NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

TRB Webinar: Mitigating Air Pollution Exposures from Transportation

November 2, 2023

1:00 – 2:30 PM

PDH Certification Information

1.5 Professional Development Hours (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Andie Pitchford at TRBwebinar@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net. A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.

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AICP Credit Information

1.5 American Institute of Certified Planners Certification Maintenance Credits

You must attend the entire webinar

Log into the American Planning Association website to claim your credits

Contact AICP, not TRB, with questions

Purpose Statement

This webinar will share the relationship between transportation, air pollution, and health effects and provide strategies to work with communities to develop mitigation strategies. Presenters will draw from meta-analysis and field studies to provide industry best practices for mitigating air pollution.

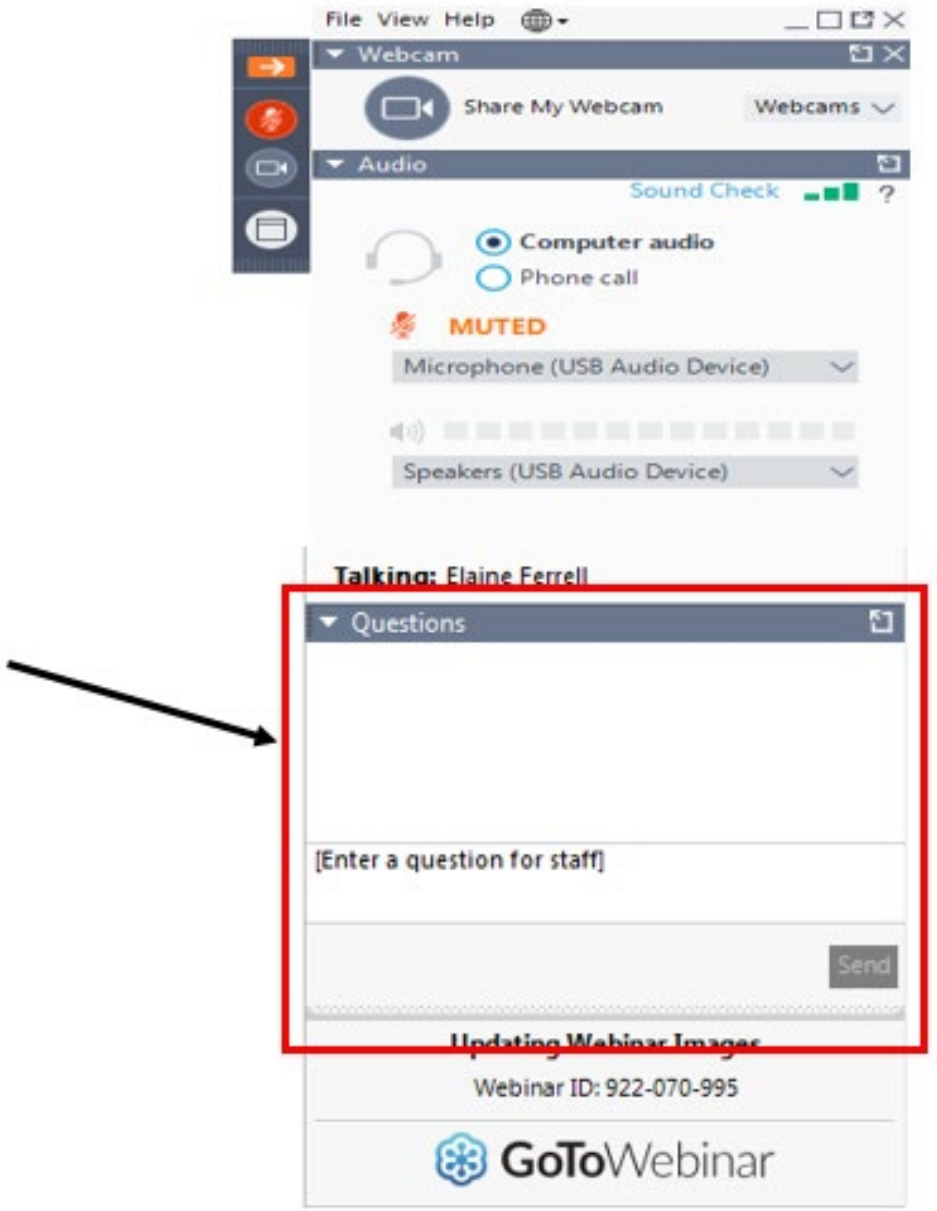
Learning Objectives

At the end of this webinar, you will be able to:

- Recognize traffic-related contributions to air pollution and its effects on health and communities
- Identify community-based initiatives to mitigate transportation air pollution
- Implement neighborhood and corridor-level green infrastructure strategies to mitigate the effects of traffic-related air pollution

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today's presenters

Richard Baldauf
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U.S. Environmental Protection Agency

Kelly Rodgers
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Streetsmart Planning, LLC

Hanna Boogaard
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Regan Patterson
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University of California, Los Angeles

Allison Harvey
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OJB Landscape Architecture

EPA United States Environmental Protection Agency

Webinar Agenda

Today's Presentations:

1. Systematic review of selected health effects of long-term exposure to traffic-related air pollution – Hanna Boogaard, Health Effects Institute
2. Impact of transportation policies and interventions on air pollution exposure disparities and environmental justice – Regan F. Patterson, University of California, Los Angeles
3. Greenscapes to Brownscapes: Neighborhood and corridor-level green infrastructure strategies – Allison Harvey, OJB Landscape Architecture

Sources of Air Pollution

United States Environmental Protection Agency

Traffic-related pollution is caused by:

Car exhaust

Particles

Gases

Truck exhaust

Particles

Gases

Brake and tire wear

Particles

Gases

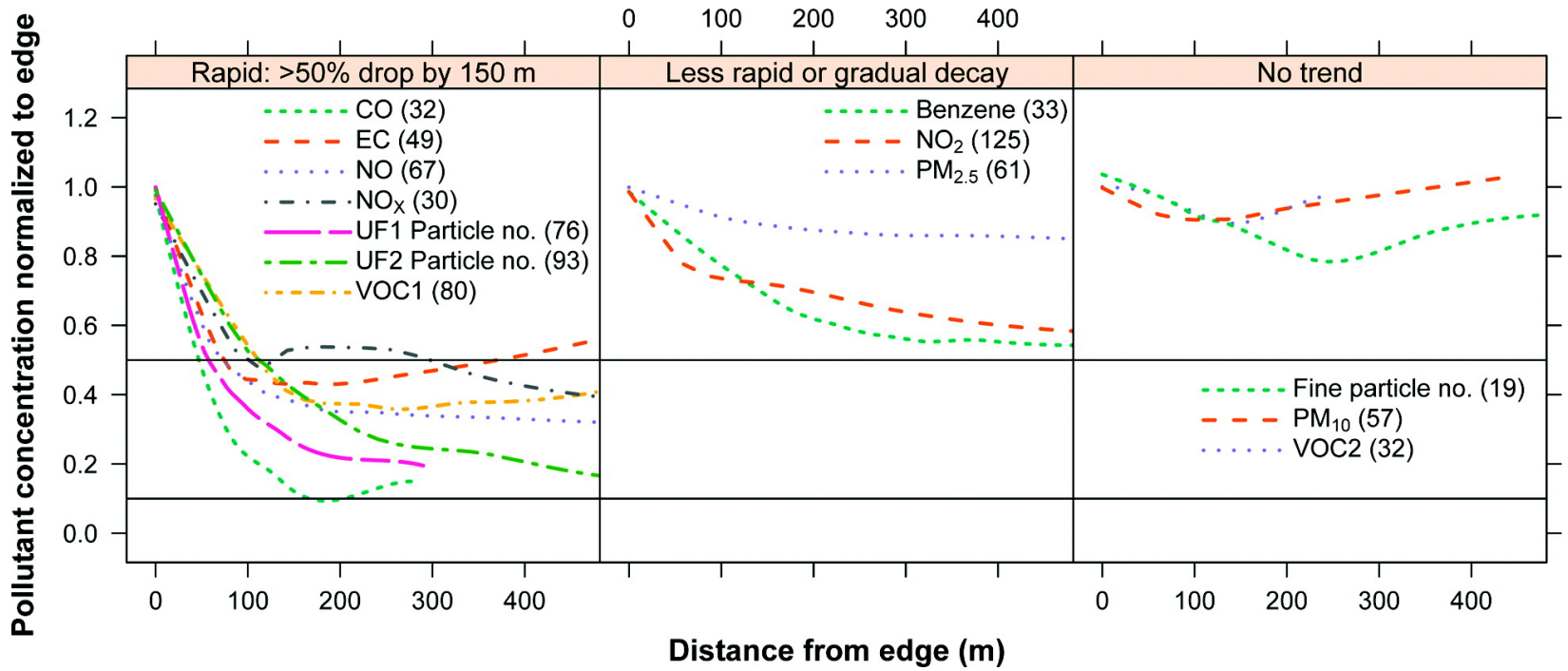
Re-suspension of dust

Particles

Health Concerns from Transport

United States Environmental Protection Agency

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

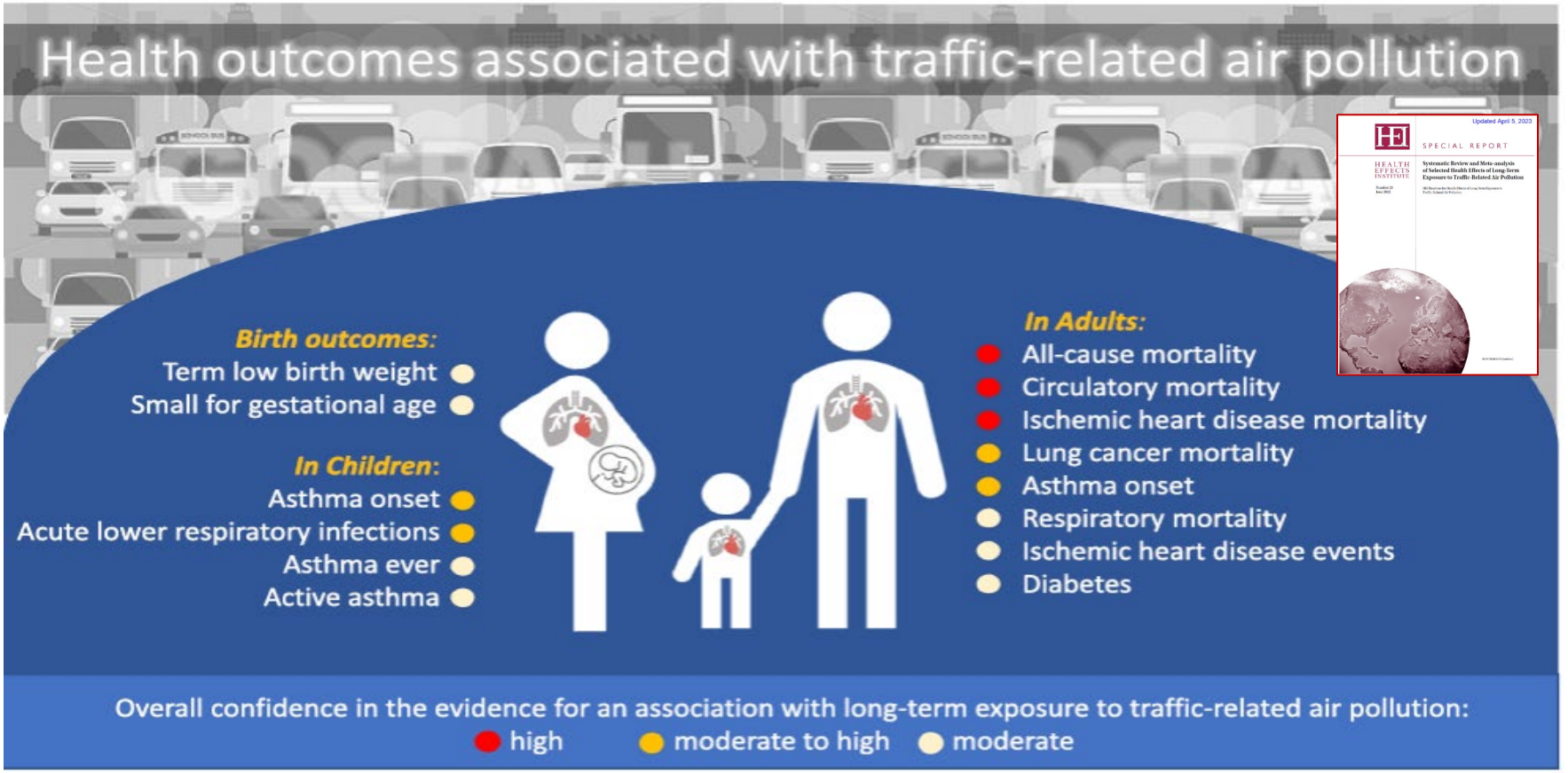


Karner et al, 2010, Environ Science & Tech, 44(14), pp.5334-5344

Health Concerns from Transport

United States Environmental Protection Agency

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



Additional studies have linked other adverse effects including:

- Childhood leukemia
- Cognitive development
- Neurological disorders including autism

Health Concerns from Transport

- **A large portion of the world's population exposed to near-road traffic emissions,**
- **EPA estimates in the US:**
  - Over 50 million people live within 100m of a large highway or other transportation facility (e.g. airport, rail yard)
  - Almost 17,000 schools located within 250m of a heavily-traveled roadway

4

Transport Mitigation Options

Mitigating transport emissions, exposures, and health effects can be achieved by:

- Reducing vehicle direct emissions
- Reducing vehicle use and activity
  - Public transit
  - Walk/bike options
  - Congestion pricing/low emission zones
- Using urban and transportation planning, such as
  - Road location and configuration
  - Compact development
  - Buffer/exclusion zones
  - **Increasing urban green infrastructure and green space**

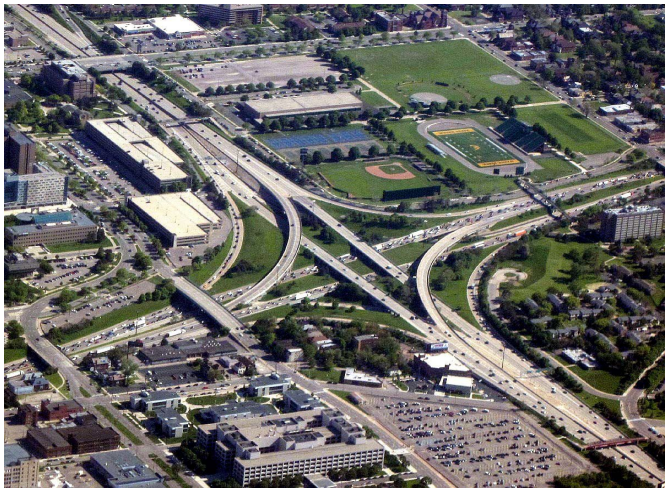
Why consider green infrastructure?

Public wants to know what can be done now for near-road health concerns at home, school, care facilities, etc.

Few other "short-term" mitigation options exist

- Vehicle 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

Green infrastructure/space often provides other co-benefits



How Urban Vegetation Mitigates Air and Climate Pollutants

The result is lower roadway pollutant concentrations in the area protected by the vegetative barrier

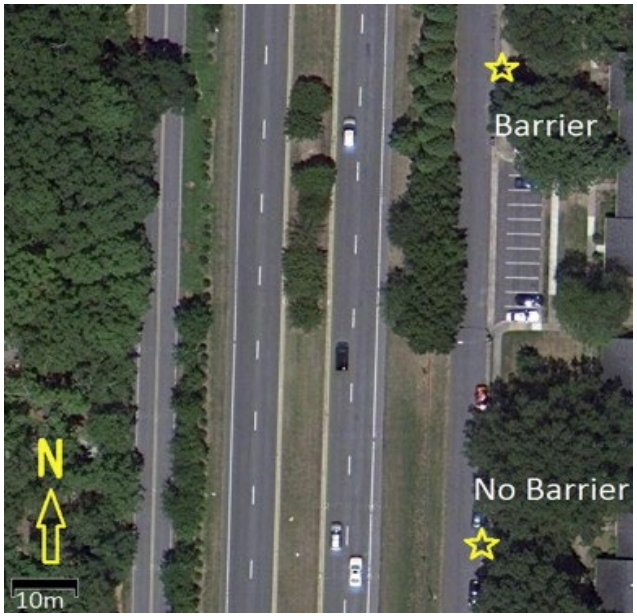
Pollutants are dispersed into the air by roadside trees

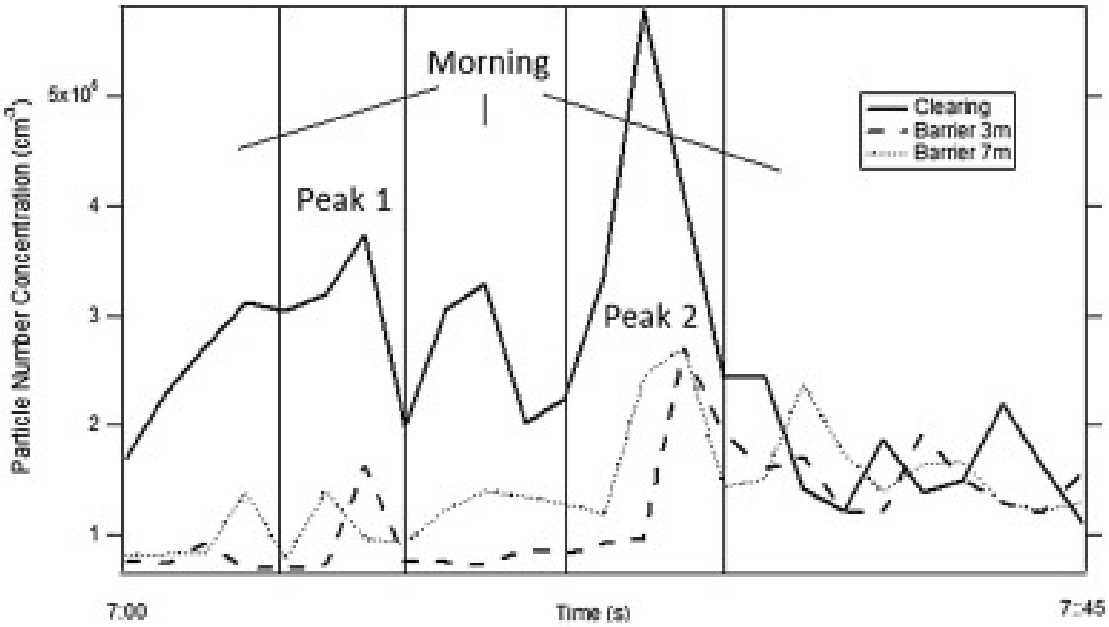
Some pollutants are filtered and others are absorbed directly by foliage

Air pollution produced by vehicles on heavily trafficked roadway

Research Example

United States Environmental Protection Agency

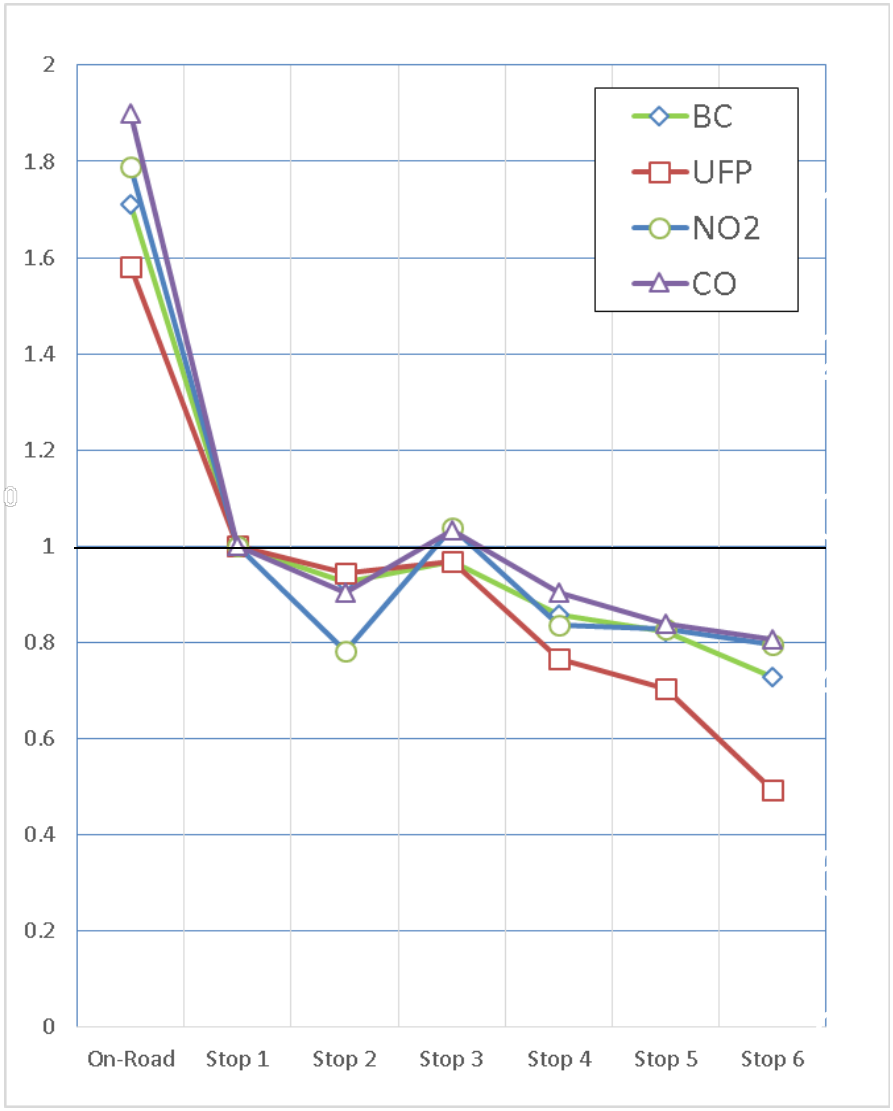




- Particulate matter including black carbon was reduced downwind of the vegetation
- Higher reductions occurred closer to ground-level with winds from the road
- Reductions in particle number could be 50% or greater

Steffens et al, 2012, Atmospheric Environment, 50, pp.120-128

Research Example



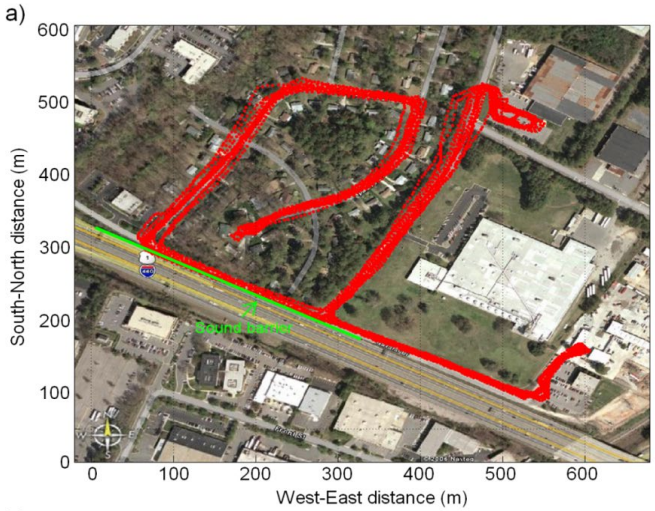
Plant conditions can affect the levels of downwind pollution

- Thick, tall and full coverage reduced pollution downwind of the road
- Gaps and porous vegetation led to no reductions or even higher levels downwind of the road

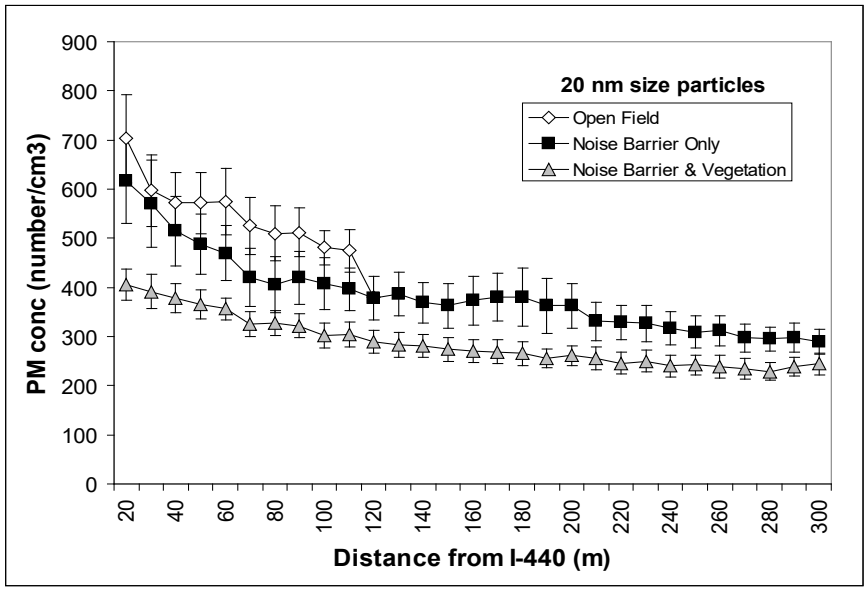
Deshmukh et al, 2019, Air Quality, Atmos & Health, 12(3), pp.259-270

Research Example

United States Environmental Protection Agency



- Solid noise barriers reduced PM ambient air concentrations compared with a clearing
- Vegetation combined with solid barriers provided further reductions of PM ambient concentrations and gradients

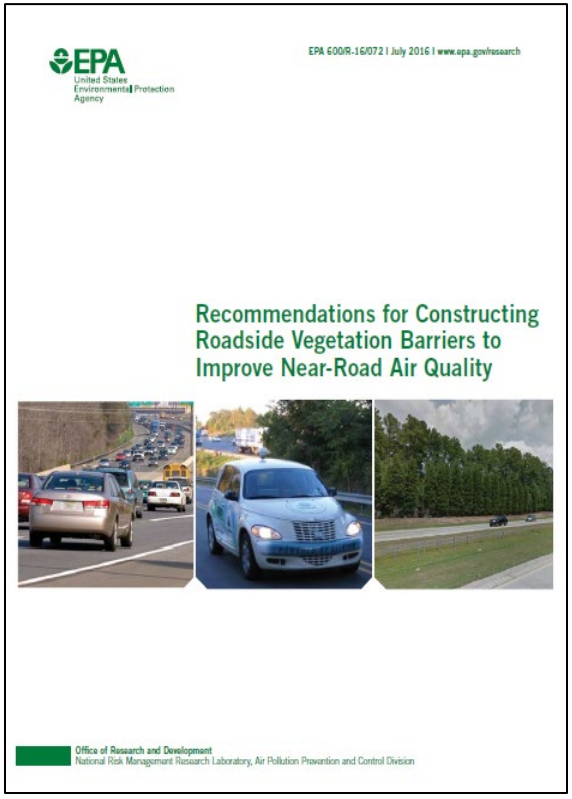


Baldauf et al, 2008, Atmospheric Environment, 42(32), pp.7502-7507

Roadside Vegetation Recommendations

The U.S. EPA developed recommendations for planting and maintaining roadside vegetation

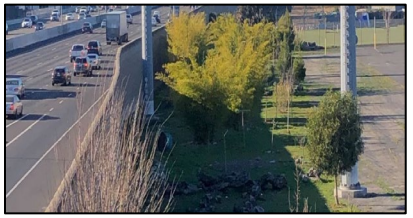
- Used to design and implement planting pilot projects in the U.S. and Europe
- Includes vegetation alone and combined with solid barriers
- Provides recommendations intended to:
  - maximize the potential for air pollution mitigation,
  - avoid unintended consequences and designs that may increase downwind concentrations and exposures, and
  - Consider other co-benefits of urban green infrastructure.



https://www.epa.gov/sites/production/files/2016-08/documents/recommendations_for_constructing_roadside_vegetation_barriers_to_improve_near-road_air_quality.pdf

Roadside Vegetation Pilot Projects

- Collecting measurements of air quality, meteorology, and noise (Detroit) before and after roadside vegetation planting
- Assessing benefits for air quality and stormwater flood control



Systematic review of selected health effects of long-term exposure to traffic-related air pollution

Hanna Boogaard, HEI

TRB Webinar Mitigating Air Pollution Exposures from Transportation

November 2, 2023

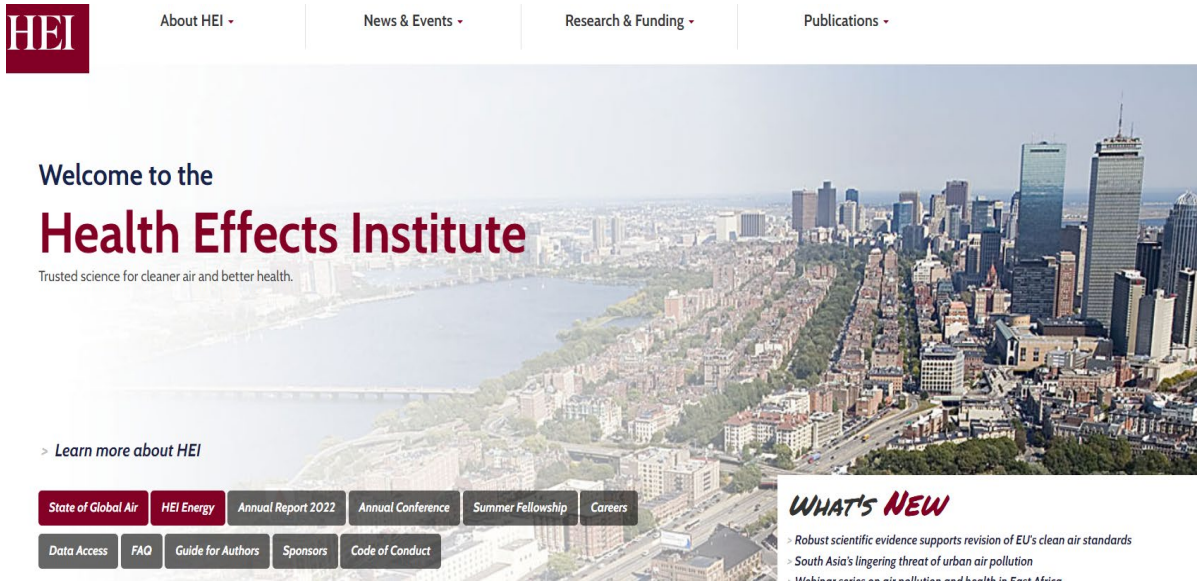
The Health Effects Institute

An independent, nonprofit corporation chartered to provide *policy-relevant, high-quality,* and *impartial science*

Funded jointly by government and the worldwide motor vehicle industry and, occasionally, private foundations

Funds research that is selected, conducted, overseen, and reviewed independently of HEI's sponsors

Does not take policy positions



https://www.healtheffects.org/

HEI 2010 Traffic and Health Review

https://www.healtheffects.org/

A Panel was convened to review the traffic and health literature **up to 2008**.

Detailed chapters on emissons, exposure, toxicology and epidemiology.

At that time, evidence was considered sufficient to support a causal relationship between traffic-related air pollution and exacerbation of **asthma** in children. Suggestive and/or limited evidence for other health outcomes.

New Review of the Traffic and Health Literature

Strong interest in an update of the review:

- ✓ Substantial new research published
- ✓ Regulations and vehicular technology have advanced
- ✓ Interest in non-tailpipe emissions and traffic noise is increasing

HEI appointed a new panel to systematically review epidemiologic studies in 2018.

The full chain of events linking TRAP to health effects. Source: Center for Advancing Research in Transportation Emissions, Energy and Health (CARTEEH), available from: https://www.carteeh.org/.

The HEI Traffic Review has been published in 2022

HEALTH EFFECTS INSTITUTE

SPECIAL REPORT

Systematic Review and Meta-analysis of Selected Health Effects of Long-Term Exposure to Traffic-Related Air Pollution

Number 23
June 2022

HEI Panel on the Health Effects of Long-Term Exposure to Traffic-Related Air Pollution

https://www.healtheffects.org/publication/systematic-review-and-meta-analysis-selected-health-effects-long-term-exposure-traffic

Environment International 164 (2022) 107262

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Short communication

Long-term exposure to traffic-related air pollution and selected health outcomes: A systematic review and meta-analysis

H. Boogaard[a,*], A.P. Patton[a], R.W. Atkinson[b], J.R. Brook[c], H.H. Chang[d], D.L. Crouse[a], J.C. Fussell[e], G. Hoek[f], B. Hoffmann[g], R. Kappeler[h,i], M. Kutlar Joss[h,i], M. Ondras[a], S.K. Sagiv[j], E. Samoli[k], R. Shaikh[a], A. Smargiassi[l], A.A. Szpiro[m], E.D.S. Van Vliet[a], D. Vienneau[h,i], J. Weuve[n], F.W. Lurmann[o], F. Forastiere[e]

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But still working to widely disseminate the HEI Traffic Review findings

- ✓ Journal papers
- ✓ Policy briefs
- ✓ Presentations
- ✓ Media outlets
- ✓ And more…

https://bit.ly/HEI-traffic-review-factsheet

Years of breathing traffic pollution increases death rates, study finds | Air pollution | The Guardian

The 2022 Traffic Review is our most downloaded report to date!

HEI Panel on the Health Effects of Long-term Exposure to Traffic-Related Air Pollution

Co-chairs:
Francesco Forastiere, *Imperial College London*
Frederick Lurmann, *Sonoma Technology*

Members:
Richard Atkinson, *University of London*
Jeffrey Brook, *University of Toronto*
Howard Chang, *Emory University*
Gerard Hoek, *Utrecht University*
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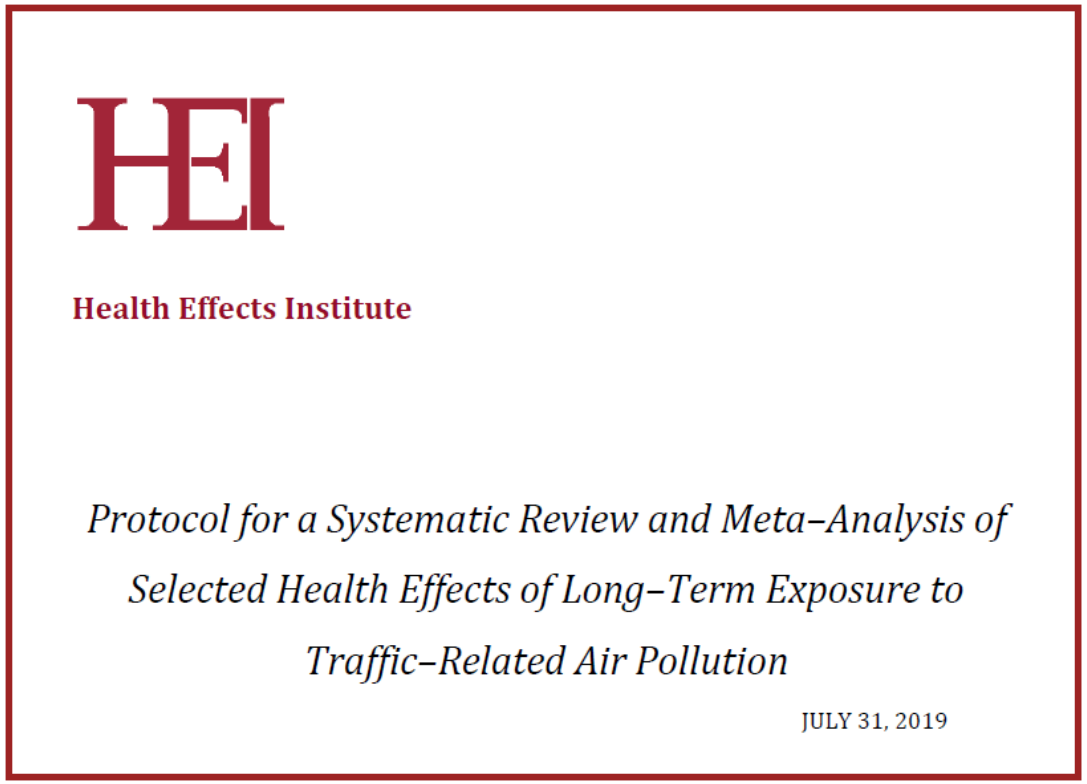
HEI: Hanna Boogaard, Dan Crouse, Dan Greenbaum, Robert O'Keefe, Martha Ondras, Allison Patton, Ellen Mantus, Rashid Shaikh, Eleanne van Vliet, Annemoon van Erp

A Systematic Review

- ✓ Use methods largely based on standards set by Cochrane Collaboration, World Health Organization, and the National Institute of Environmental Health Sciences
- ✓ Summarize epidemiological results quantitatively, where possible
- ✓ Include an evaluation of the risk of bias in individual studies
- ✓ Reach conclusions about the confidence in the quality of the body of evidence and with assessing the level of confidence in the presence of an association.



The review protocol was published in July 2019 on the HEI website* and registered with Prospero**

* https://www.healtheffects.org/announcements/panel-publishes-protocol-review-traffic-related-air-pollution
** https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=150642

Important Methodological Features of the Traffic Review

Conducted largest effort of this type to date.

- Evaluates the epidemiologic literature only.
- Focuses on a selected set of health outcomes chosen *a priori,* including mortality, cardiovascular and respiratory morbidity and birth outcomes.

Applies a new exposure framework.

- Considers only long-term exposure to traffic-related air pollution.
- Considers exposure contrasts in near-roadway and neighborhood environments.

Assesses confidence in the evidence for an association.

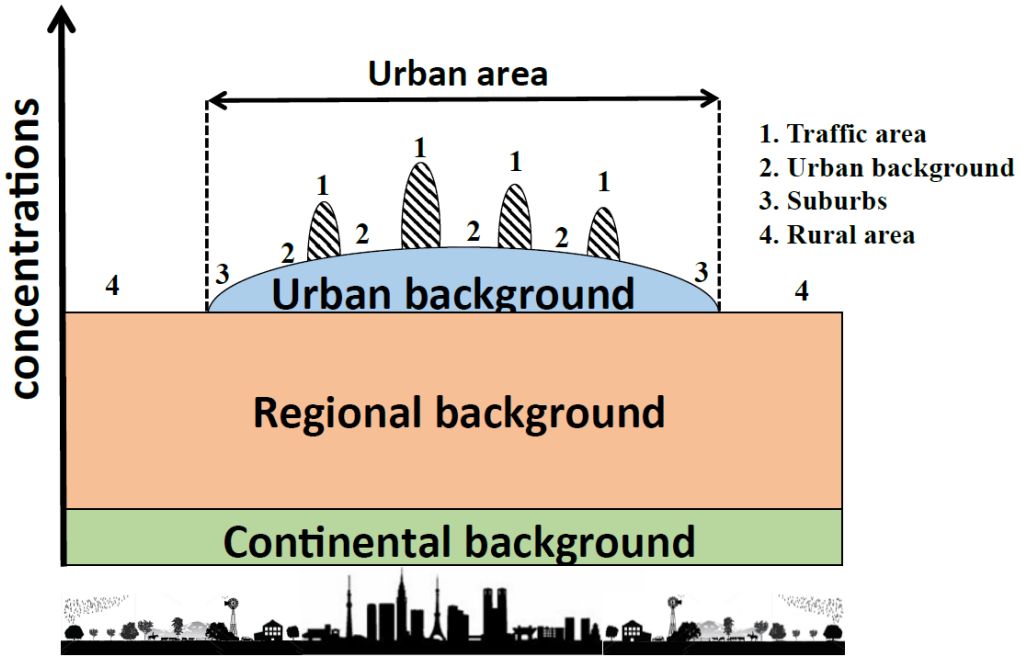
- 2 complementary methods with ratings of very low, low, moderate, or high for traffic-related air pollution mixture, not individual pollutants.

Exposure Framework

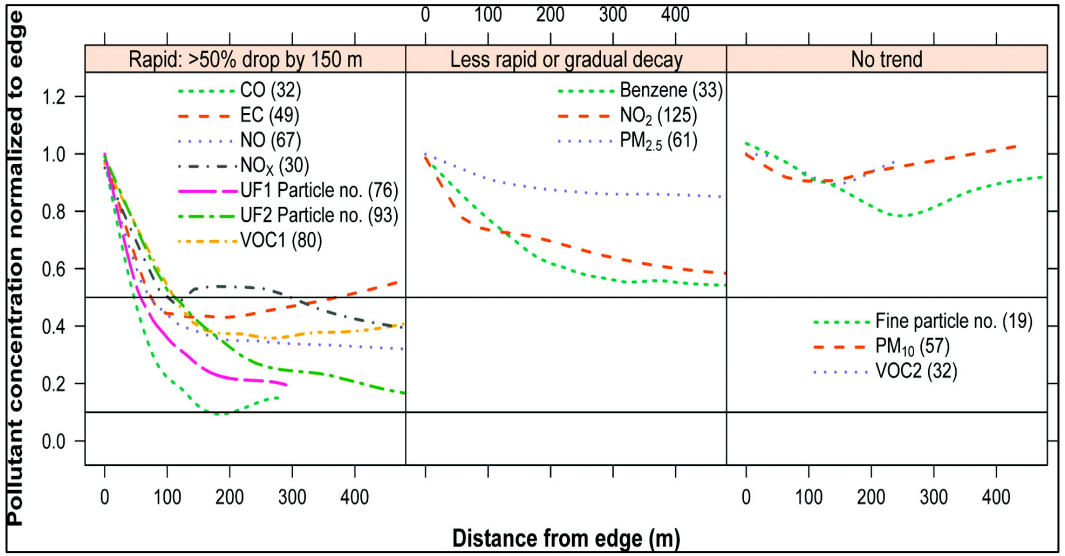
Exposure assessment of TRAP is challenging because it is a complex mixture and is characterized by high spatial and temporal variability.

- ✓ Still no pollutant specific for traffic sources
- ✓ TRAP impacts at different scales

Three strategies were developed to select 'traffic-related' studies, namely the selection of traffic-related pollutants, the exposure assessment method and its spatial resolution.

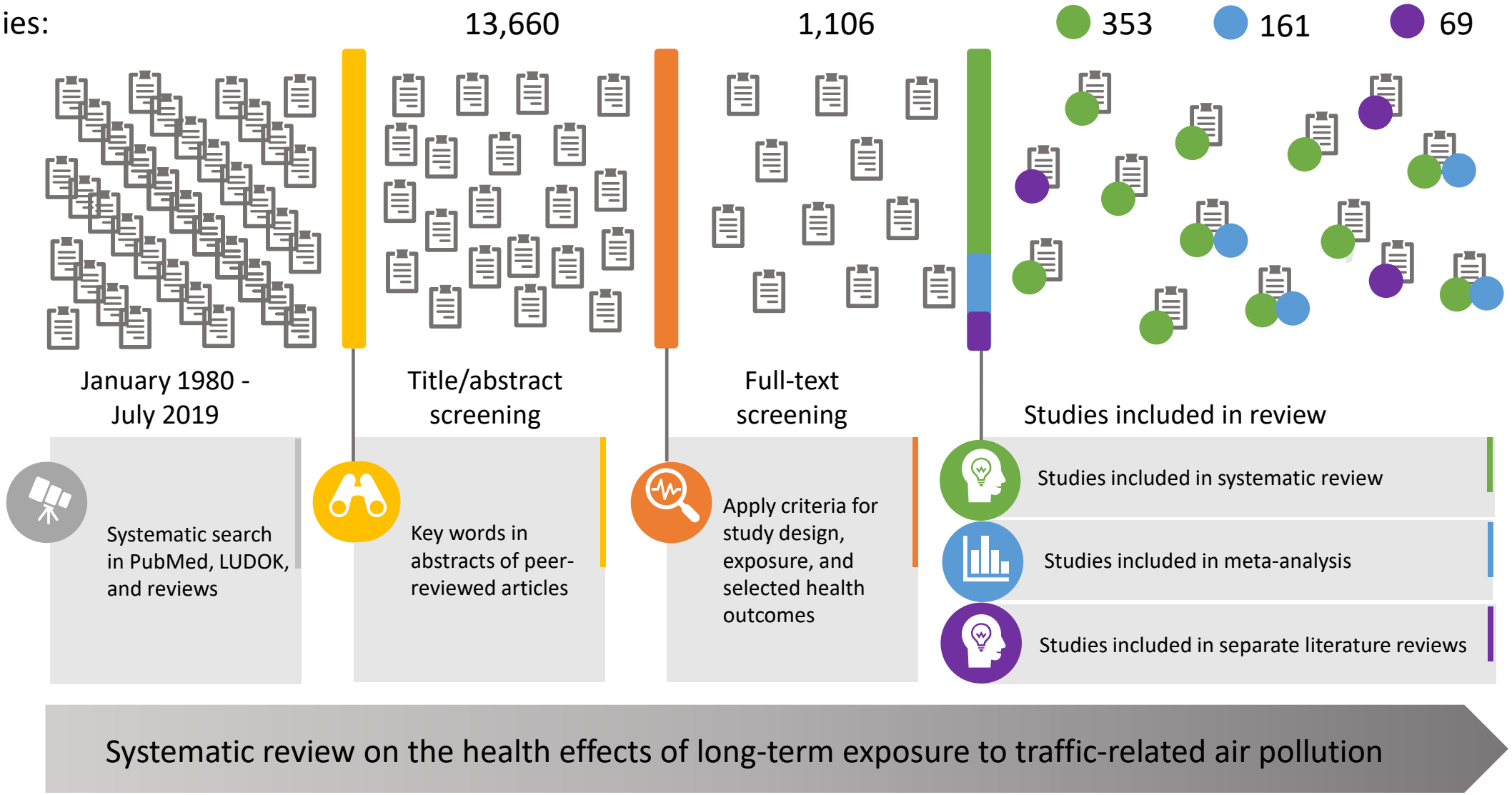


Source: Fuzzi et al. 2015.



Source: Karner et al. 2010.

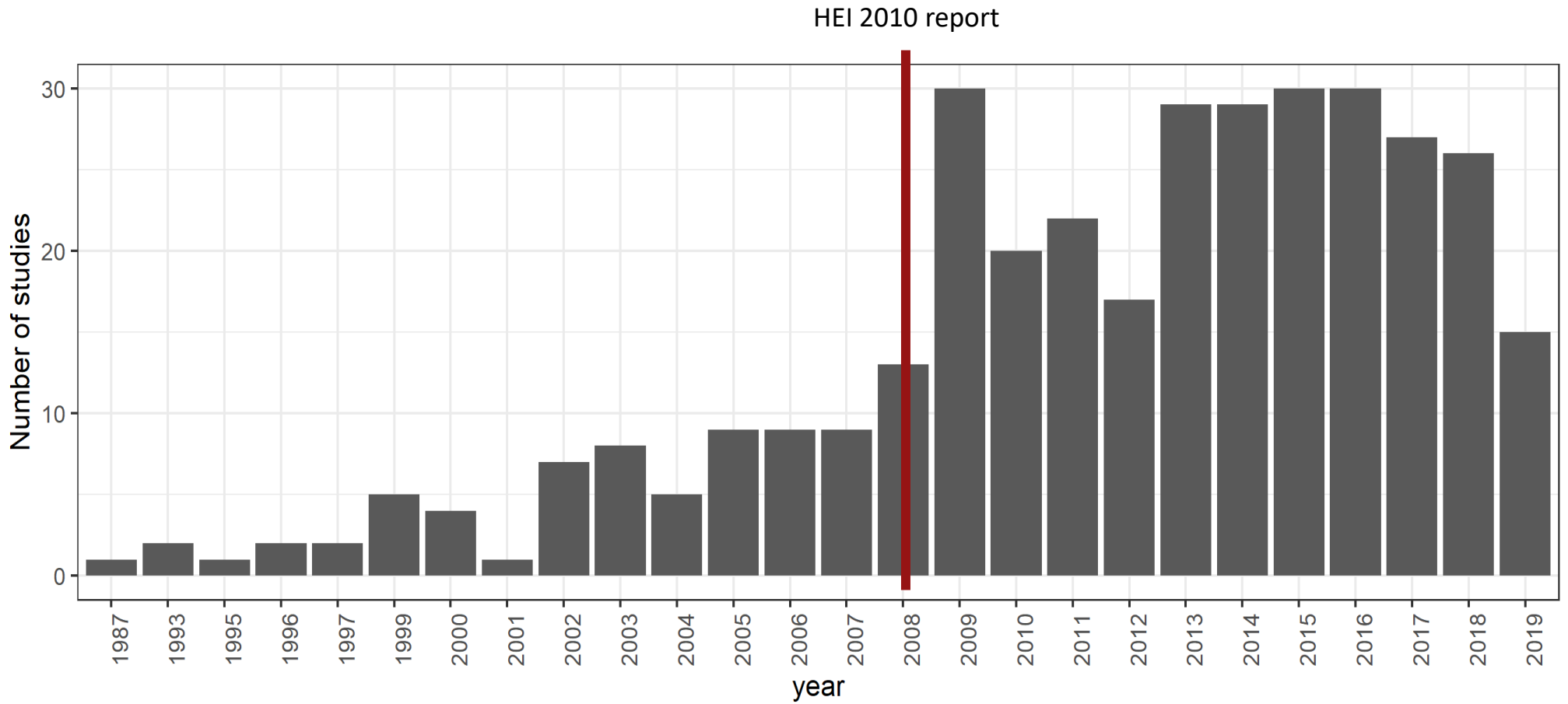
Number of studies identified



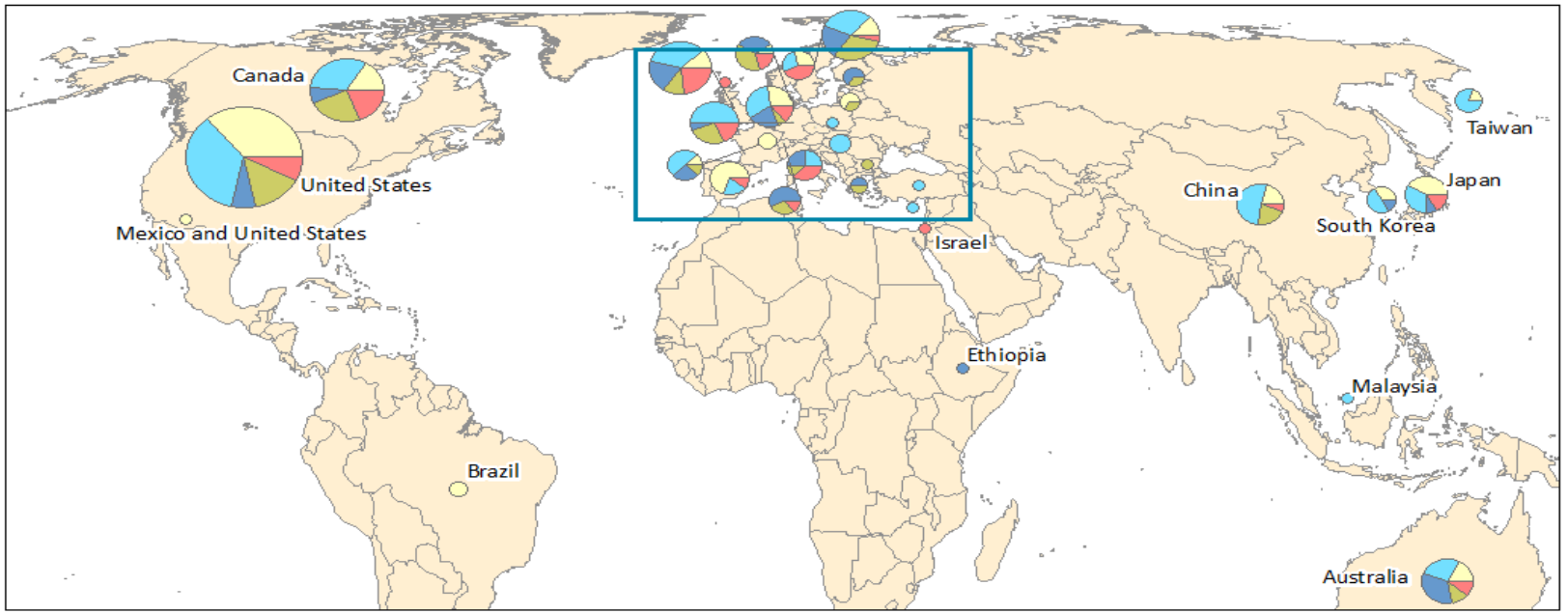
Literature Search Results

353 studies included

Health outcome Category	Total number of studies
Birth outcomes	86
Respiratory outcomes - children	118
Respiratory outcomes - adults	50
Cardiometabolic outcomes	57
Mortality	48



Geographical Location of the Studies



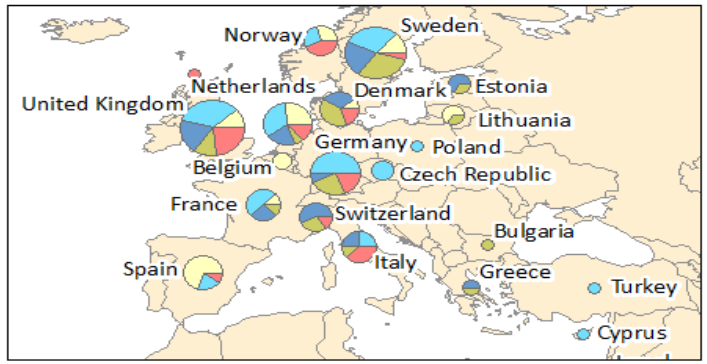
Studies in World Countries

Legend

28 Circle size indicates total studies for country
Range: 1 to 91

Health outcomes studied

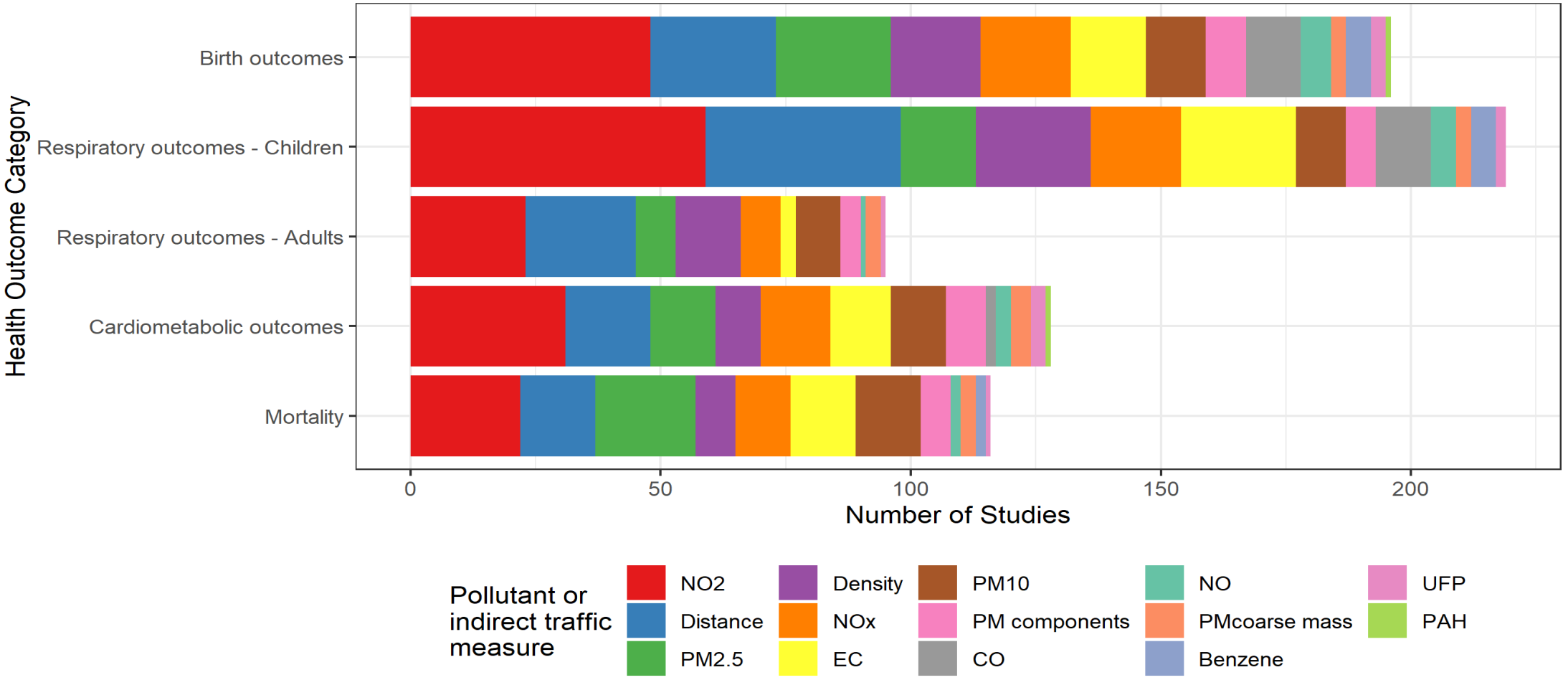
- Birth outcomes
- Respiratory outcomes - children
- Respiratory outcomes - adults
- Cardiometabolic outcomes
- Mortality



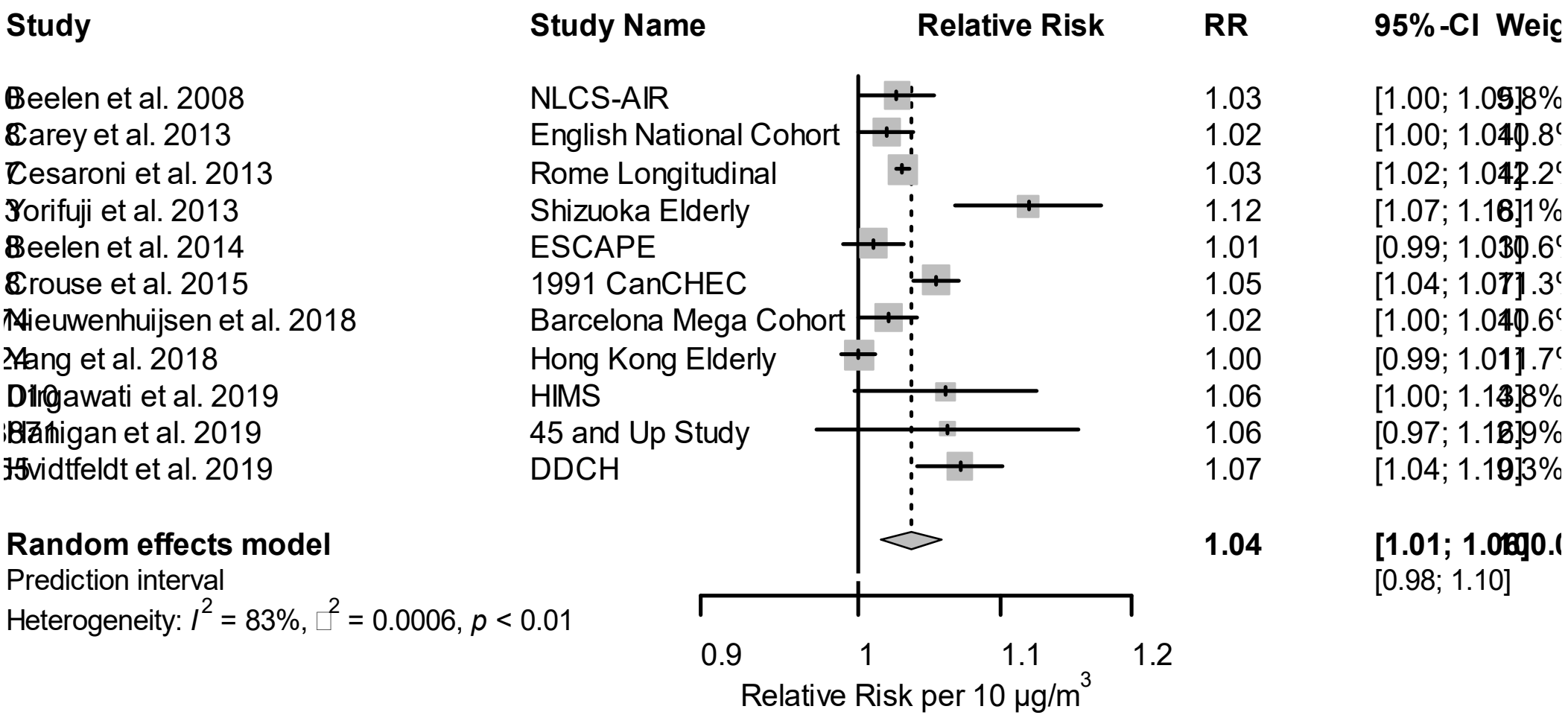
Studies in European countries

Region	Total number of studies
Europe	163
North America	130
Asia	41
Other regions	19

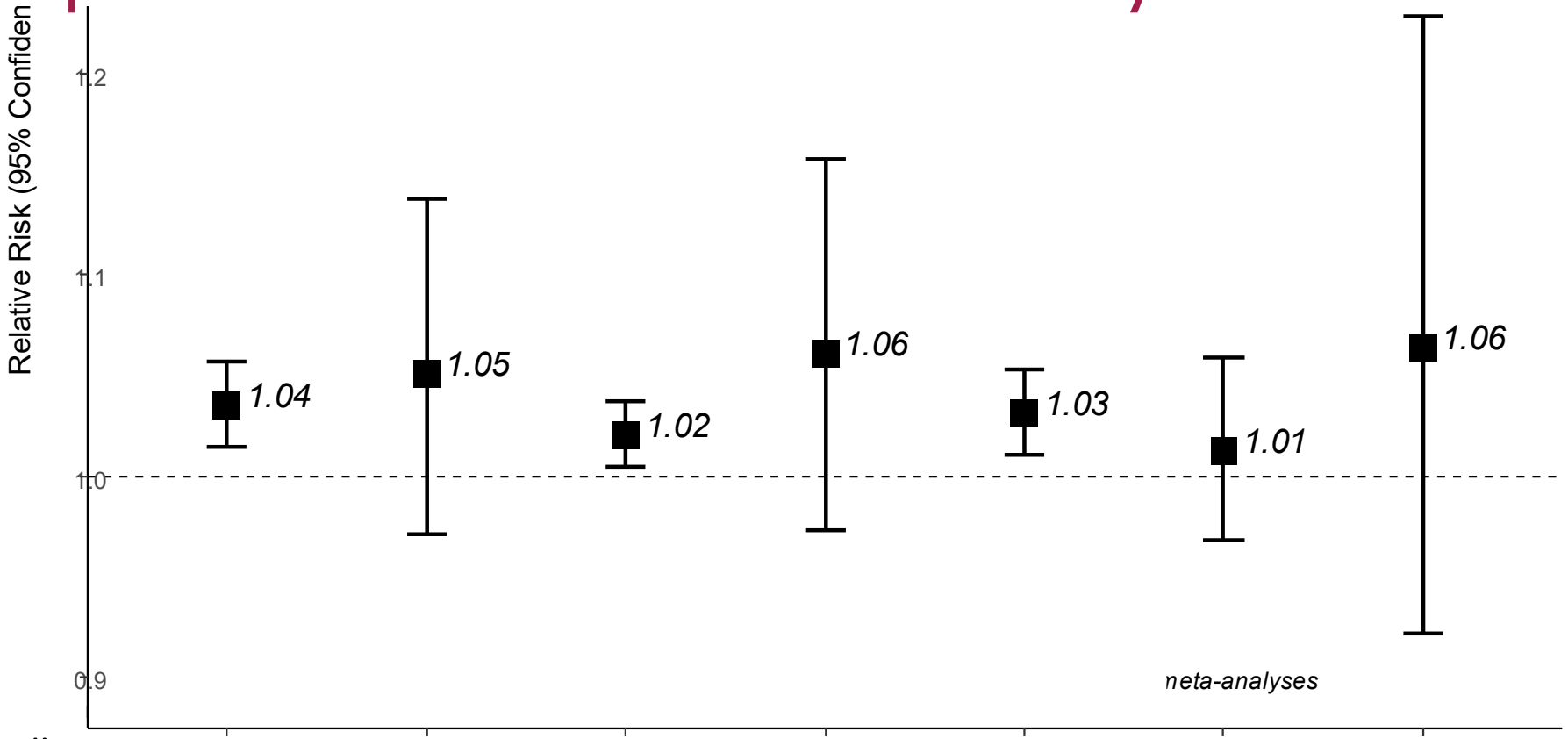
Number of Studies by Outcome and Pollutant



Meta-analysis NO_2 – All cause mortality



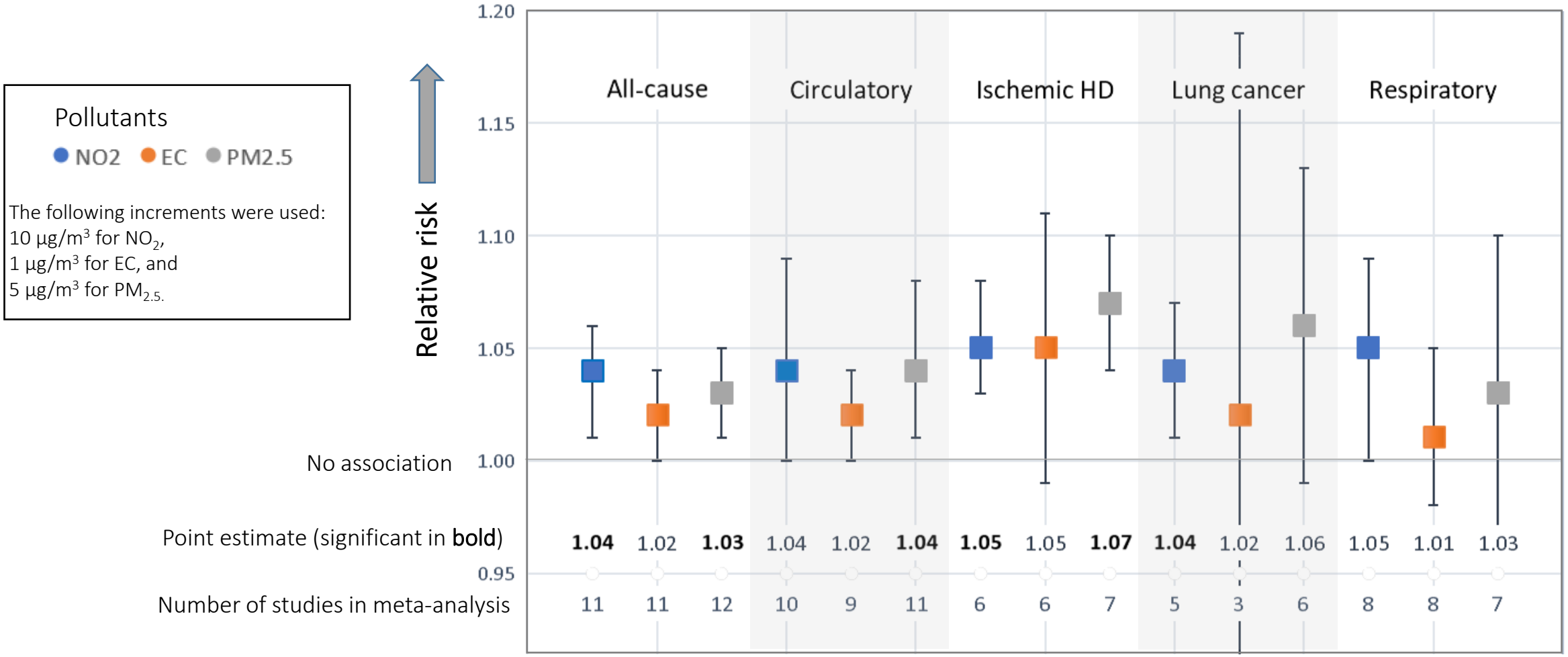
Meta-analysis of associations between traffic-related air pollutants and all-cause mortality



Pollutant:	NO_2	NO_x	EC	PM_{10}	$PM_{2.5}$	Cu□$PM_{2.5}$	Fe□$PM_{2.5}$
No. studies in meta-analysis:	11	5	11	6	12	3	3
Increments:	10 µg/m³	20 µg/m³	1 µg/m³	10 µg/m³	5 µg/m³	5 ng/m³	500 ng/m³

Effect estimates cannot be directly compared across the different traffic-related pollutants because the selected increments do not necessarily represent the same contrast in exposure. The individual pollutants are considered as indicators of the TRAP mixture.

Meta-analysis of associations between traffic-related air pollutants and selected mortality outcomes*



*Outcomes selected where the confidence in the evidence for an association with TRAP was judged high (all-cause, circulatory and ischemic HD; moderate to high (lung cancer), or moderate (respiratory).

Meta-analysis of associations between traffic-related air pollutants and selected morbidity outcomes

Pollutants

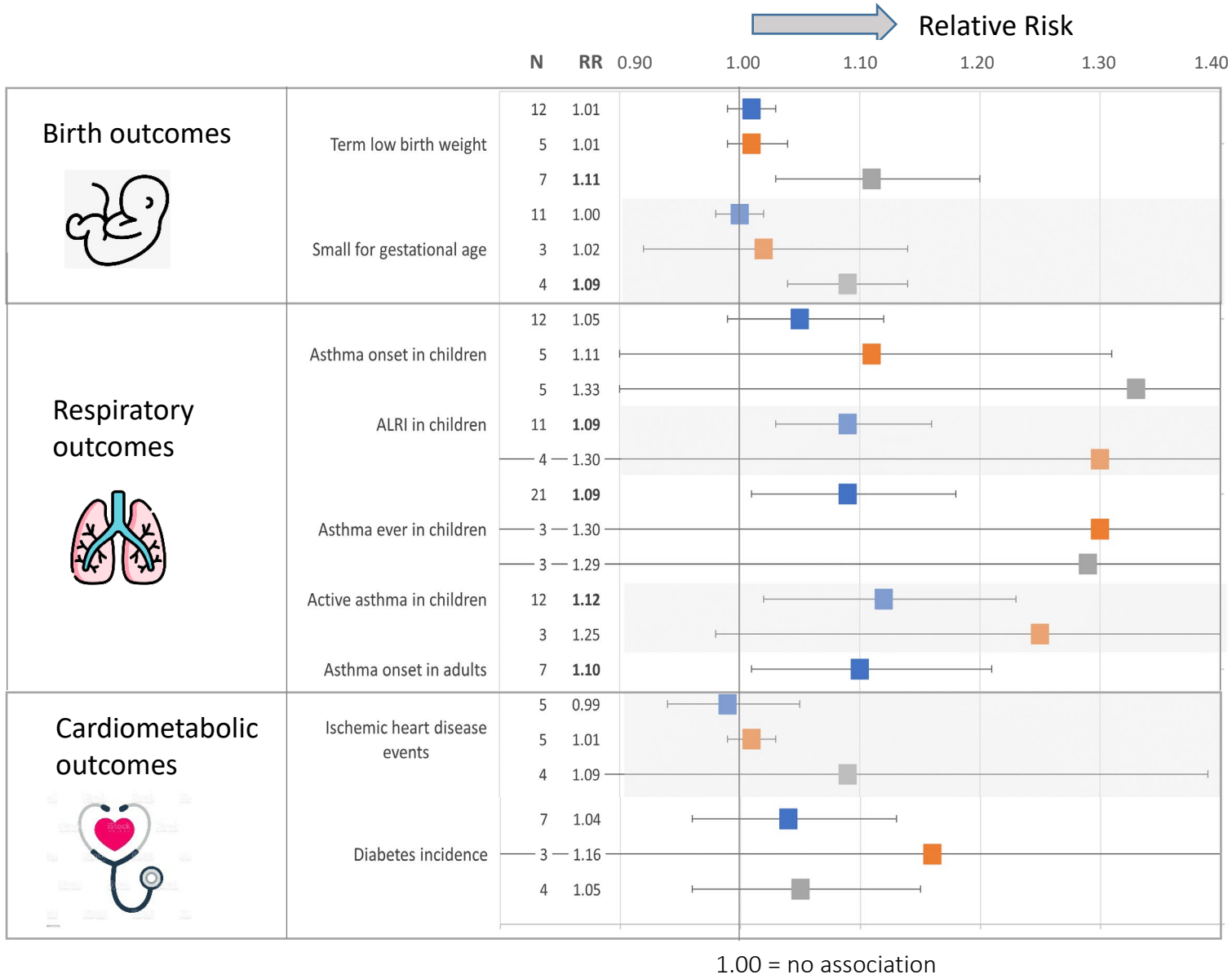
● NO2 ● EC ● PM2.5

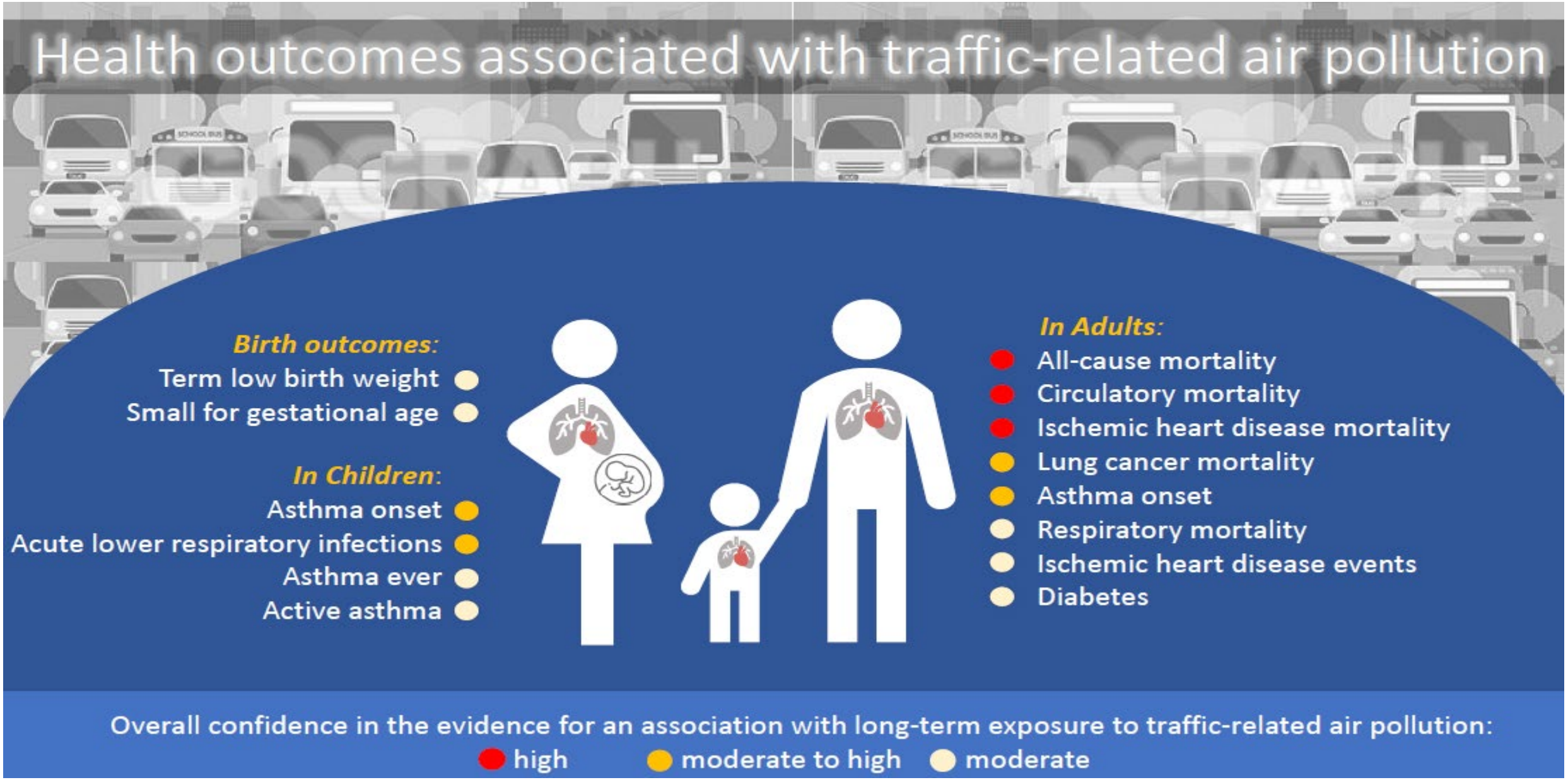
The following increments were used:
10 µg/m^3 for NO_2
1 µg/m^3 for EC
5 µg/m^3 for $PM_{2.5}$

RR = point estimate (significant in **bold**)

N = number of studies in meta-analysis

*Outcomes selected where the confidence in the evidence for an association with TRAP was judged moderate to high (asthma onset, acute lower respiratory infections), or moderate (remainder)





Footnote: health outcomes for which the overall confidence in the evidence was low-to-moderate, low or very low are not in the picture.

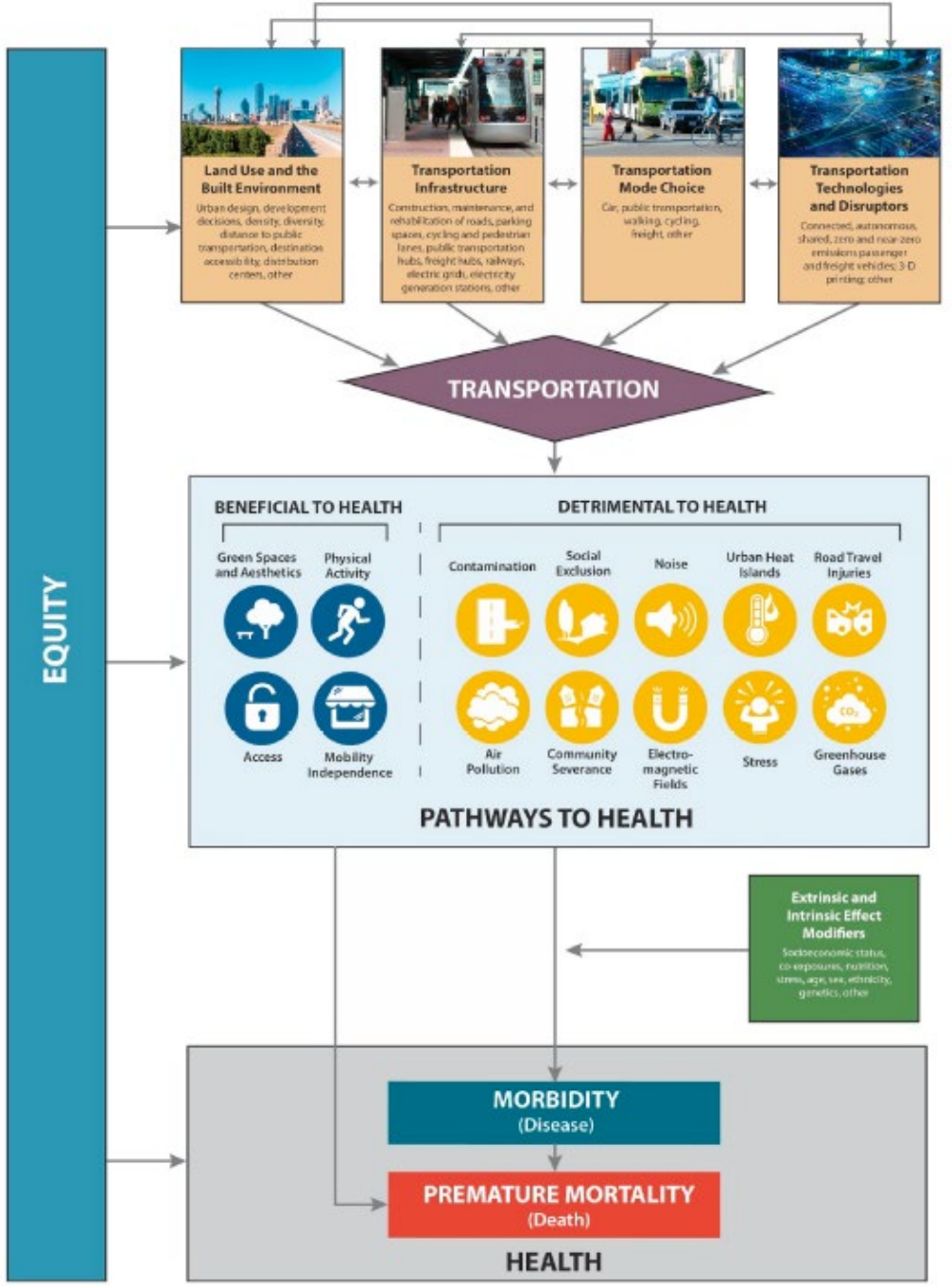
Some Key Observations

- ✓ This review has 3 times more studies than the 2010 report, though a direct comparison is difficult because of the difference in scope.
- ✓ Only half of the total number of identified studies entered a meta-analysis.
- ✓ The most common reason for a lower confidence judgement was "*imprecision*", most often for cardiometabolic outcomes.
- ✓ Most of the studies were rated as low to moderate "risk of bias" for all but the "confounder" domain, for which about one third of the meta-analyzed studies were rated as high "risk of bias".
- ✓ Several future research opportunities emerged from this report.

Several Future Research Opportunities

- ✓ Conduct additional epidemiological studies on an array of traffic pollutants, including UFP and non-tailpipe PM indicators.
- ✓ Conduct more health studies in areas outside North America and Europe.
- ✓ Evaluate the role of spatially correlated factors that might either confound or modify the health effects of TRAP, most notably socioeconomic status, traffic noise, and greenspace
- ✓ Evaluate the fuller range of potential impacts of transportation and (new) mobility on public health.
- ✓ Improve methods in systematic reviews and evidence synthesis of observational studies in environmental health

And many more…



Glazener et al. 2021. Fourteen pathways between urban transportation and health: A conceptual model and literature review. Journal of Transport & Health

Overall Conclusions

The findings have provided an overall high or moderate-to-high level of confidence in an association between long-term exposure to traffic-related air pollution and the adverse health outcomes

all-cause, circulatory and ischemic heart disease mortality, lung cancer mortality, asthma onset in children and adults, and acute lower respiratory infections in children.

The Panel's confidence in the evidence was considered moderate, low or very low for the other selected outcomes.

In light of the large number of people exposed, the findings indicate that traffic-related air pollution remain an important public health concern and deserve greater attention from the public and from policymakers.

THANK YOU!

Hanna Boogaard
jboogaard@healtheffects.org

Additional slides

Confidence Assessments

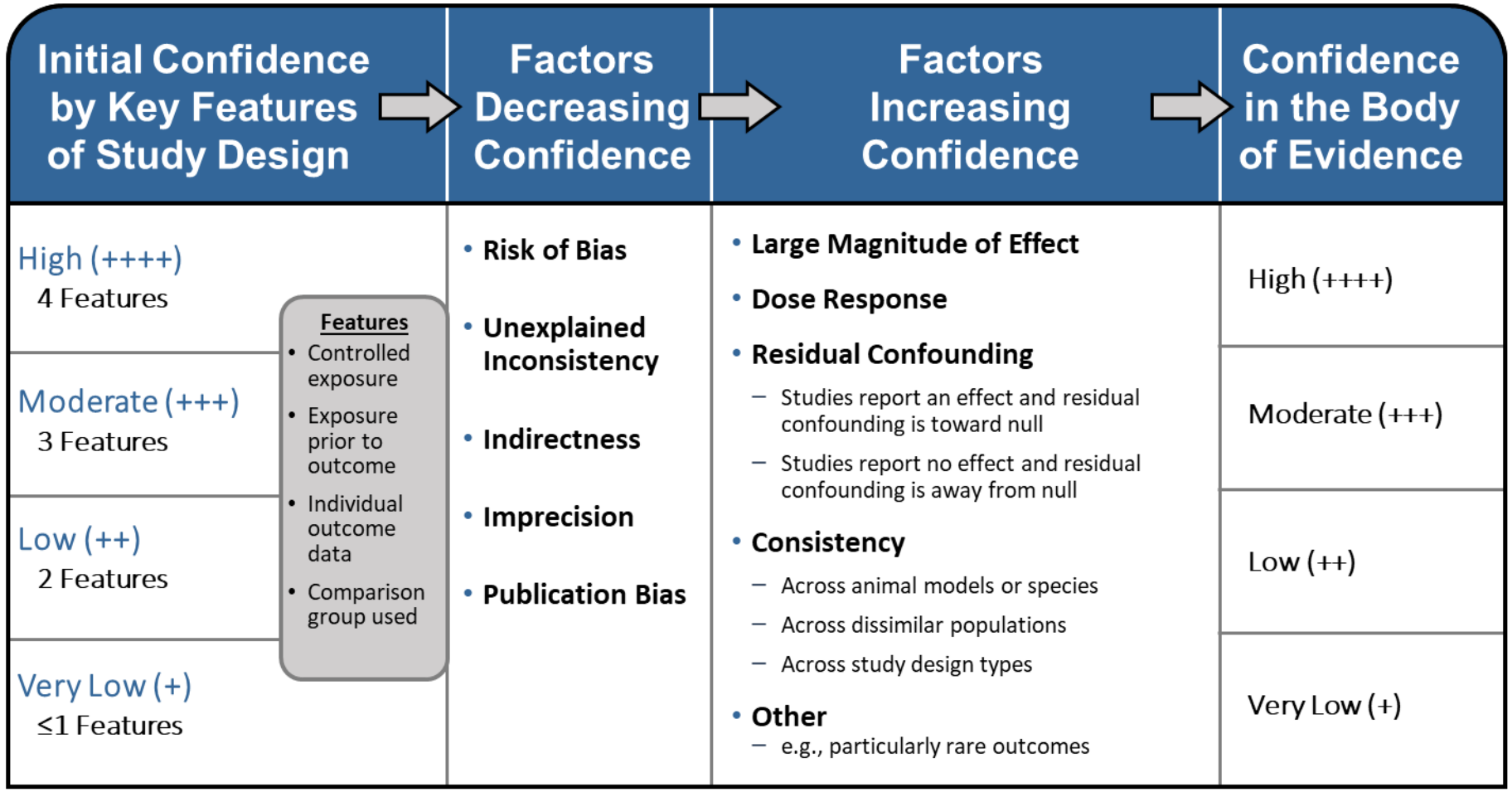
Separate assessments for confidence
in the quality of the body of evidence (modified OHAT) and
in the presence of an association (narrative)
(high, moderate, low, and very low)

For each exposure-outcome pair by study design → For each exposure-outcome pair → For each health outcome

↓

Overall confidence

Methods for Confidence in the Quality of the Body of Evidence (Modified OHAT* – or GRADE**-type approach)



- ✓ Initial rating based on study design features
- ✓ Upgrade or downgrade based on certain factors
- ✓ The Panel did not apply the methods in a "mechanistic" way

*Office of Health Assessment and Translation (OHAT), 2019. Handbook. National Toxicology Program, National Institute of Environmental Health Sciences, U.S. Dept of Health and Human Services.

**Grading of Recommendations Assessment, Development and Evaluation (GRADE). 2013. Handbook.

IMPACT OF TRANSPORTATION POLICIES & INTERVENTIONS ON AIR POLLUTION EXPOSURE DISPARITIES & ENVIRONMENTAL JUSTICE

DR. REGAN F. PATTERSON, UCLA

RACIAL-ETHNIC DISPARITIES IN TRAFFIC-RELATED AIR POLLUTION

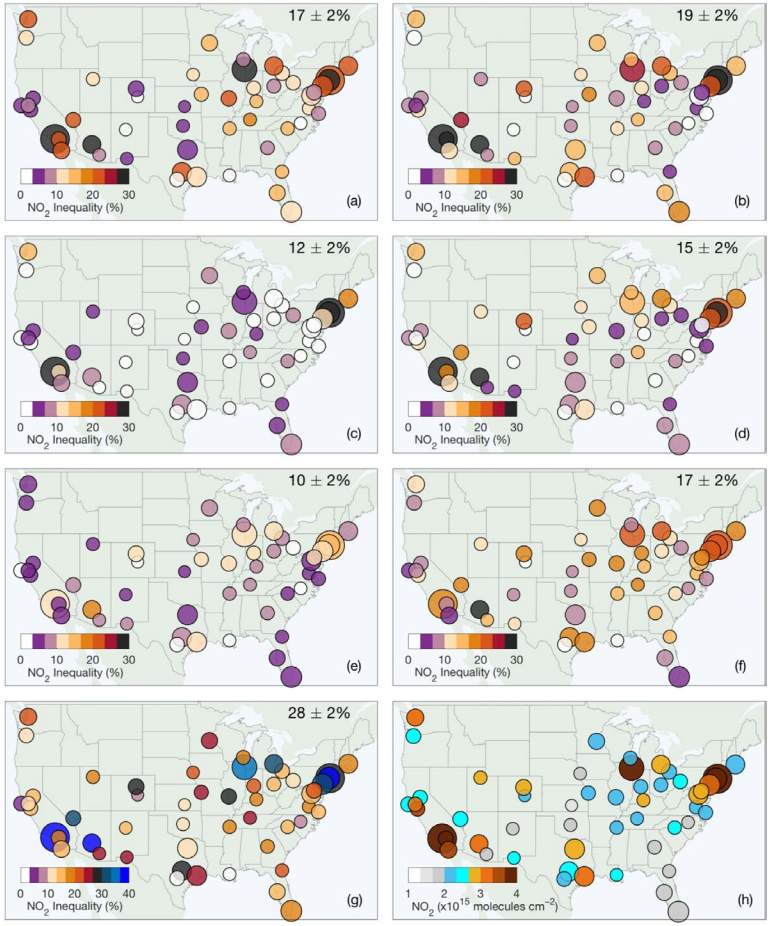
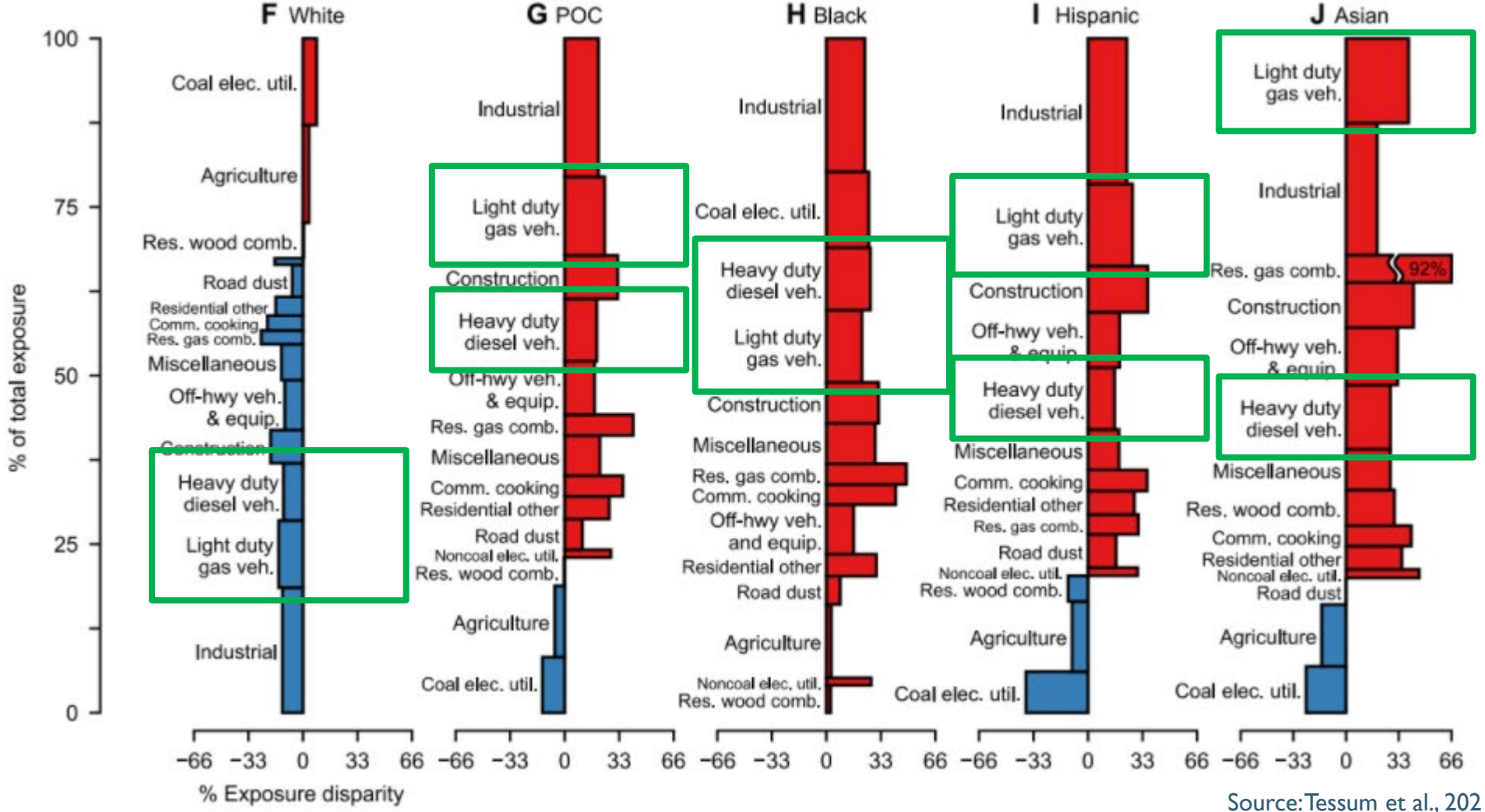


Figure 1. Relative NO_2 inequalities (percentage difference between population-weighted NO_2 means) for 52 major US cities over all days in June 2018–February 2020. Marker size reflects the total city population with the smallest markers representing cities with <1.5 million residents and the largest markers for cities with >10 million residents. Average NO_2 inequalities are shown for Black and African American (a), Hispanic/Latino (b), Asian (c), and Native American (d) compared to white residents. Inequalities are also mapped for people living near (e) and below (f) versus above the poverty line and for LINs compared to HIWs (g). Displayed mean values for each group are weighted by urban population size. City-averaged NO_2 tropospheric vertical column densities are shown (h).

Source: Demetillo et al., 2021

RACIAL-ETHNIC DISPARITIES IN TRAFFIC-RELATED AIR POLLUTION



Source: Tessum et al., 2021

INFRASTRUCTURE INEQUITY

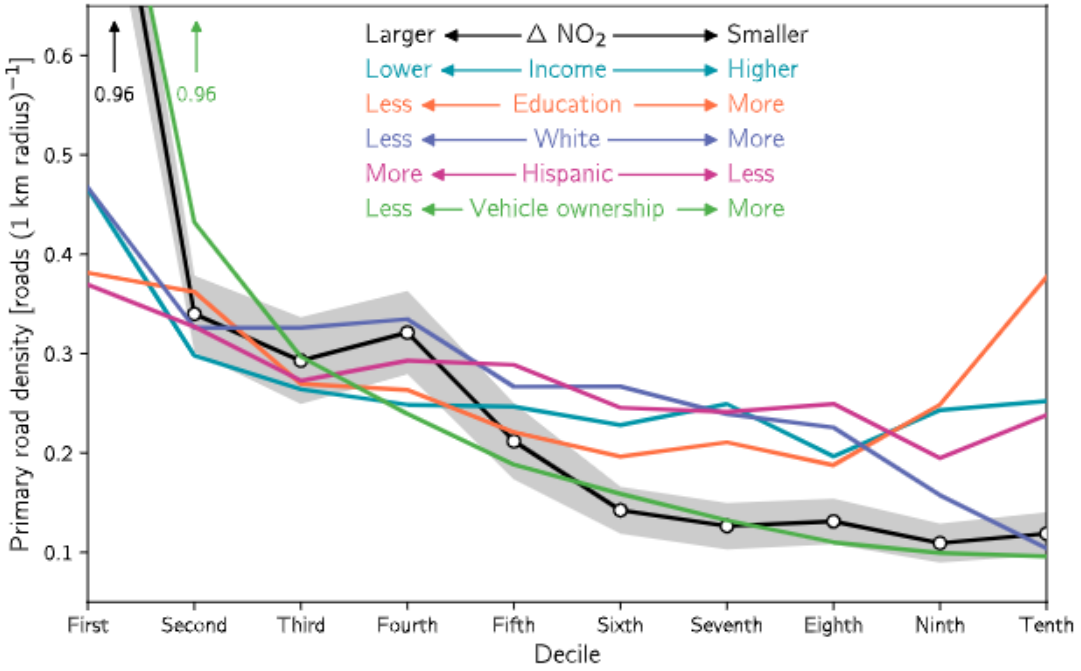


Fig. 3. The relationship of road density with urban lockdown-related drops in NO_2 columns and demographic variables. Road density is calculated as the number of primary road segments within a 1-km radius of tracts' centroids for each decile of demographic variables. The colored legend indicates the directionality of each demographic variable. As an example, the density corresponding to the lowest decile of the "White" curve represents the road density in urban tracts that are the least White (i.e., in the first decile of the percentage of their population that is White). Shading for the ΔNO_2 curve illustrate the 90% CI.

Source: Kerr et al., 2021

INFRASTRUCTURE INEQUITY

Chrysler Freeway construction in Detroit, MI

INFRASTRUCTURE INEQUITY

Hastings Street, a main street running through Paradise Valley and Black Bottom, predominantly Black neighborhoods in Detroit, MI

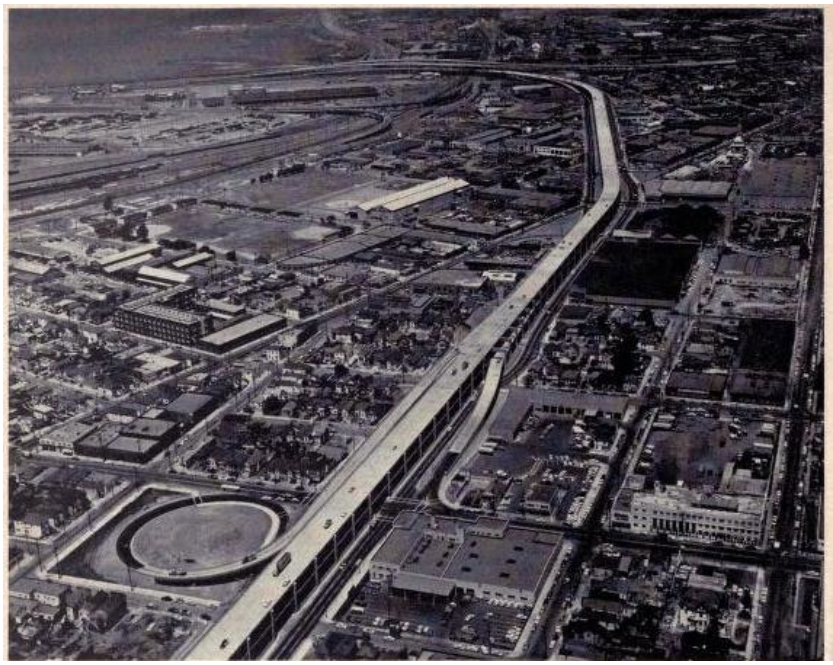
Chrysler Freeway, as viewed from the same location

INFRASTRUCTURE INEQUITY

WEST OAKLAND, CALIFORNIA

Demolition of West Oakland neighborhood

Future site of Cypress Freeway

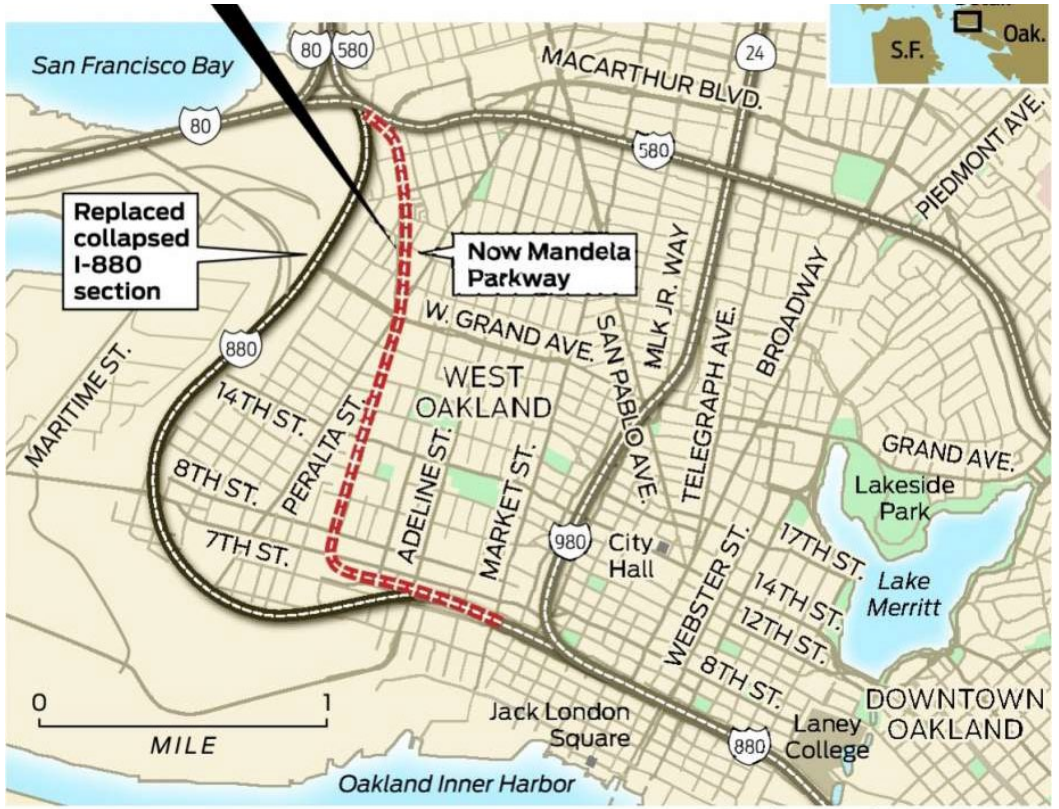


Cypress Freeway

Source: shadowballexpress.wordpress.com

CYPRESS FREEWAY ⟶ MANDELA PARKWAY

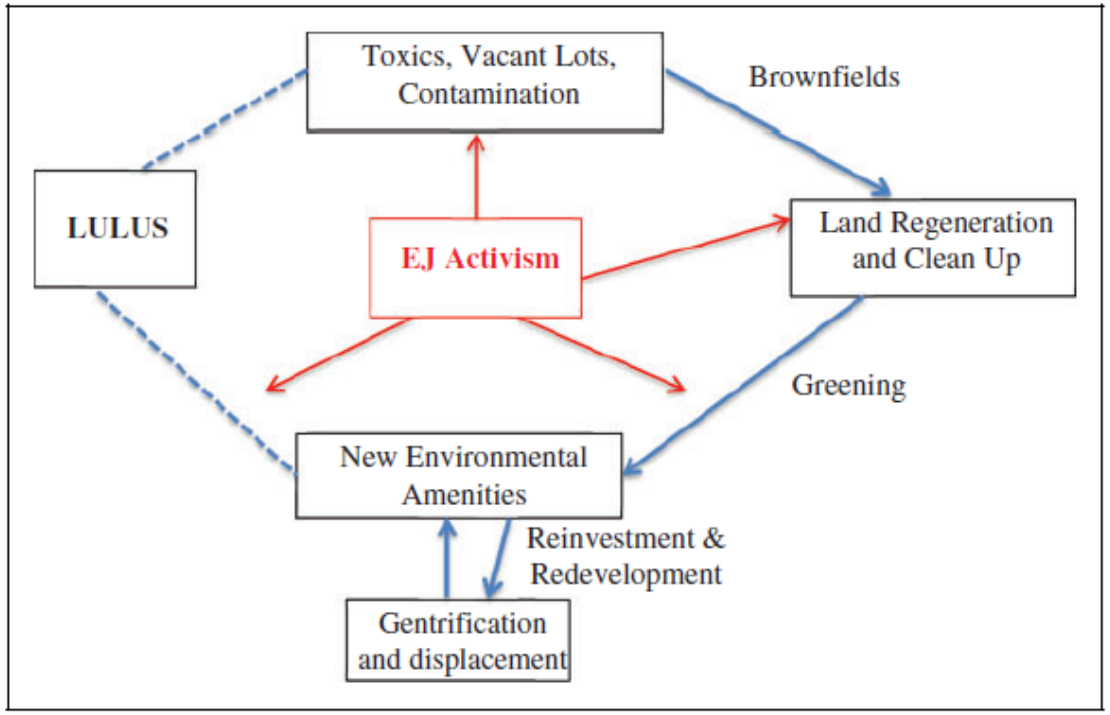
- National Environmental Policy Act of 1969 (NEPA) mandated public involvement
  - Citizens Emergency Relief Team (CERT)
  - 2 years of dialogue led to rerouting
- *Clean Air Alternative Coalition v. US Department of Transportation* broadened scope of mitigation measures, including transformation of former freeway into landscaped boulevard



Source: sfchronicle.com

ENVIRONMENTAL GENTRIFICATION

- Green Space Paradox (Wolch et al. 2014)
- "**environmental gentrification** builds on the material and discursive successes of the urban environmental justice movement and appropriates them to serve high-end redevelopment that displaces low-income residents" (Checker 2011)



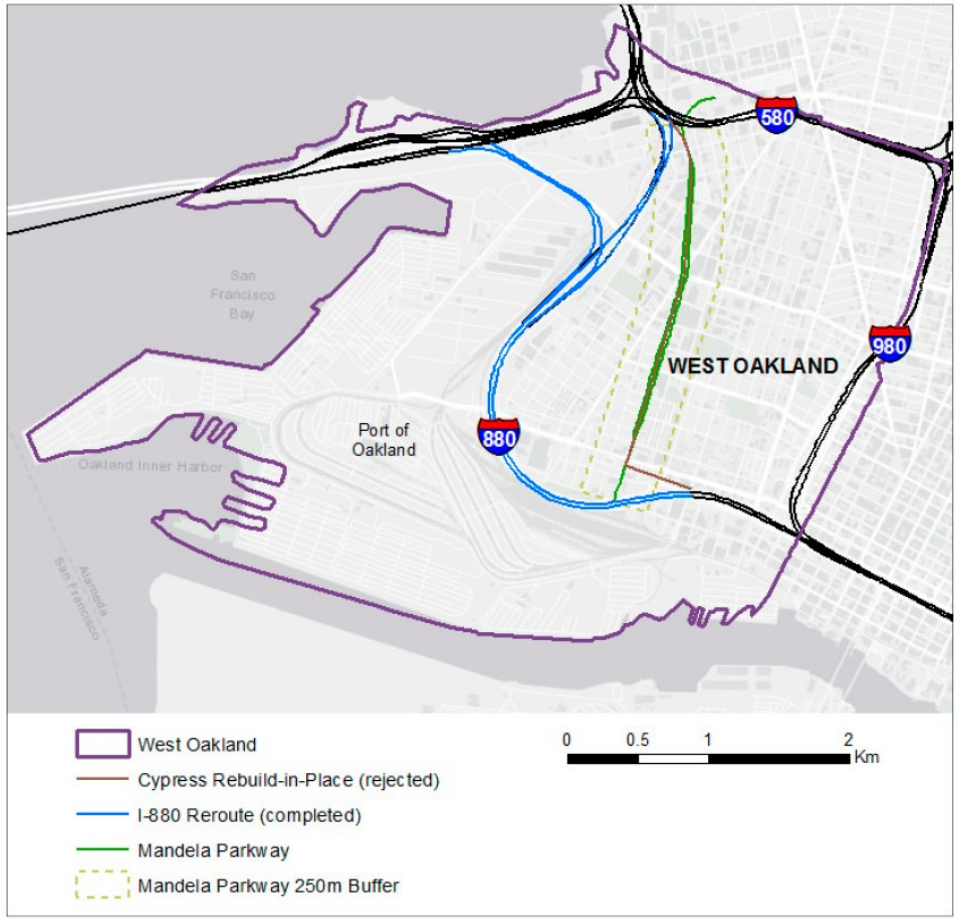
Source: Anguelovski 2016

SPECIFIC OBJECTIVES

1) Quantify the local effects of rerouting the Cypress Freeway on air pollution by comparing two routing scenarios

2) Examine neighborhood socioeconomic and demographic impacts, as reflected by spatiotemporal changes in indicators of gentrification

METHODS: POLLUTION EXPOSURE

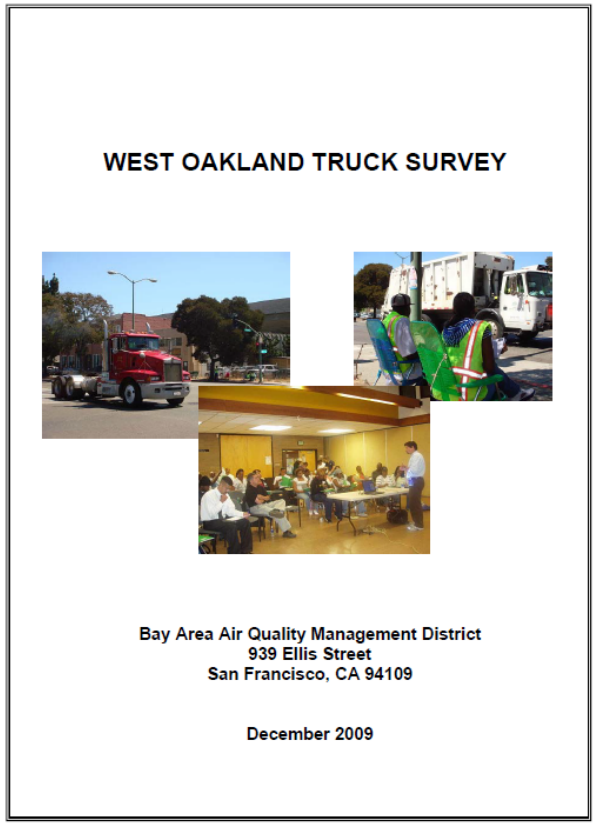


- Two routing scenarios:
  1) Cypress Rebuild-in-Place
  2) I-880 reroute + Mandela Parkway

- Estimated near-roadway concentrations of NOx and BC along the Cypress Rebuild-in-Place and Mandela Parkway

METHODS: POLLUTION EXPOSURE

1. Estimated traffic counts
   a. Mandela Parkway: West Oakland Truck Survey
   b. Cypress Rebuild-in-Place: West Oakland Truck Survey + Caltrans
2. Estimated pollutant emissions
3. Modeled near-roadway concentrations using the RLINE line-source dispersion model

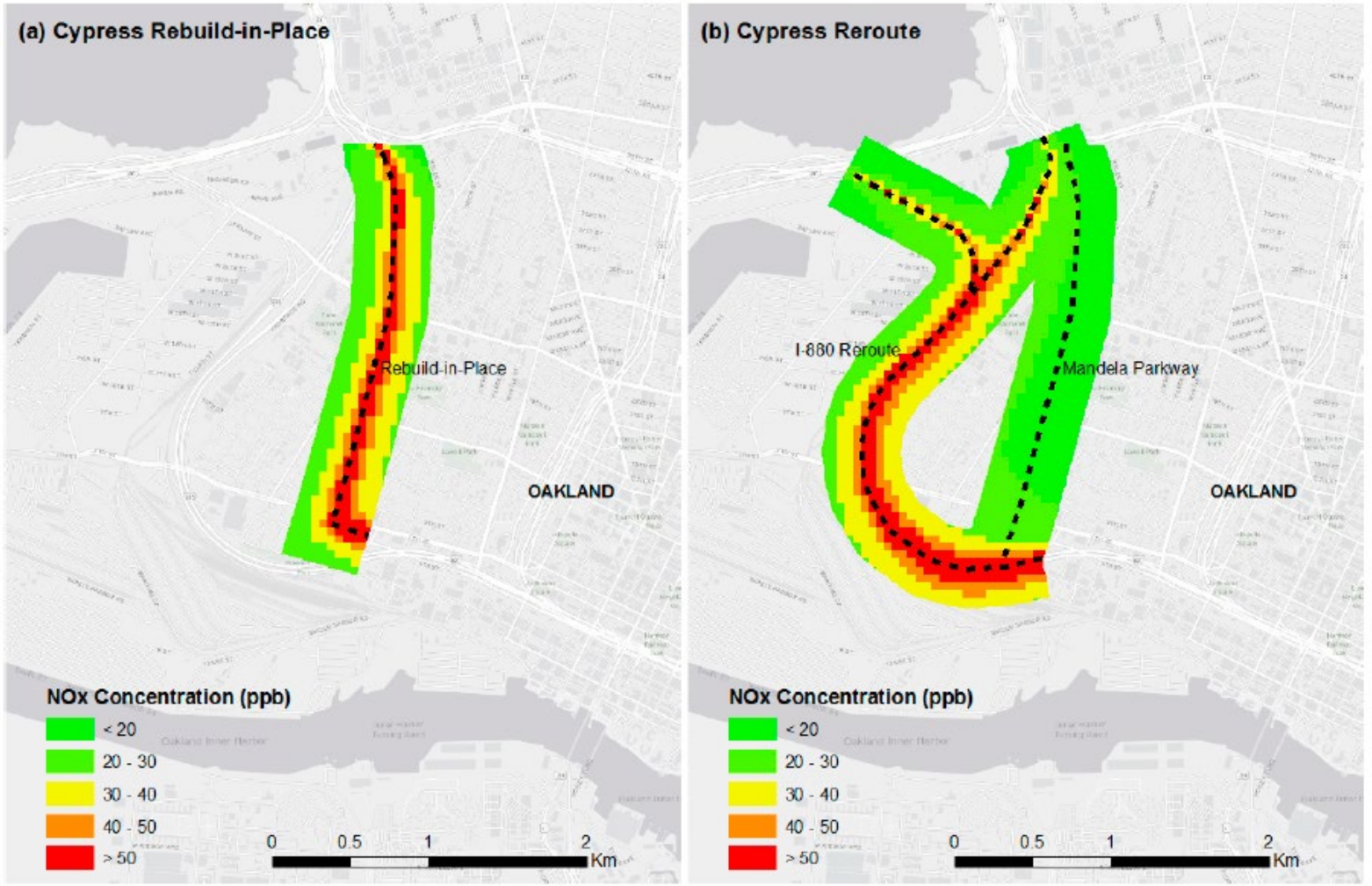


METHODS: NEIGHBORHOOD CHANGE

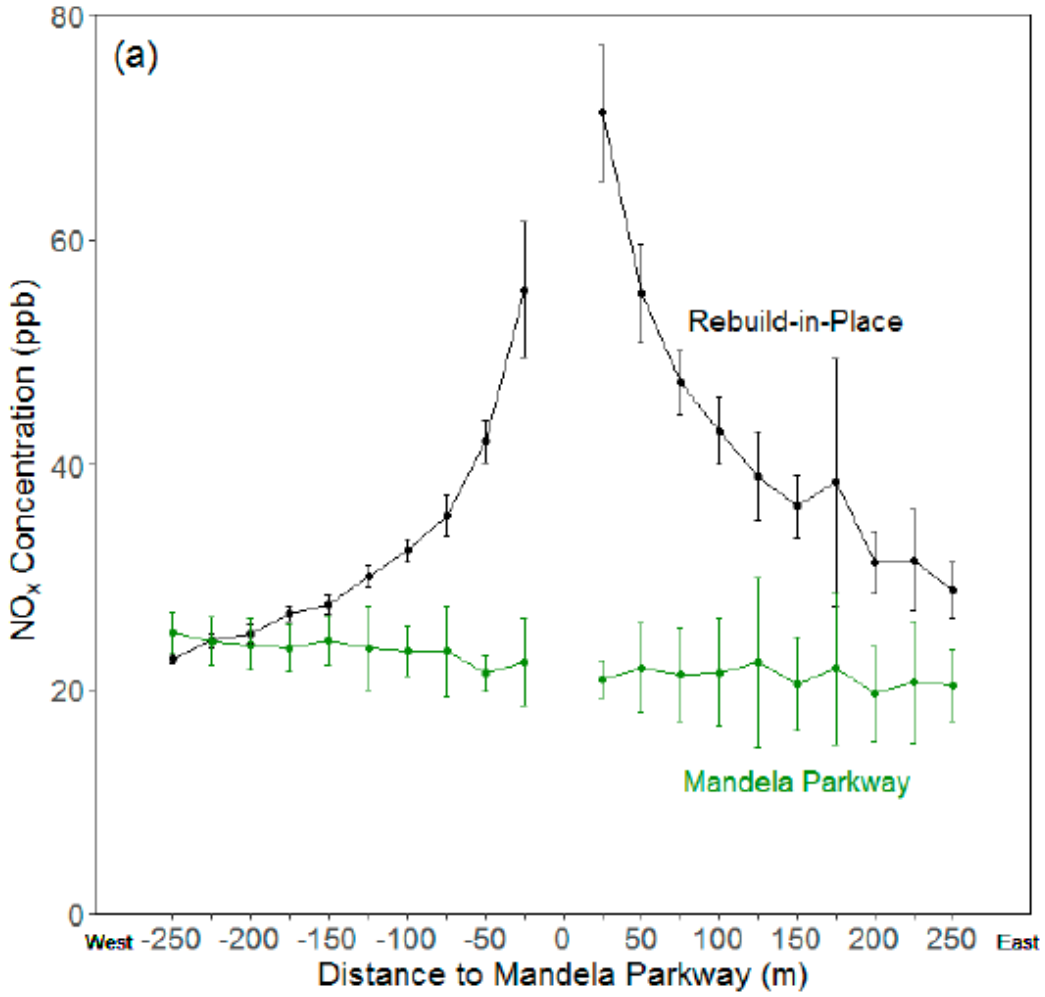
Compared 1990 and 2010 Census variables for all of West Oakland and within 250m band

Demographic	Socioeconomic	Housing
% Nonwhite	Median Household Income	Median Rent
% Non-Hispanic Black	% College	Median Home Value
% Hispanic	% Poverty	% Renter-Occupied

SPATIAL DISTRIBUTION OF POLLUTANT CONCENTRATIONS



REDUCTIONS IN POLLUTANT CONCENTRATIONS



ENVIRONMENTAL GENTRIFICATION

	West Oakland	250m of Mandela
Change in % Nonwhite	-11.4	-9.4
Change in % Non-Hispanic Black	-23.2	-28.3
Change in % Hispanic	2.5	9.6
Increase in Median Household Income[a] (%)	34.6	54.5
Change in % Poverty[b]	-13.9	-19.5
Change in % Renter Occupied	-7.3	-4.1
Increase in Median Gross Rent[a] (%)	29.7	19.3
Increase in Median Home Value[a] (%)	136	184
Change in % College Educated[c]	16.8	12.6

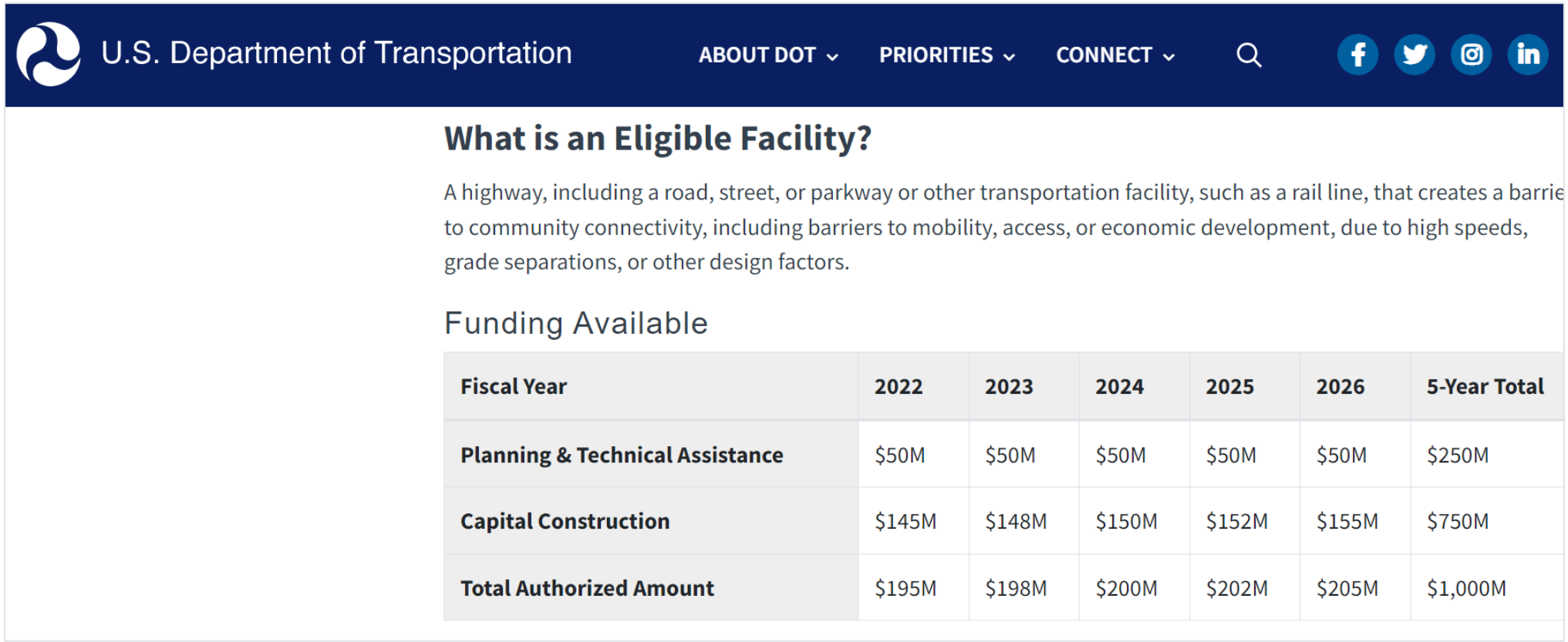
[a] In 2010 inflation-adjusted dollars
[b] Percentage with income less than twice the poverty level
[c] Includes college and advanced degrees

CONCLUSIONS

- Large reductions in NOx and BC concentrations due to rerouting the Cypress Freeway and replacing the route with a landscaped boulevard

- Freeway rerouting and construction of a landscaped boulevard *can be* a mechanism of environmental gentrification

RECONNECTING COMMUNITIES



What is an Eligible Facility?

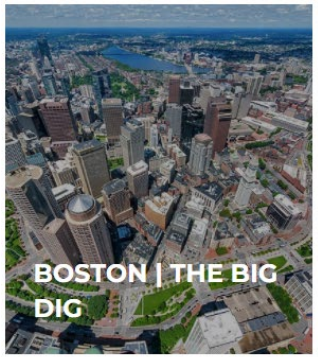
A highway, including a road, street, or parkway or other transportation facility, such as a rail line, that creates a barrie to community connectivity, including barriers to mobility, access, or economic development, due to high speeds, grade separations, or other design factors.

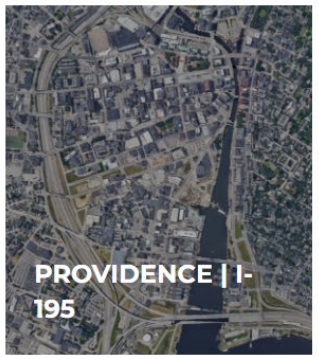
Funding Available

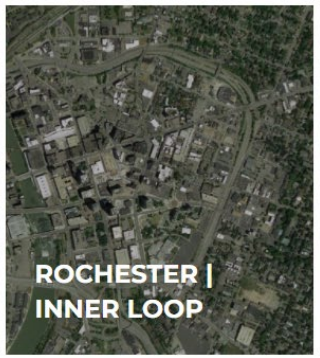
Fiscal Year	2022	2023	2024	2025	2026	5-Year Total
Planning & Technical Assistance	$50M	$50M	$50M	$50M	$50M	$250M
Capital Construction	$145M	$148M	$150M	$152M	$155M	$750M
Total Authorized Amount	$195M	$198M	$200M	$202M	$205M	$1,000M

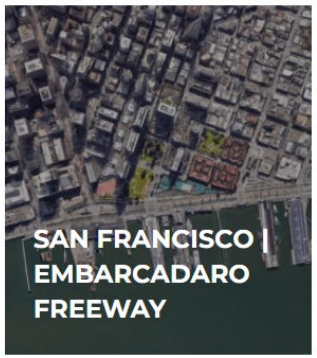
Source: www.transportation.gov/grants/reconnecting-communities

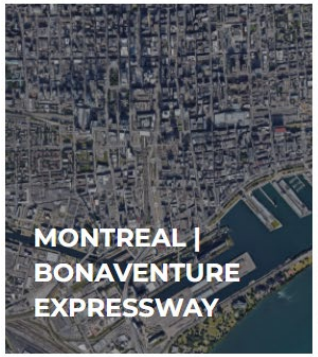
COMPLETED PROJECTS

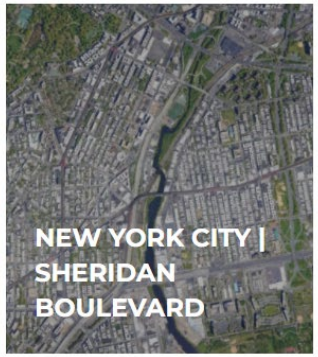


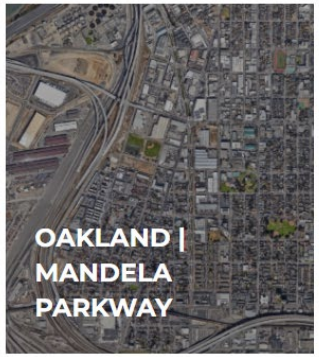


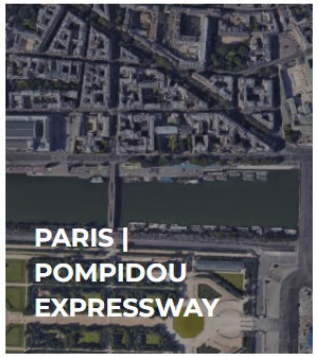


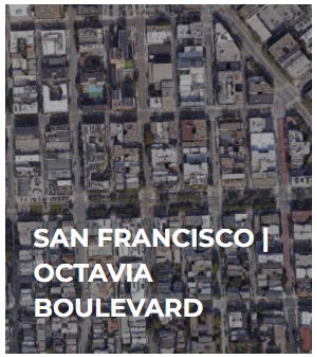


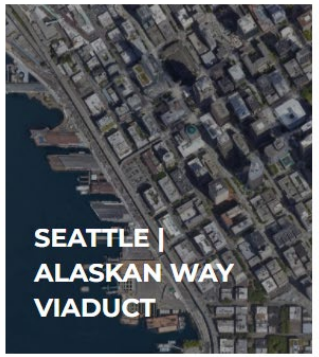




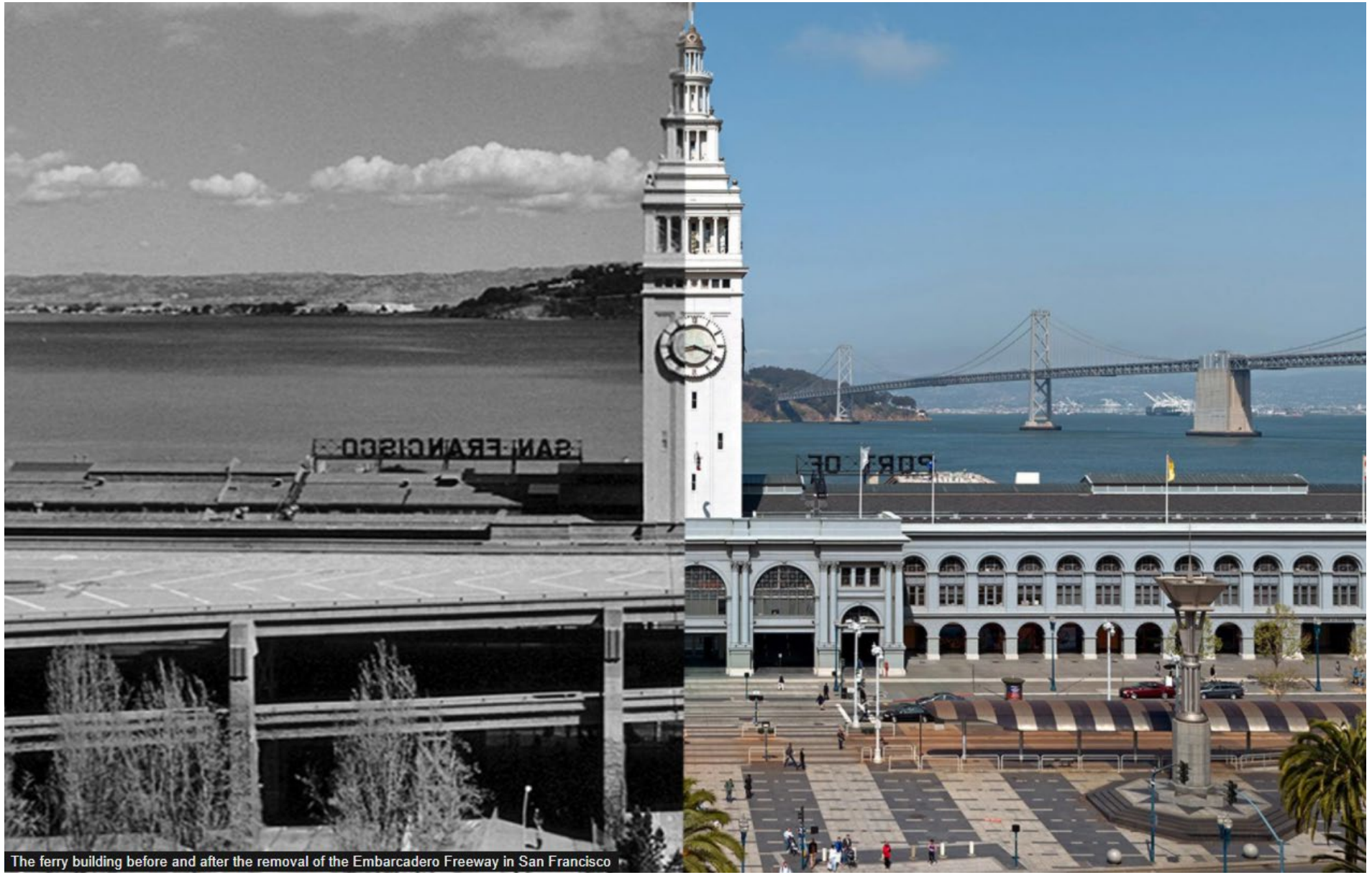








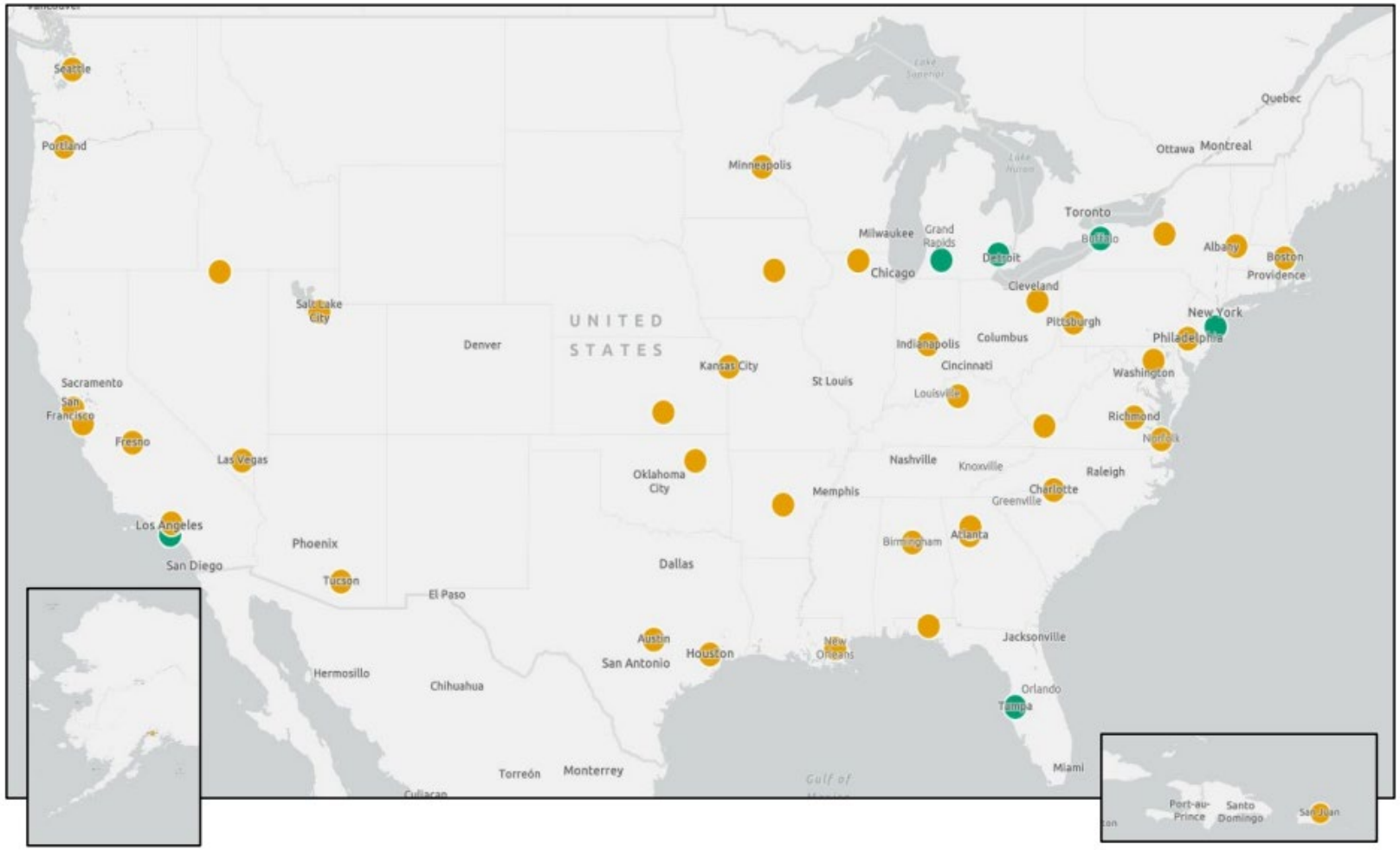
Source: cnu.org



The ferry building before and after the removal of the Embarcadero Freeway in San Francisco

Source: cnu.org

AWARDED PROJECTS



I-81 proposed boulevard ***Source:*** *James H Kunstler*

Source: cnu.org

CARS

ELECTRIC CARS

AUTONOMOUS CARS

UBER/LYFT CARS

CONCLUSION

- Advancing environmental justice and infrastructure equity requires transformative solutions
- Research needs to provide data for community-led visions

@Regan_Felice; @EngineerEJ
@Engineer_EJ
reganfp@ucla.edu

Greenscapes to **Brownscapes**

a pilot project for reclaiming highways

Introduction

“The panel identified an exposure zone within a range of up to 300 to 500m from a highway or a major road as the area most highly affected by traffic emissions... and estimated that 30% to 45% of people living in large North American cities live within such zones.”

- The Health Effects Institute

IMAGE CREDIT: LA TIMES

A Transdisciplinary Approach

Human + Community Health

Approach to Studying the Interface of Public Space + Highway

Actionable Change


This is a discussion about responsible design that ensures **benefits outweigh risks**
increases property value
provides access to greenspaces
transforms our cities into the future
reconnects severed neighborhoods
creates new urban opportunities
improves safety
offers amenities to a neighborhood
creates a sense of place
provides healthy food options
supports community creation
re-vegetates the urban environment
reduces the burden of stormwater runoff
creates space for social and physical health

The Conversation of the Moment

HEALTH

9 in 10 people globally breathe bad air

4 in 10 US residents breathe bad air

the W.H.O. estimates **4.2 million die prematurely** every year from outdoor air pollution

the Health Effects Institute (HEI) deems exposure from **living within 300-500m of a high traffic road** a public health concern

COMMUNITIES

in 84% of US counties, minority homes are over-represented within 500m of highways

racist land covenants created highway barriers that isolated and cut-off minority populations from resources

over 50 million Americans live within 100m of major transportation

NATURAL LANDS

96% of national parks suffer from significant ozone pollution

the average ozone concentration in 33 of the most visited national parks was **the same as those found in the 20 largest urban areas in the US**

MONITORING

there are approximately **70 EPA near-road air monitors** in the united states

32% of US counties do not have a single EPA air monitor

Profeta, Tim. "Air Pollution Now Top Environmental Health Risk." National Geographic

Clark, Lara P., Dylan B. Millet, and Julian D. Marshall. "National Patterns in Environmental Injustice and Inequality: Outdoor NO2 Air Pollution in the United States." PLoS ONE 9

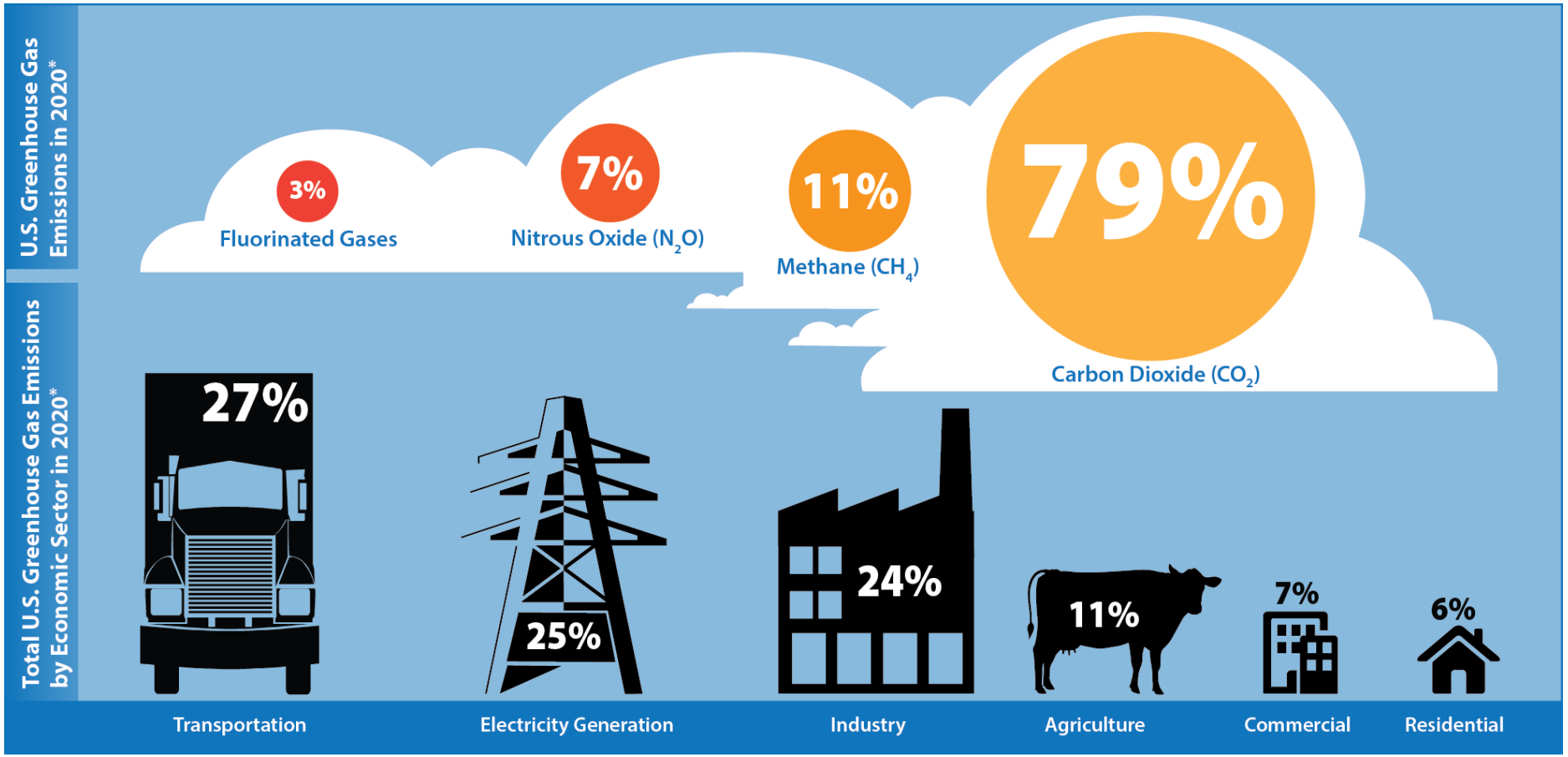
Rowangould, Gregory M. "A Census of the US Near-roadway Population: Public Health and Environmental Justice Considerations." Transportation Research Part D: Transport and Environment

Daley, Jason. "Signficant Air Pollution Plagues Almost All U.S. National Parks." Smithsonian Magazine

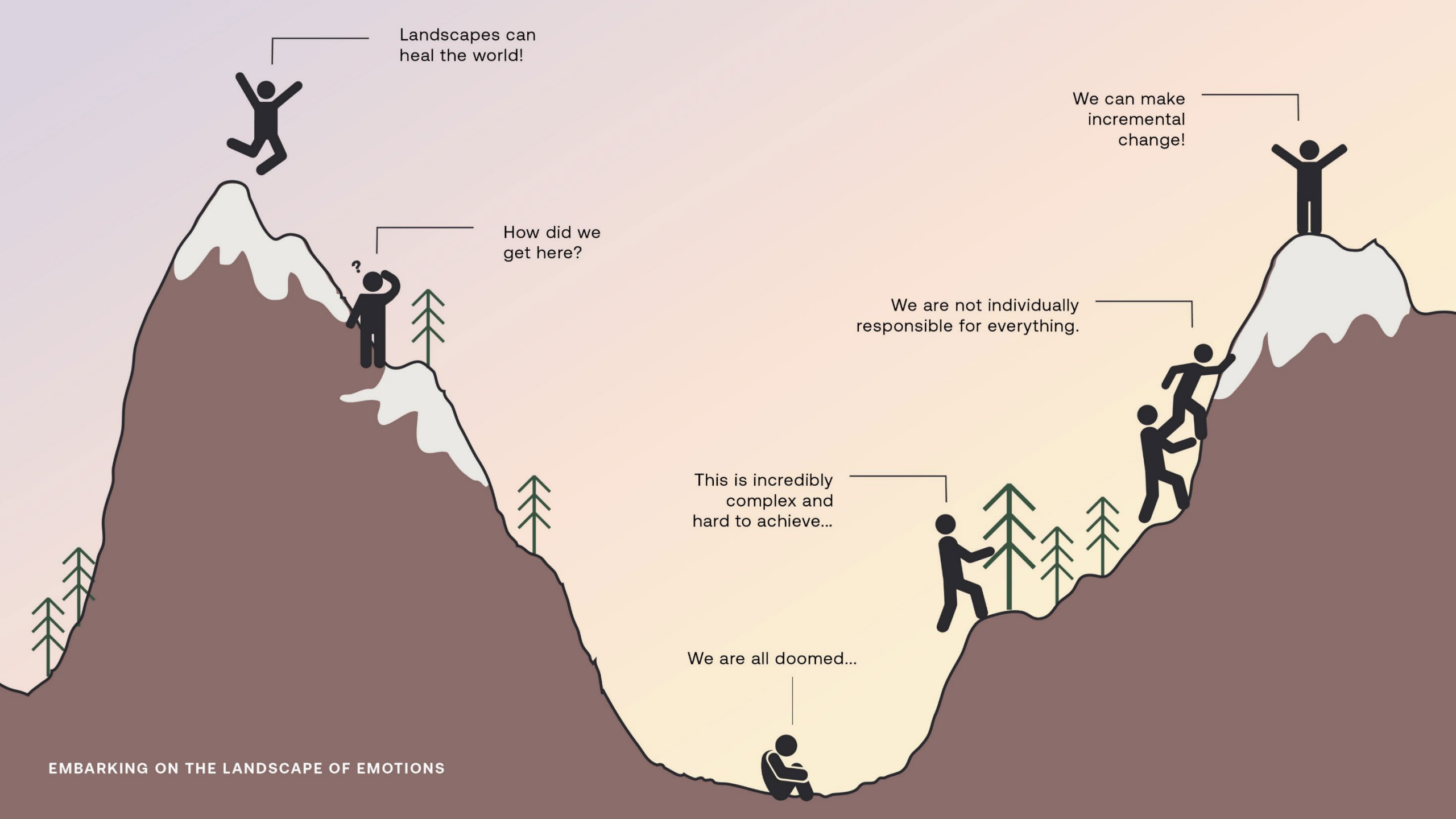
Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects

Health Effects Institute Special Report 17, 2010

A Transdisciplinary Approach

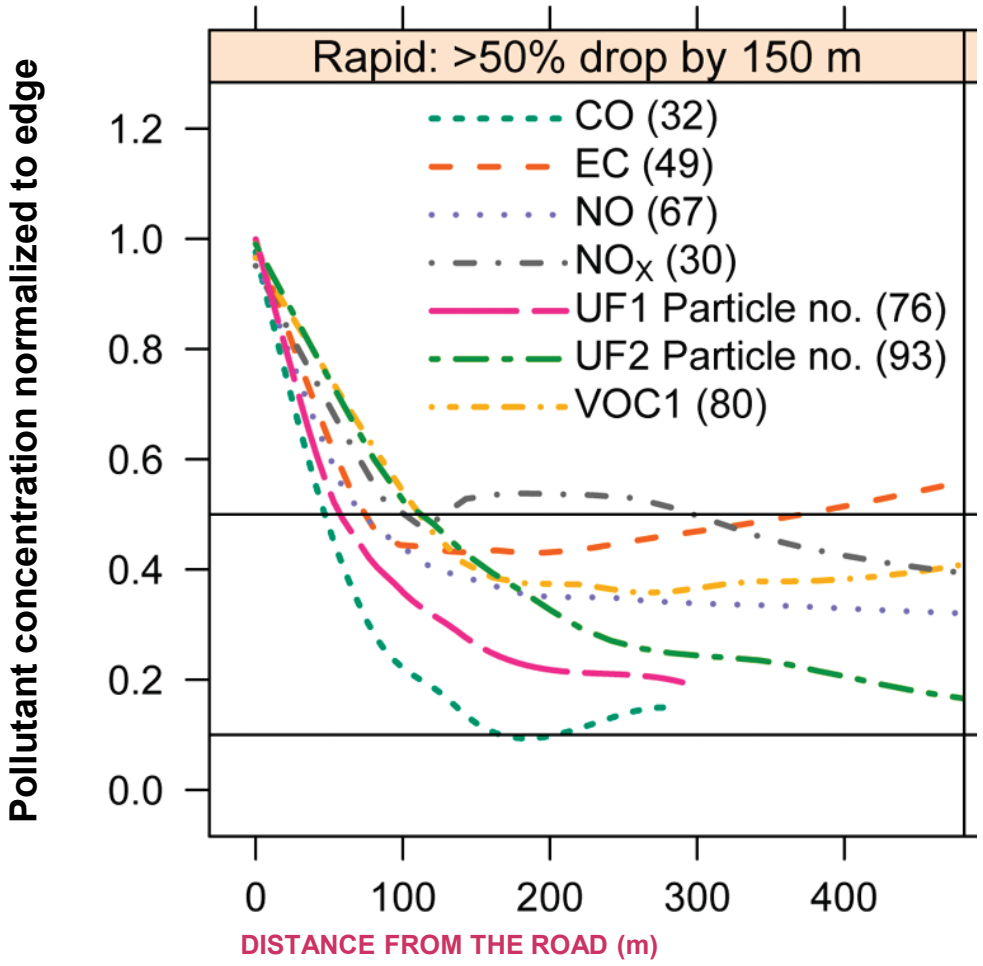


For the fifth year in a row, the transportation sector accounts for the largest portion of total U.S. greenhouse gas emissions


Landscapes can heal the world!
How did we get here?
We can make incremental change!
We are not individually responsible for everything.
This is incredibly complex and hard to achieve...
We are all doomed...
EMBARKING ON THE LANDSCAPE OF EMOTIONS

How can we reclaim the health of our communities?

Particulate Matter



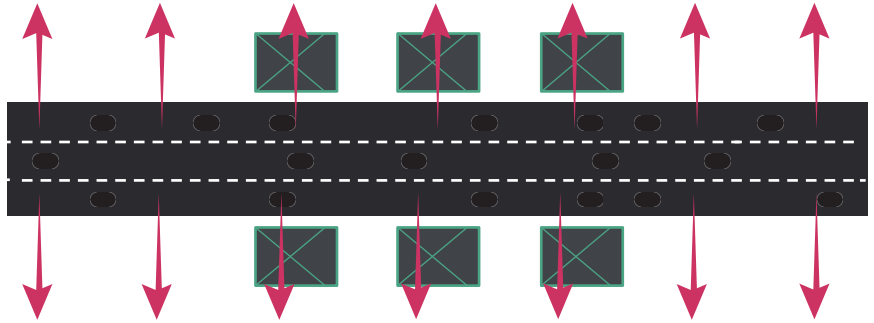
Alexa Karner, Douglass Eisinger, and Deba Niemeier - Near-roadway air quality: synthesizing the findings from real-world data. Environmental science & technology, 2010

How does Design Impact Human Exposure?

IMAGE CREDIT: BOSTON GLOBE

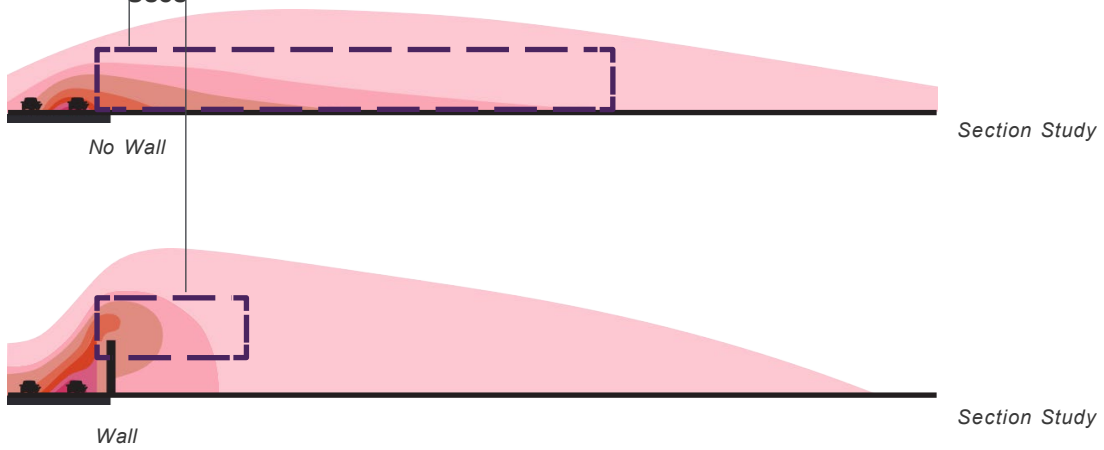
Understanding the Role of the Built Environment

Continuous

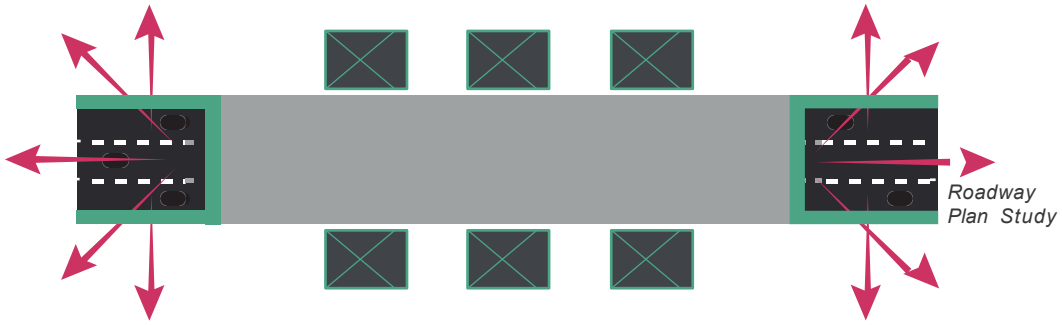


Roadway Plan Study

Caution For Sensitive Uses



Elevated At Exits, Lowered Roadside



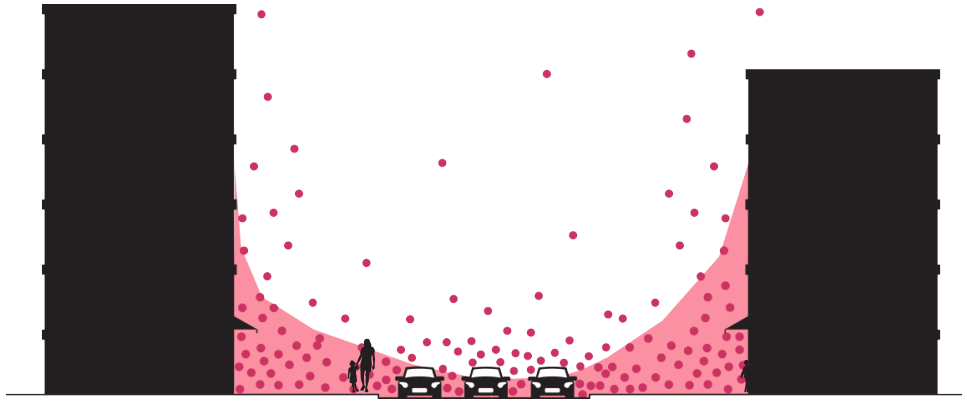
Roadway Plan Study

Fluid Dynamics play a Major Role

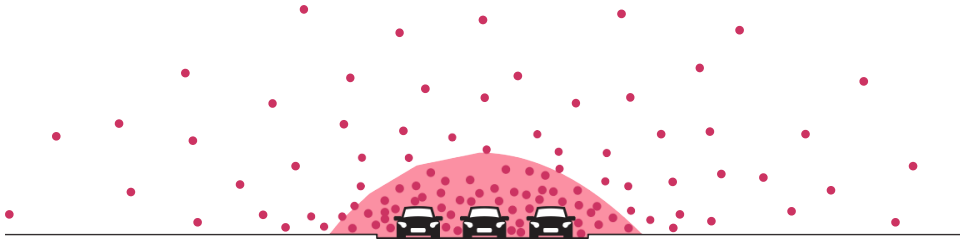
Air particulates travel in the fluid of air. The build environment can create zones of concentration, deposition, and relief that need to be studied in three dimensions

Baldauf, Richard. "Summary of EPA Research on Near-Road Air Quality: Impacts of Solid Noise Barriers and Roadside Vegetation."

Understanding the Role of the Built Environment



Street Canyon



Open Road

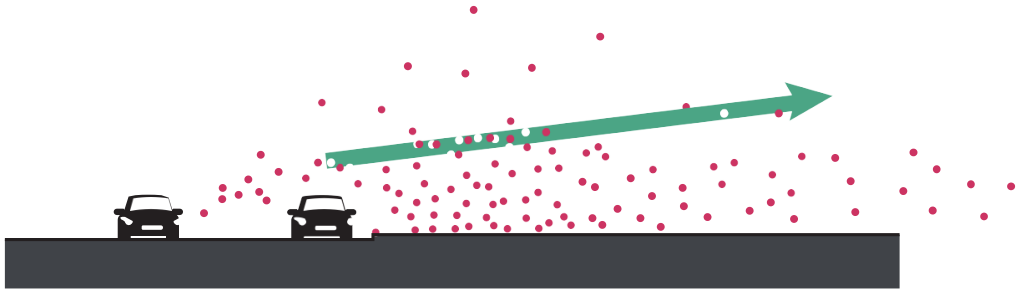
Street Trees

Landscapes + Architecture can trap air pollution

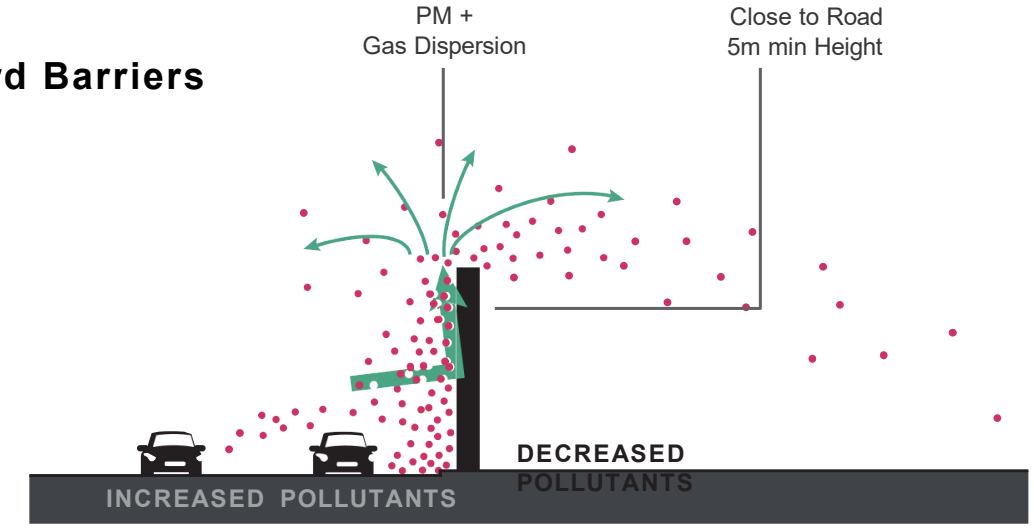
Foliage tames winds, decreasing dispersion and trapping exhaust below the canopy. Rows of tall buildings cause a build up of pollutants at their base

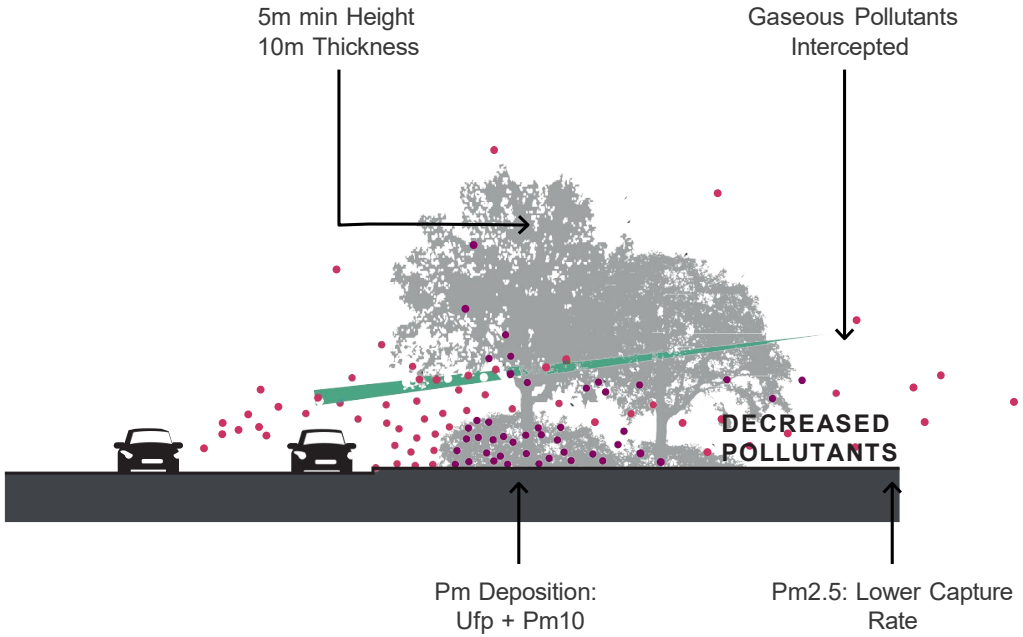
Baldauf, Richard. “Summary of EPA Research on Near-Road Air Quality: Impacts of Solid Noise Barriers and Roadside
Vegetation.” CARB/EPA Conference Call - Presentation. PDF. EPA, July 11, 2016.

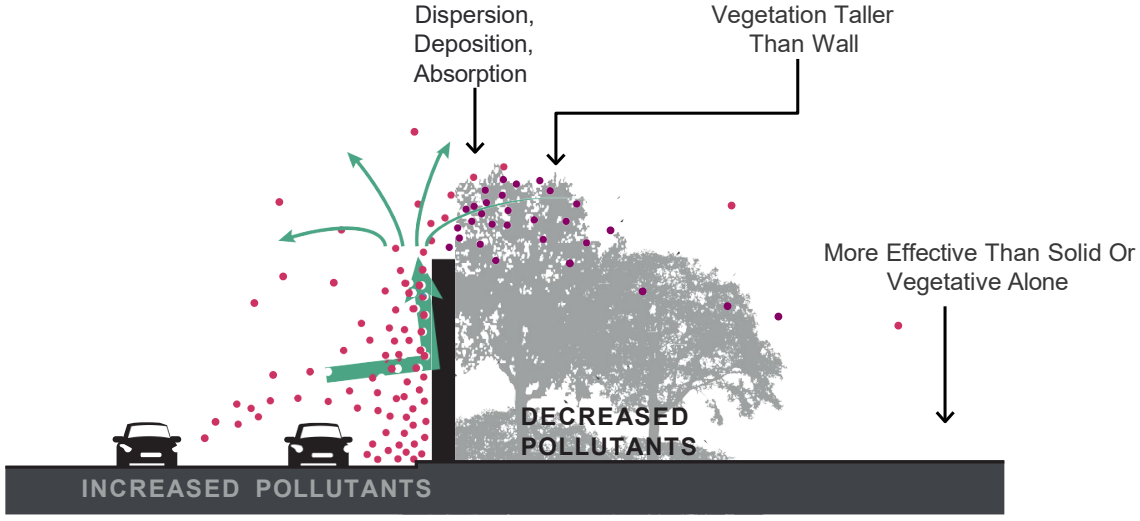
Understanding the Role of the Built Environment: Soft & Hard Barriers



GASES
PM
PM DEPOSITION



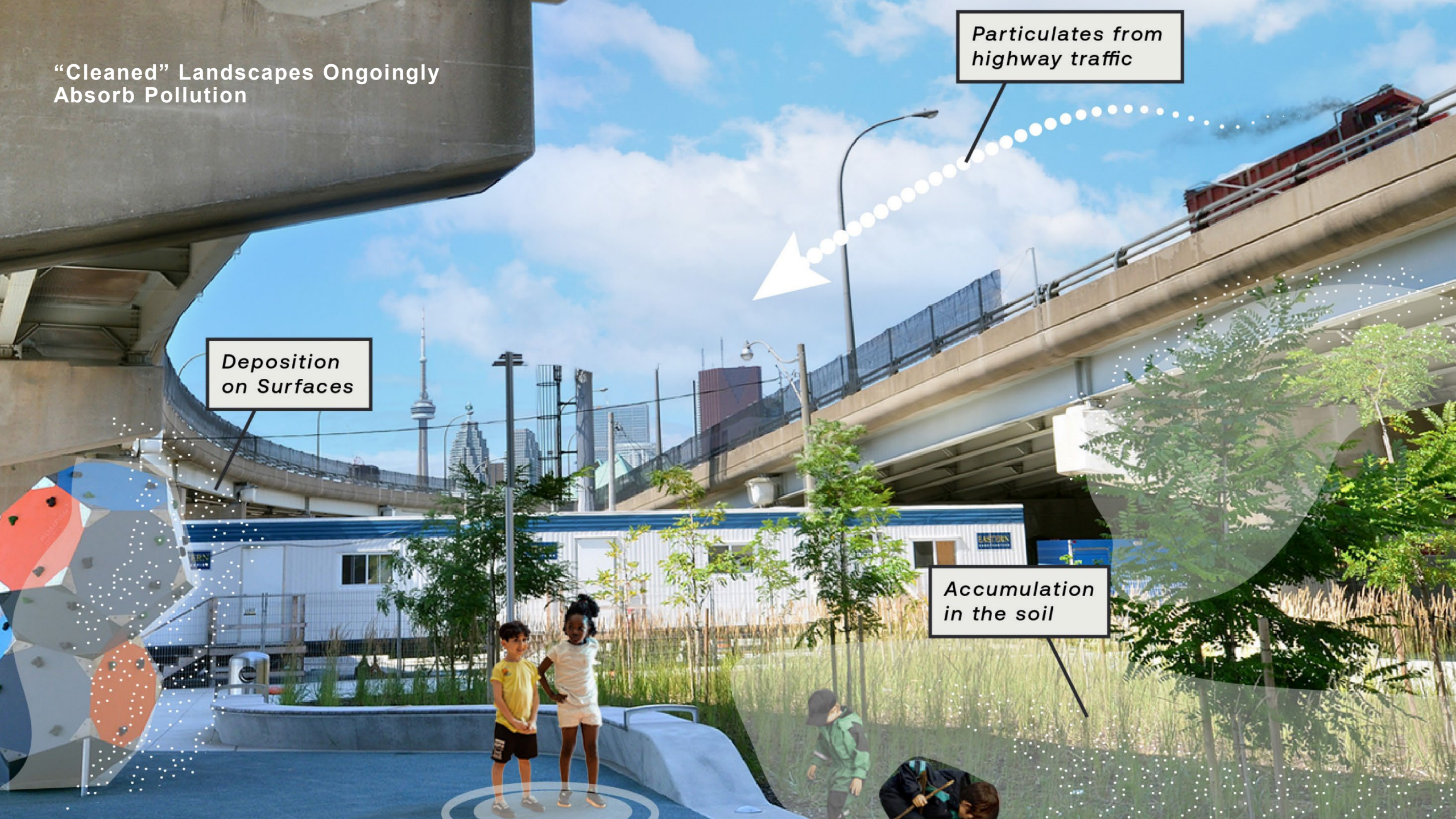




Baldauf, Richard. "Summary of EPA Research on Near-Road Air Quality: Impacts of Solid Noise Barriers and Roadside Vegetation."

Case Study
LAF Grant - Philadelphia Pilot

IMAGE CREDIT: LA CURBED


“Cleaned” Landscapes Ongoingly Absorb Pollution
Particulates from highway traffic
Deposition on Surfaces
Accumulation in the soil

In burdened landscapes, how can we **make human interactions more healthful?**

PHOTO: https:// therivardreport.com

Public Space User Groups

asthma

cardiovascular morbidity

decreased lung function

pulmonary disease (COPD)

low birth weight

birth defects

cancer (various)

developmental delays + autism

Alzheimers + Parkinsons

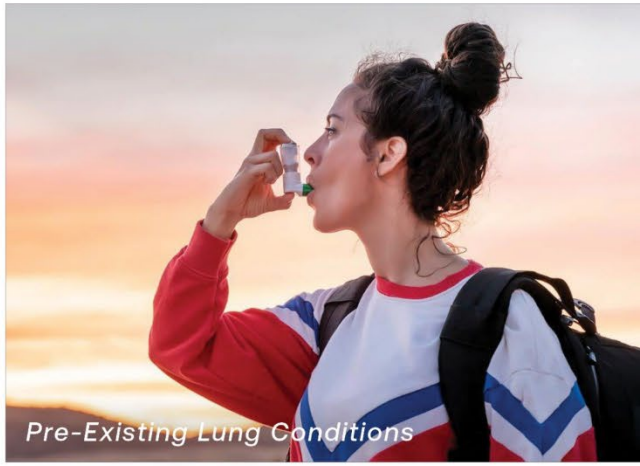
stroke

EVIDENCE: sufficient | suggestive | more research needed

Mapping US Counties Where Traffic Air Pollution Hurts Kids the Most - GVWire (formerly CityLab)

USC Environmental Health Centers: References

https://envhealthcenters.usc.edu/infographics/infographic-living-near-busy-roads-or-traffic-pollution/references-living-near-busy-roads-or-traffic-pollution



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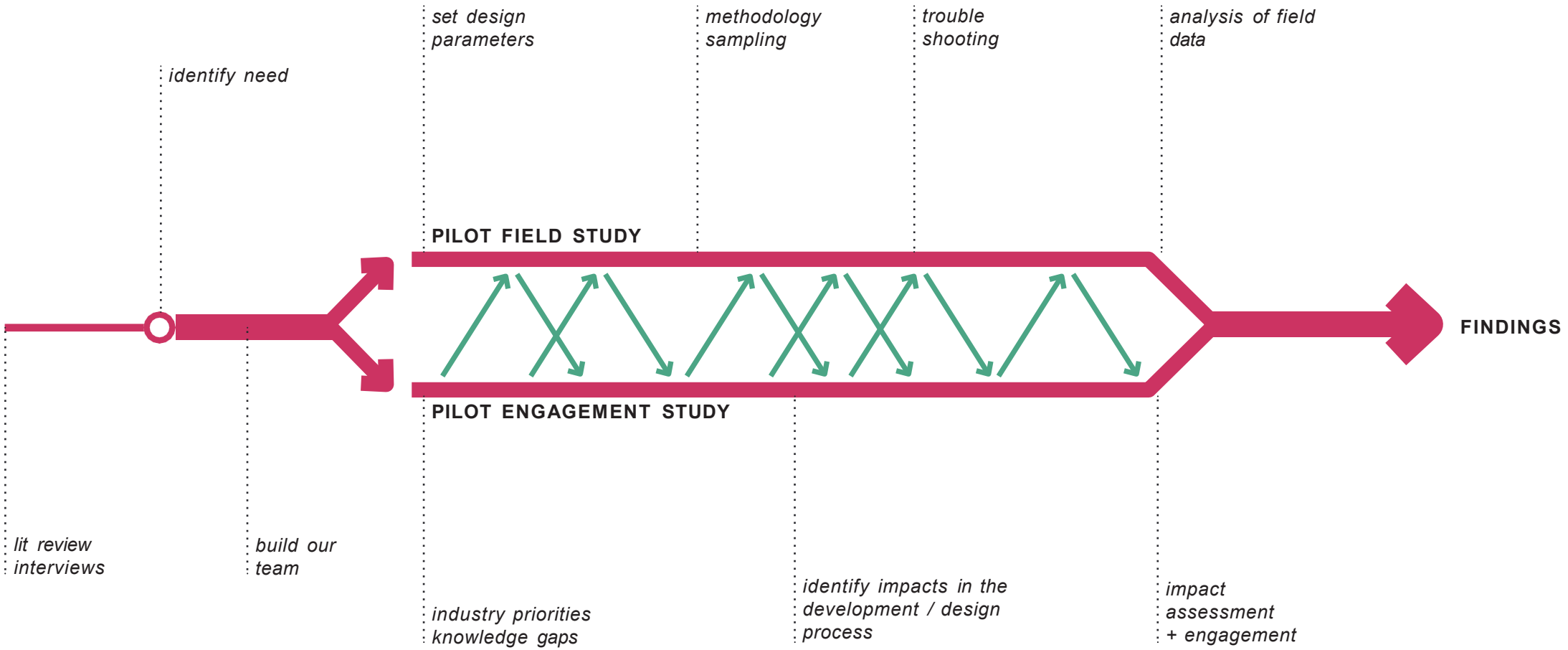
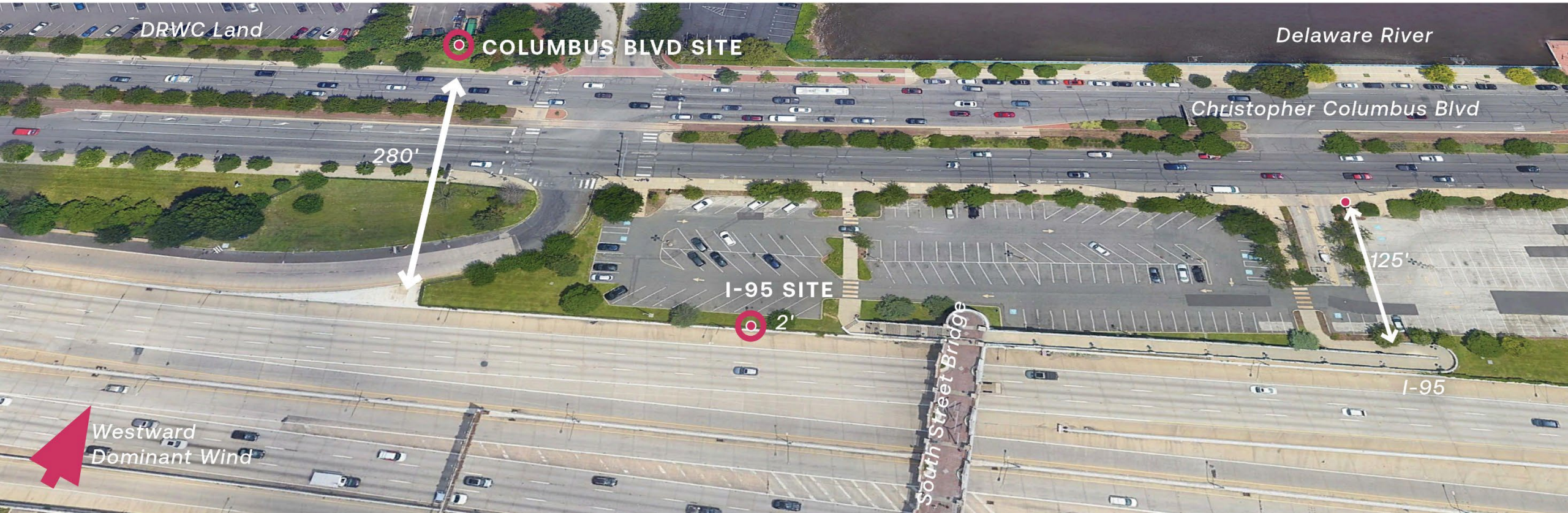
Building the Pilot




I-95 SITE
MAERSK


COLUMBUS BLVD SITE
TOPSOIL
TOPSOIL


DRWC Land
COLUMBUS BLVD SITE
Delaware River
Christopher Columbus Blvd
280'
I-95 SITE
2'
125'
I-95
South Street Bridge
Westward
Dominant Wind

Pilot Field Study: Sampling Methods

Soil Samples

Top 1" of soil
Heavy Metals
PAH's

Vegetation Swabs

Sterile Wipes
Heavy Metals
PAH's

Air Monitor

Purple Air
Air Note
pm2.5

Pilot Field Study: What We Measured For

HEAVY METALS

Arsenic (As)
Barium (Ba)
Cadmium (Cd)
Chromium (Cr)
Copper (Cu)
Lead (Pb)
Manganese (Mn)
Nickel (Ni)
Zinc (Zn)

POLYCYCLIC AROMATIC HYDROCARBONS

Anthracene
Acenaphthylene
Benzo(A)Anthracene
Benzo(A)Pyrene
Benzo(B)Flouoranthene
Benzo(G,H,I)Perylene
Benzo(K)Flouranthene
Chrysene
Dibenz(A,H)Anthracene
Fluoranthene
Indeno(1,2,3-CD)Pyrene
Phenanthrene
Pyrene

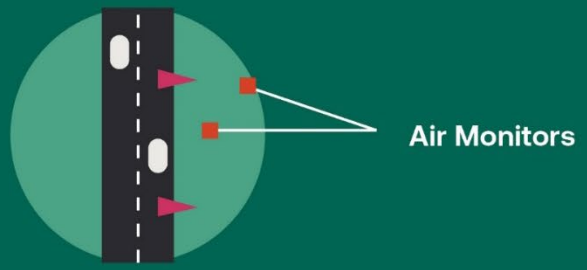
Air Quality

Spikes in PM 2.5 conc. In case of predominant wind in windward direction as highway and wind gust.

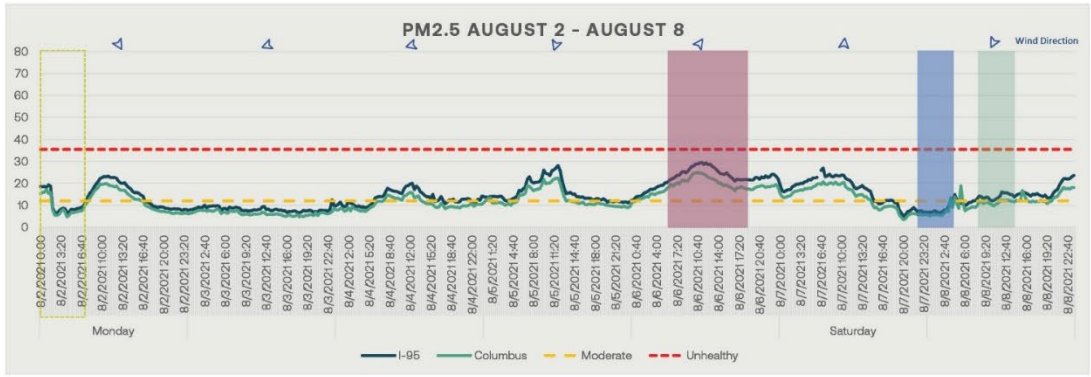
Reduction in case of change in wind direction.

Dip in PM 2.5 concentration right after a precipitation event.

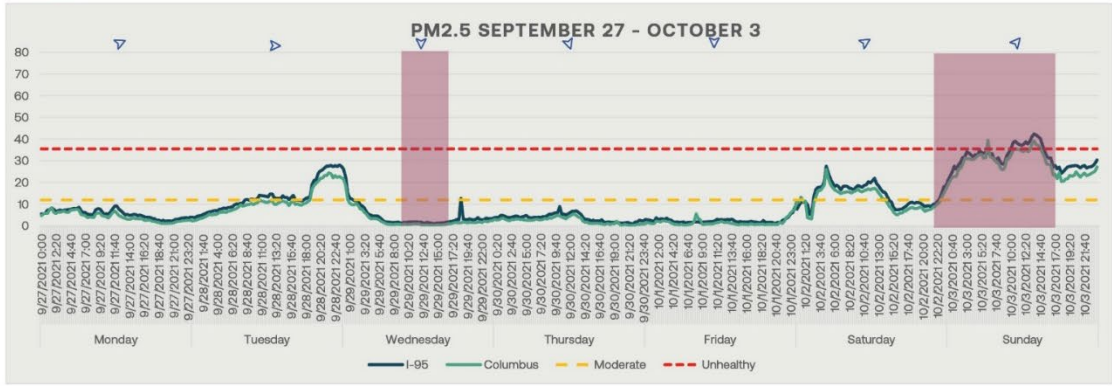
Higher PM 2.5 levels at I-95 than Columbus Blvd.



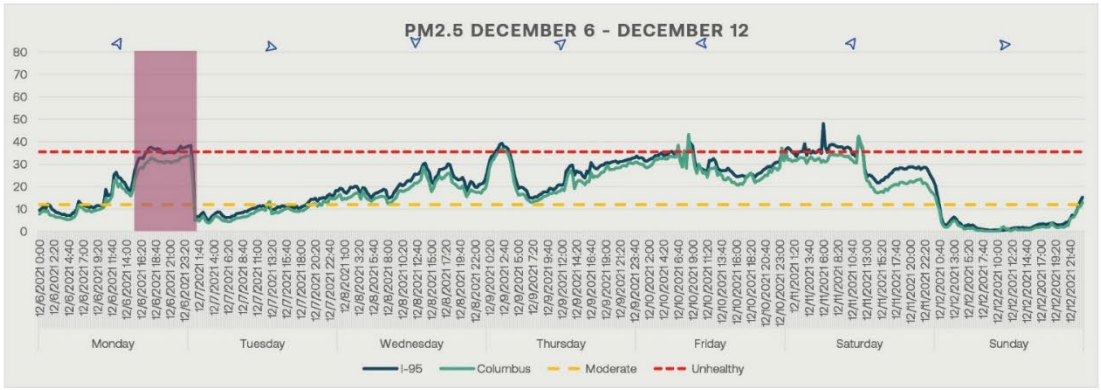
SUMMER



FALL



WINTER



µg/m³

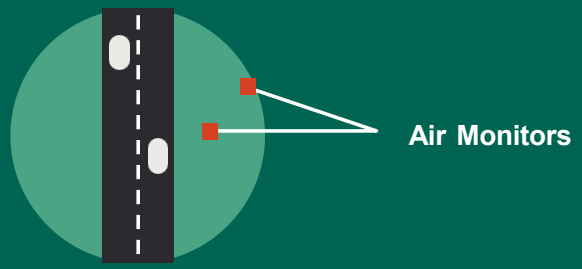
Precipitation

Wind Gust

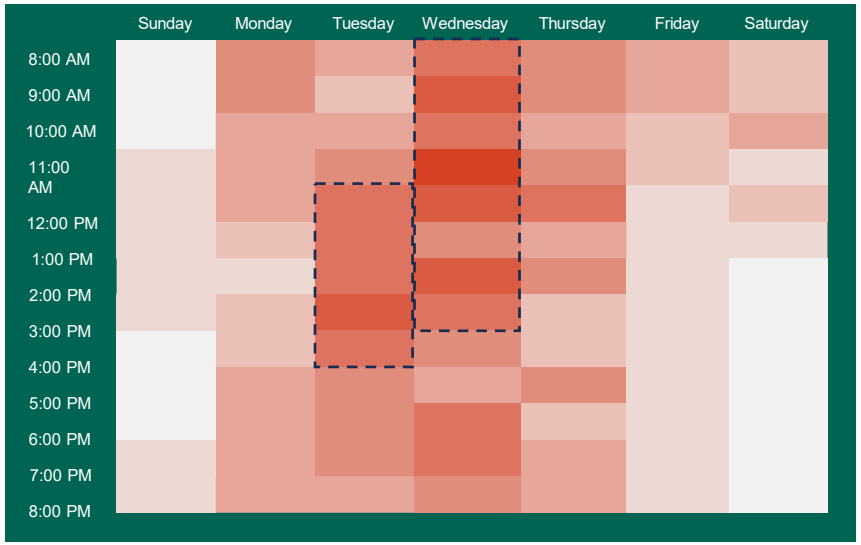
Air Quality - Unhealthy

Higher PM 2.5 concentrations during mid-week at each of the sites and reduction during the weekends.

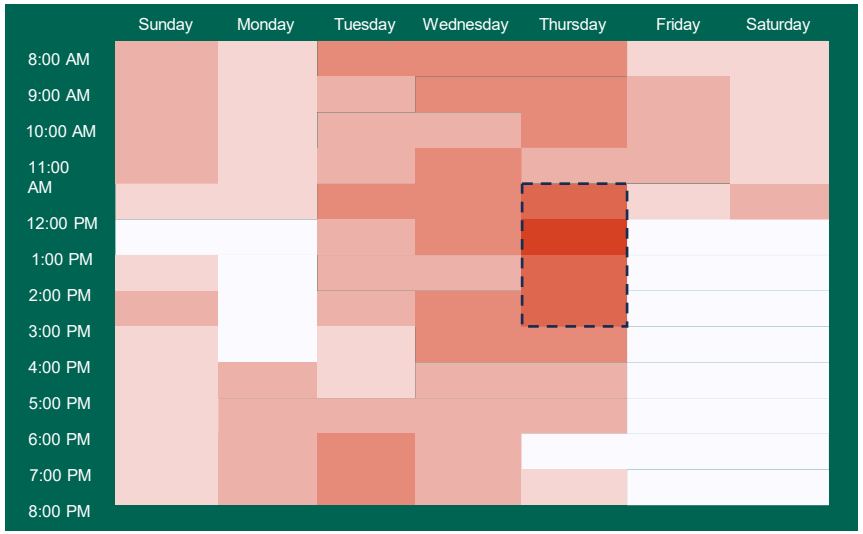
What does this mean for programming and activation?



I-95

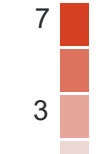


COLUMBUS BLVD



air quality comparison between our monitor and other monitors

traffic data more specific to the site

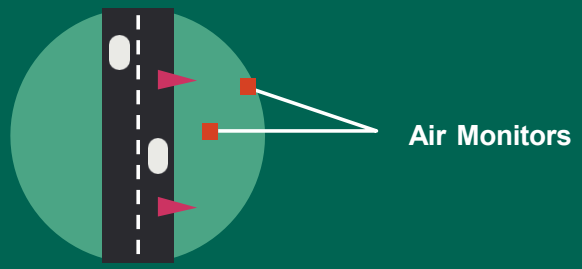


DAYS

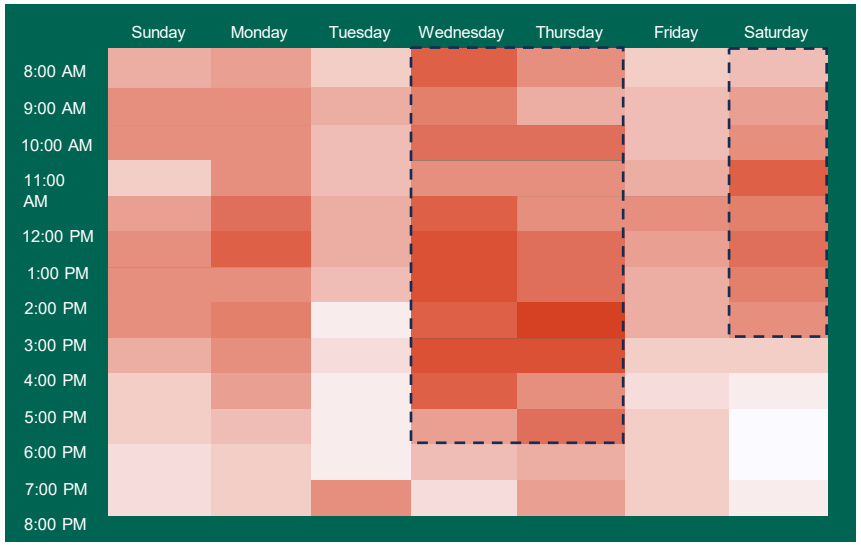
Air Quality - Moderate

Higher PM 2.5 concentrations during mid-week at each of the sites and reduction during the weekends.

What does this mean for programming and activation?

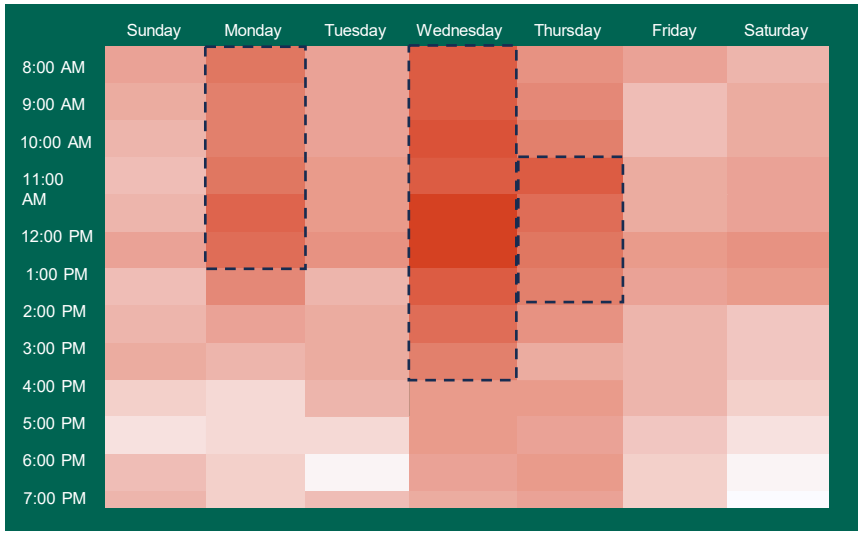


I-95

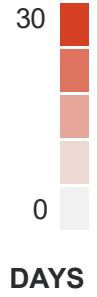


Avoid Programs Targeted for Sensitive User Groups on Wednesdays + Thursdays and Saturday mornings

COLUMBUS BLVD



Avoid Programs Targeted for Sensitive User Groups on Wednesdays + Monday mornings and Thursday mid-day

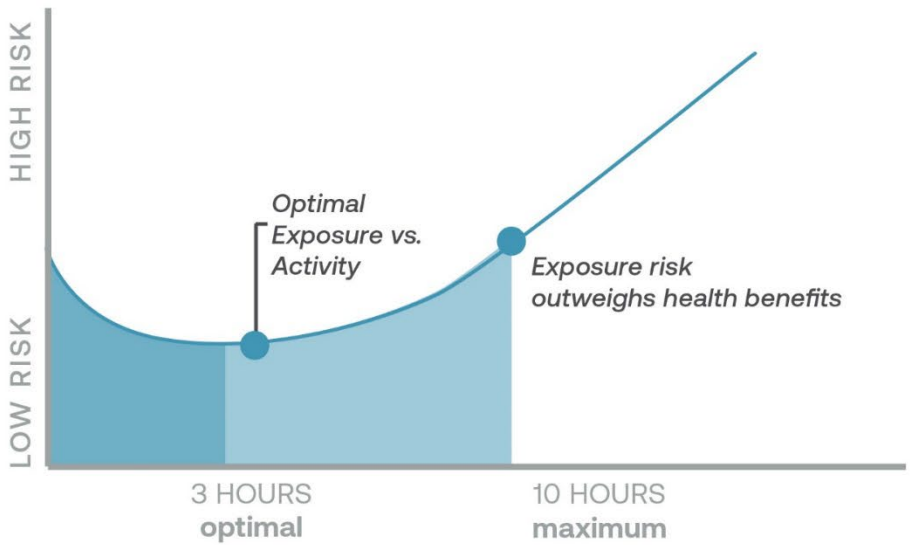


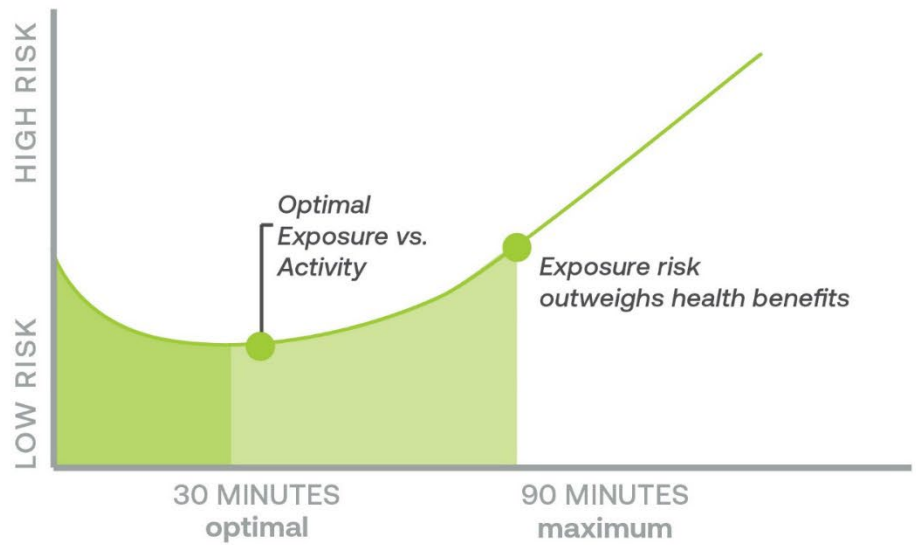
LOW RESPIRATORY RATES

e.g., walking

HIGH RESPIRATORY RATES

e.g., cycling



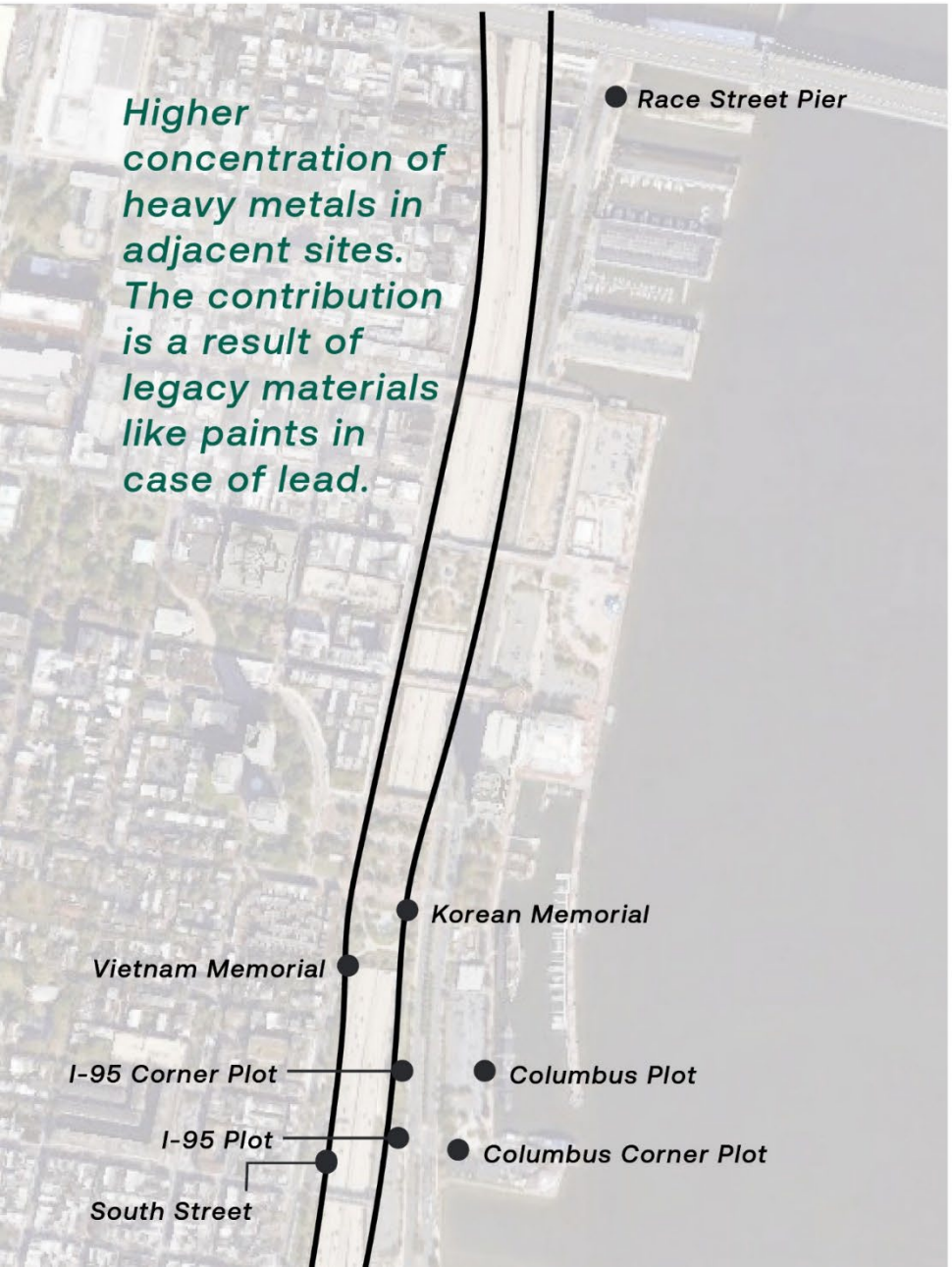


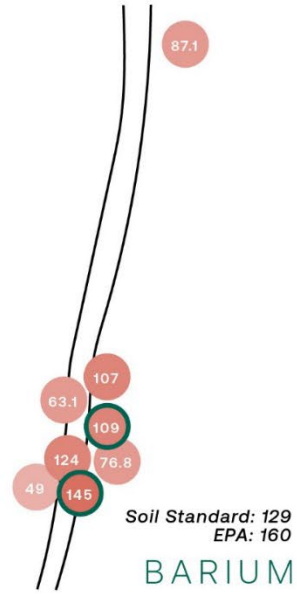
Marko Tainio, Audrey J. de Nazelle, Thomas Götschi, Sonja Kahlmeier, David Rojas-Rueda, Mark J. Nieuwenhuijsen, Thiago Hérick de Sá, Paul Kelly, James Woodcock, Can air pollution negate the health benefits of cycling and walking?, Preventive Medicine, Volume 87, 2016, Pages 233-236, ISSN 0091-7435, https://doi.org/10.1016/j.ypmed.2016.02.002.

(https://www.sciencedirect.com/science/article/pii/S0091743516000402)

ADJACENT SITES SOIL HEALTH - HEAVY METALS

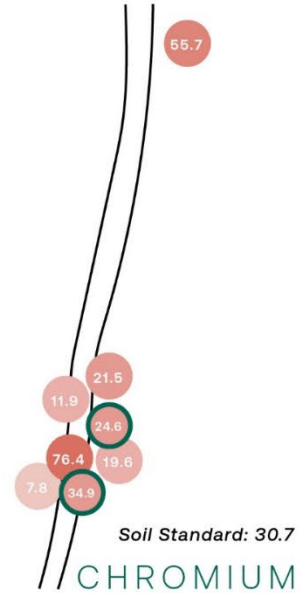
(mg/kg)²





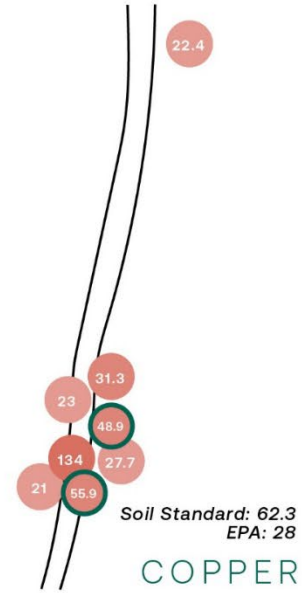
Soil Standard: 129
EPA: 160

BARIUM



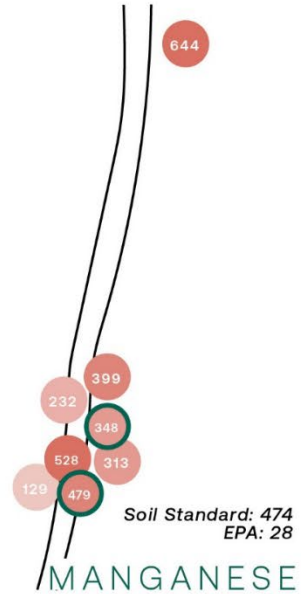
Soil Standard: 30.7

CHROMIUM



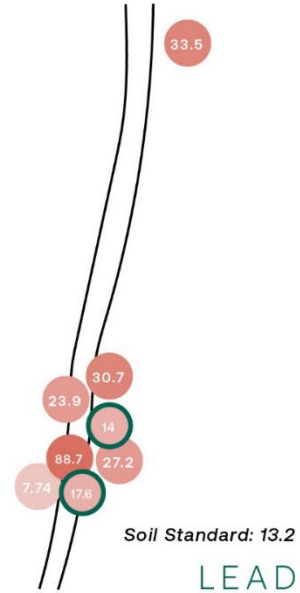
Soil Standard: 62.3
EPA: 28

COPPER



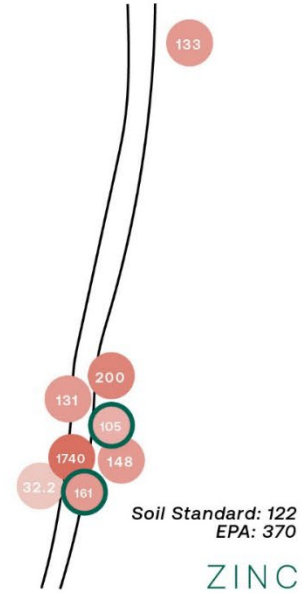
Soil Standard: 474
EPA: 28

MANGANESE



Soil Standard: 13.2

LEAD



Soil Standard: 122
EPA: 370

ZINC

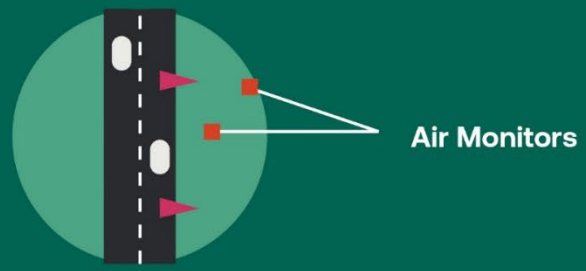
SOIL HEALTH - HEAVY METALS

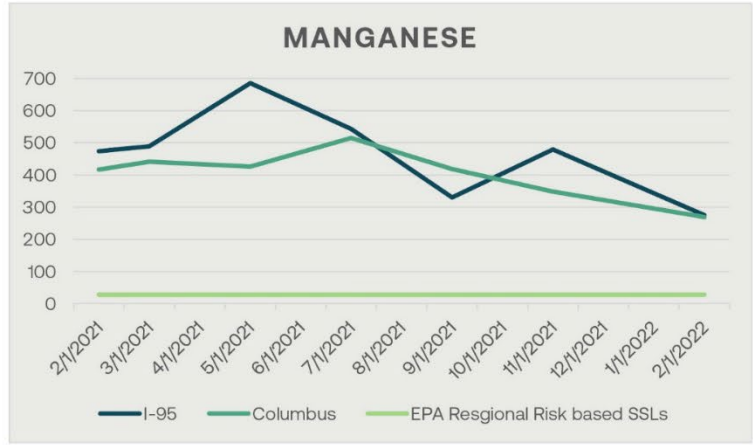
(mg/kg)²

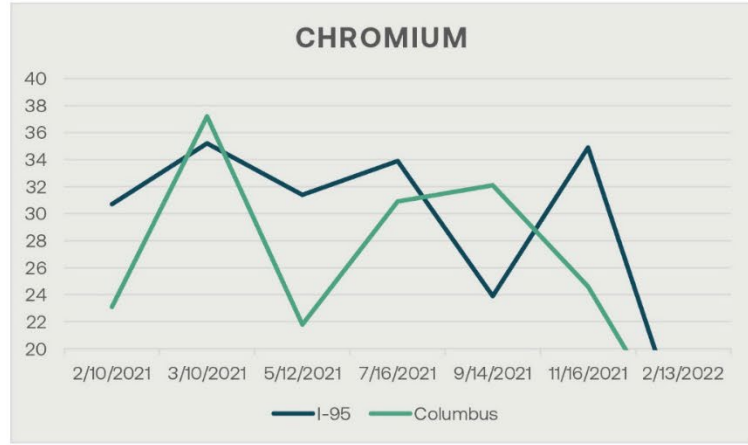
Hypothesis of steady but quick accumulation in heavy metals or PAHs through the study was not seen.

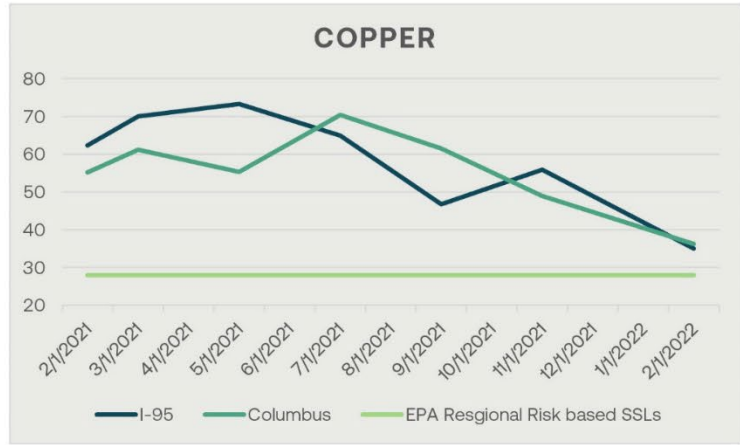
Leaching could be the reason for decrease in accumulation.

Questioning need for barriers to be placed to reduce accumulation.



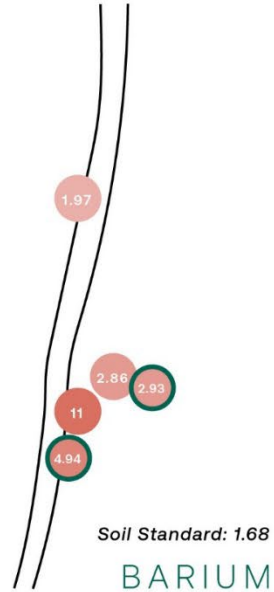






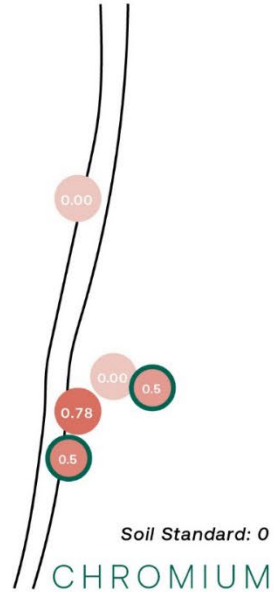
ADJACENT SITES SWAB DATA - HEAVY METALS

(µg/kg)²



Soil Standard: 1.68

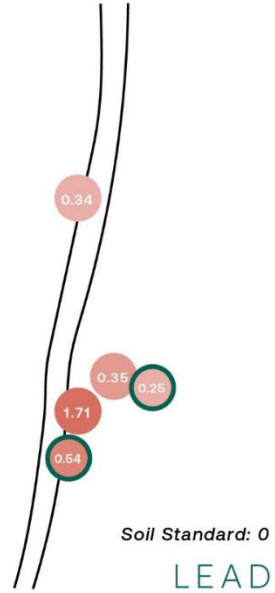
BARIUM



Soil Standard: 0

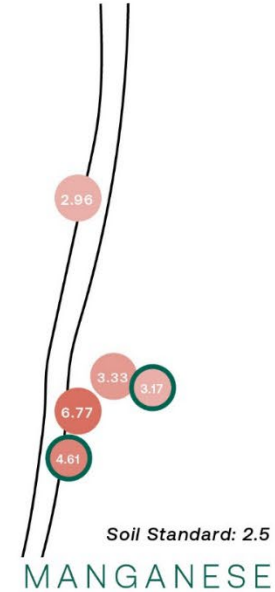
CHROMIUM

Higher concentration of heavy metals on the site at I-95.



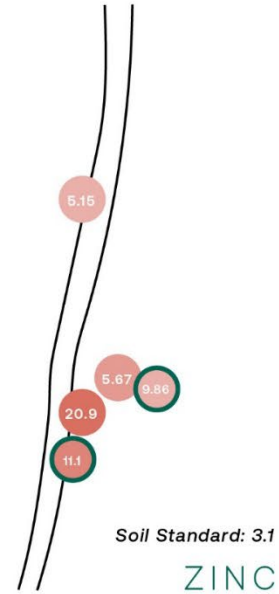
Soil Standard: 0

LEAD



Soil Standard: 2.5

MANGANESE

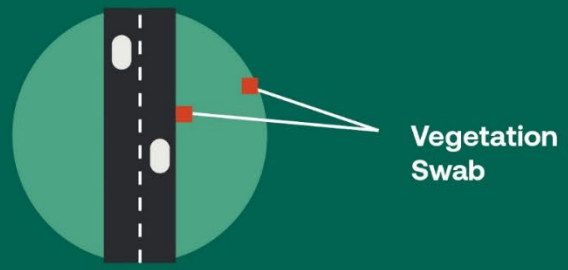


Soil Standard: 3.1

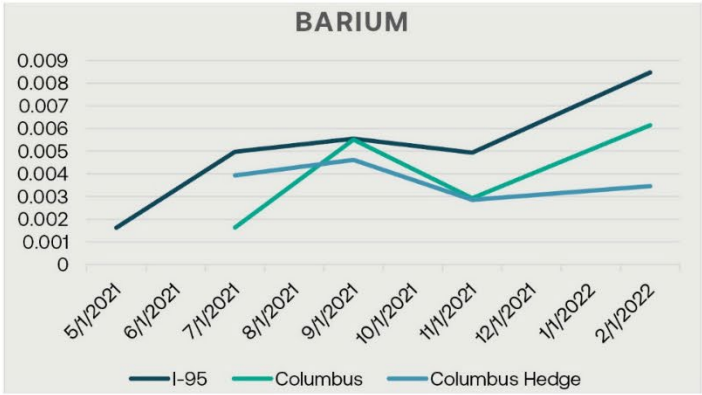
ZINC

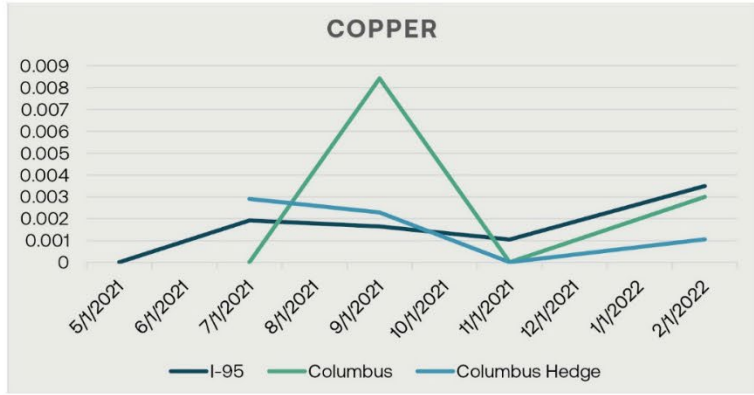
SWAB DATA - HEAVY METALS

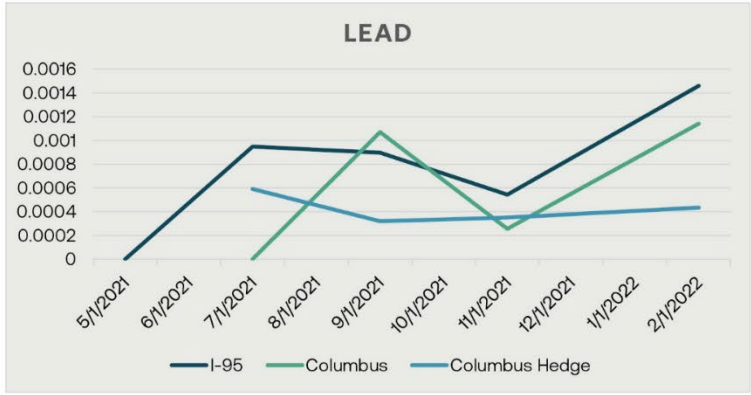
Within limited data, we saw a trend of increasing accumulation of heavy metals.

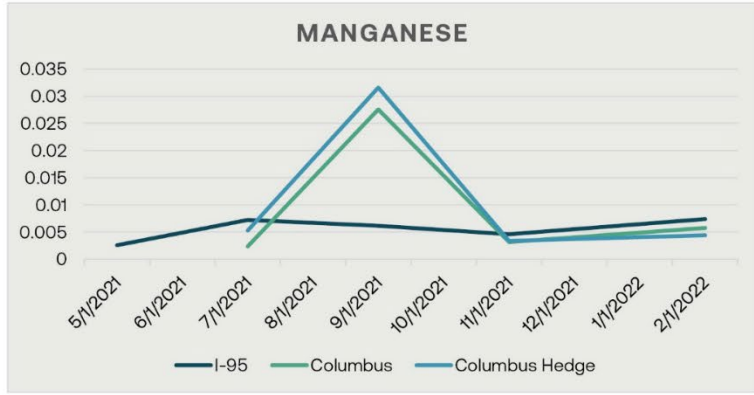


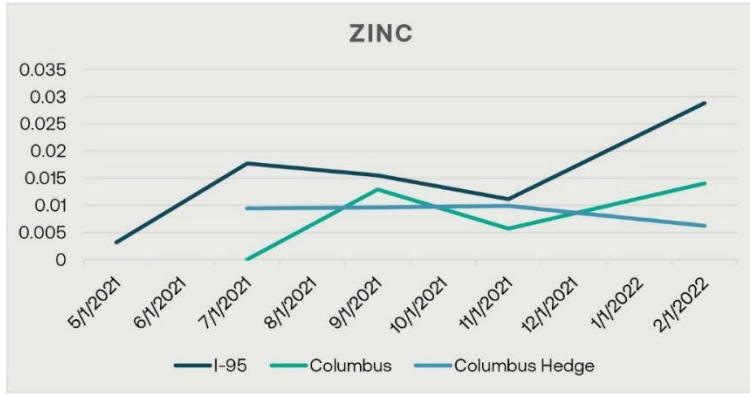
(µg/kg)²











Programming for Health + Wellness

STROLL / ACCESSIBILITY

wind

direct solar radiation / glare

comfort

air quality

LUNCH / QUICK BREAK

wind

direct solar radiation / glare

comfort

air quality

OUTDOOR WORKSPACES

wind

direct solar radiation / glare

comfort

air quality

The Engagement Pilot: Advisory Group Visioning

1 Current State of the Problem

- Industry Priorities
- Shared Interests
- Gaps in Knowledge

2 Opportunities to change current practices

- Opportunities for collaboration
- Impacting development/ design processes

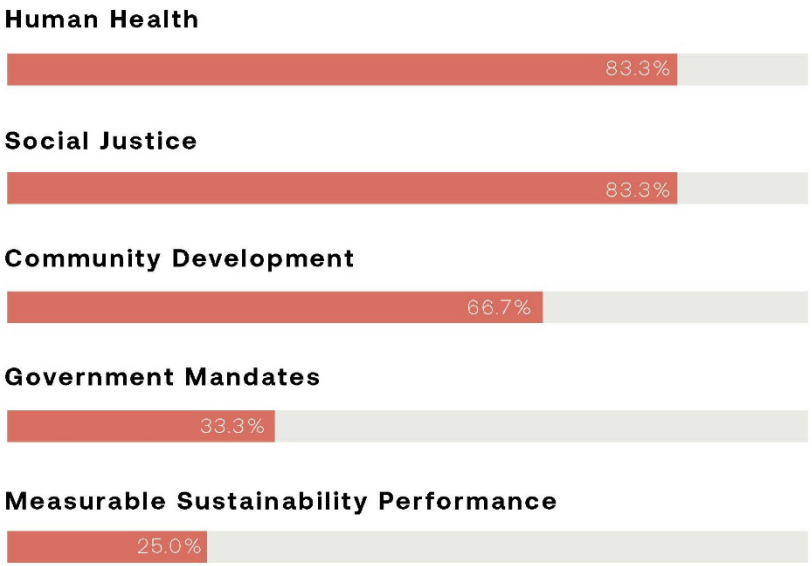
3 Risk Mitigation and Outreach

- Opportunities for collaboration
- Impacting development/ design processes

Engagement Findings – Session 1

Where is the focus of industry conversation

In your industry of field of work, what have you observed to be major discussion or trends related to air quality and public landscapes adjacent to roadways



What is meaningful to our work

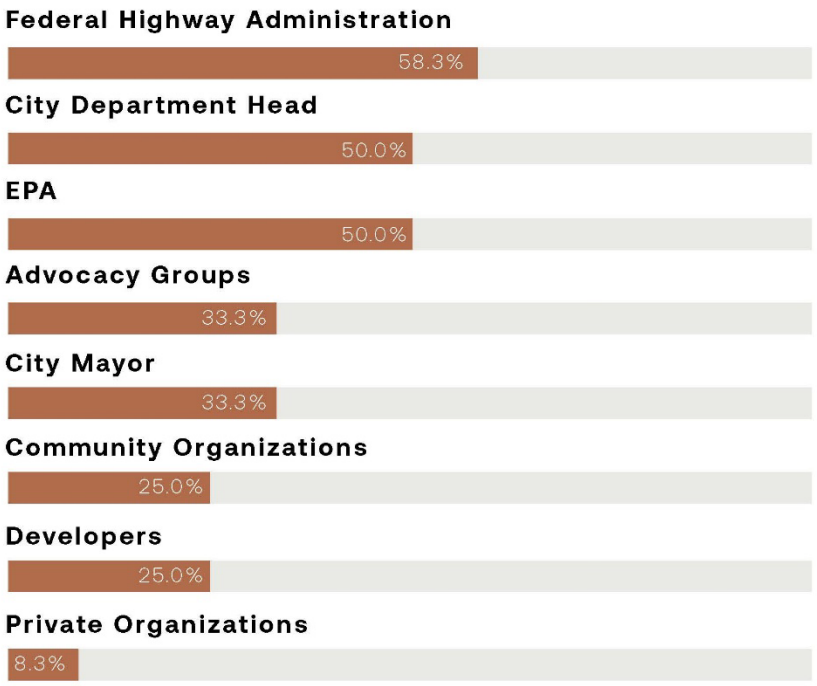
Rank impacts that would make for a meaningful research project focused on public landscapes adjacent to roadways

#1	**Social Justice**	#2.83 avg
#2	**Human Health (mental, physical, community)**	#2.92 avg
#3	**Environmental Health (soil, water, air)**	#3.25 avg
#4	**Community Ownership/Place Making**	#4.42 avg
#5	**Habitat Health (flora & fauna)**	#5.25 avg
#6	**Economic Health**	#6.08 avg
#7	**Design Innovation**	#6.17 avg
#8	**Legacy (history of person or place)**	#7.00 avg
#9	**Longevity (next generation, futures)**	#7.08 avg

Engagement Findings – Session 1

Who should we be working with to make positive change

Who do you believe has the most influence to ensure research findings on roadside air quality in public landscapes have the biggest positive impact to human health



Other: Federal Agencies, State DOTs

Who needs to be at the table

What other groups would you be most interested in collaborating with on roadside air quality issues?

- Landscape architects
- Materials scientists (particulate capture)
- Psychologists
- Medical doctors
- Health Agencies
- Environmental Protection Agency (EPA)
- Department of Environmental Protection (DEP)
- Academic Partners
- Field Researchers
- City Policy Makers / City Council . Mayor
- City Departments - Health, Air Quality, Transportation
- Highway agencies
- Developers
- Community groups

Where are our knowledge gaps?

What are the biggest knowledge gaps in our understanding of landscapes adjacent to roadways / air pollution sources?

Human Health & Behavior

- The **sonic impacts** of roadway infrastructure on collective psychological health.
- Why do **people choose** to live so close to a highway when given a choice
- Are deck parks or under-freeway parks **safe** for repeated and daily use?

Our Understanding of Air Quality

- The **Complex chemistry** among pollutants, deposition of pollutants on plants, soils, barriers
- A **systems analysis** of air quality/pollutant cycles and how a series of potential interventions might upend those cycles/patterns
- Data collection and **meshing** these data sets together
- Localized, un-averaged, **short term air quality**

The Built Environment

- **Design** to lessen long-term impacts to human health
- How long will **highways last** given the evolving workplace and transportation/energy state.
- Quantifying the impacts
- Designing innovative **mitigation strategies** for these complex locations and conditions
- Is air quality improved by capping, do **parks help**

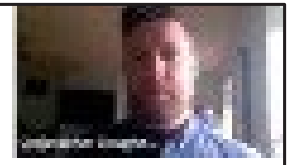
Engagement Findings – Session 2

Project Planning

Project Design

Project Operations

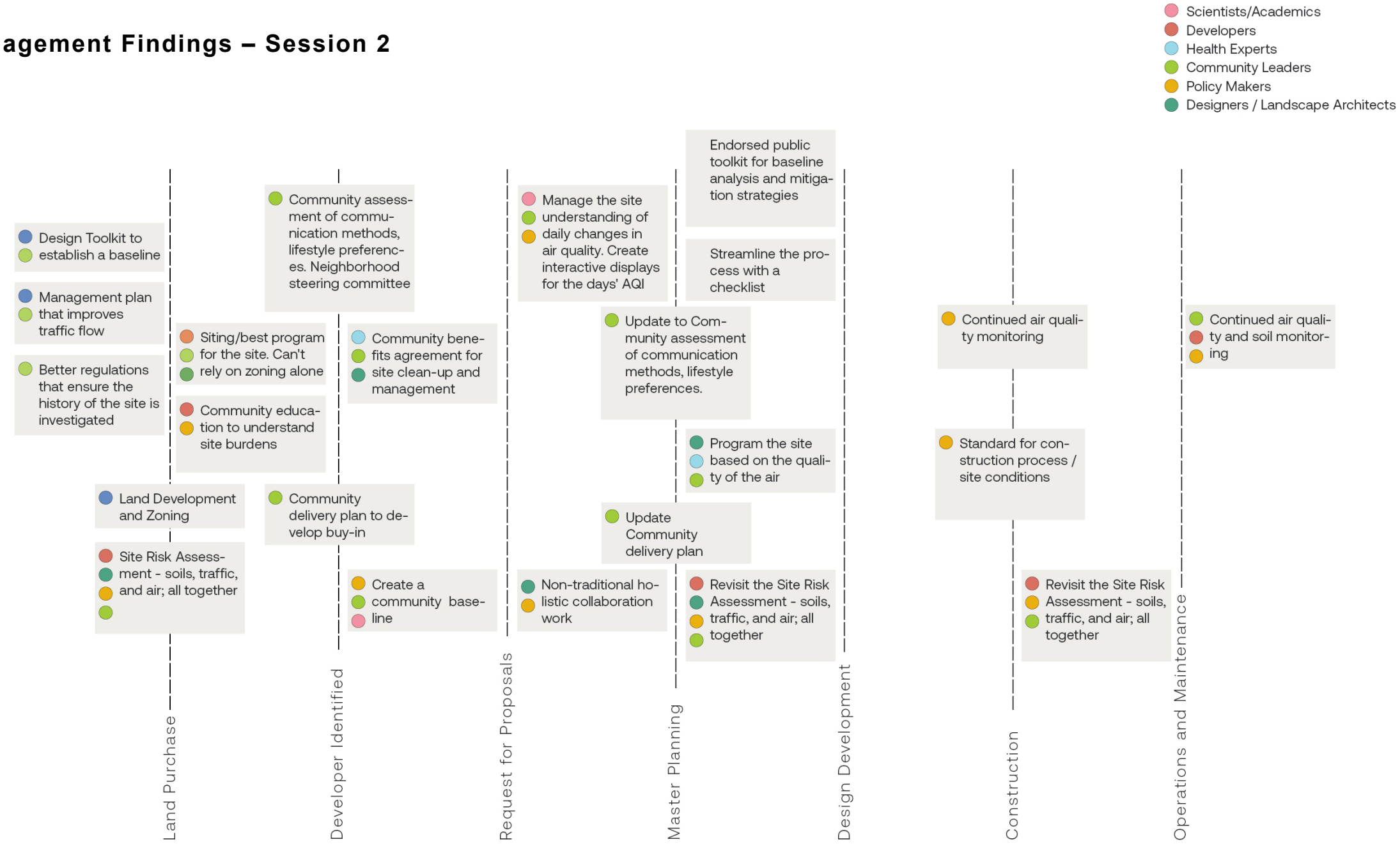
2009 PWD FISHERIES STUDY - CONCEPTUAL RENDERING



Implications from Conceptual Study:

- **Increased potential for recreational activities**
  - Boating
  - Fishing
  - Passive Recreation
- **Increased economic value of properties along Delaware Riverfront**
- **Future development must balance economic interests with ecological protection**
- **Increased level of mitigation required for altering inter-tidal or open water areas**
- **This site provides one of the few "areas of opportunity for freshwater tidal wetland enhancement or creation" along the Delaware River in Philadelphia.**

Engagement Findings – Session 2



Engagement Findings

Land development, zoning + programming based on risk assessment of the site.

Perform a pre-evaluation of site from human health perspective at project planning stage. This should include air + sound sampling.

Need for regulations that ensure a site is assessed for any risks based on site history of contamination activities, proximity to a pollution source etc.

Need for development of community baseline for a site for both public, as well as private projects a site-based on standard risk assessment.

Educating community of the risks, and developing community benefits agreement including site clean-up and other ways of mitigating risks.

Need for non-traditional collaborations at different stages of a projects with experts.

Continued air quality as well as soil contamination monitoring of a site which further informs future baseline studies/standards.

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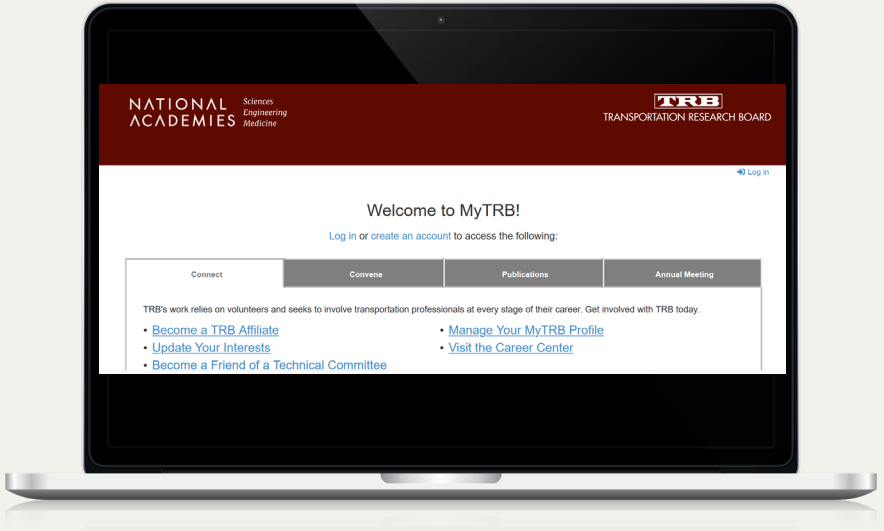

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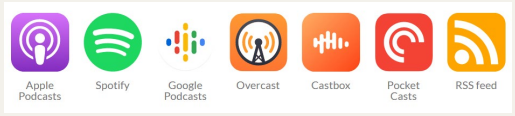

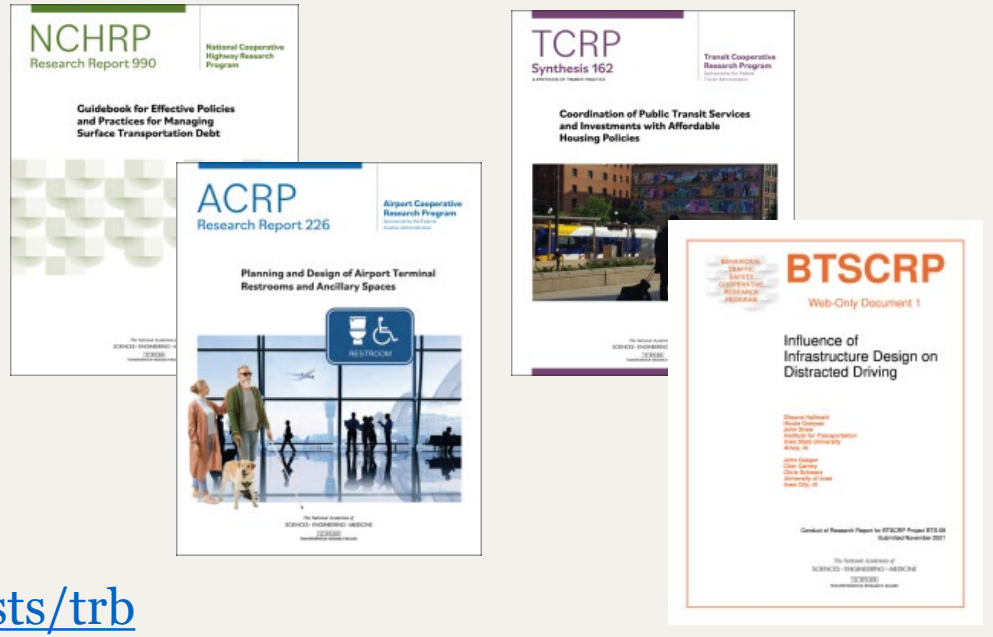

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