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

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NITC
NATIONAL INSTITUTE for TRANSPORTATION and COMMUNITIES

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

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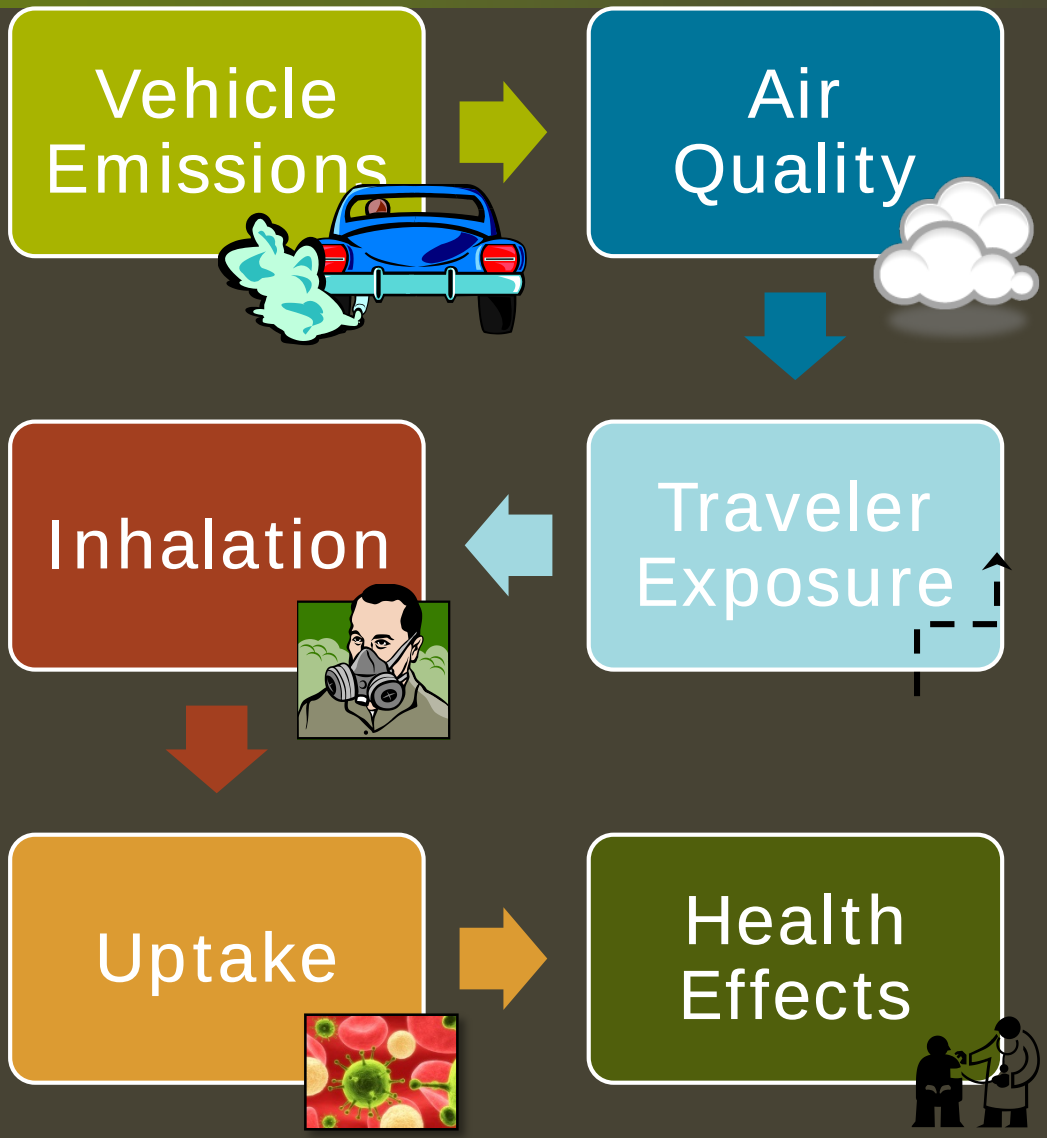
Health Effects of Bicycling

- 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


Vehicle Emissions
Air Quality
Traveler Exposure
Inhalation
Uptake
Health Effects

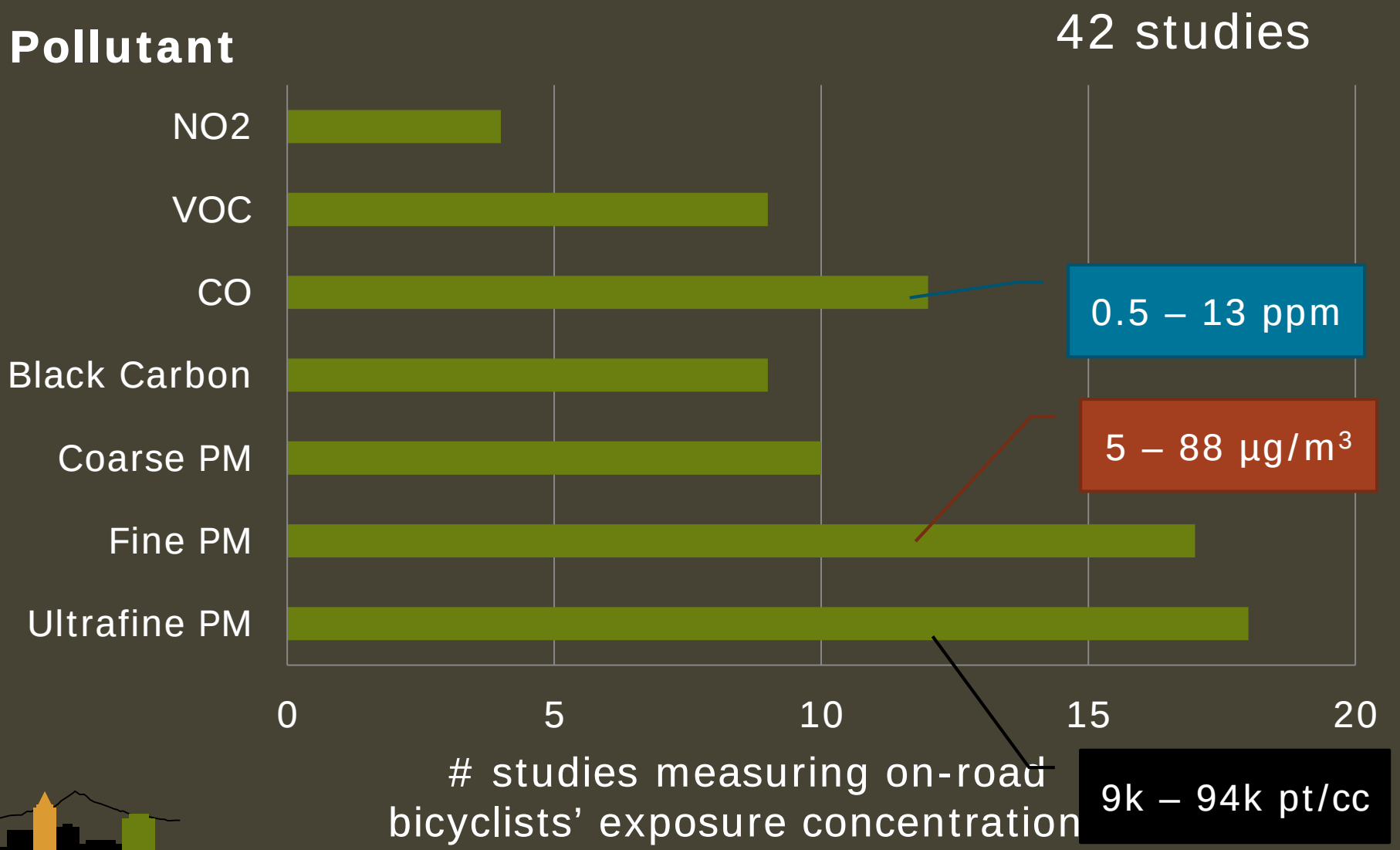
Outline

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

Traveler Exposure

Bicyclist Exposure Concentrations

Bicyclists' Exposures



Modal Comparisons of Exposure

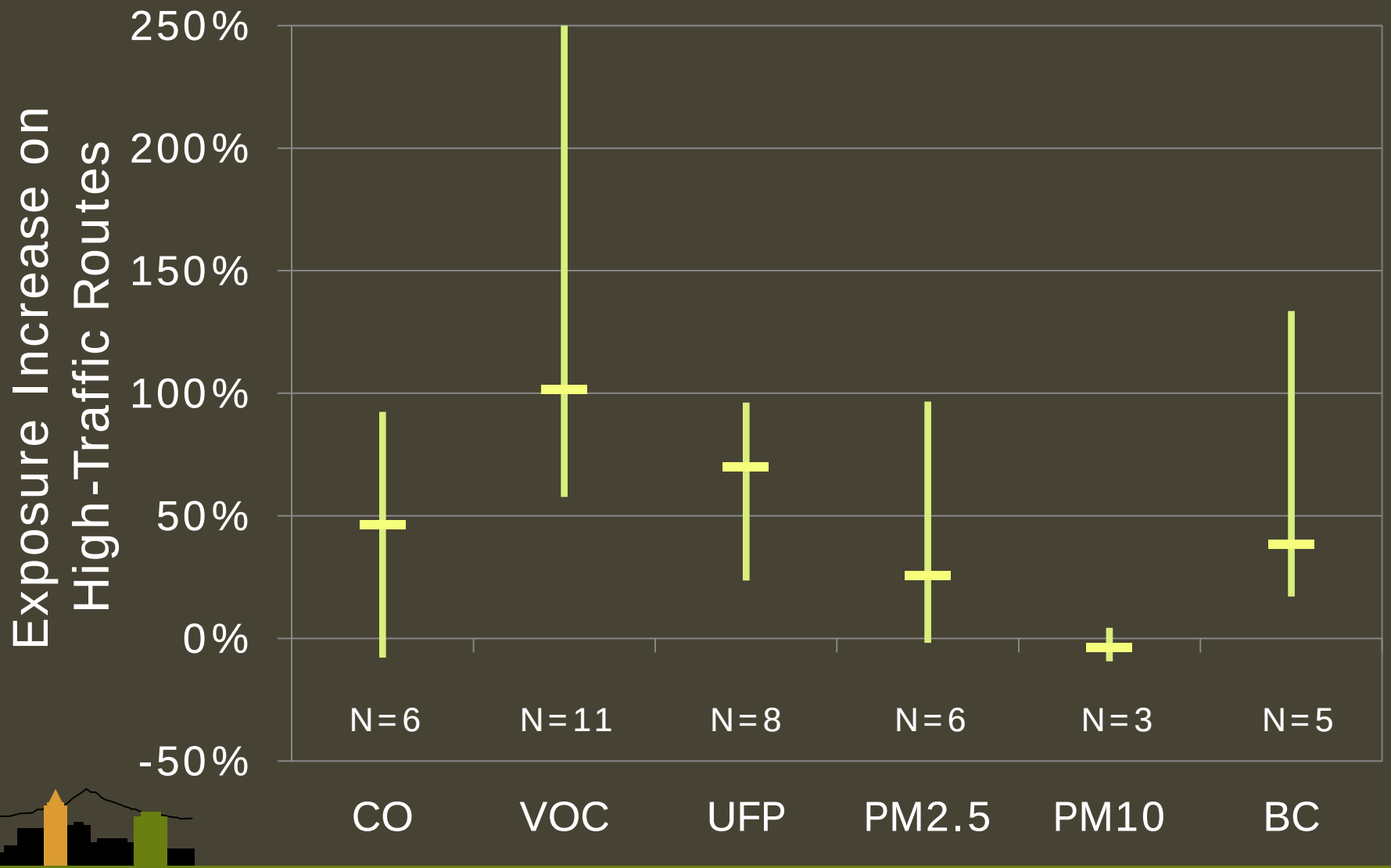
 vs  vs 

- Is this actionable information?

Context-dependent results

- Bicyclists lower if separated

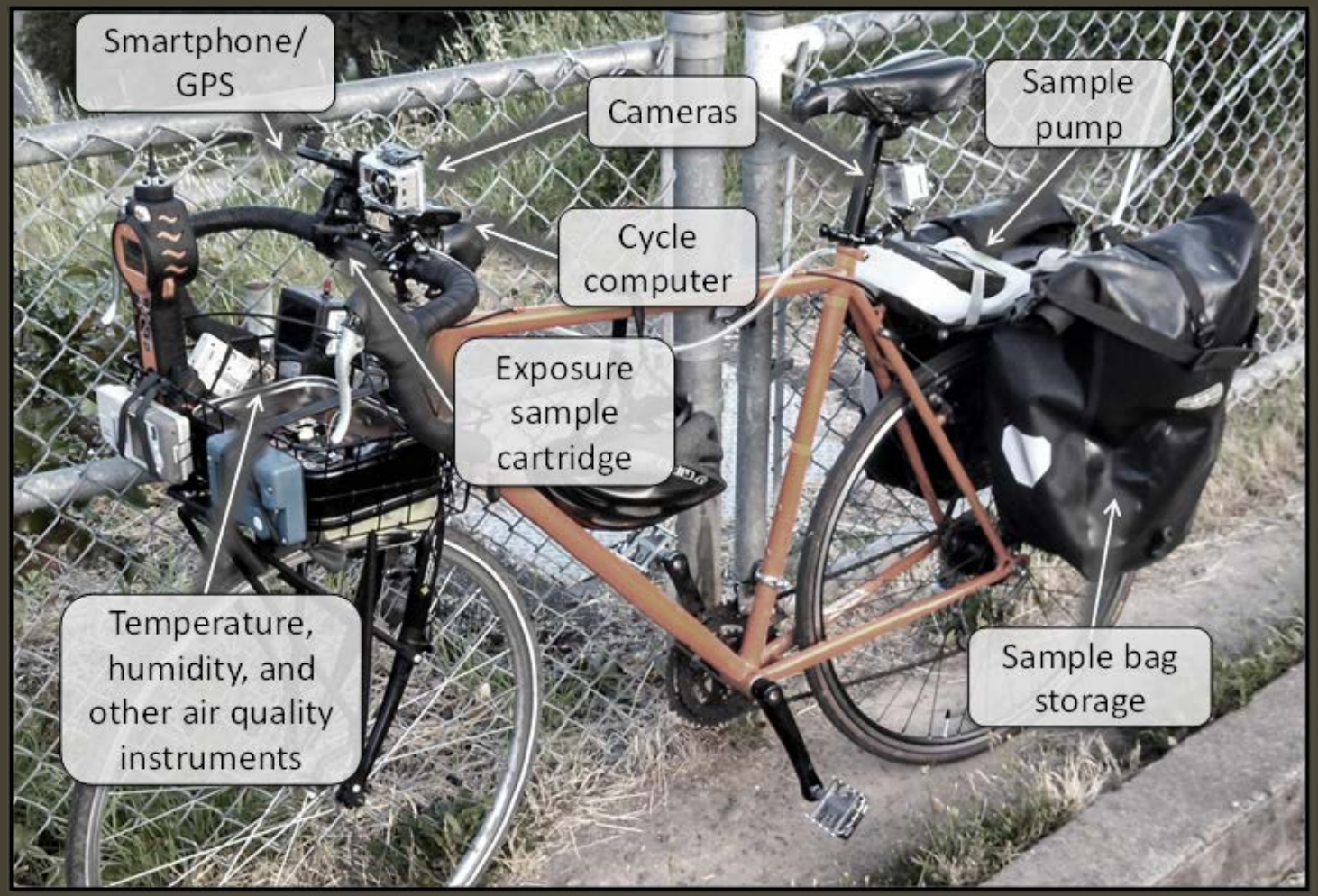
High-Traffic/Low-Traffic Routes



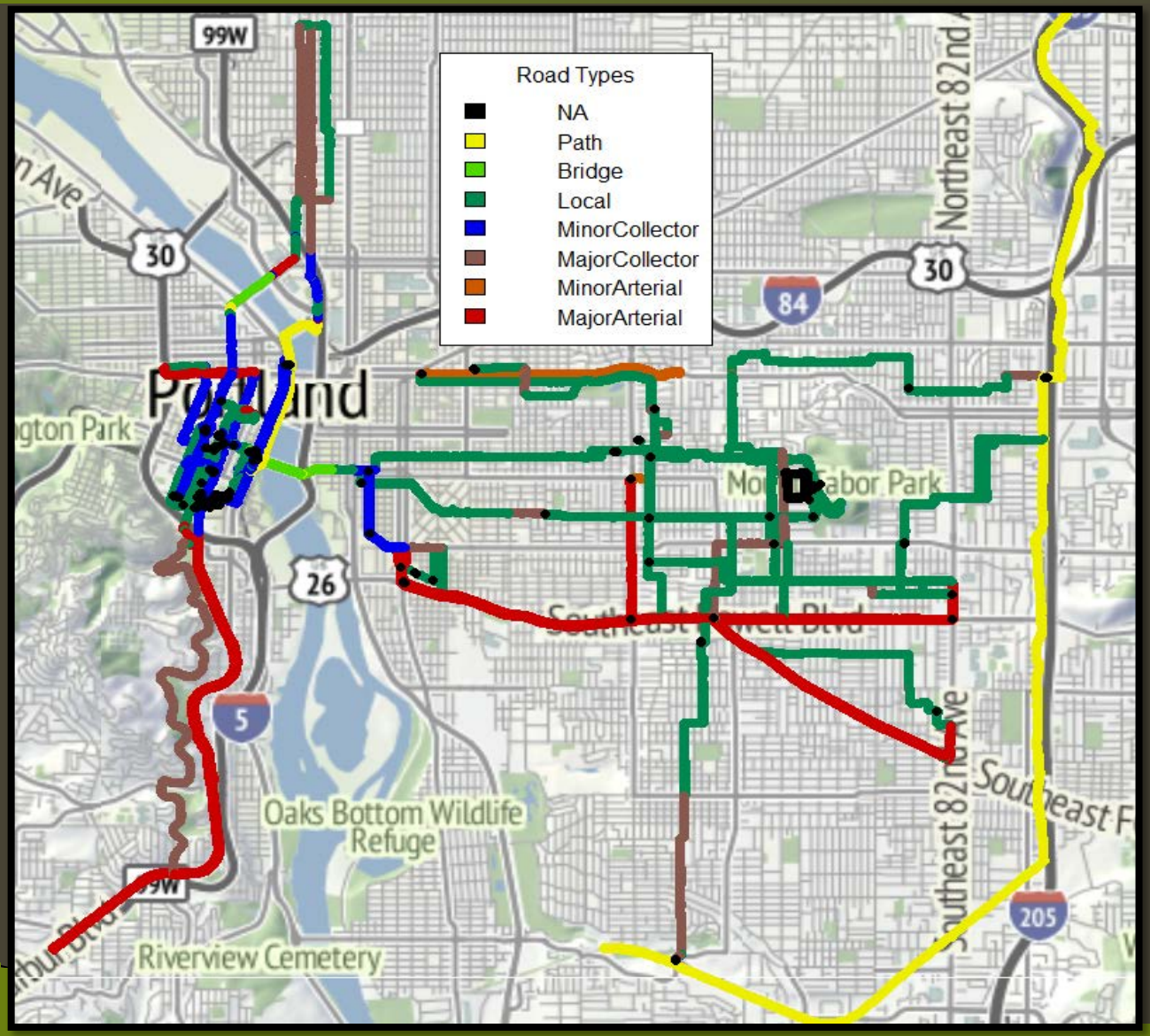
PSU Bike Exposure Research

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

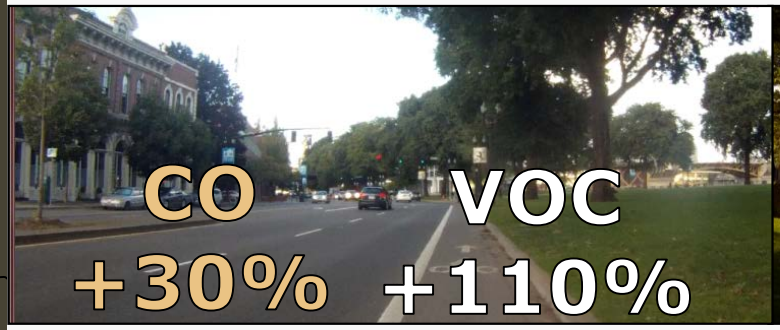
Parallel Path Comparison

E Burnside St.

SE Ankeney St.

N Williams Ave.

NE Rodney Ave.



Naito Pkwy.

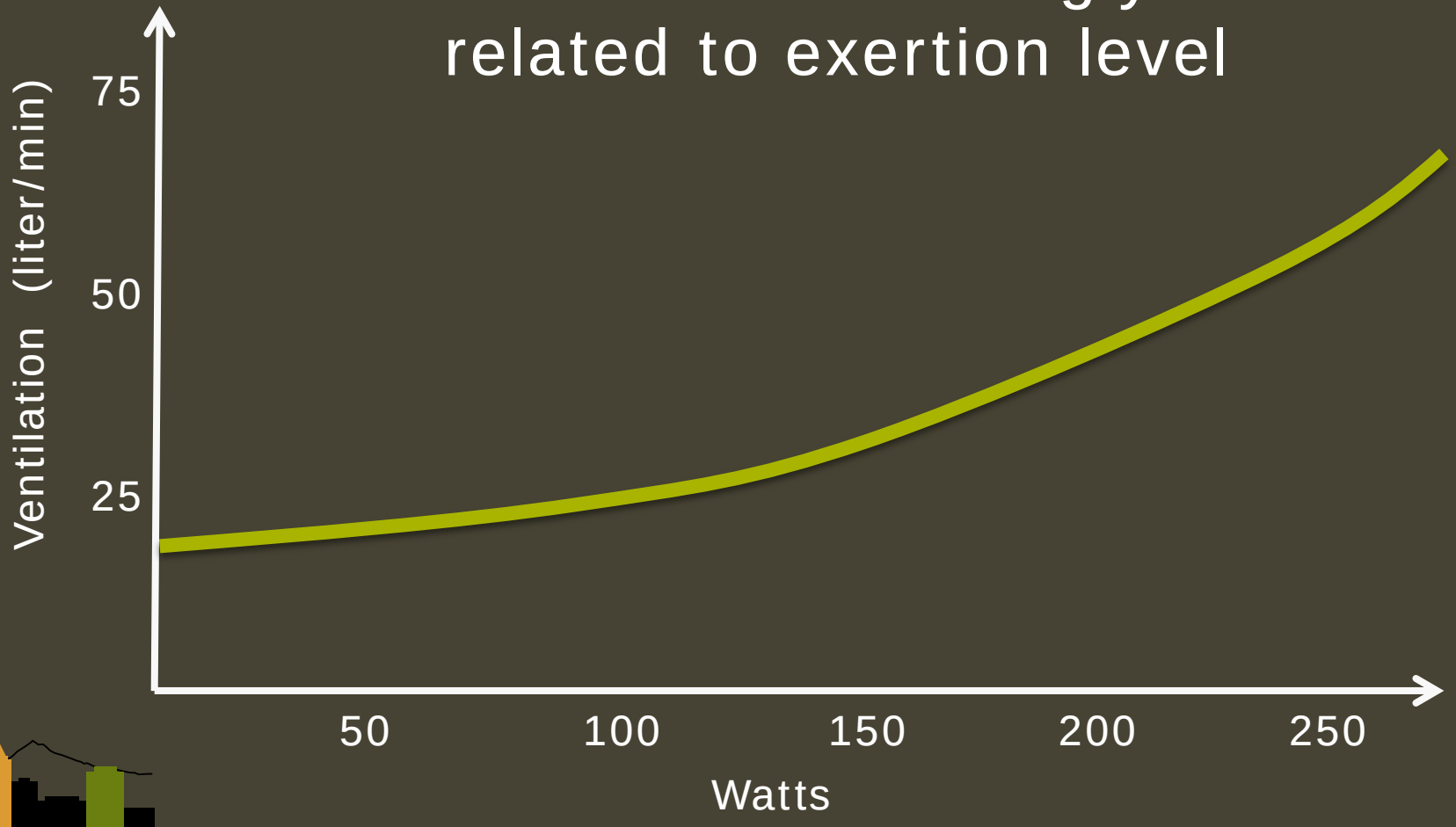
Riverside Path

Inhalation

Bicyclist Pollution Inhalation

Ventilation and Exercise

Ventilation is strongly related to exertion level



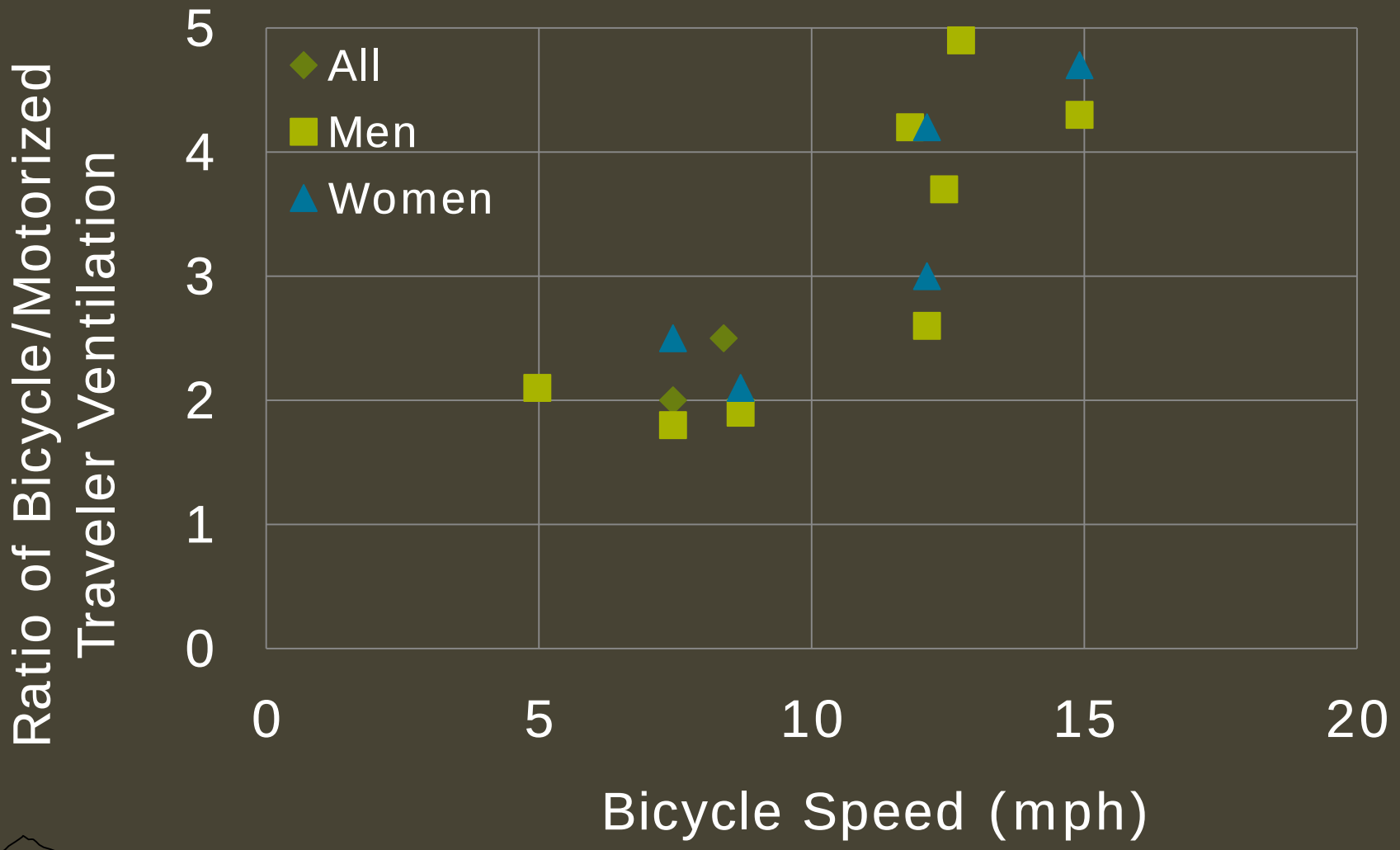
Ventilation & Bicycle Studies

57 studies assess bicyclists' exposure

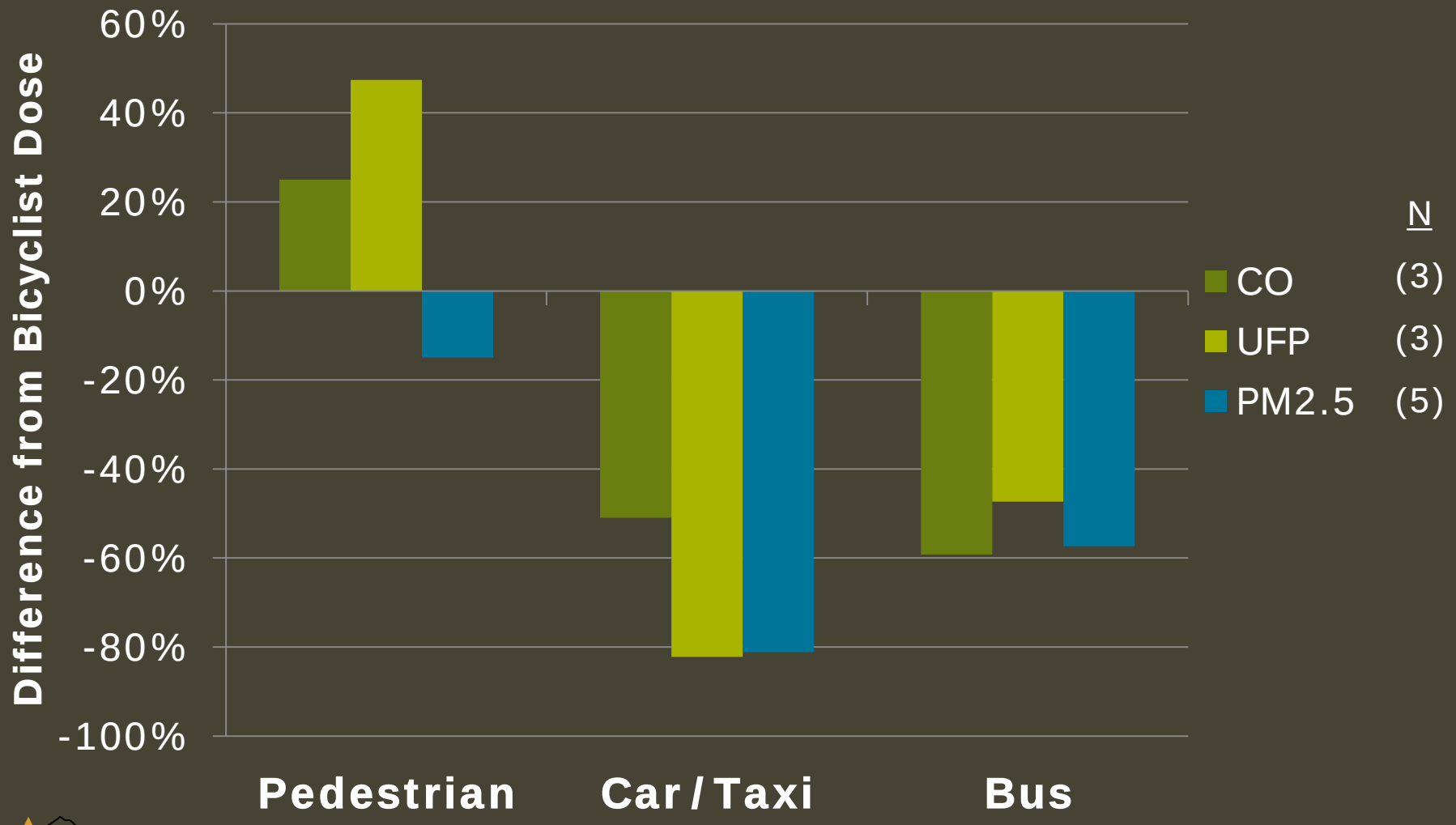
Ventilation:

Ignored	Constant		Variable	
38	16		3	
	Assumed/ Modeled	Measured	Modeled	Measured
	15	1	2	1

Bicyclist Ventilation

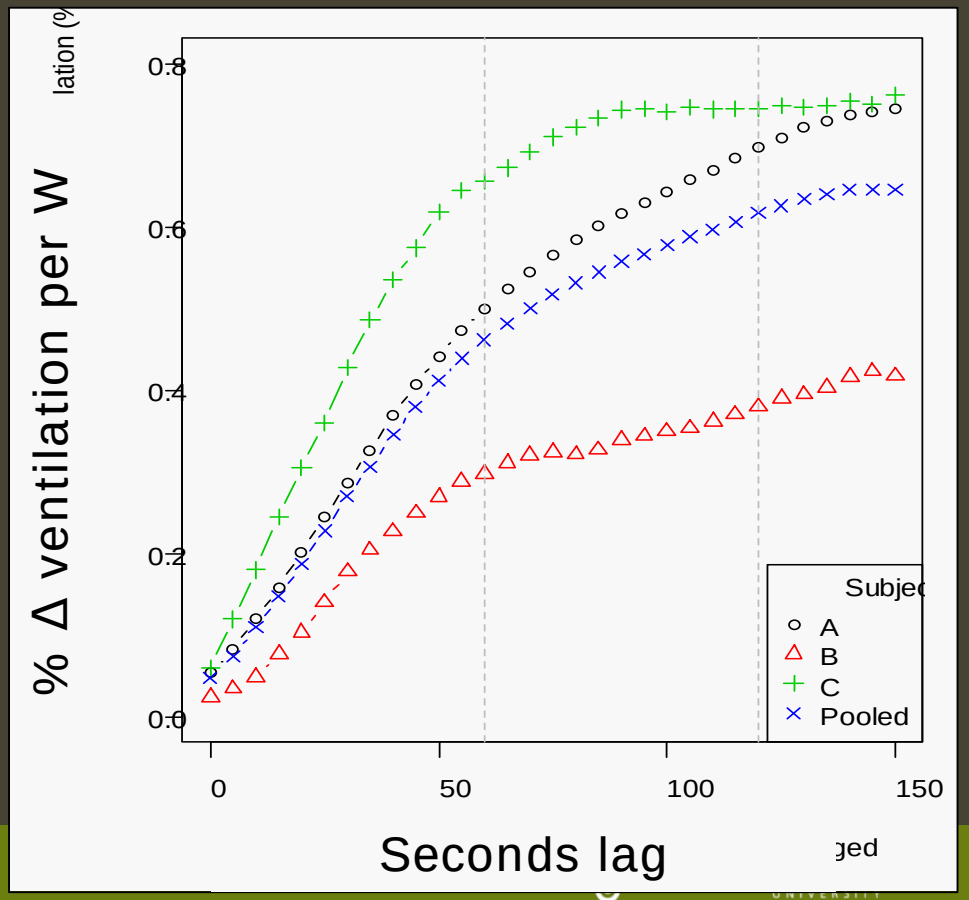


Modal Comparisons of Dose



PSU Research Findings

- 4-8% increase in ventilation per 10 W
- Mean lag ~50 sec
- Highly variable on-road



Bicyclist Pollution Uptake

Uptake

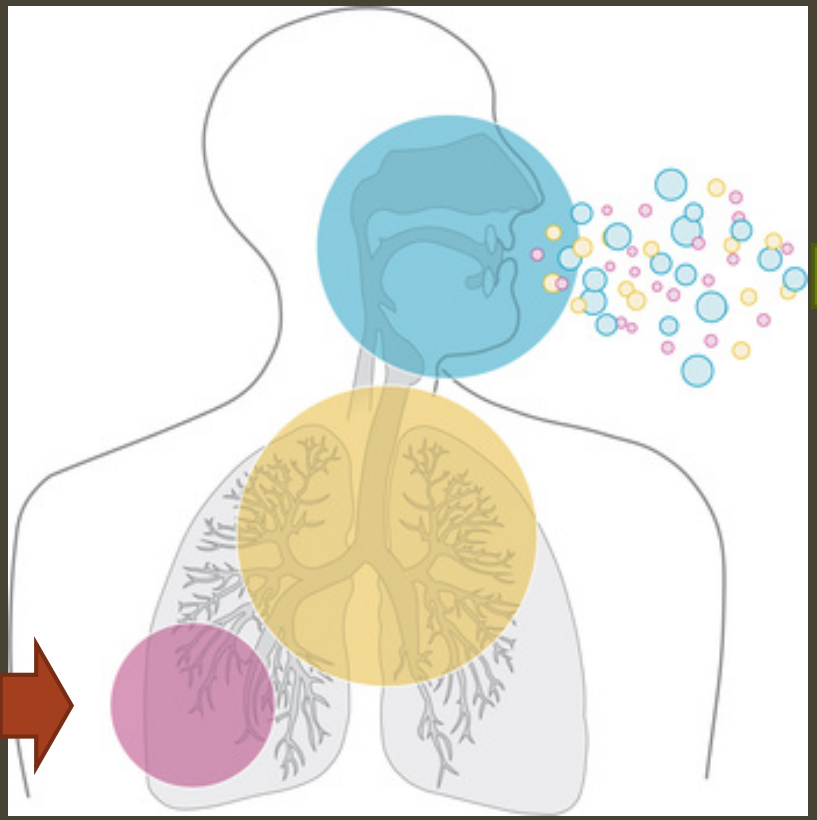
Bicyclist Uptake Studies

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



alphaszenszor.com

VOC in blood

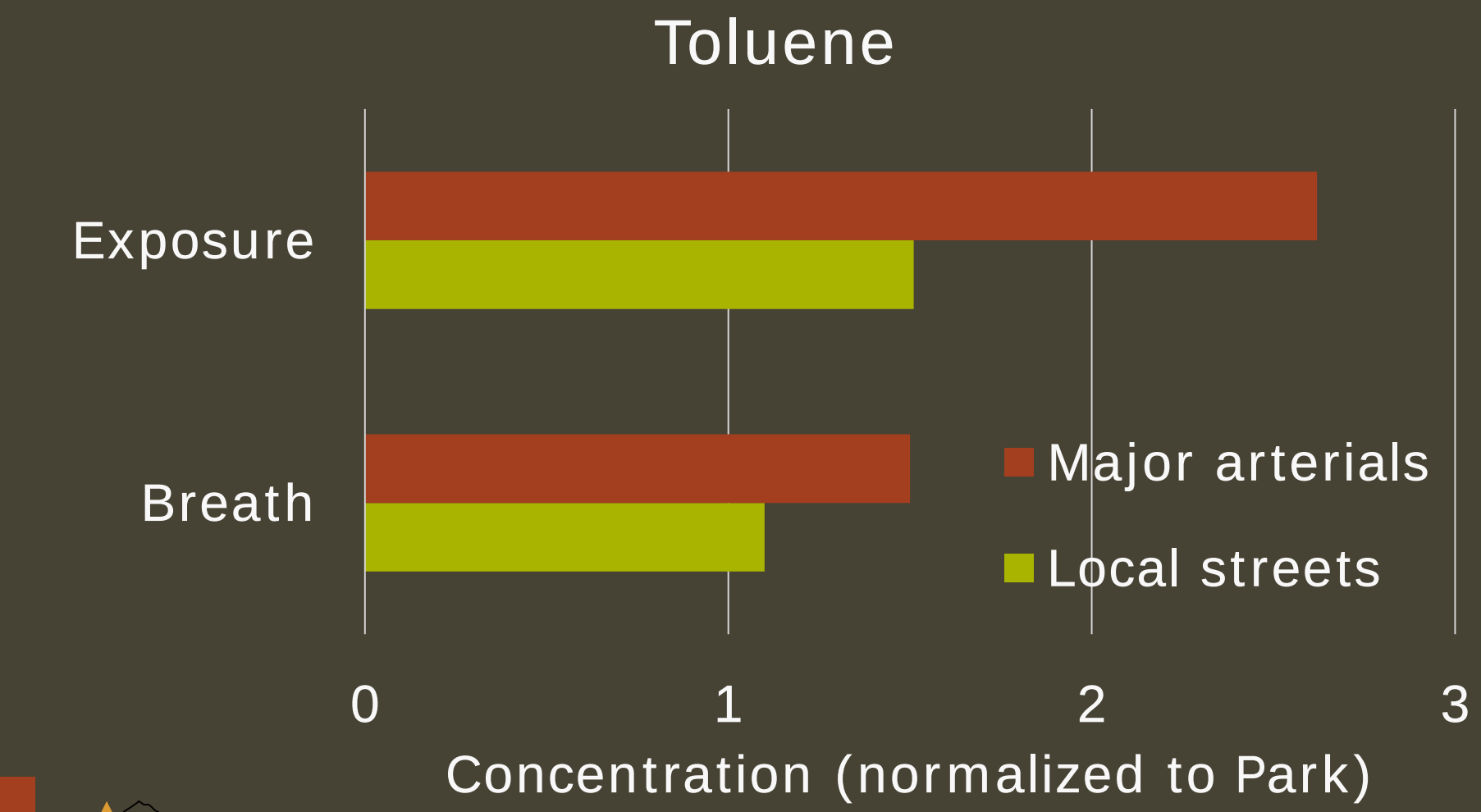
PSU On-Road Sampling

20-30 minutes, 3-5 miles

Exposure & breath VOC

Paired subjects

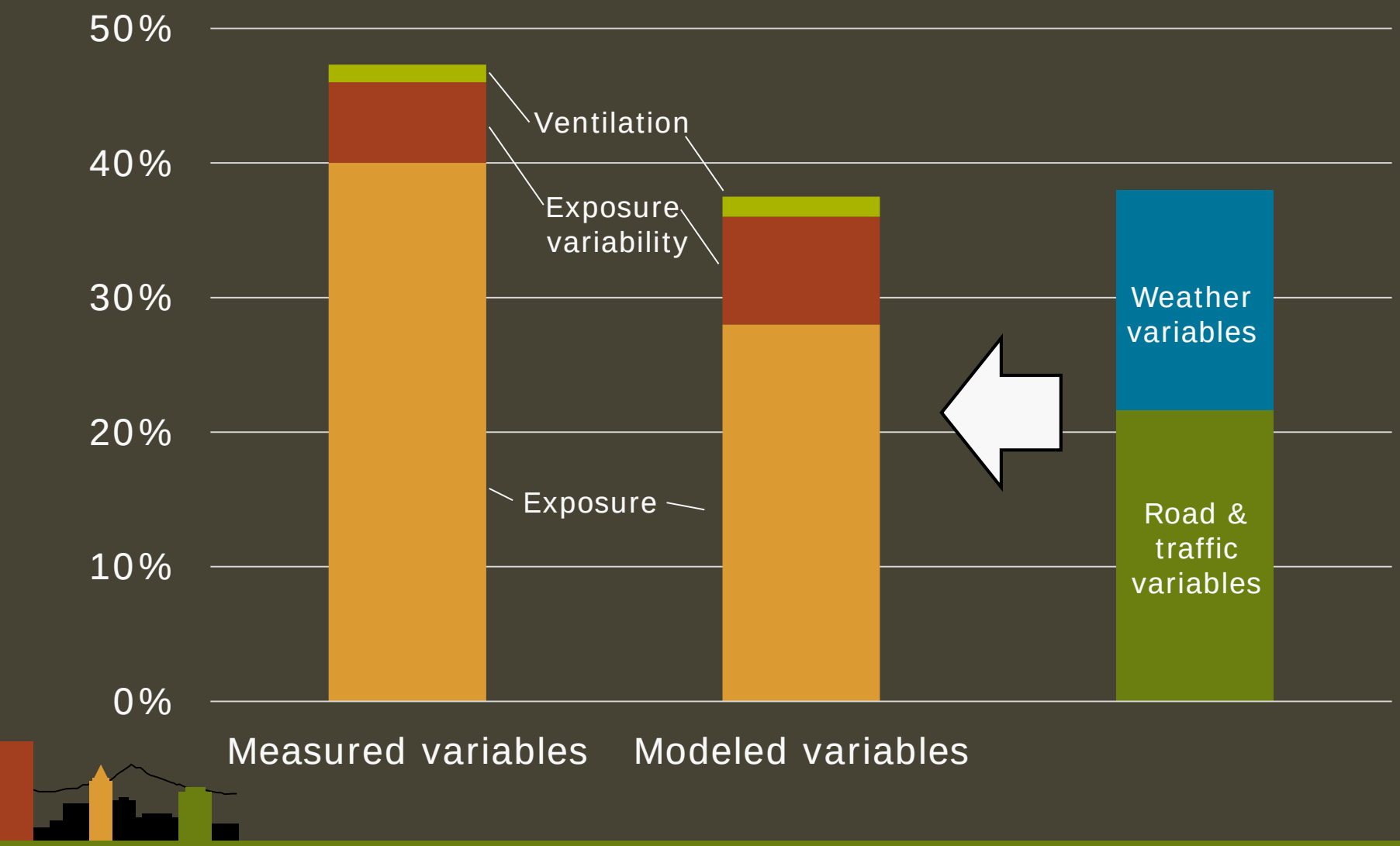
Breath and Exposure Concentrations



Breath Sampling Results

- The breath sampling method works
  - Exposure predicts breath concentrations
  - Δ Breath ~ ½ Δ 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



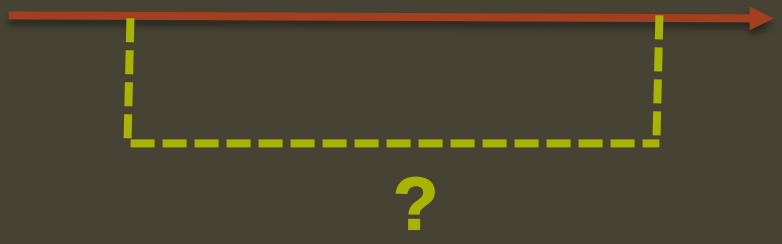
Exercise and Uptake

- Ventilation/inhalation rate: 2-5x higher
- PM uptake: ≥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

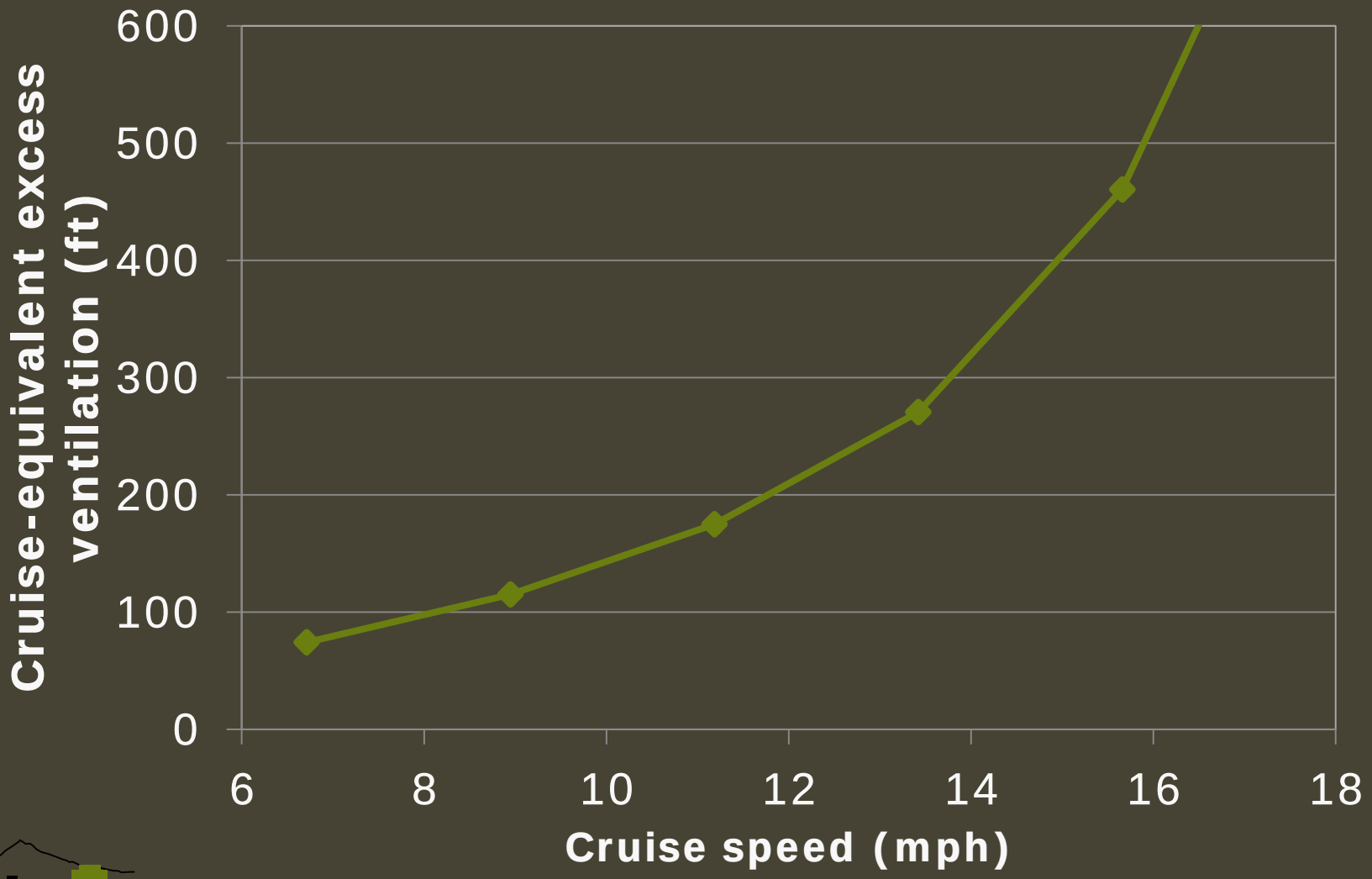
vs. Minor arterial (no bike lane)

- Slightly over-avoid

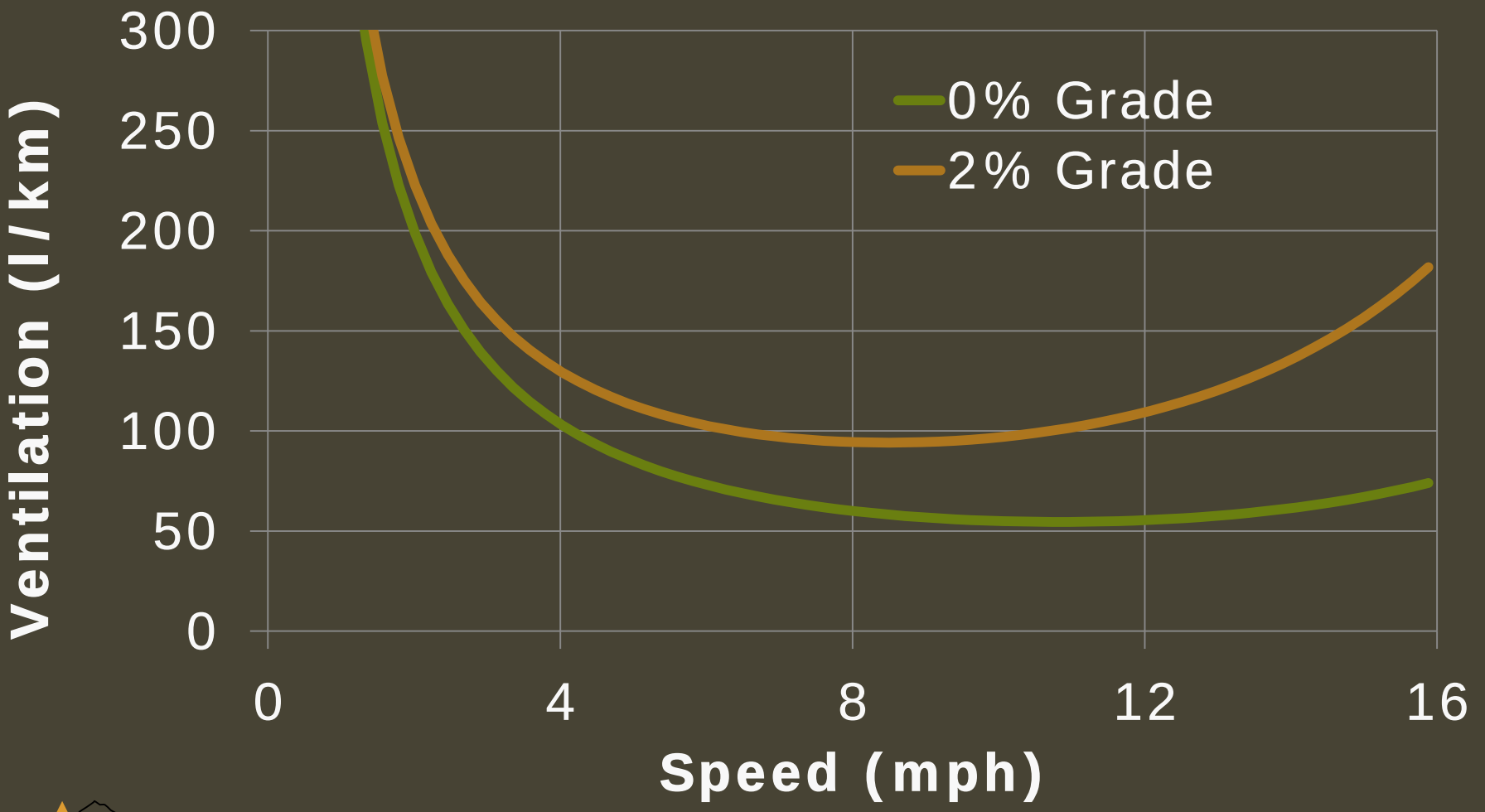
vs. Major arterial (no bike lane)

- Greatly over-avoid

Inhalation and Stops



Inhalation and Speed



Bikeway Design Considerations

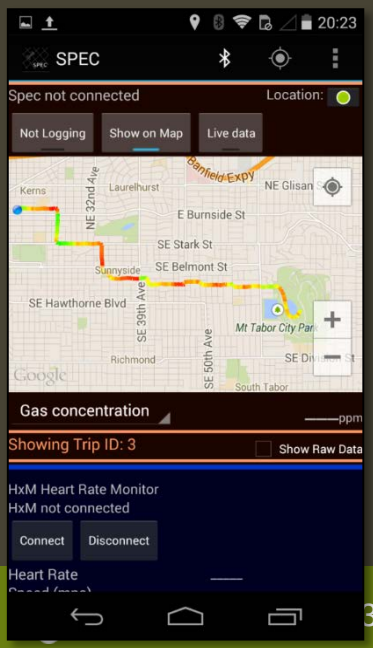
Bike lane	• Higher-traffic streets • Some lateral separation • Dedicated lane reduces stops in congestion
Cycle track	• Higher-traffic streets • More lateral separation
Bike boulevard	• Low-traffic streets • Additional benefits from traffic calming • Fewer stops reduces doses
Off-street path	• Low exposure (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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Portland State
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National Science Foundation
WHERE DISCOVERIES BEGIN

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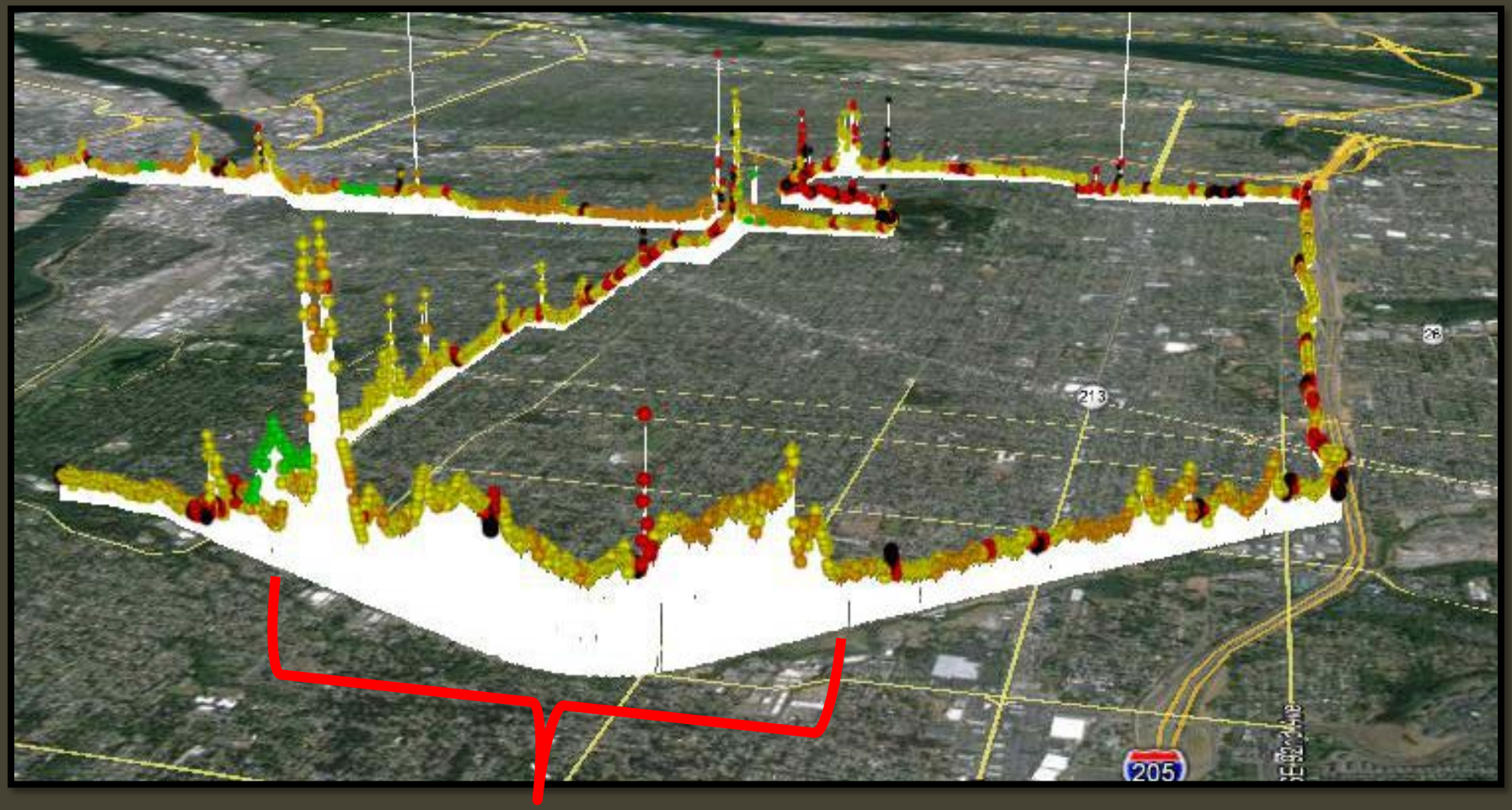
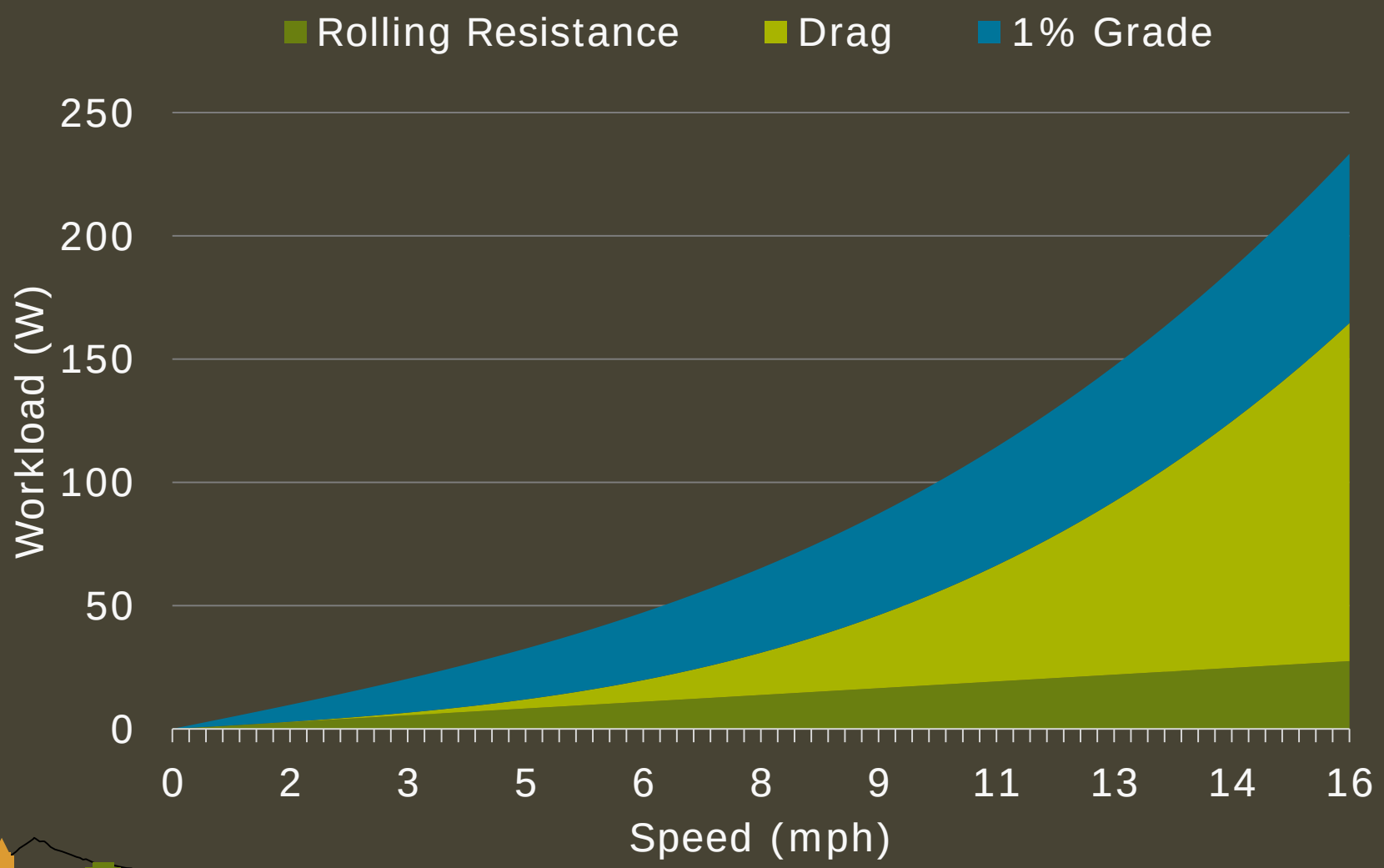
Industrial Corridor



Steady-state biking work



Minimum-Inhalation Speed