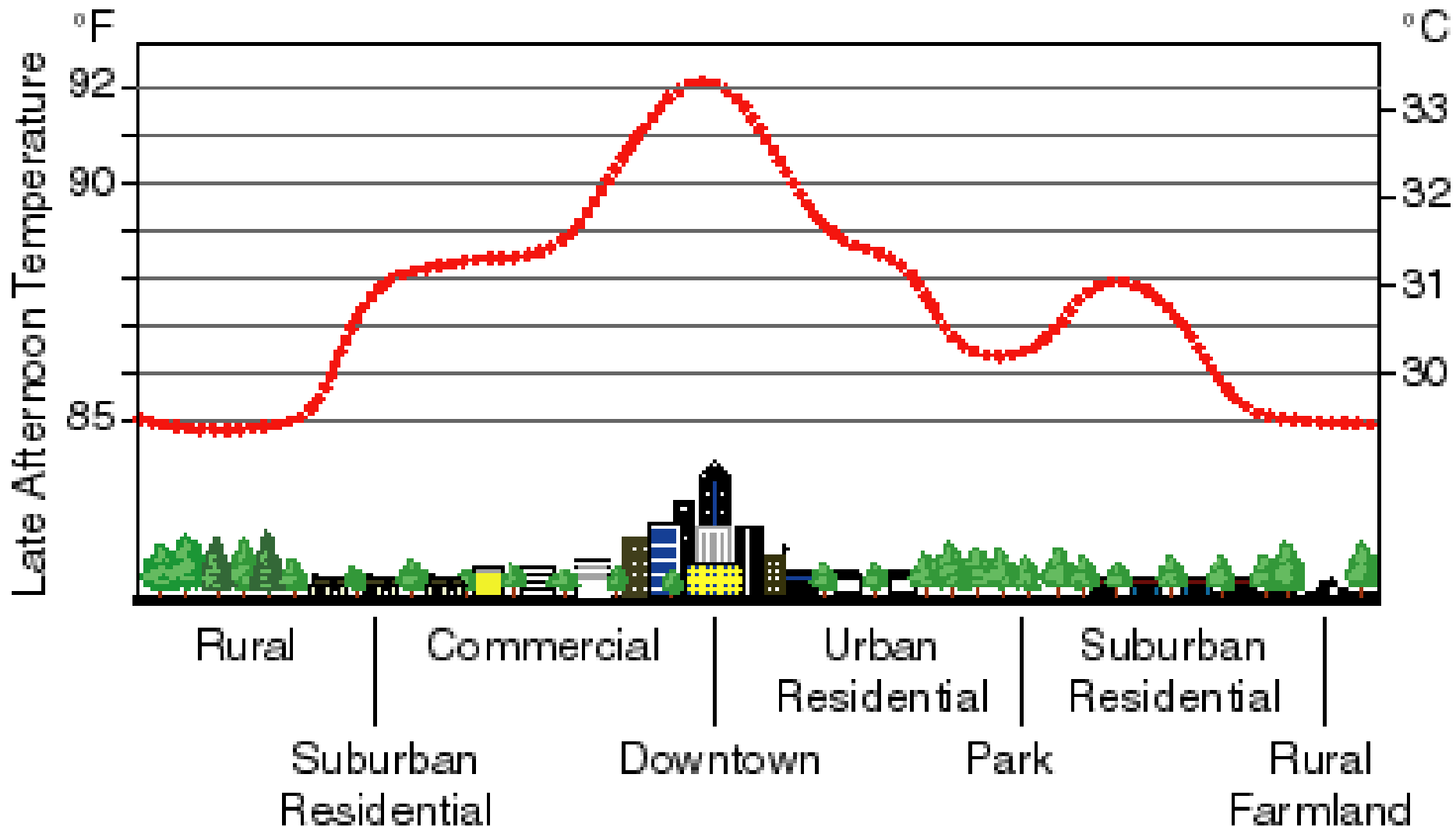
- Large leaf area
- High transpiration
- Low VOC emissions
- Evergreen
- Long-lived
- Low maintenance
- Healthy – right tree for location
- Leaf texture (particles)

# Potential Environmental Benefits

- Temperature– reduced urban heat-island effect
- Water regulation – modulates flooding and droughts
- Water filtration – reduces sediments and toxins



# Sketch of an Urban Heat-Island Profile

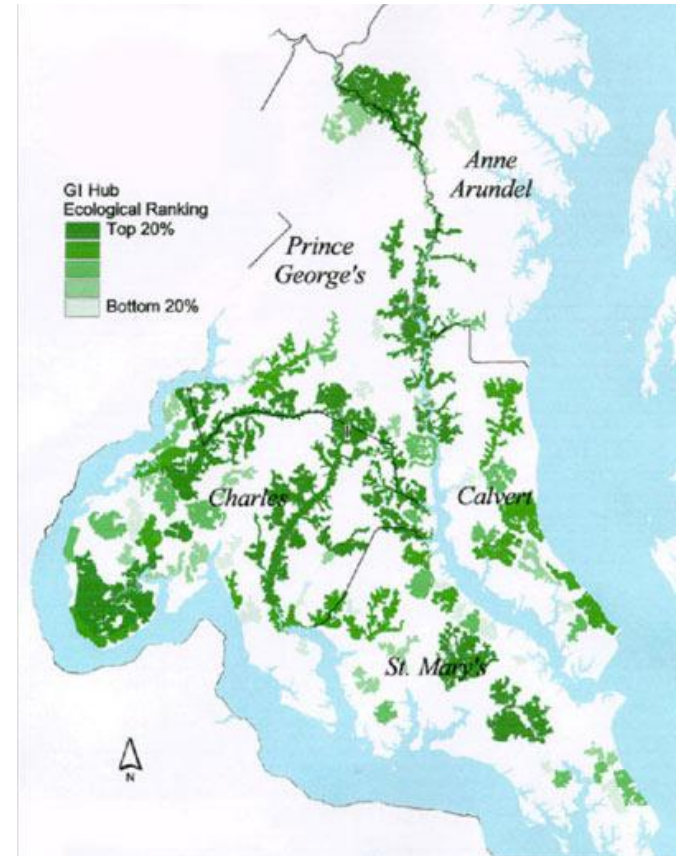


( from Akbari et al., 1992)

Source: Heat Island Group, LBNL, <http://EETD.LBL.gov/HeatIsland>

# Potential Additional Benefits to Human Health and Well-Being

- Carbon storage – mitigate global warming
- Reduce air conditioning – decreased energy use, save \$\$
- Connect nature preserves through corridors
  - increase resilience of wildlife populations
- Improved aesthetics



# Carbon Storage

## **CARBON SEQUESTRATION PILOT PROGRAM**

**Estimated Land Available for Carbon Sequestration  
in the National Highway System**

**FINAL  
May 2010**



U.S. Department of Transportation  
Federal Highway Administration  
Office of Planning, Environment, and Realty



U.S. Department of Transportation  
Research and Innovative Technology Administration  
John A. Volpe National Transportation Systems Center

established in 2008 to  
assess whether a roadside  
carbon sequestration effort is  
appropriate and feasible for  
state DOTs

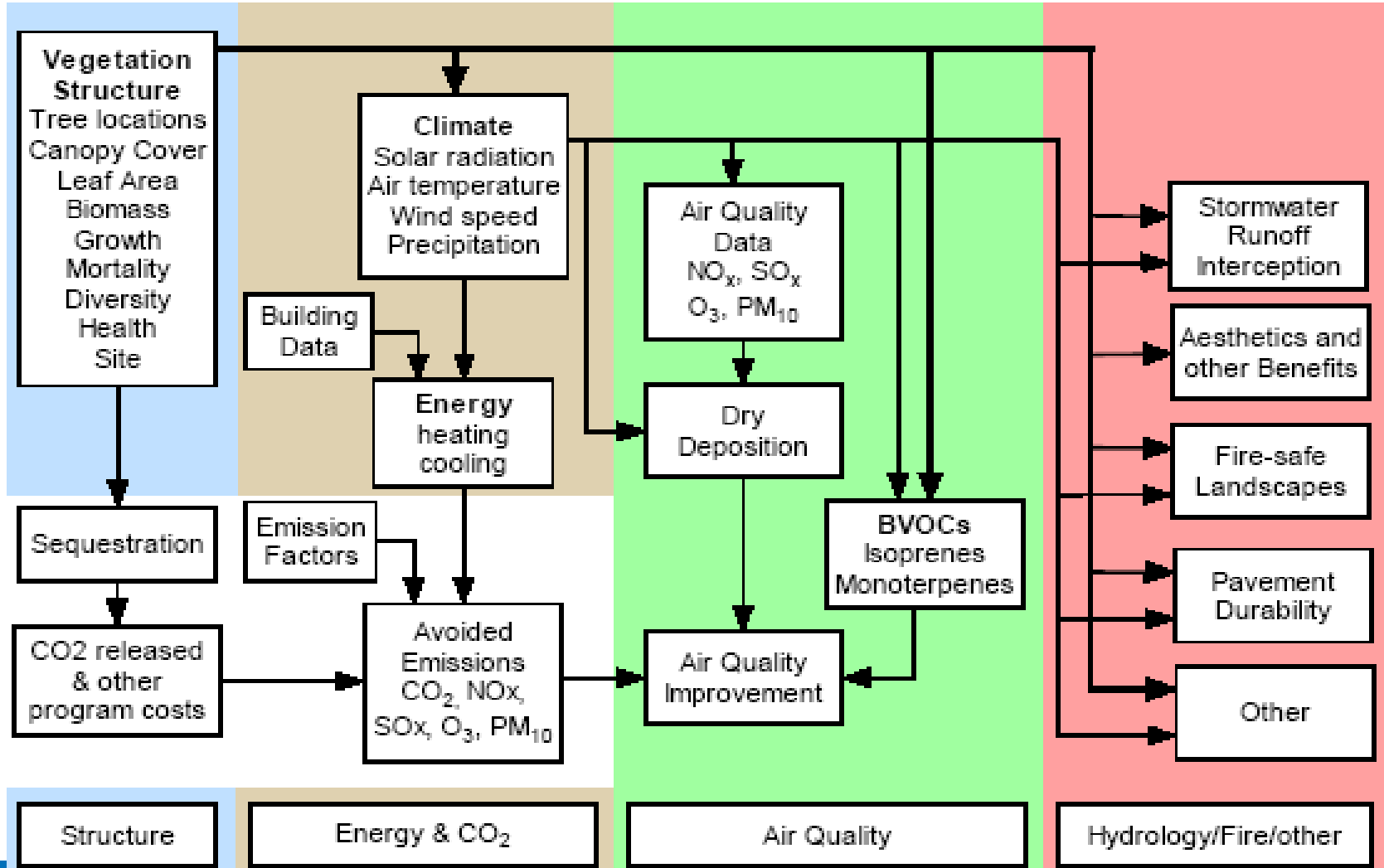
# Potential Societal and Ecological Dis-Benefits

- May provide corridors for fire, invasive pests, crime
- May increase pollen load
- May result in net water loss
- May increase sprawl
- How healthy are trees/soils used as pollutant buffers?

*Buffer Design and Species Selection are Critical to Minimize Dis-Benefits*



# Comprehensive Net-Benefits Analysis



# Summary

- Growing interest in near road air quality due to public health concerns
- Data suggests vegetation may play a role in mitigating near-road air quality
  - Removal of PM and other traffic-related pollutants
  - Benefits may be site-specific
  - Key factors include:
    - Local meteorology
    - Site configuration
    - Traffic activity
    - Vegetation parameters
    - Other pollution sources behind vegetation
  - Trade-off may exist between on-road and near-road air quality

# Summary

- Areas identified for future policy and research:
  - Field data assessing long-term concentration difference for behind-vegetation vs. unobstructed air flow
  - Effects of vegetation configuration
    - Leaf area distribution
    - Height
    - Width
  - Species effectiveness
  - Assessing importance of “breaks” in vegetative barrier
  - Assessing effect of distributed vegetation vs. noise wall
  - Quantifying on-road impacts
  - Integrated studies linking local to regional impacts
  - Standardized open source measurement methods
  - Integration of policy and science in the planning and design process



## Near Roadway Research

U.S. ENVIRONMENTAL PROTECTION AGENCY



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**Our Web site will be operating at diminished capacity because of scheduled maintenance on Saturday, August 7, 2010. We apologize for any inconvenience.**

### The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions

On April 27-28, 2010, a meeting was held in Research Triangle Park, North Carolina on "The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions." Concerns over population exposures to traffic-generated pollutants near roads have grown with an increasing number of health studies reporting links between proximity to roads and adverse health effects. Recent studies indicate that vegetation present along roadways may help to mitigate air pollutant concentrations near roads. This workshop brought together representatives from government agencies, academia, state and local agencies, and environmental advocacy groups with expertise in air quality, urban forestry, and policy to review the current science and identify future activities in evaluating the potential role of vegetation in mitigating near-road air pollutant concentrations.

For more information contact: [Rich Baldauf](#)

US EPA. Baldauf, Rich. (2010). ["Why are we concerned with near-road air quality?" \(PDF\)](#) (11 pp, 443 KB) Presentation, The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions Seminar, EPA Campus, RTP, NC, April 27-28.

US EPA. Cook, Rich. (2010). ["What impacts can be expected in the future?" \(PDF\)](#) (12 pp, 47 Kb) Presentation, The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions Seminar, EPA Campus, RTP, NC, April 27-28.

USDA Forest Service. McPherson, Greg. (2010). ["Overview of Urban Forestry Programs." \(PDF\)](#) (44 pp, 6 Mb) Presentation, The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions Seminar, EPA Campus, RTP, NC, April 27-28.

US EPA. Hagler, Gayle. (2010). ["How does vegetation affect pollutant transport and dispersion?" \(PDF\)](#) (32 pp, 2.9 Mb) Presentation, The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions Seminar, EPA Campus, RTP, NC, April 27-28.

DELTA Group, Univ. of California and the Health Effects Task Force, Breathe California of Sacramento-Emigrant Trails. Cahill, Tom. (2010). ["How does vegetation affect pollutant removal?" \(PDF\)](#) (50 pp, 3.5 Mb) Presentation, The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions Seminar, EPA Campus, RTP, NC, April 27-28.

USDA Forest Service. Nowak, Dave. (2010). ["Are certain types of vegetation and characteristics more/less beneficial to pollution reduction?" \(PDF\)](#) (33 pp, 4.36 Mb) Presentation, The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions Seminar, EPA Campus, RTP, NC, April 27-28.

Cornell University. Zhang, Max. (2010). ["What models are available to evaluate vegetative effects of air pollution?" \(PDF\)](#) (31 pp, 2.7 Mb) Presentation, The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions Seminar, EPA Campus, RTP, NC, April 27-28.

US EPA. Bailey, Chad. (2010). ["What environmental regulations and programs could play a role?" \(PDF\)](#) (36 pp, 837 Kb) Presentation, The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions Seminar, EPA Campus, RTP, NC, April 27-28.

US EPA. Wood, Peri. (2010). ["Tales of Region 9." \(PDF\)](#) (10 pp, 857 Kb) Presentation, The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions Seminar, EPA Campus, RTP, NC, April 27-28.

Breathe California. Titus, Kori. (2010). ["Using vegetation to improve public health." \(PDF\)](#) (6 pp, 76 Kb) Presentation, The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions Seminar, EPA Campus, RTP, NC, April 27-28.

US EPA. Jackson, Laura. (2010). ["Potential multiple benefits and dis-benefits of near-road vegetation." \(PDF\)](#) (10 pp, 440 Kb) Presentation, The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions Seminar, EPA Campus, RTP, NC, April 27-28.

[List of Participants \(PDF\)](#) (2 pp, 16 Kb)

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