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Webinar: Impacts of Roadway and Traffic Characteristics on Air Pollution Risks for Bicyclists

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TREC Webinar
22 April, 2015

Impacts of Roadway and Traffic Characteristics on Air Pollution Risks for Bicyclists

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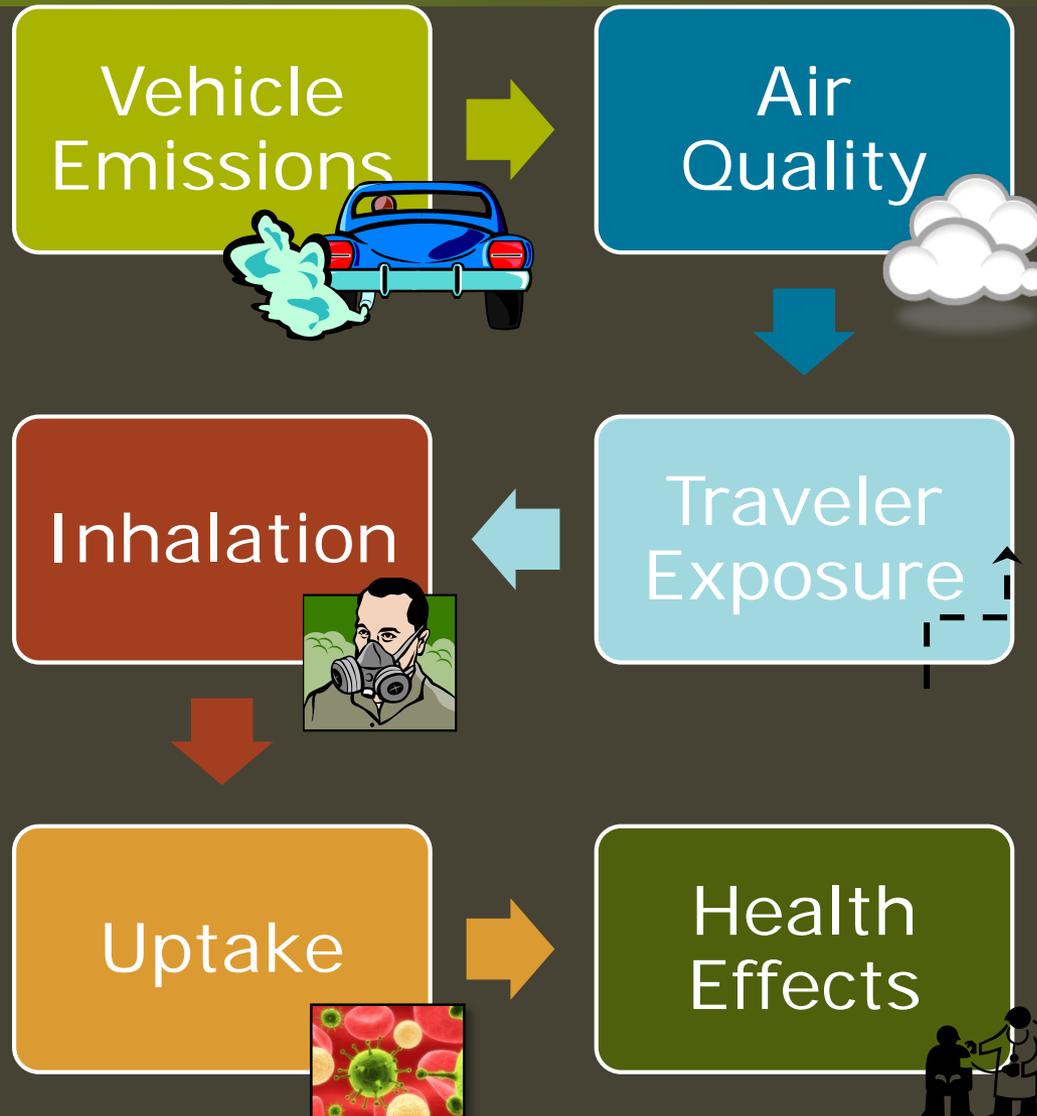
Portland State
UNIVERSITY

Health Effects of Bicycling

- Health impact studies for walking & biking have shown that physical activity benefits outweigh crash & air pollution risks by an order of magnitude or more
- Still, we can & should reduce pollution risks



Framework



Outline

1. Exposure concentrations
2. Ventilation & inhalation dose
3. Pollutant uptake
4. Applications for transportation planning and design





Traveler
Exposure

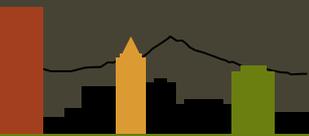
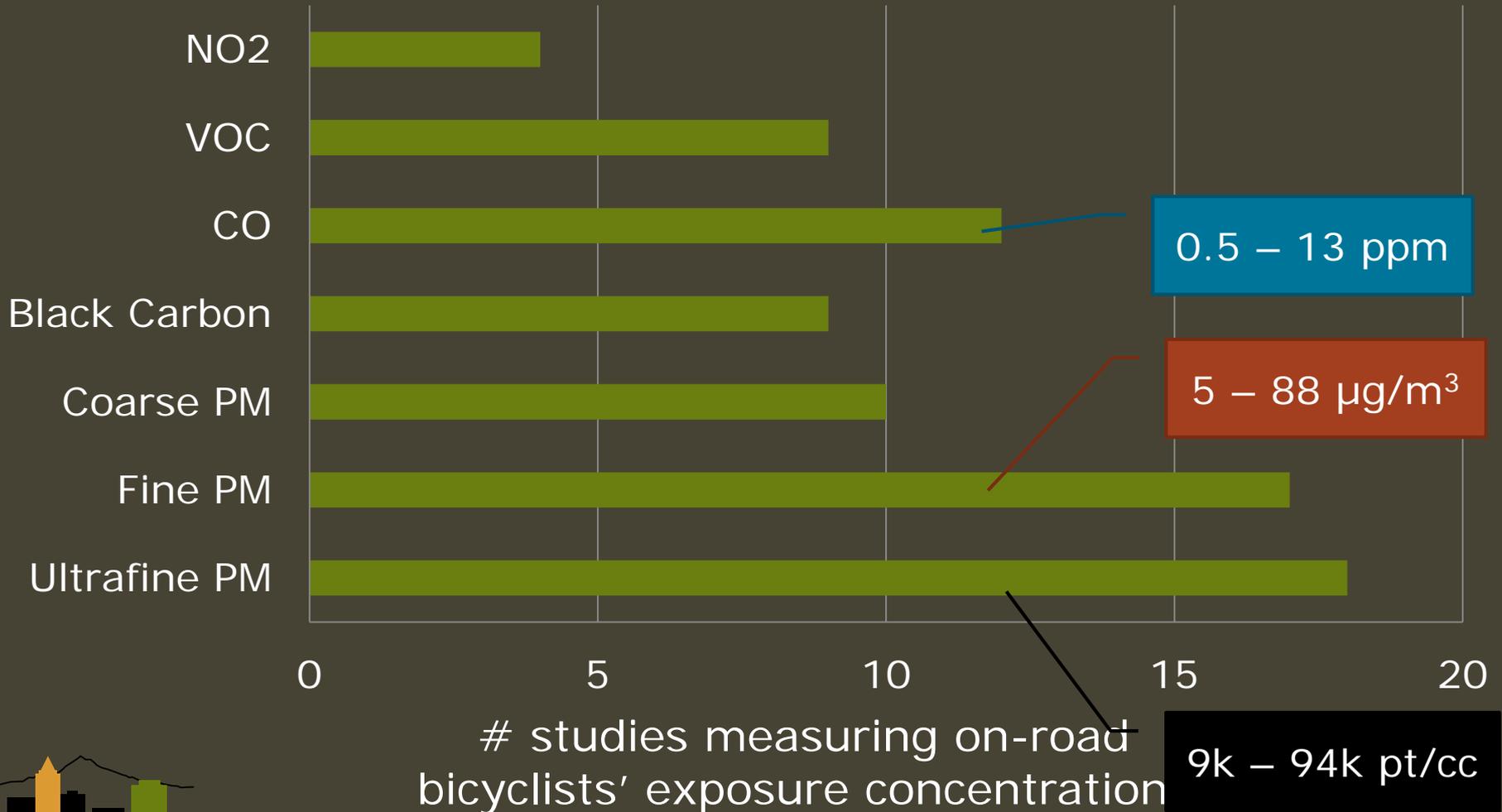
Bicyclist Exposure Concentrations



Bicyclists' Exposures

Pollutant

42 studies



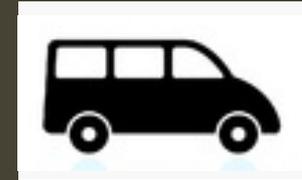
Modal Comparisons of Exposure



VS



VS



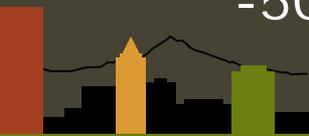
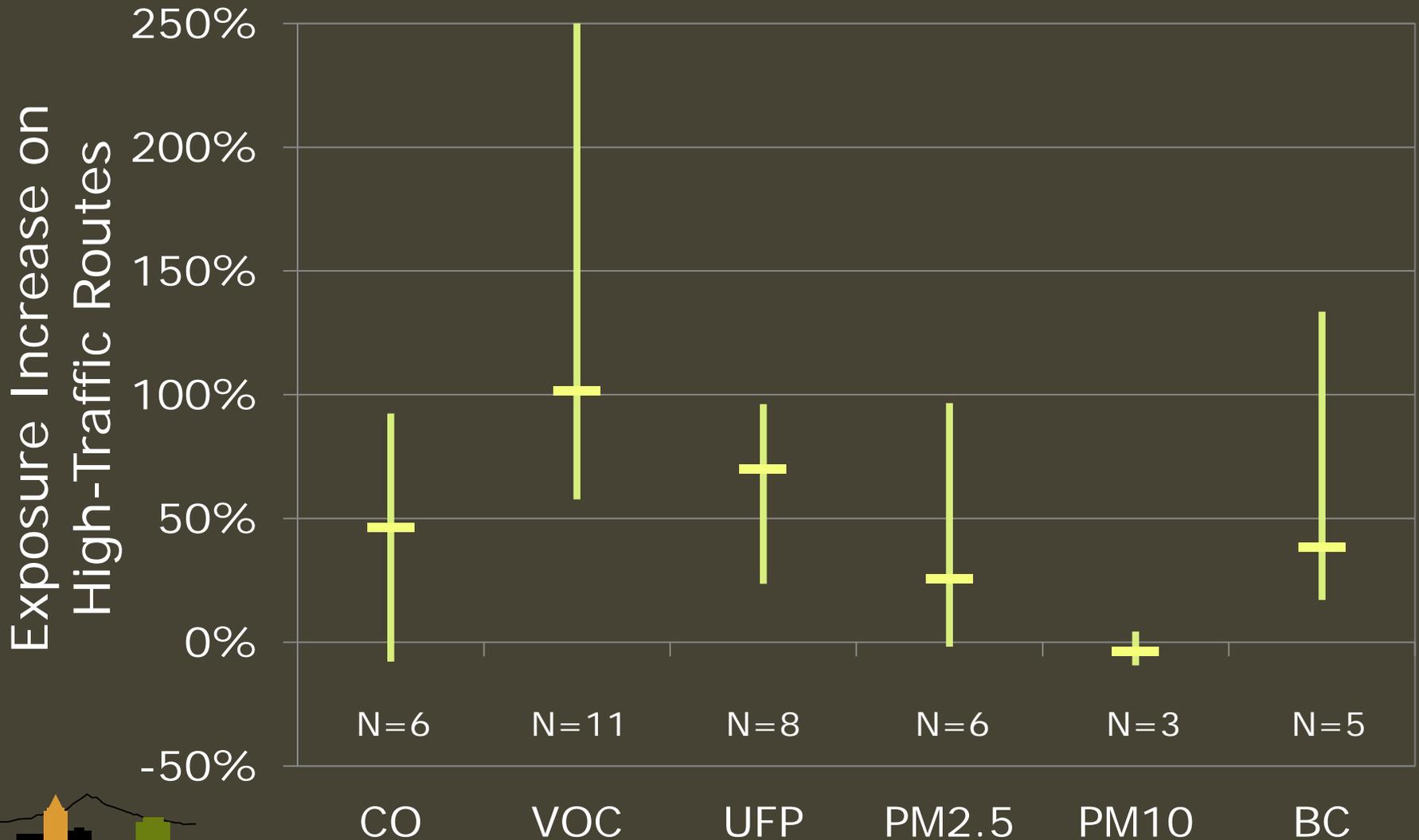
- Is this actionable information?

Context-dependent results

- Bicyclists lower if separated



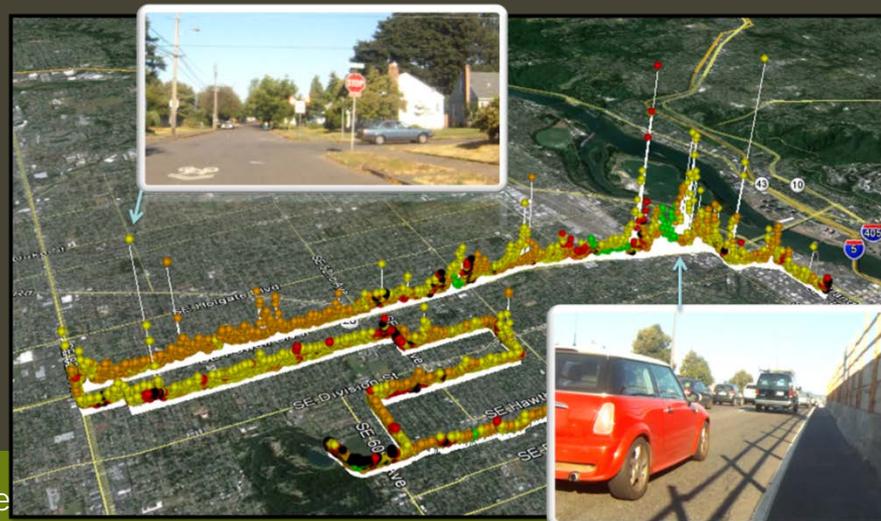
High-Traffic/Low-Traffic Routes



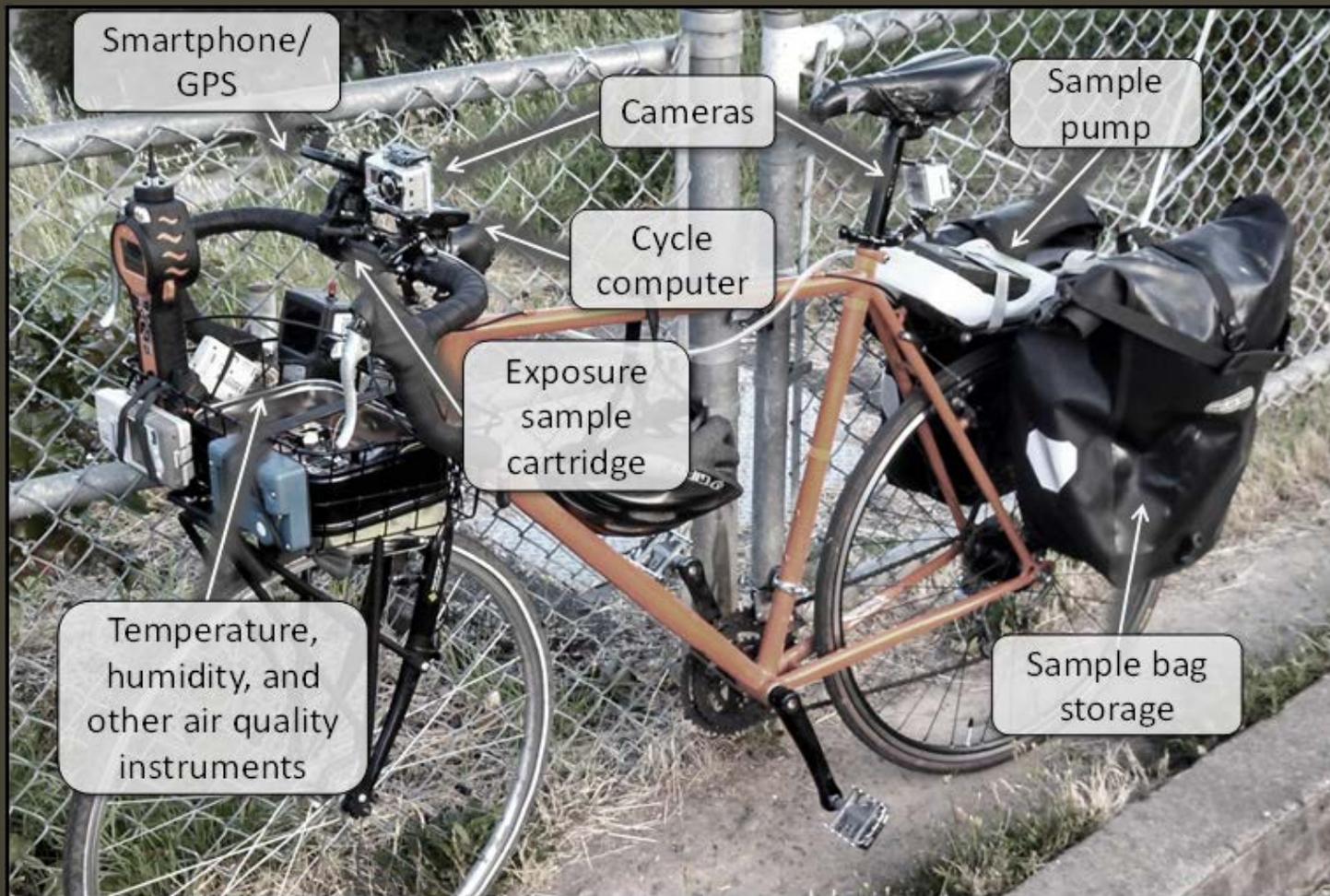


PSU Bike Exposure Research

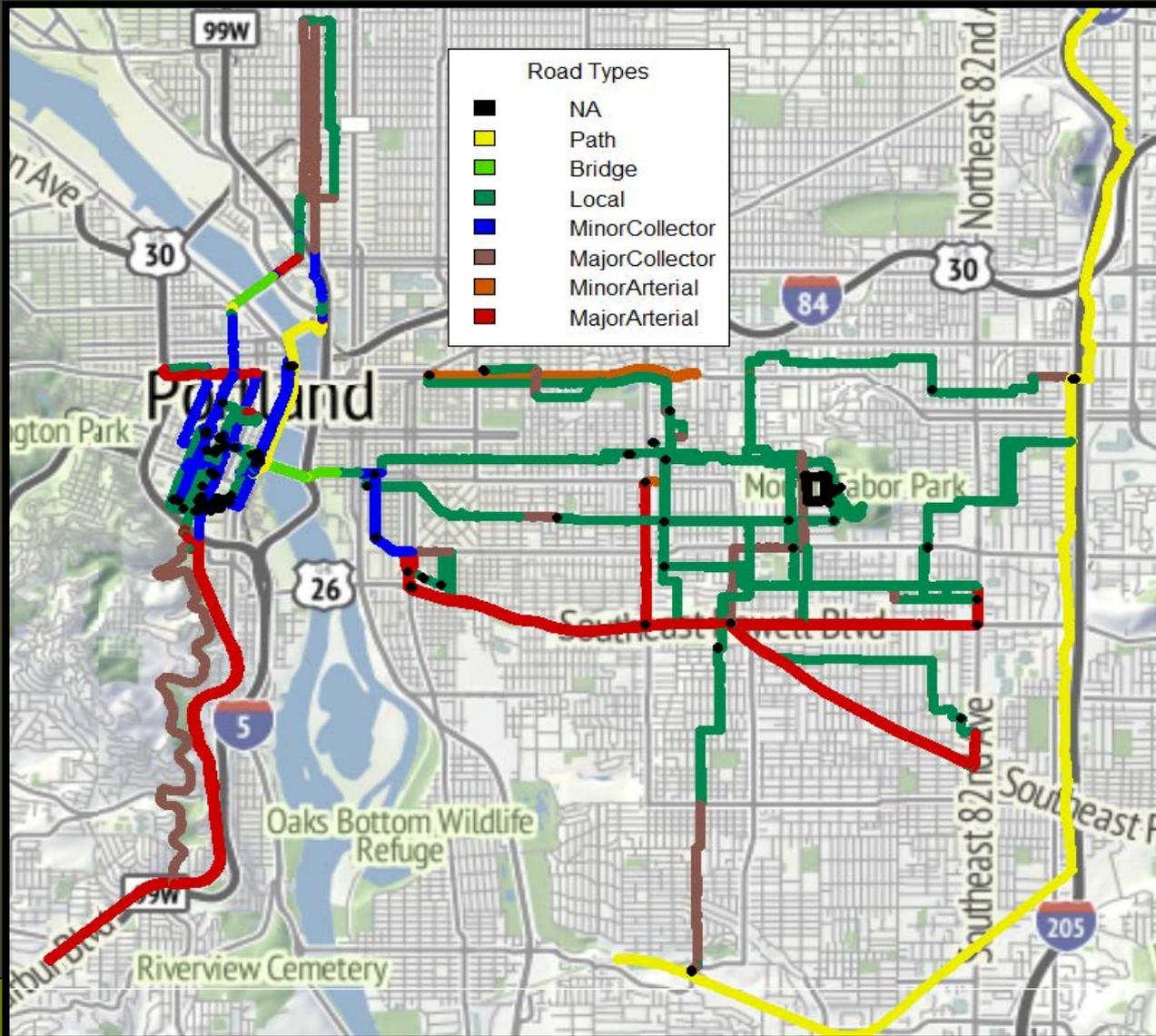
How can we reduce exposure risks for bicyclists?



Sampling Equipment



Exposure Data coverage



Results: VOC Exposure Models

- +2% per 1,000 ADT
- +20-30% in stop-and-go riding
- Off-street path +300% in industrial corridor



Parallel Path Comparison



E Burnside St.



SE Ankeney St.



N Williams Ave.



NE Rodney Ave.



Naito Pkwy.



Riverside Path

Inhalation

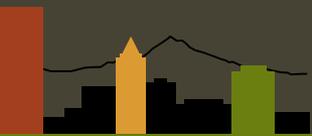
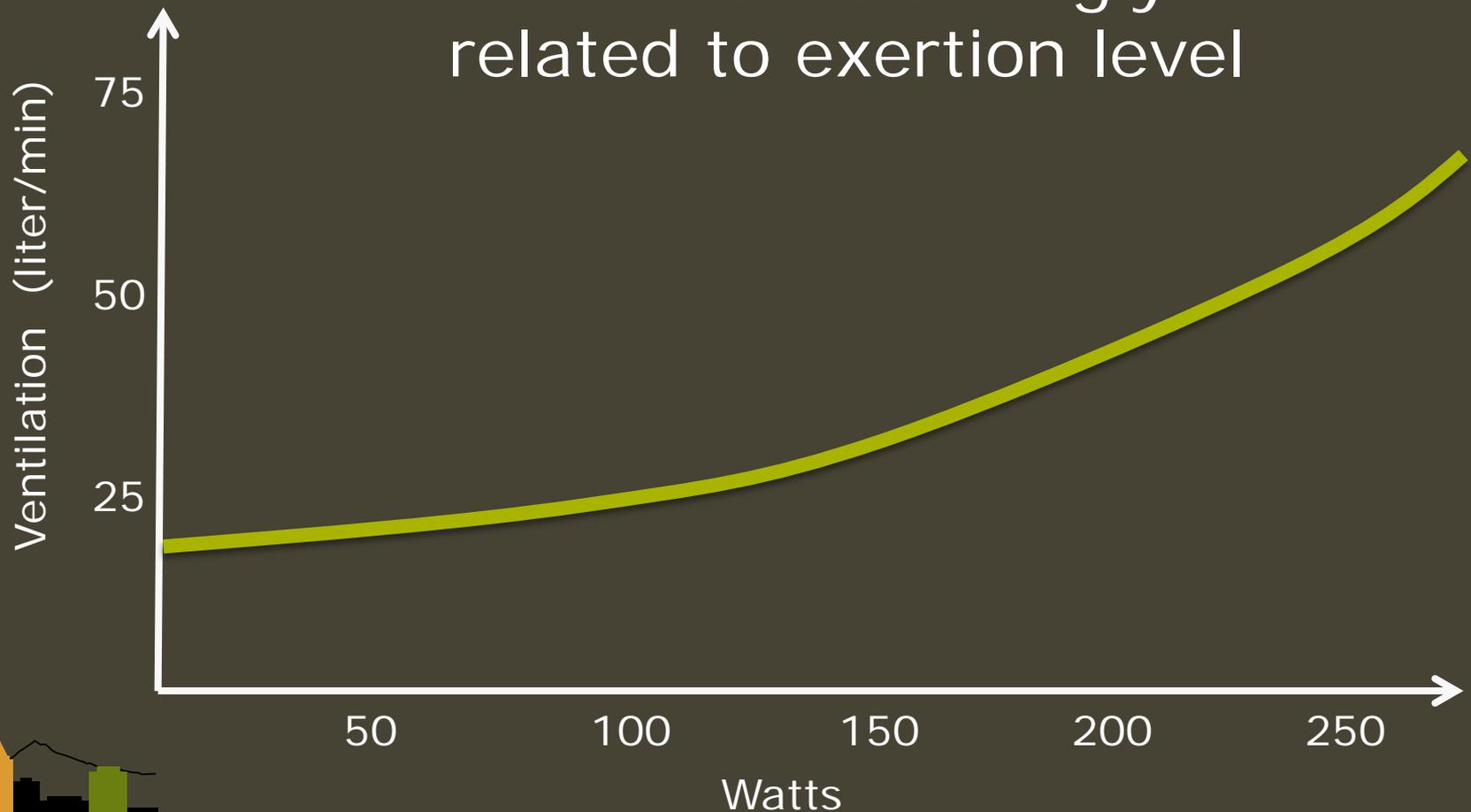


Bicyclist Pollution Inhalation



Ventilation and Exercise

Ventilation is strongly related to exertion level



Ventilation & Bicycle Studies

57 studies assess bicyclists' exposure

Ventilation:

Ignored
38

Constant
16

Variable
3

Assumed/
Modeled
15

Measured
1

Modeled
2

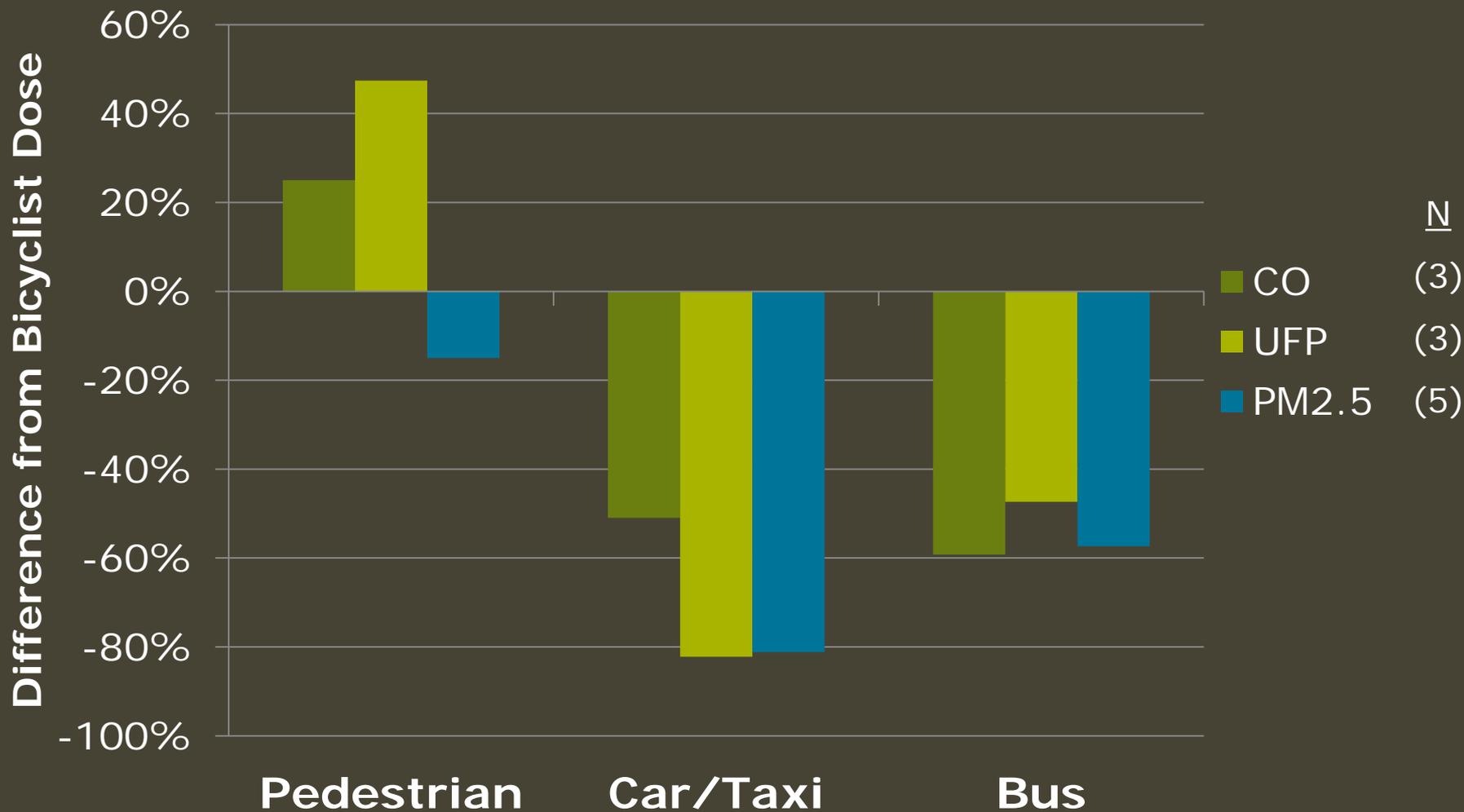
Measured
1



Bicyclist Ventilation



Modal Comparisons of Dose

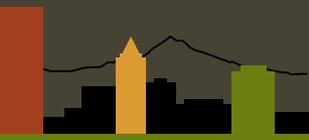
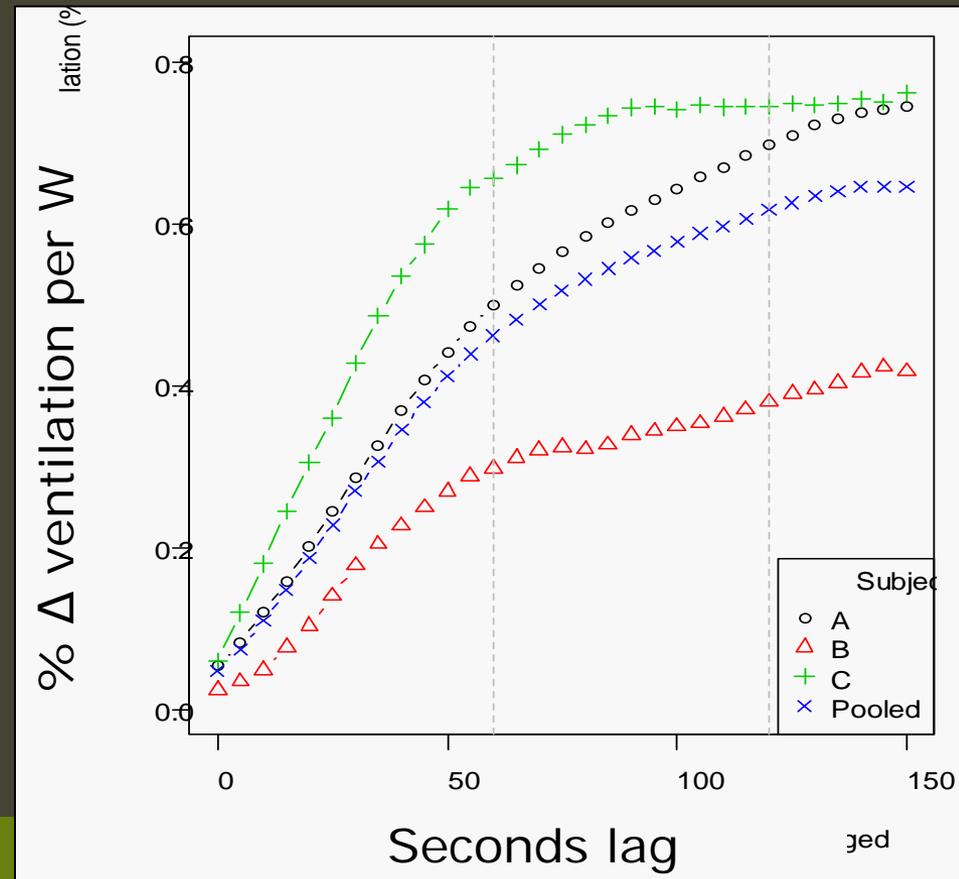


PSU Research Findings



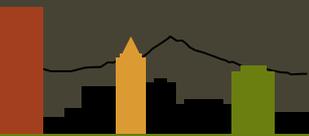
- 4-8% increase in ventilation per 10 W

- Mean lag ~50 sec
- Highly variable on-road



Bicyclist Pollution Uptake

Uptake



Bicyclist Uptake Studies

2 studies of biomarkers:

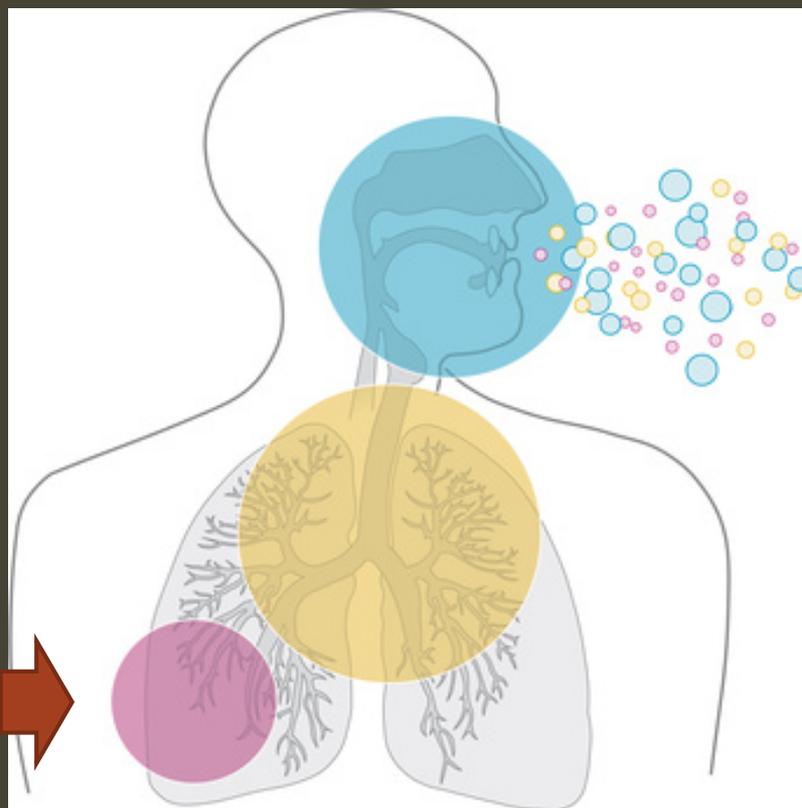
- VOC: blood & urine
 - Urban bikers > rural bikers
- BC: induced sputum
 - Bicyclists > transit riders



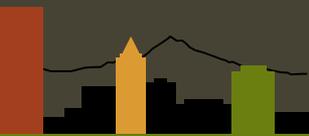
Breath Biomarkers

Exhaled breath is a good proxy for blood concentrations of VOC

VOC in blood



alphasenzor.com



PSU On-Road Sampling

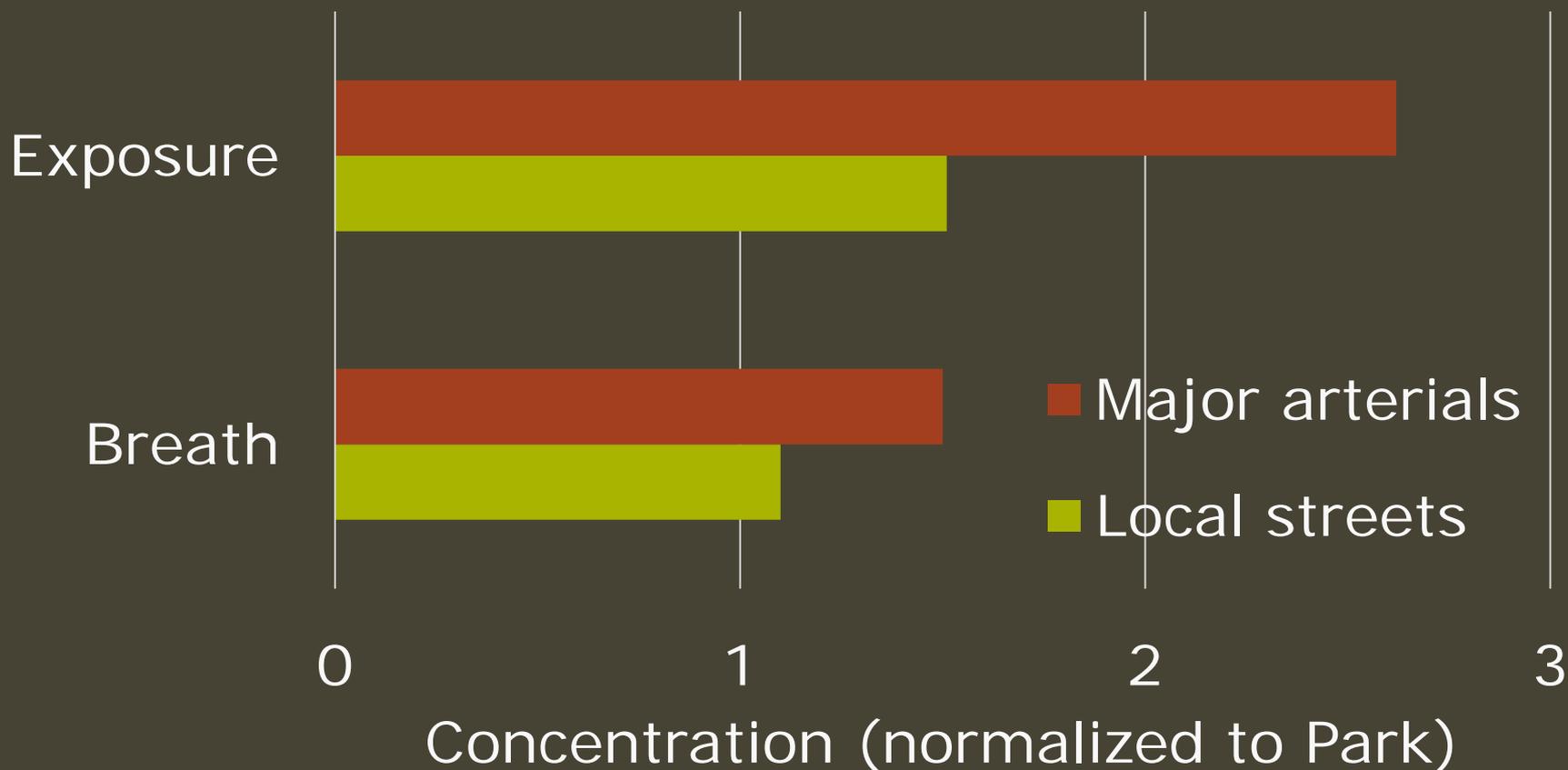


20-30 minutes, 3-5 miles
Exposure & breath VOC
Paired subjects



Breath and Exposure Concentrations

Toluene

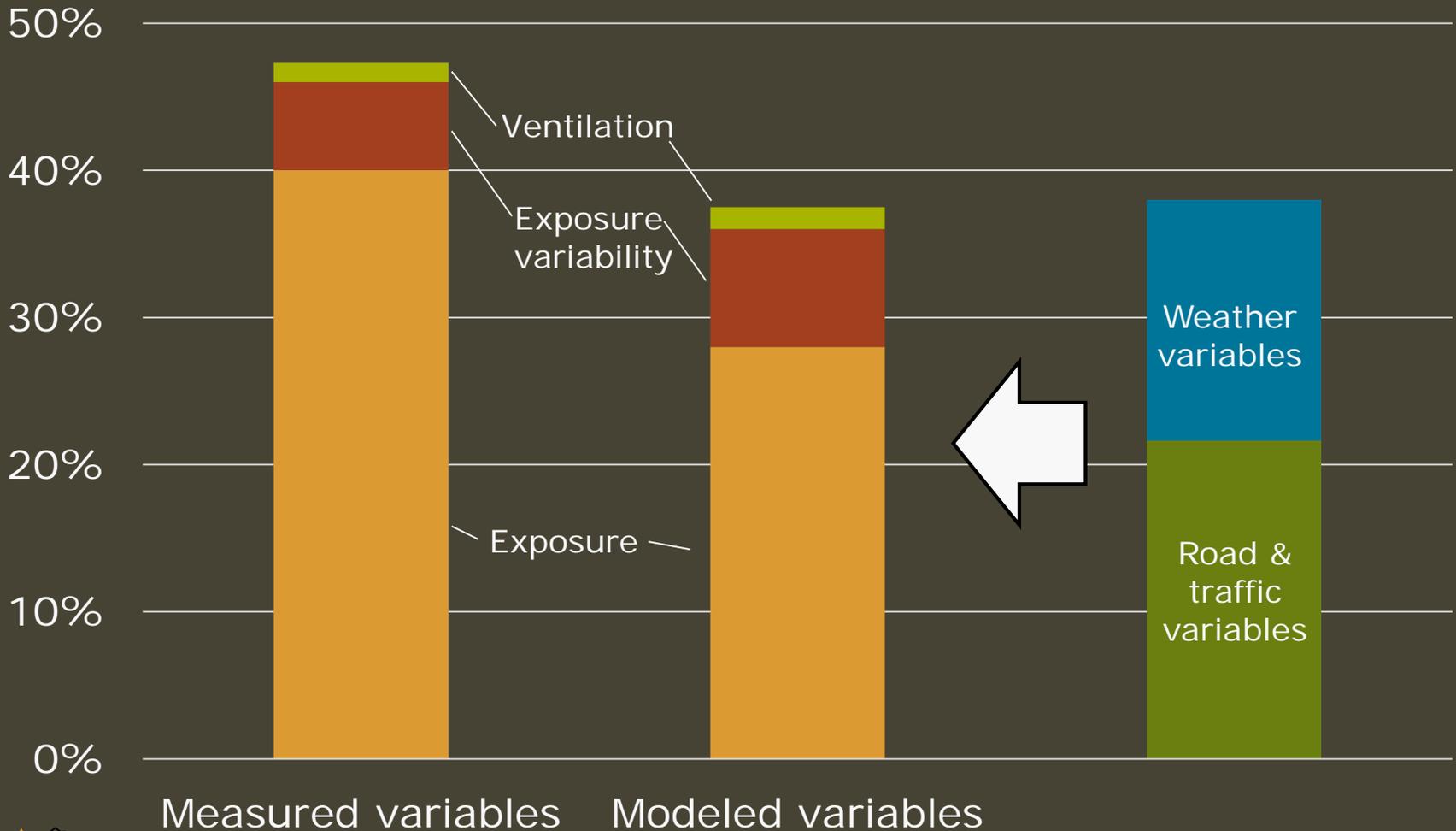


Breath Sampling Results

- The breath sampling method works
 - Exposure predicts breath concentrations
 - Δ Breath $\sim \frac{1}{2} \Delta$ Exposure
- 10-60% higher on major arterials than local streets
 - Traffic impact (over BG) 3-5x greater on major arterials than local streets

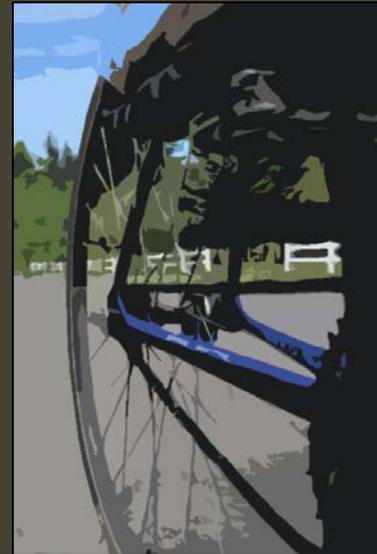


Explained variance in breath BTEX

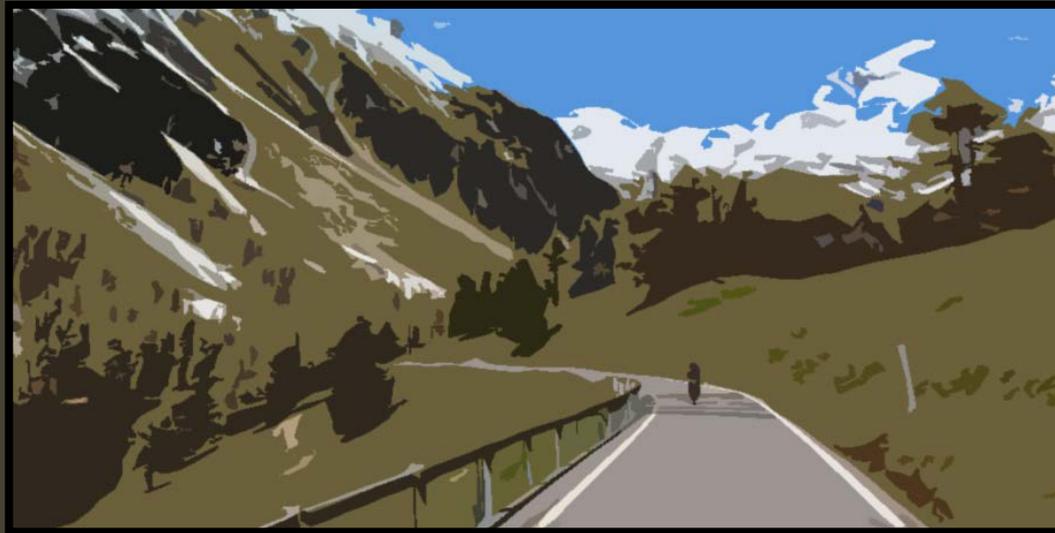


Exercise and Uptake

- Ventilation/inhalation rate: 2-5x higher
- PM uptake: $\geq 2-5x$ higher
- VOC uptake: 1.5-2x higher



Applications



Route Choice

- Detour to reduce inhalation dose if:
 - <46% longer than minor arterial route
 - <123% longer than major arterial route



- Inhalation doses +20-30% per 1% grade



Comparison with Preferences

Will bicyclists naturally minimize inhaled dose over a trip?

Bike boulevard
or
neighborhood greenway

VS.

Bike lane

- Balance on collectors (6-10k ADT)
- Under-avoid arterials

VS.

Minor arterial
(no bike lane)

- Slightly over-avoid

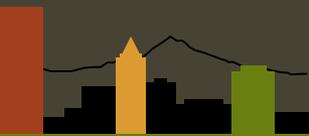
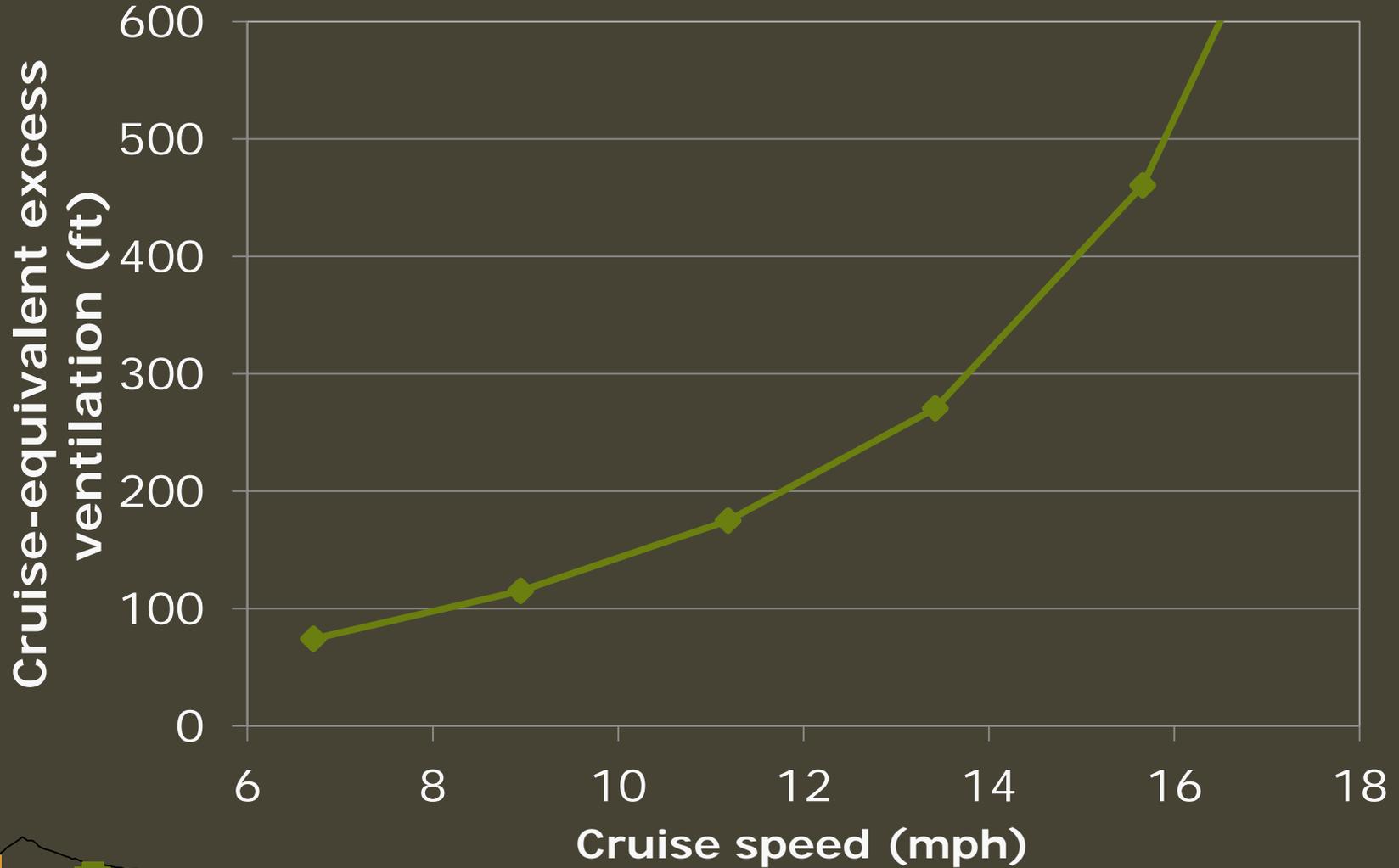
VS.

Major arterial
(no bike lane)

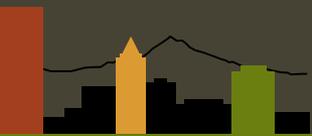
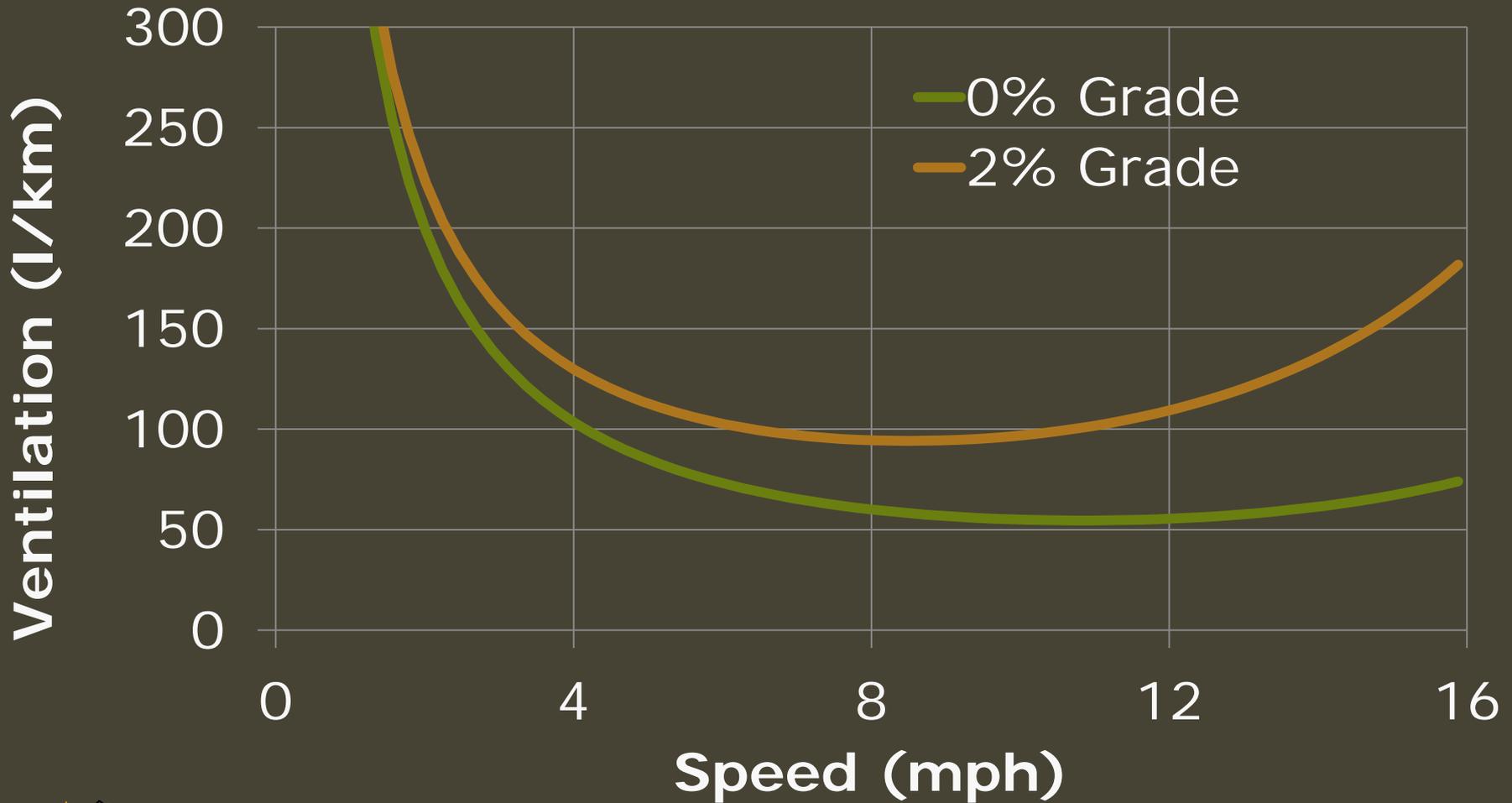
- Greatly over-avoid



Inhalation and Stops



Inhalation and Speed



Bikeway Design Considerations

Bike lane

- Higher-traffic streets
- Some lateral separation
- Dedicated lane reduces stops in congestion

Cycle track

- Higher-traffic streets
- More lateral separation

Bike boulevard

- Low-traffic streets
- Additional benefits from traffic calming
- Fewer stops reduces doses

Off-street path

- Low exposure (nearby industry?)
- Fewer stops reduces doses

Take-Away Principles

1. Bicyclist Exposure

- a) Many different pollutants
- b) Traffic, weather, and land-use all important
- c) Benefits of separation from traffic

2. Bicyclist Inhalation

- a) Varies greatly with workload (speed, grade)
- b) Breath response spread out over 1-2 min

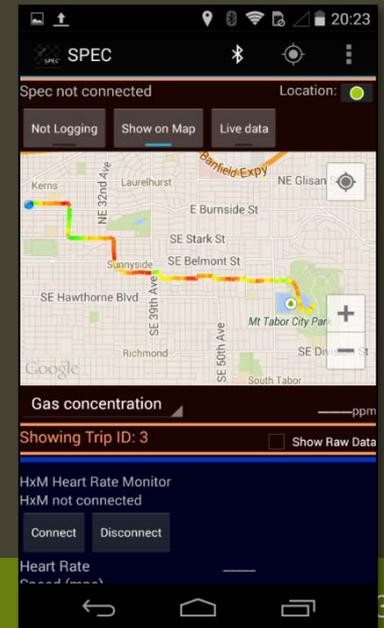
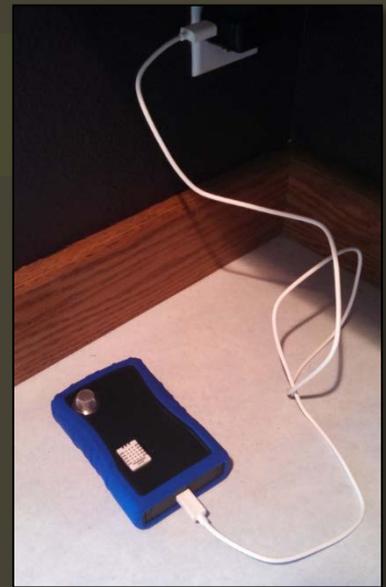
3. Bicyclist Uptake

- a) For particles, highly sensitive to breathing
- b) For some gases, more sensitive to exposure & duration



Future Work

- Abstraction for HIA & CBA
- Characterizations of urban bicyclists
- Similar study for pedestrians
- Crowd-source pollution data



Questions?

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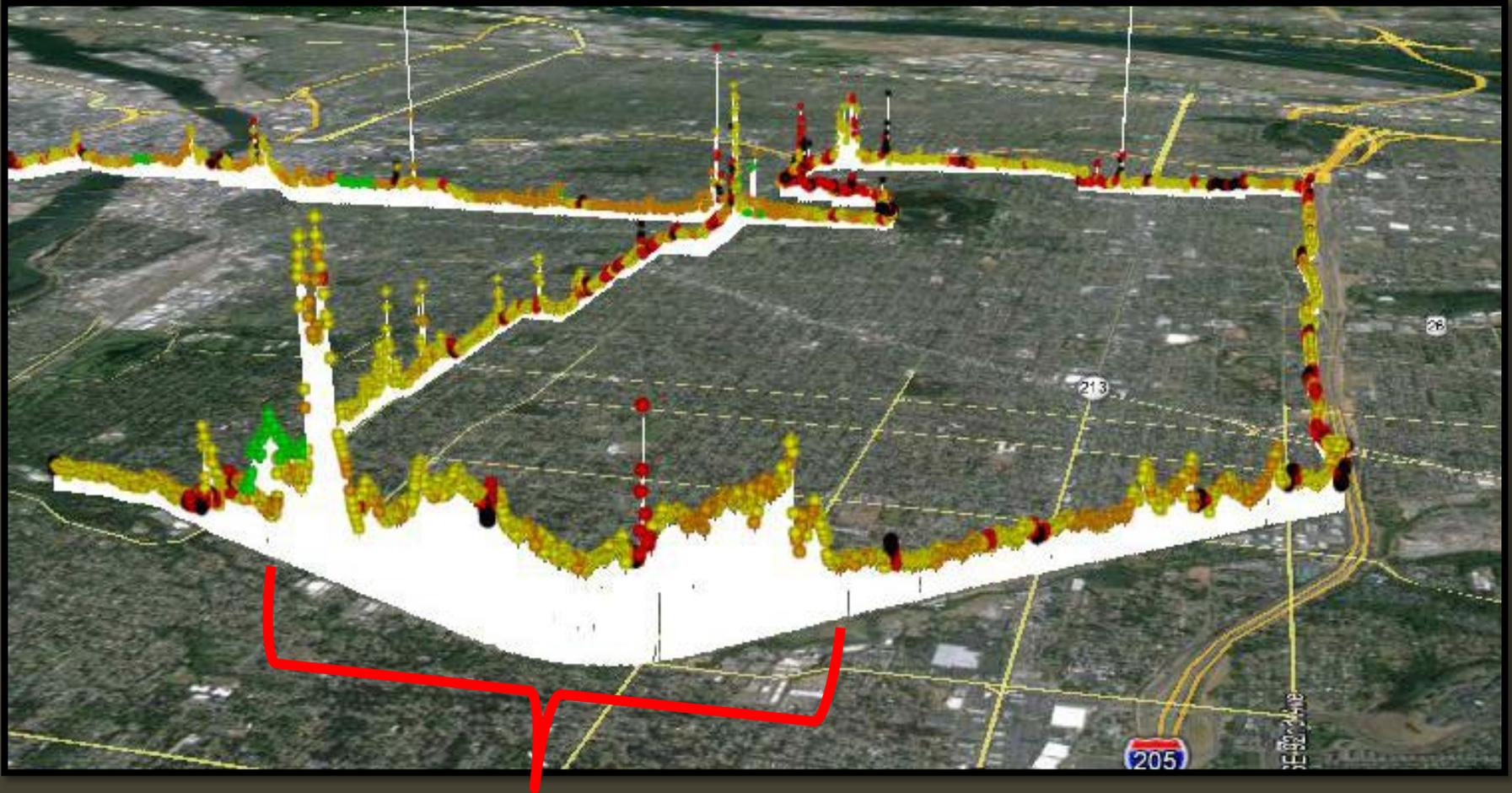


National Science Foundation
WHERE DISCOVERIES BEGIN

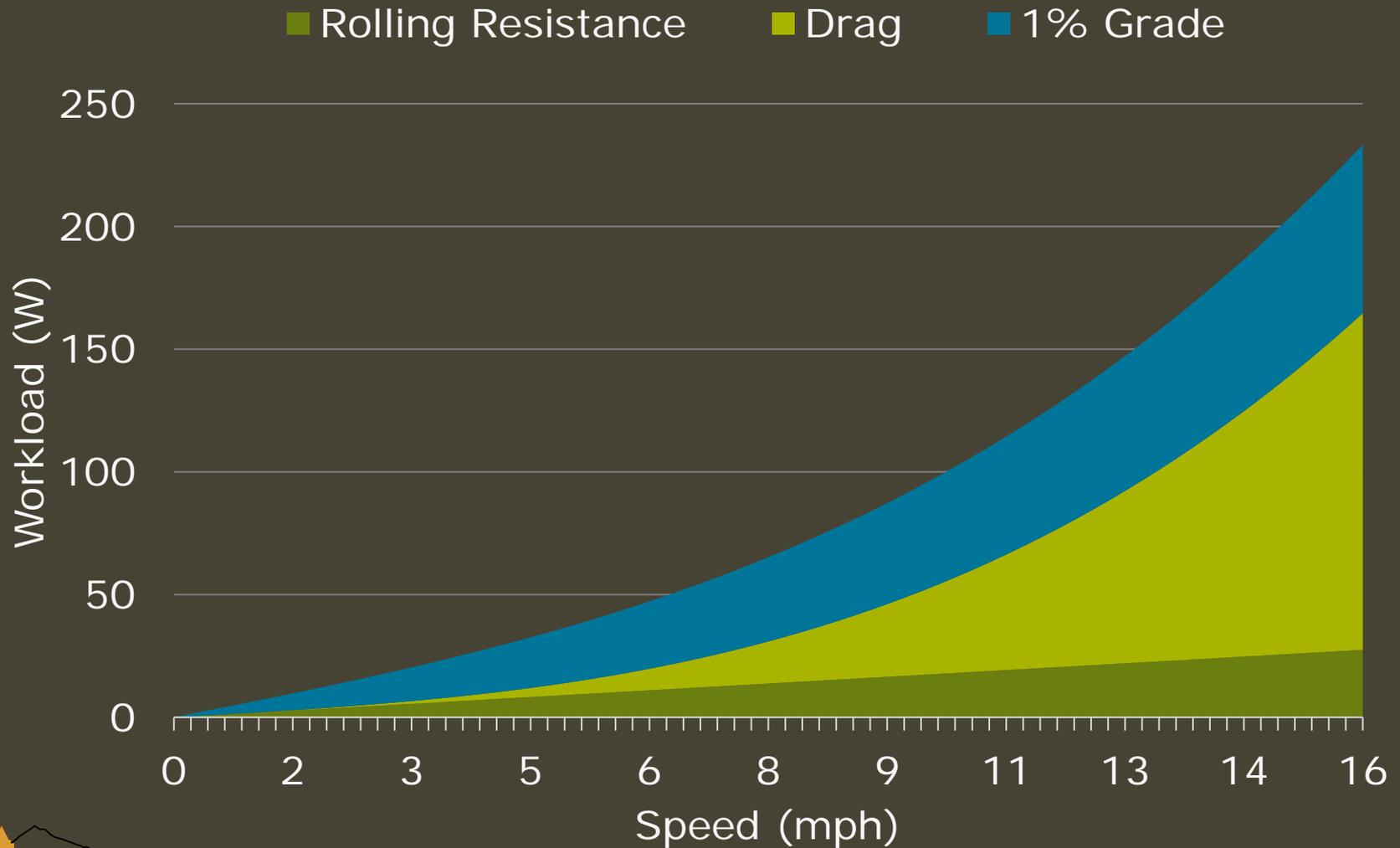


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OREGON TRANSPORTATION RESEARCH
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Industrial Corridor



Steady-state biking work



Minimum-Inhalation Speed

