Wildfire Smoke and Public Health
- Why is the EPA Concerned?

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The Sand Fire Santa Clarita Valley July 2016. Credit: Kevin Gill/flickr

Clean Air Spaces: Indoor Air Filtration to Protect Public Health During Wildland Fires: What are the Known and Unknows?
Web Summit
Research Triangle Park June 12, 2019

Protection of Public Health

Assisting the States Address Environmental Challenges

- The Clean Air Act 1970 Title 1; Part A – protection of "public health" is noted 64 times – founded on the principle of **endangerment**
- In §7403 (Research) – "human health" is noted 9 times; "welfare" or "environment" 12 times; "training" 14 times; "multiple" pollutants and stressors" twice
- Protection of sensitive subpopulations

How does Wildland Fire Smoke Factor In?

- **Wildland fires are a national challenge impacting public health and environmental quality through complex multi-media pathways**
- **Uncontrolled wildfires and the use of prescribed fire are raising questions related to benefits and harms to:**
  - Ambient air quality
  - Water quality
  - Land management
  - Ecosystem services
  - Public health
  - Local economic health

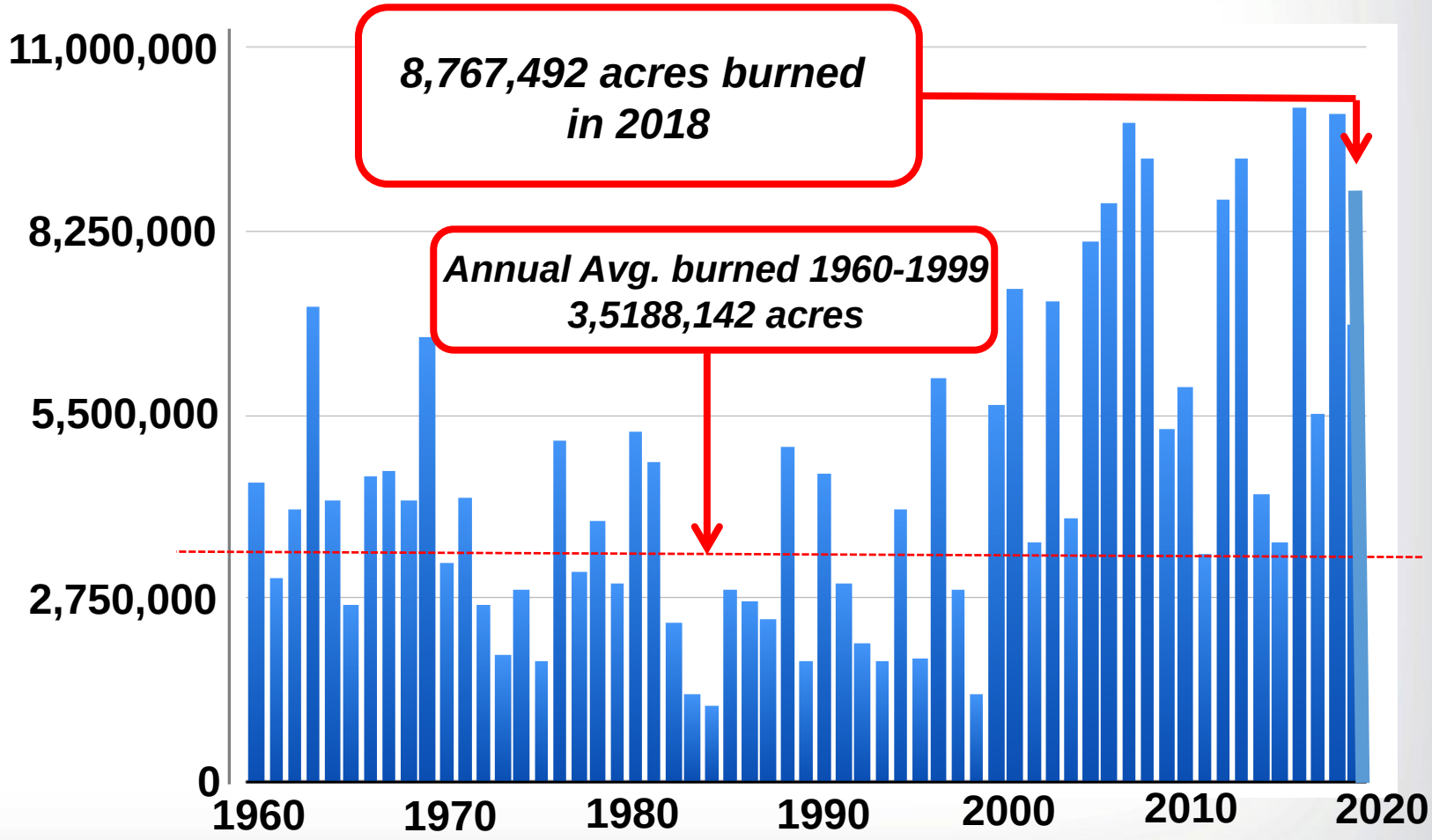

Colorado Springs, CO

Wildfire in the U.S.

Acreage Burned in the U.S. Annually

Present Concerns

- *Increasing acreage burned*
- *Increasing impact on urban areas*
  - *10% of all land with housing is situated in the wildland-urban interface*
- *Increased vulnerability of populations*
  - *Expanding WUI*
  - *Aging US population*
  - *Increasing chronic disease*



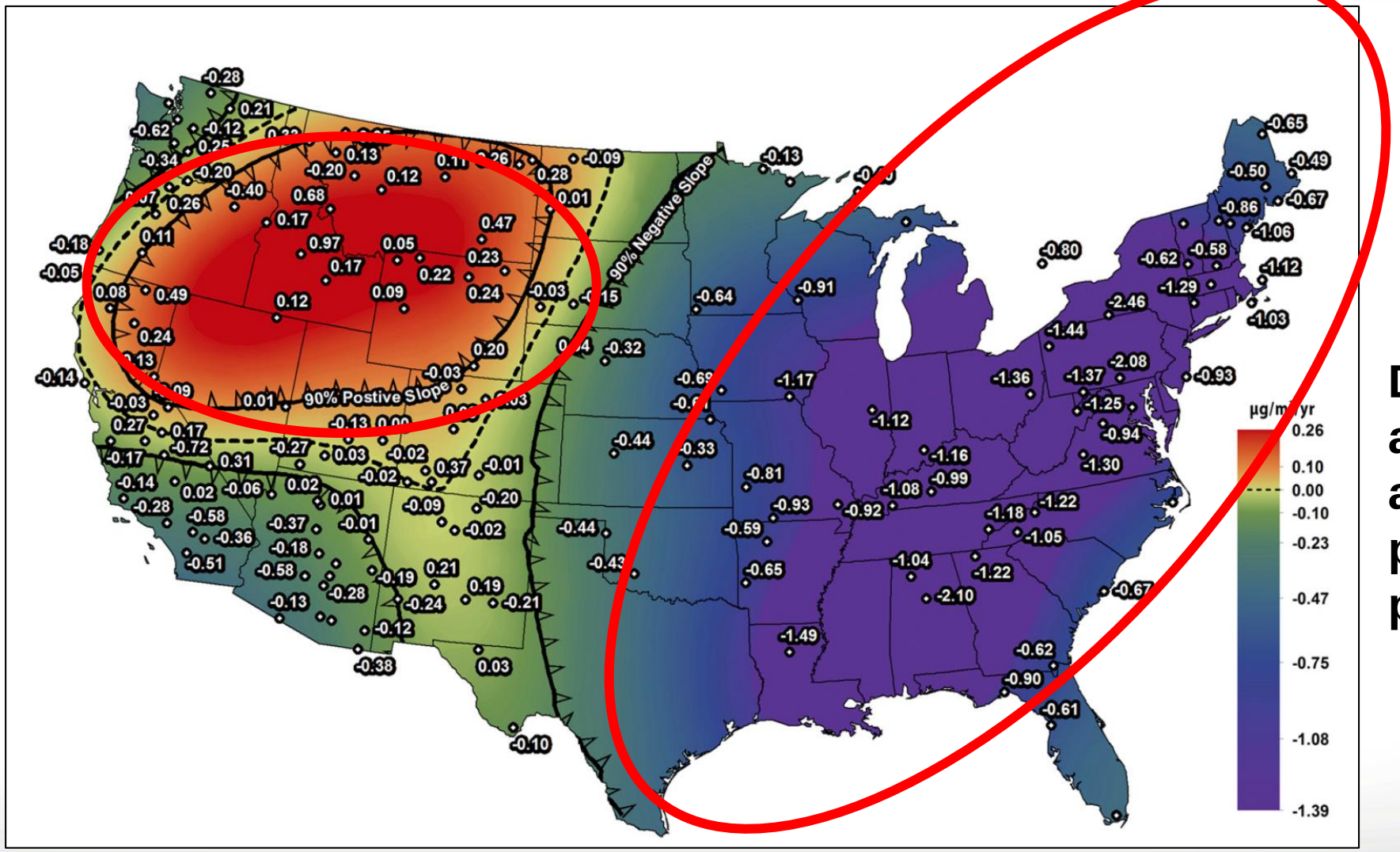
Adapted from https://www.nifc.gov/fireInfo/fireInfo_stats_totalFires.html

U.S. Air Quality Improves 1988-2016
Except in Wildfire-Prone Areas

Worsening Air Quality

$PM_{2.5}$

Increasing annual ambient air particle pollution



Improving Air Quality

$PM_{2.5}$

Decreasing annual ambient air particle pollution

McClure CD and Jaffe DA. PNAS 115 (31): 7901-7906, 2018

Air-Quality Impacts Extend Long Distances & Affect Urban Areas

Health Impacts Can Extend Hundreds of Miles

- **Forest fires in Quebec, Canada, during July 2002 (red circles)**
- **Baltimore, Maryland, a city nearly a thousand miles downwind**
- **30-fold increase in airborne fine particle concentrations**

Source: Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on the Terra satellite, Land Rapid Response Team, NASA/GSFC

Health Effects of Wildfire Smoke

Systematic Reviews are Now Available

Environmental Research 136 (2015) 120–132

Contents lists available at ScienceDirect

Environmental Research

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

Review

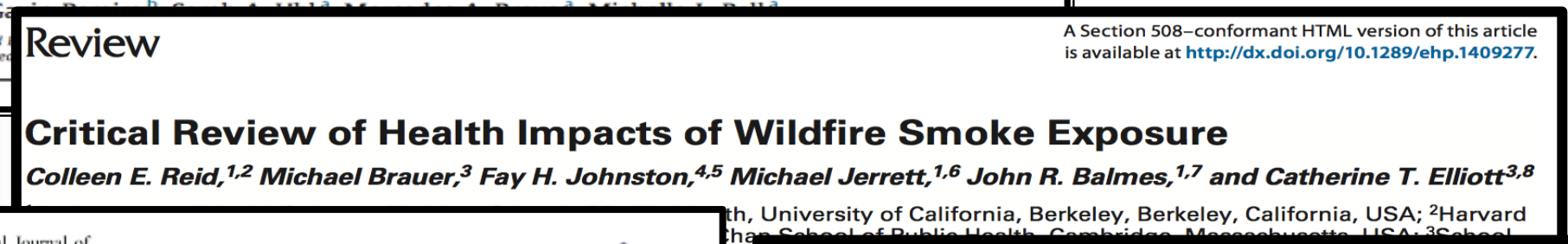
A systematic review of the physical health impacts from non-occupational exposure to wildfire smoke

Jia C. Liu [a,*], Ga

[a] School of Forestry and
[b] Center for Perinatal Pe

[Environ Res.](#)
2015;136:120-32

[Environ Health Perspect.](#)
2016; 124:1334–1343



Review

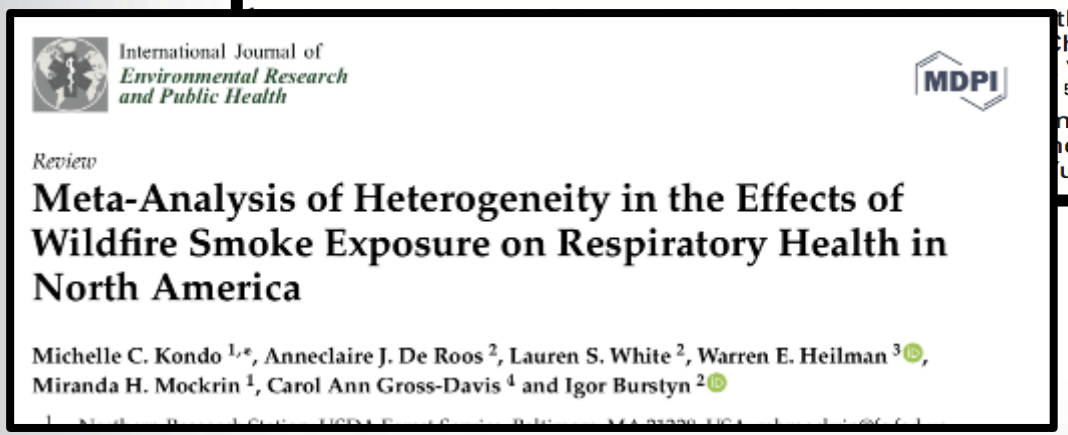
A Section 508–conformant HTML version of this article is available at http://dx.doi.org/10.1289/ehp.1409277.

Critical Review of Health Impacts of Wildfire Smoke Exposure

Colleen E. Reid,[1,2] Michael Brauer,[3] Fay H. Johnston,[4,5] Michael Jerrett,[1,6] John R. Balmes,[1,7] and Catherine T. Elliott[3,8]

th, University of California, Berkeley, Berkeley, California, USA; [2]Harvard

[Environ Toxicol Pharmacol.](#)
2017;55:186-195



International Journal of Environmental Research and Public Health

MDPI

Review

Meta-Analysis of Heterogeneity in the Effects of Wildfire Smoke Exposure on Respiratory Health in North America

Michelle C. Kondo [1,*], Anneclaire J. De Roos [2], Lauren S. White [2], Warren E. Heilman [3], Miranda H. Mockrin [1], Carol Ann Gross-Davis [4] and Igor Burstyn [2]

[Internat J Environ Res.](#)
2019; 16:690

Contents lists available at ScienceDirect

Environmental Toxicology and Pharmacology

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

Review or Mini-review

Wildfire smoke exposure and human health: Significant gaps in research for a growing public health issue

Carolyn Black[a], Yohannes Tesfaigzi[b], Jed A. Bassein[a], Lisa A. Miller[a,c,*]

Health Effects Linked to Smoke from Wildland Fires

Health effects known or suspected to be caused by wildland fire smoke

- *Symptoms such as eye irritation, sore throat, wheeze and cough*
- *Asthma & chronic obstructive pulmonary disease (COPD) exacerbations*
- *Bronchitis & pneumonia*
- *Childhood respiratory disease*
- *Cardiovascular outcomes*
- *Adverse birth outcomes*
- *All-cause mortality*

Who's at Risk from Smoke?

At-risk populations include –

- Pregnant women and fetuses
- Children
- Older populations
- Populations with pre-existing respiratory disease
- Populations with pre-existing cardiovascular disease

27% of U.S. population is at-risk

Populations suspected to be at greater risk –

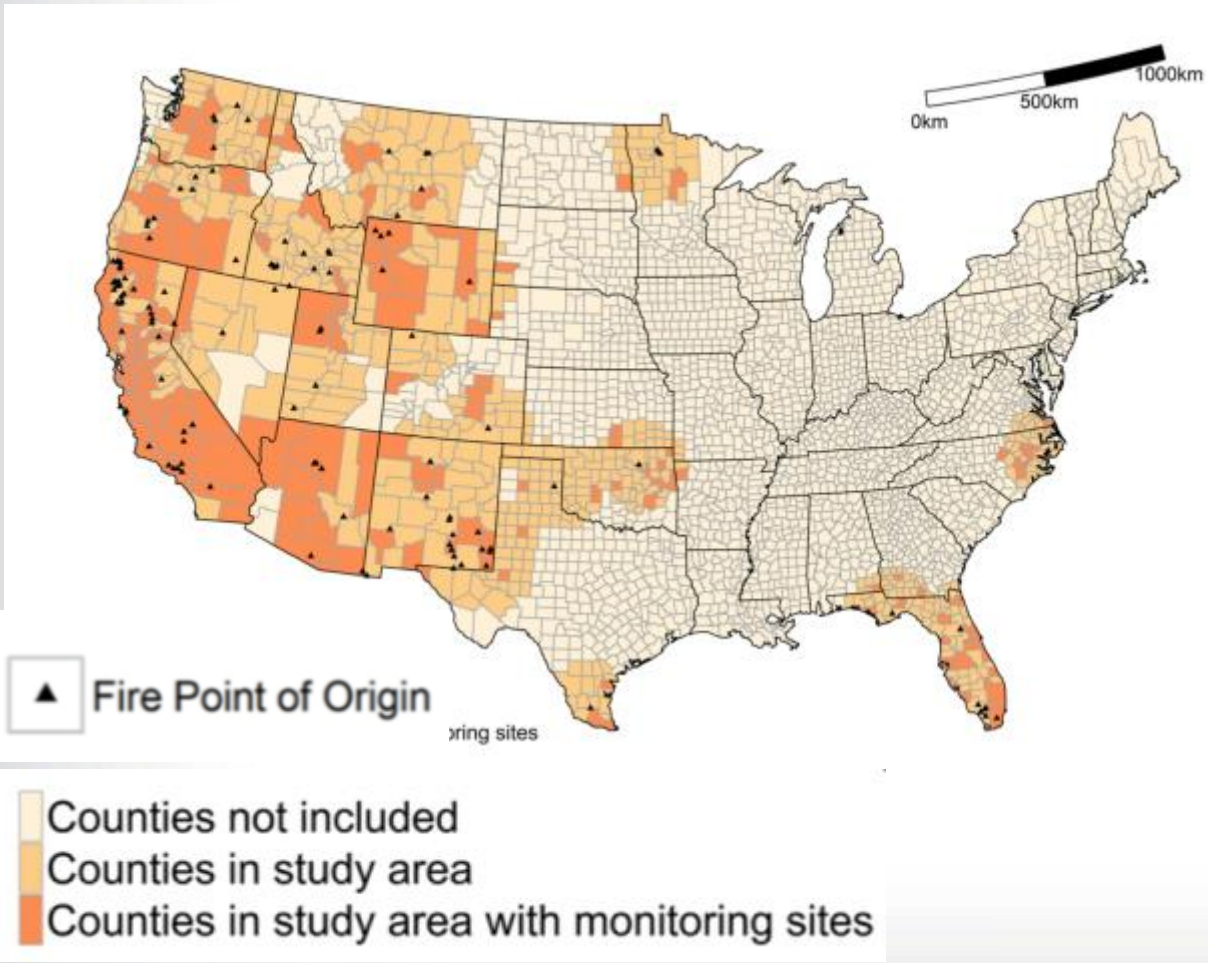
- Populations with chronic inflammatory diseases (e.g., diabetes, obesity)
- Women, African-Americans and populations with lower socio-economic status*

** Liu JC et al. Am J Epidemiol 2017*

Cardiac Effects of Fine Particulate Matter

Wildfire and Non-Wildfire Periods 2008-2010 in U.S.

Cardiopulmonary hospitalizations among adults ≥65 years



- ***Exposure to $PM_{2.5}$, on all days and locations, was associated with increased hospitalizations on smoke and non-smoke days.***
- ***Estimated effects persisted across multiple exposure days.***
- ***CV outcomes increased by 0.61% on smoke days and 0.69% on non-smoke days.***
- ***No apparent difference between wildfire and non-wildfire $PM_{2.5}$***

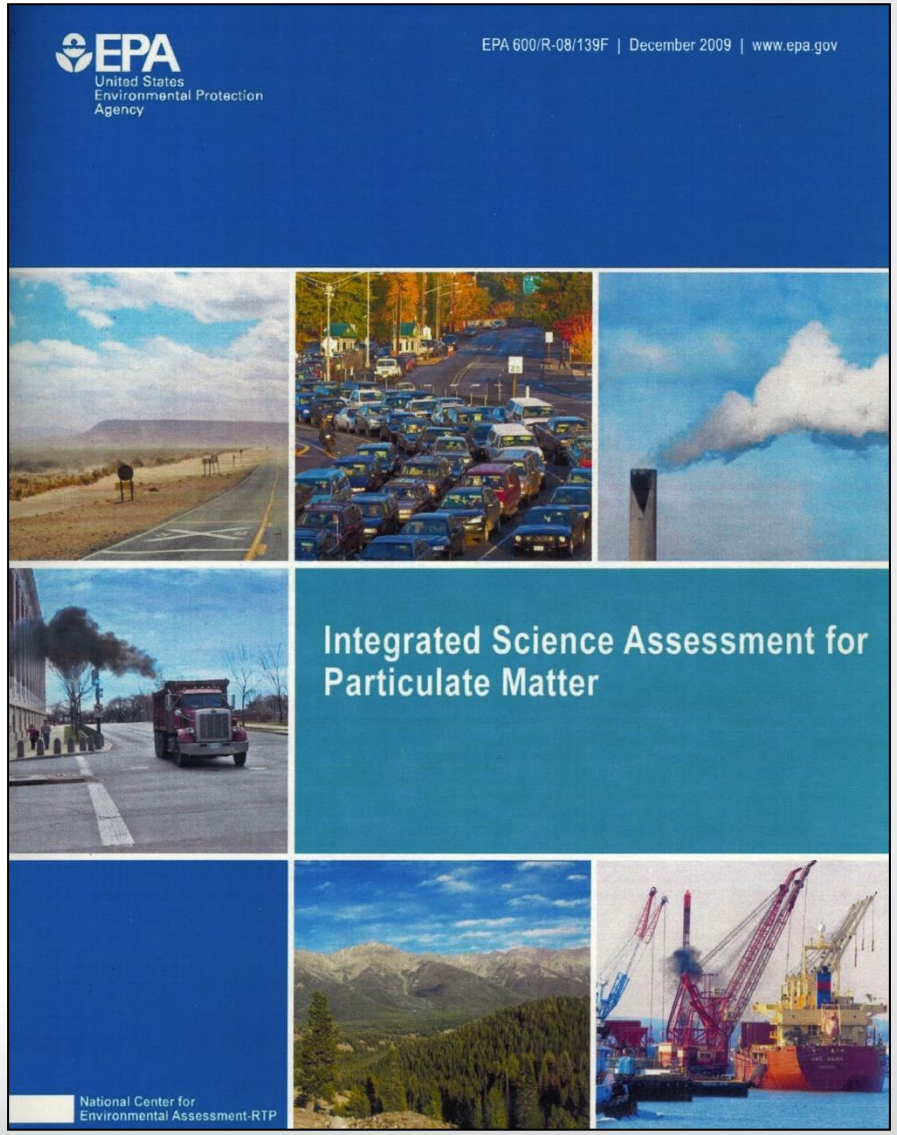
DeFlorio-Barker Environmental Health Perspectives 2019

$PM_{2.5}$ Causes Cardiovascular Mortality and Morbidity

EPA:

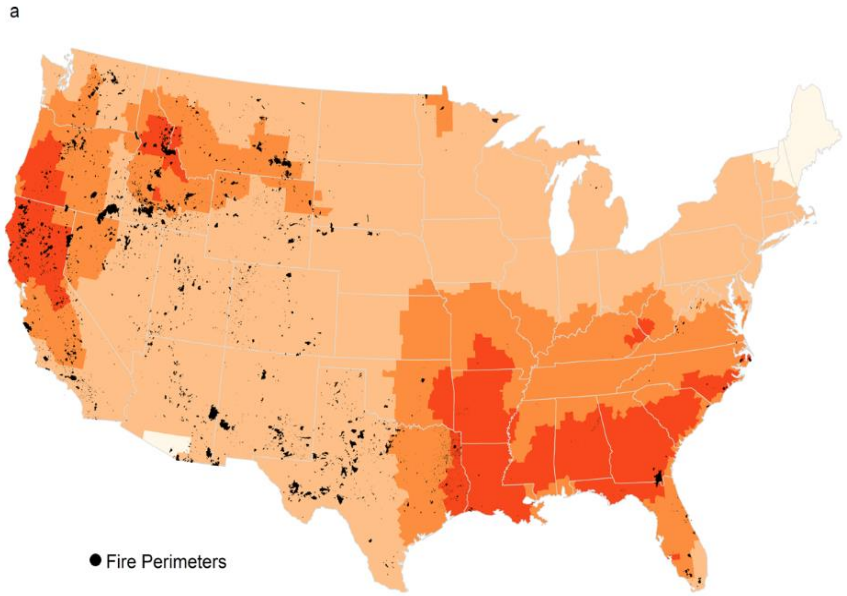
"Epidemiologic evidence is sufficient to conclude that a causal relationship exists between: ***short-term and long-term exposure to $PM_{2.5}$ and cardiovascular mortality."***

Integrated Science Assessment (ISA) for Particulate Matter 2009



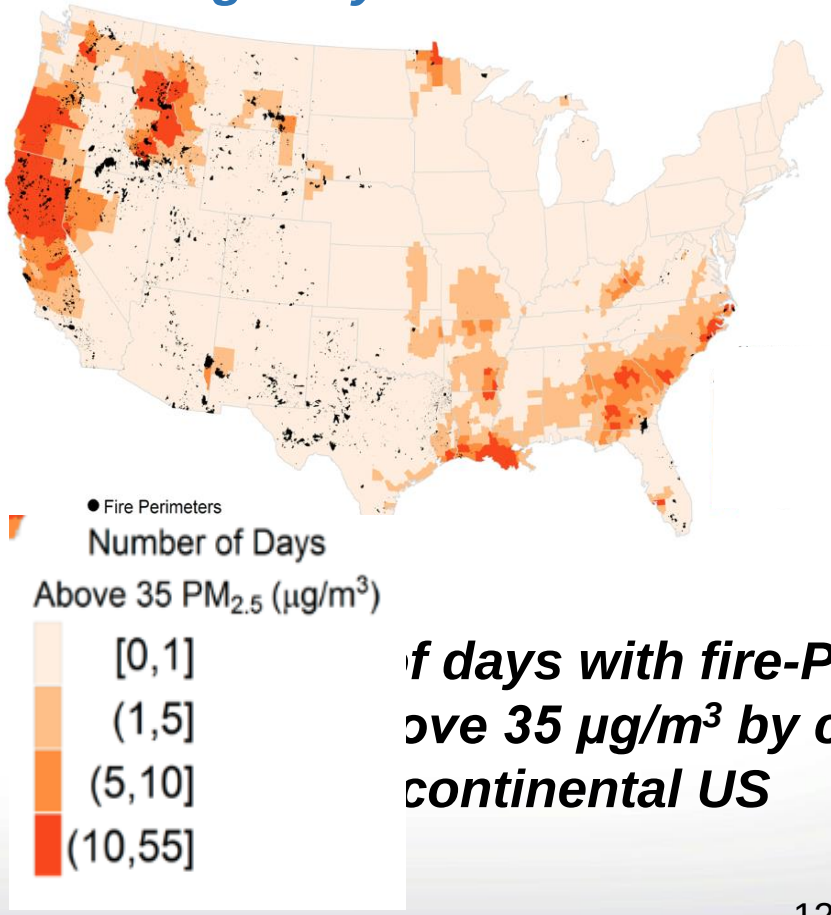
Air Quality Impacts of Wildland Fires

Annual average daily fire-$PM_{2.5}$ footprint for US counties



Health protective standards
Annual: 12 µg/m³ daily avg.
Daily: 35 µg/m³

How much does smoke contribute to air quality and how often does it lead to exceeding daily standard?



f days with fire-$PM_{2.5}$
ove 35 µg/m³ by counties
continental US

Rappold AG, et al Environ Sci Technol 2017

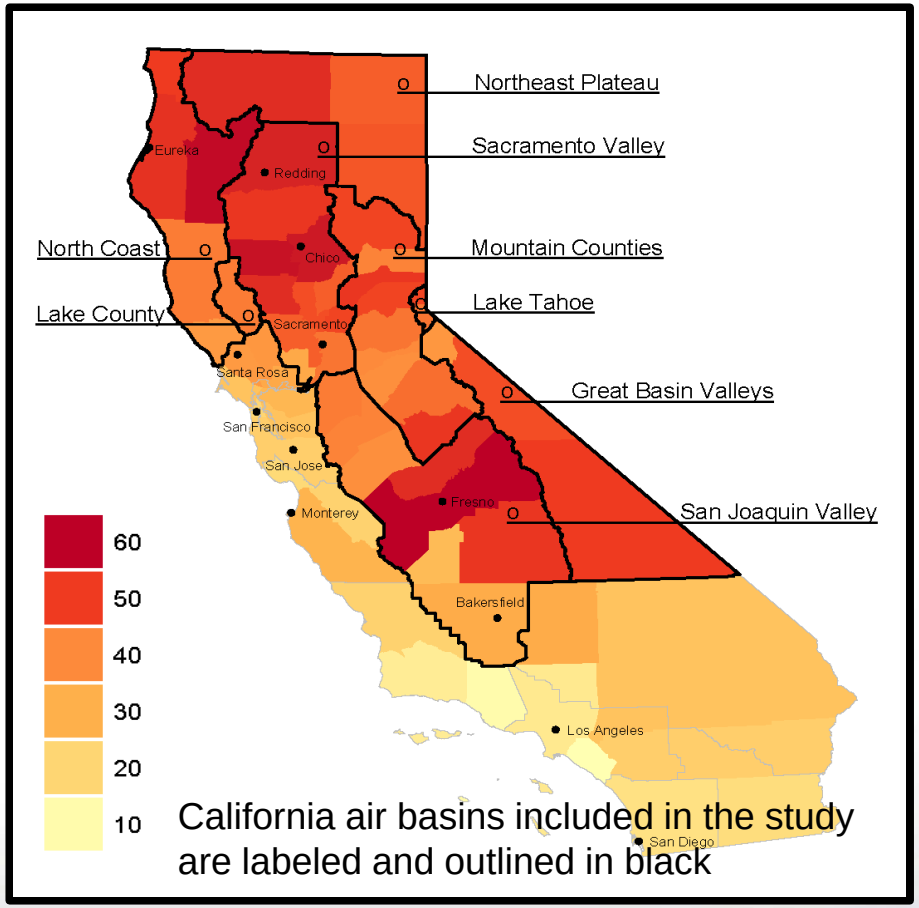
Measuring the Health Effects of Wildfire Smoke

California 2015 Wildfire Study

Epidemiology study designed to examine respiratory, cardiovascular, & cerebrovascular health effects of wildfire smoke

- *Associated wildfire-$PM_{2.5}$ exposure with emergency department visits for cardiovascular and respiratory diagnoses*

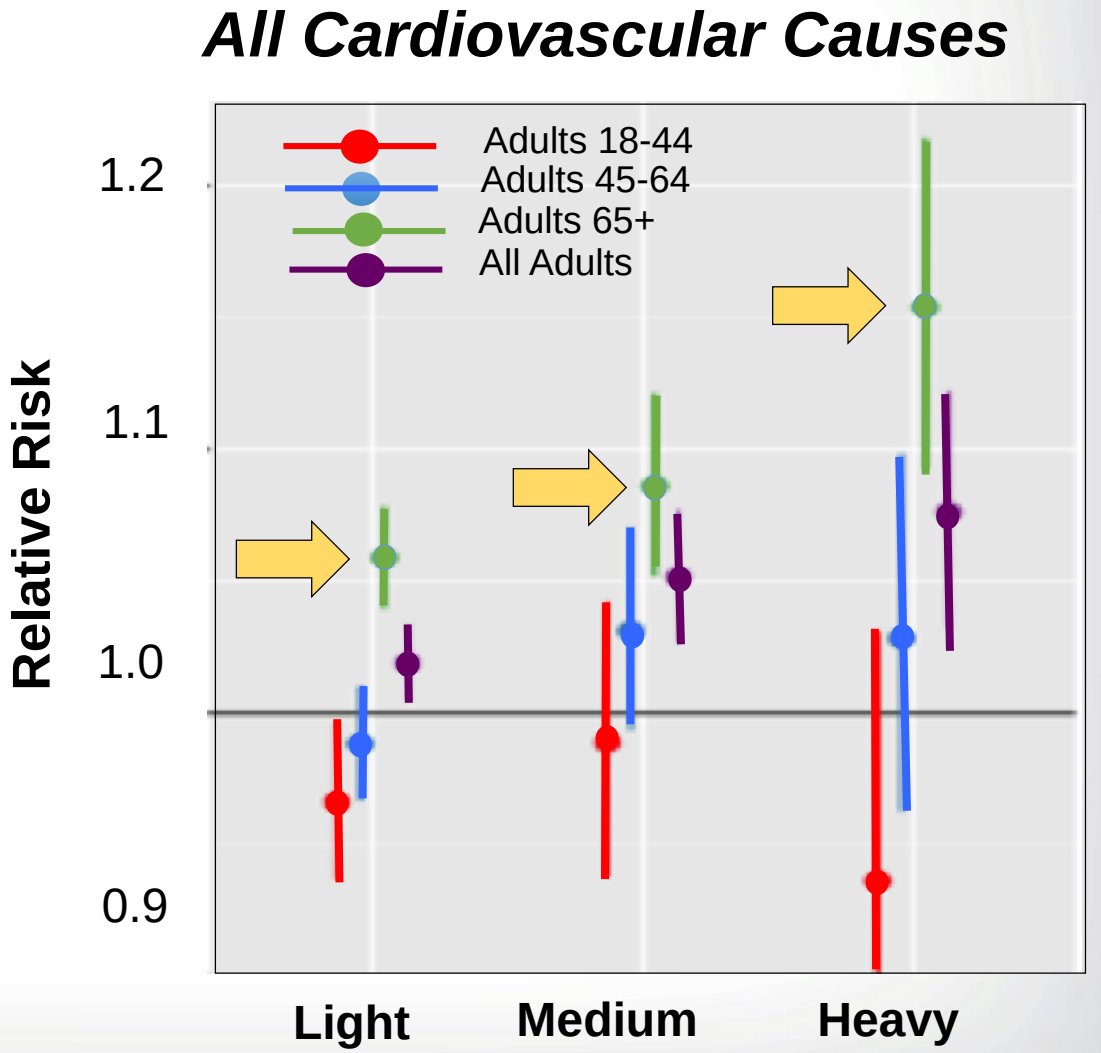
Smoky days/county during the study: May through September 2015



Wettstein Z, Hoshiko S, Cascio WE, Rappold AG et al. JAHA 2018

Wildfire-$PM_{2.5}$ Exposure Increases Heart Attack & Stroke

- ***Wildfire-$PM_{2.5}$ associated with heart attacks and strokes for all adults, particularly for those over 65 years old***
- ***Increase in risk the day after exposure:***
  - **All cardiovascular, 12%**
  - **Heart attack, 42%**
  - **Heart failure, 16%**
  - **Stroke, 22%**
  - **All respiratory causes, 18%**
  - **Abnormal heart rhythm, 24%**
    (on the same day as exposure)



Wettstein Z, Hoshiko S, Cascio WE, Rappold AG et al. JAHA April 11, 2018

Air-Quality Impacts
Urban Areas, at a Distance, High Exposures

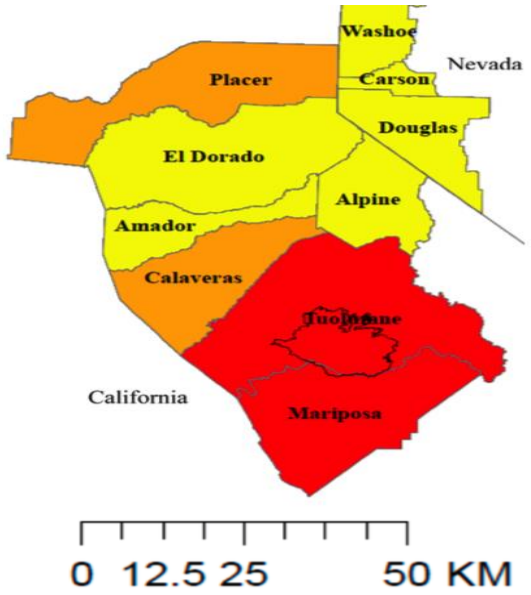
2013 California Rim Fire

Daily mass intake breathing PM at the EPA 24 hr $PM_{2.5}$ standard (35µg/m³) = 486 µg $PM_{2.5}$/day

Navarro KM *et al. Environ Sci Tech* 2016

Affected Californian Counties

Aug. 30 – Sep. 10



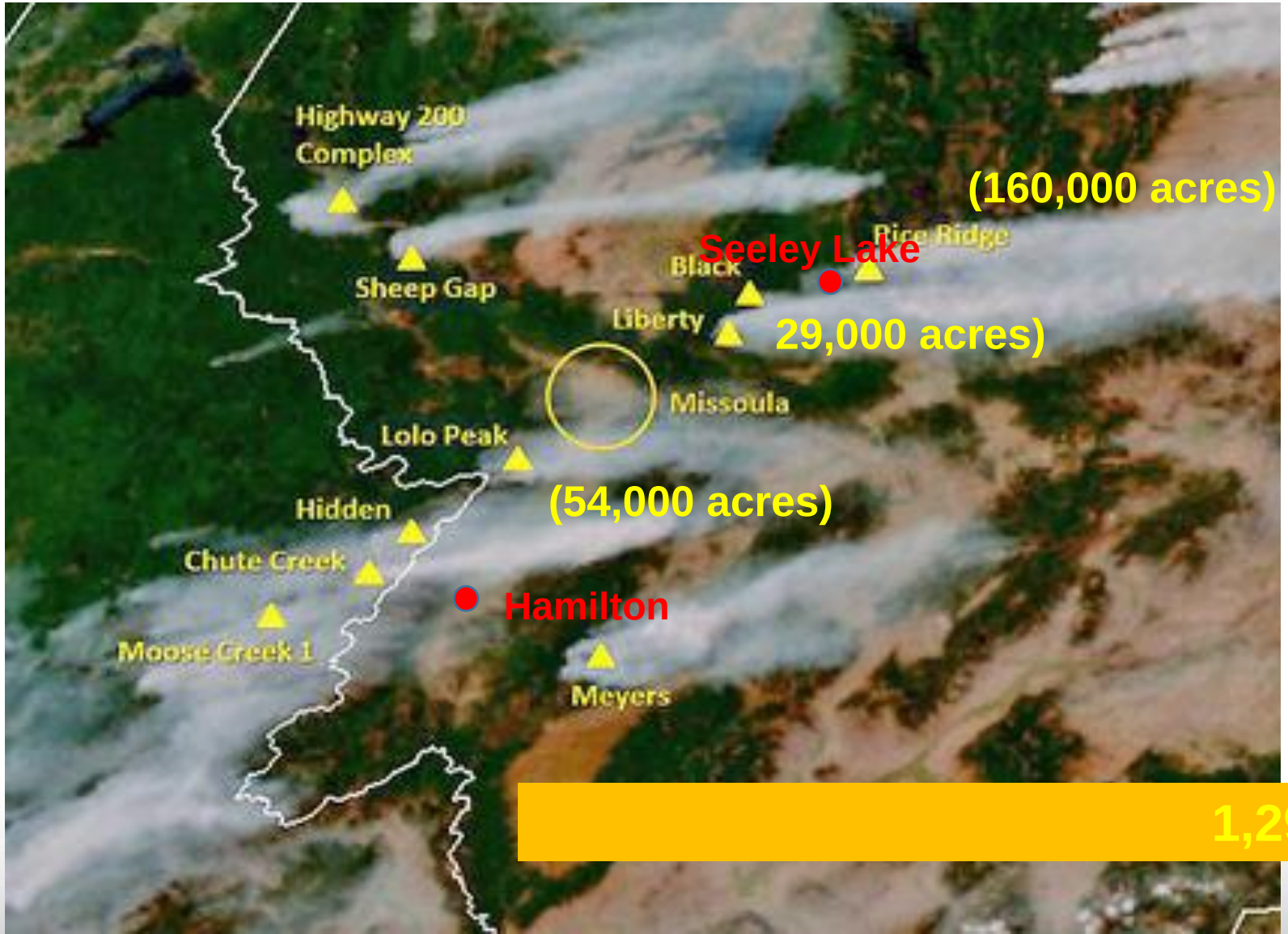
Daily Mass Intake
µg $PM_{2.5}$ per Person

- **0 – 486**
- **487 – 1,459**
- **1,460 – 2,919**
- **2,920 – 18,141**

Exposure up to 35 times greater than the 24 hr $PM_{2.5}$ standard

Seeley Lake Montana 2017 Wildfire Season

Raised a New Public Health Issue Prolonged Exposure

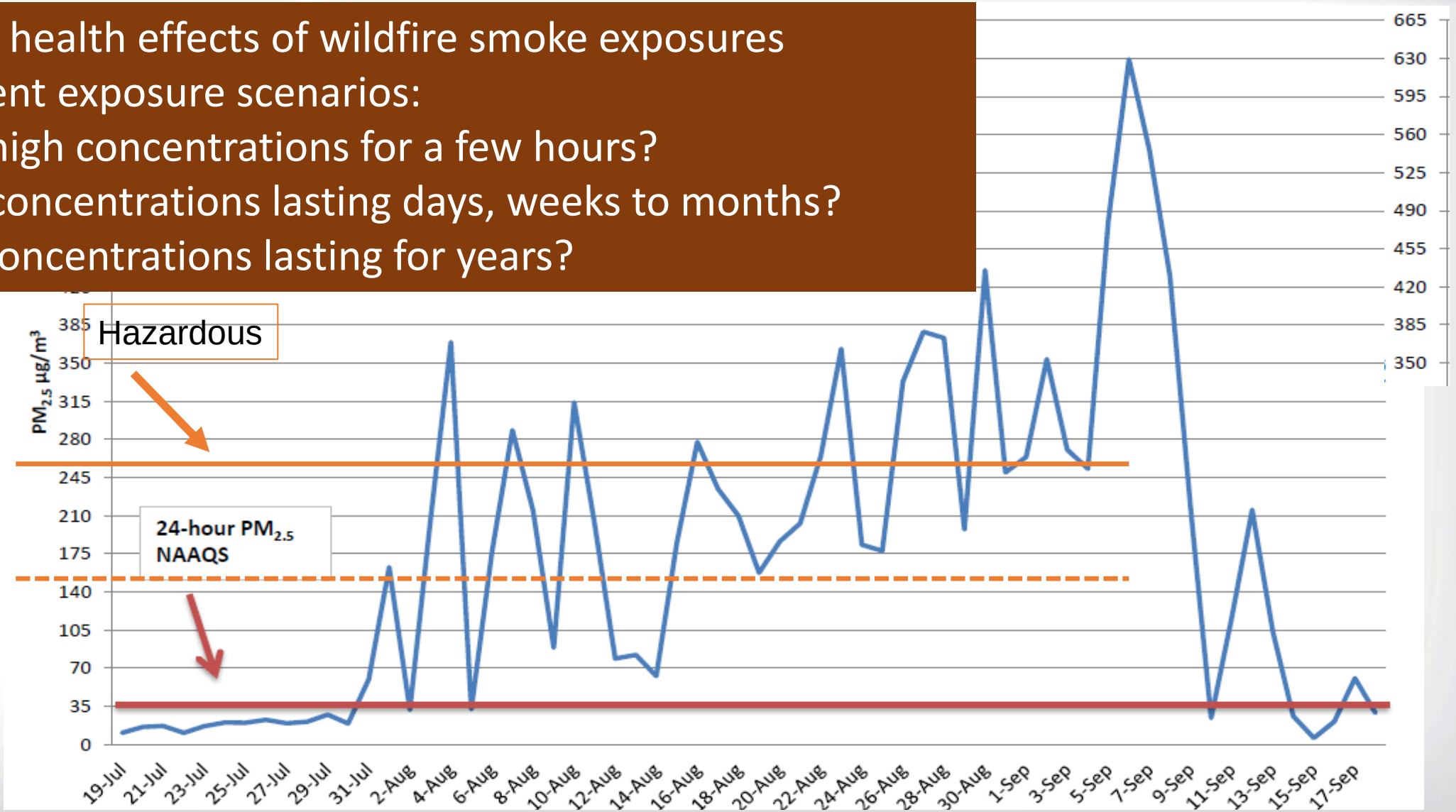


Courtesy of
Dr. Paul Smith
Missoula, MT

Seeley Lake 2017 Wildfire Season
Average 24-hour $PM_{2.5}$ Concentration

What are the health effects of wildfire smoke exposures under different exposure scenarios:

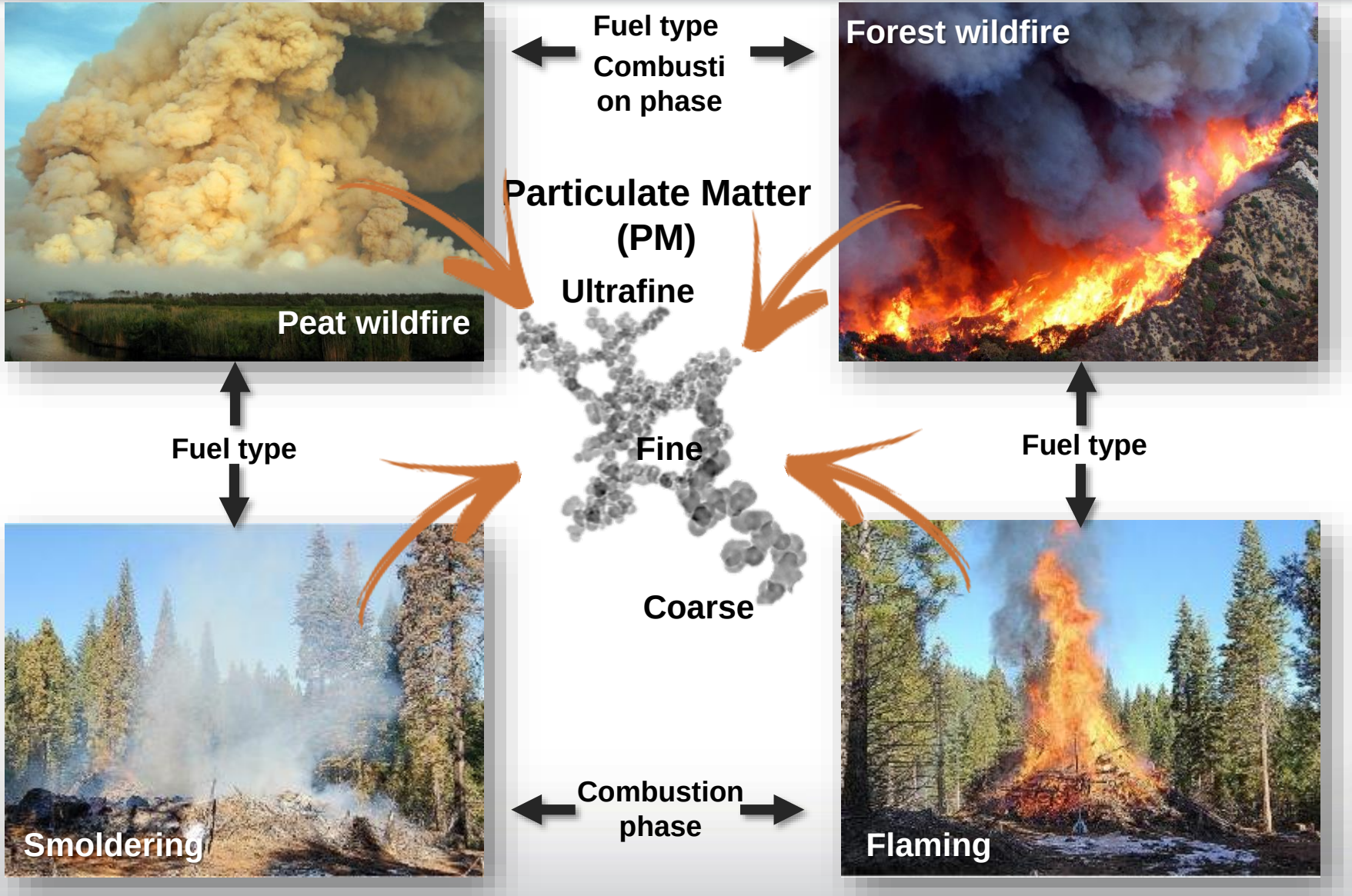
- Very high concentrations for a few hours?
- High concentrations lasting days, weeks to months?
- Low concentrations lasting for years?



Courtesy of
Dr. Paul Smith
Missoula, MT

Different Types of Wildfire Smoke

Do Different Fuels Have Different Toxicity Profiles?

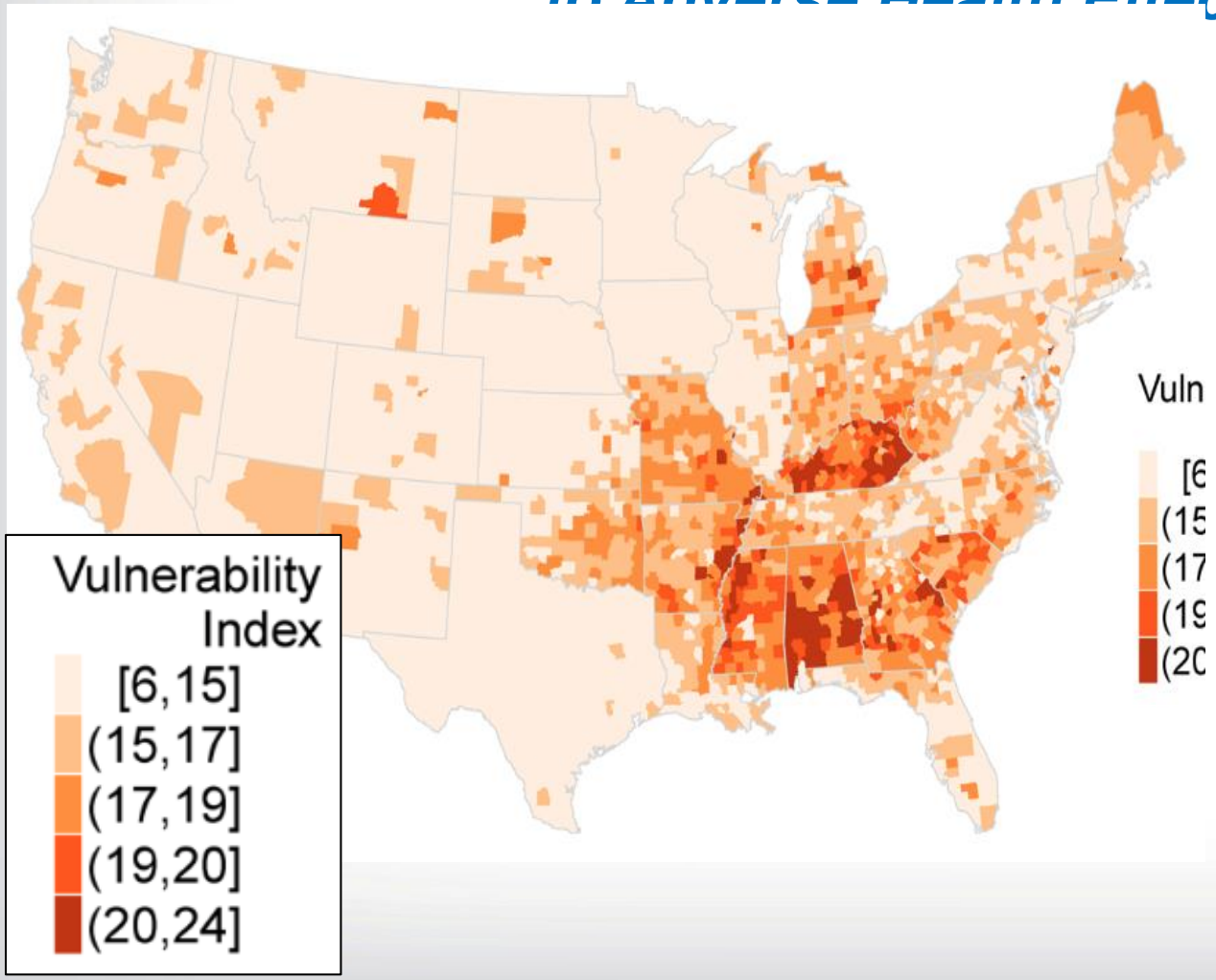


Courtesy of
Dr. Ian Gilmour

Community Health-Vulnerability

Community-Health Vulnerability Index

National map of Community-Health Vulnerability Index to Adverse Health Effects from Wildfire Smoke



The Community Health-Vulnerability Index identifies the most vulnerable counties:

- shows that these communities experience more smoke exposures in comparison to less vulnerable communities
- may help prepare responses, increase the resilience to smoke and improve public health outcomes during smoke days

Rappold AG, et al Environ Sci Technol 2017

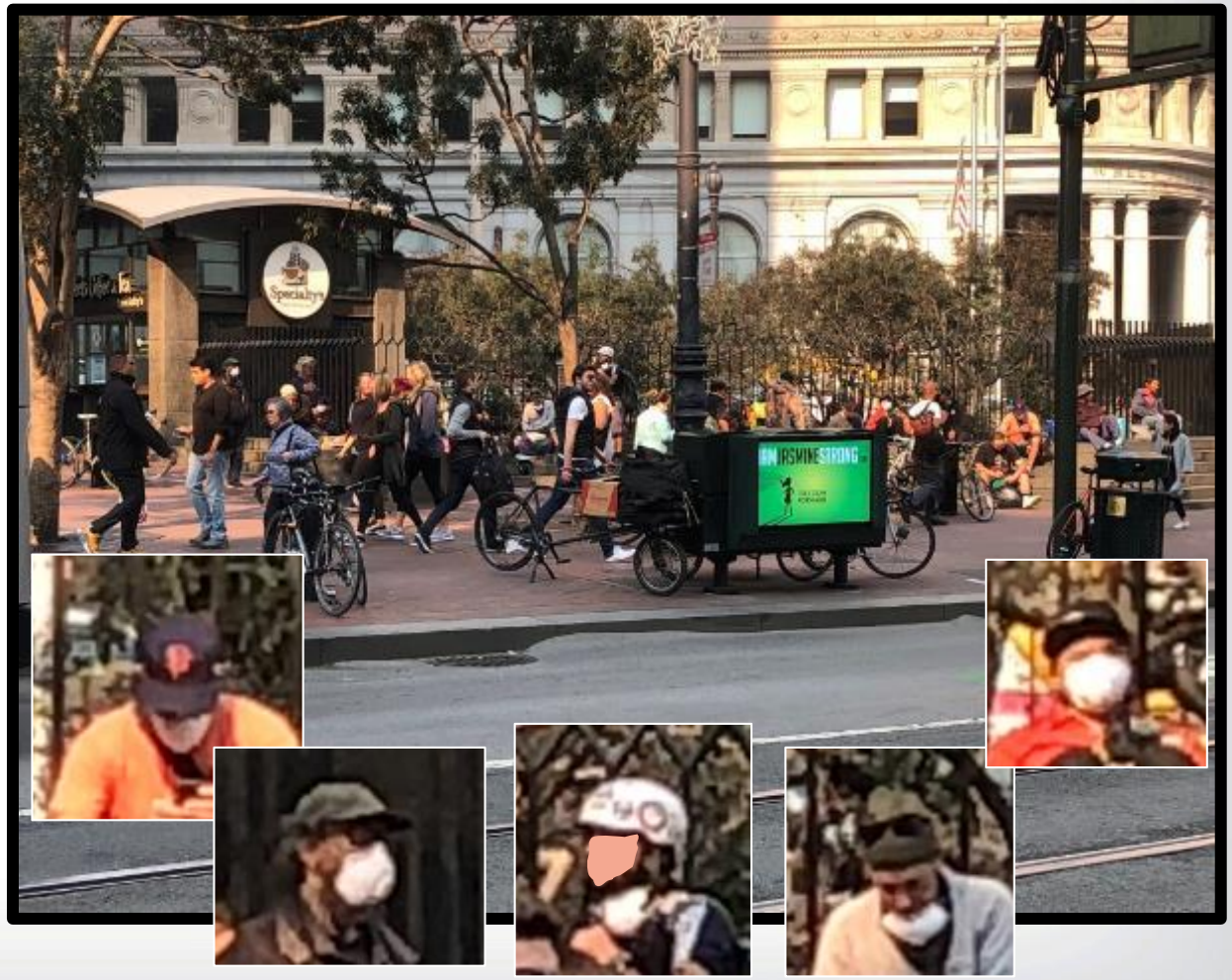
What Interventions Are Effective and Practical?

California Camp Fire – San Francisco November 9, 2018

Golden Gate Bridge from Lands End Trail

Air Quality Index 156 Unhealthy

N-95 Use on Market Street, San Francisco



Cardiovascular and Lung Disease in the U.S.
Size of the Vulnerable Population

Cardiovascular Disease

- **Number of adults with diagnosed cardiovascular disease 121 million (48%)**
- **Number of adults with diagnosed heart disease: 28.2 million (11.5%)**

Lung Disease

- **Number of adults with diagnosed chronic bronchitis: 8.6 million**
- **Number of adults diagnosed with emphysema: 3.4 million (1.4%)**

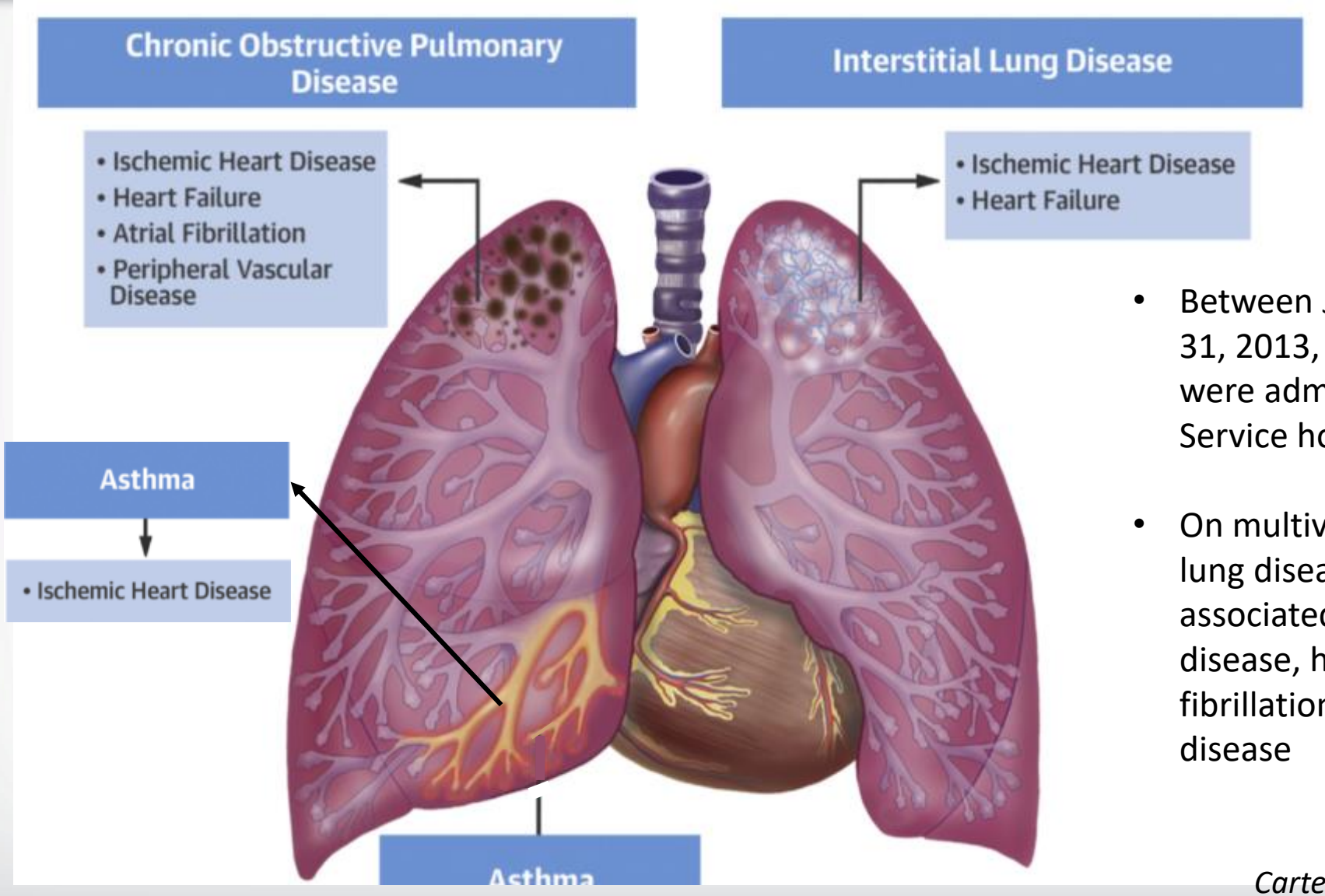
By 2035 –

- **More than 130 million adults, or 45.1% of the US population, are projected to have some form of CVD.**

- **Total costs of CVD are expected to reach $1.1 trillion in 2035, with direct medical costs projected to reach $748.7 billion and indirect costs estimated to reach $368 billion.**

Source: CDC Fast Facts, and American Heart Association Published: Jan. 31, 2019

Chronic Lung Diseases are Independently Associated with Heart Disease

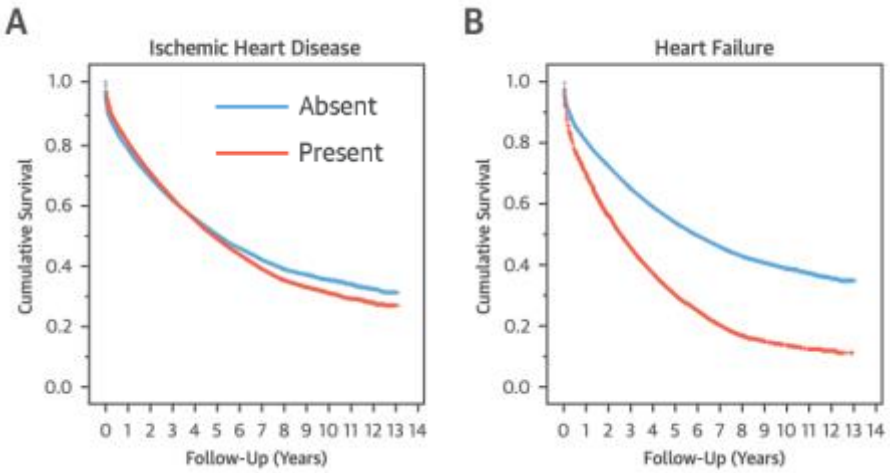


- Between January 1, 2000, and March 31, 2013, patients with lung diseases were admitted to 7 National Health Service hospitals NW England.
- On multivariable analysis, chronic lung diseases are independently associated with ischemic heart disease, heart failure, atrial fibrillation, and peripheral vascular disease

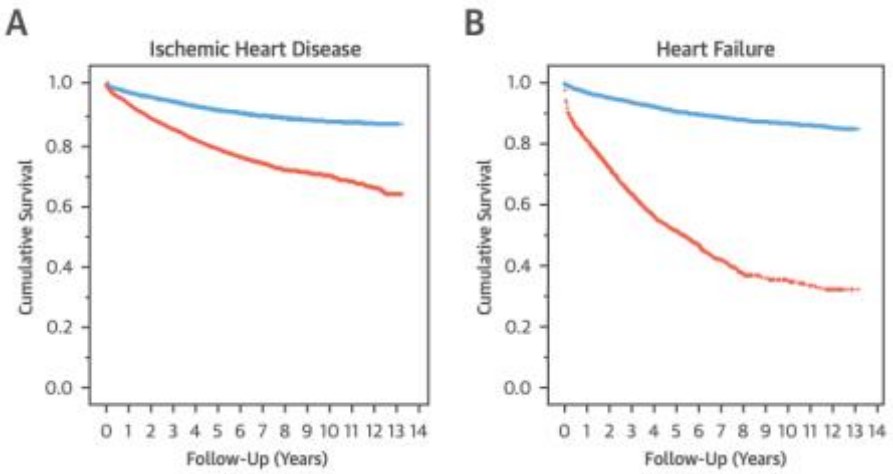
Carter P, et al. J Am Coll Cardiol 2019

Survival in Chronic Lung Diseases is Impacted by Heart Disease

Impact of Cardiovascular Diseases on All-Cause Mortality in COPD



Impact of Cardiovascular Diseases on All-Cause Mortality in Asthma



Kaplan-Meier survival curves illustrate the impact of heart disease on survival among patients with lung diseases.

COPD 31,646 Patients with follow-up of 5.2±3.6 years

53% (16,812 patients) died.

Ischemic heart disease, heart failure, AF & peripheral vascular disease were independently associated with death.

Asthma 60,424 Patients with follow-up of 5.2±3.6 years

11% (6,649 patients) died.

Ischemic heart disease and heart failure were independently associated with death.

Carter P, et al. J Am Coll Cardiol 2019

Annual Personal Health Care Spending in U.S. for Chronic Disease is High

COPD	$ 53.8 billion	$136.5 billion
Asthma	$ 32.5 billion	
Pneumonia	$ 37.1 billion	
Lung cancer	$ 13.1 billion	
Ischemic heart disease	$ 88.1 billion	$274.7 billion
High blood pressure	$ 83.9 billion	
Stroke	$ 43.8 billion	
Heart failure	$ 28.5 billion	
Atrial fibrillation	$ 27.7 billion	
Peripheral vascular disease	$ 2.7 billion	
Diabetes	$101.4 billion	$101.4 billion
Preterm birth	$ 4.9 billion	

½ Trillion Dollars in 2013

Dieleman JL et al.
JAMA 2016

Wildfire Smoke and/or PM Exposure is a Risk Factor for Each

Wildfire Smoke Research Needs for Better Public Health Protection

- Establish more reliable exposure estimates and non-pulmonary health effects of wildfire emissions
- Identify biomarkers of exposure and health effects
- Identify intrinsic factors that increase susceptibility to wildfire smoke
- Identify built environment and socio-demographic factors that increase a community's susceptibility to wildfire smoke-related health responses

Wildfire Smoke Research Needs for Better Public Health Protection

- **Determine health effects associated with combustion of different types of biomass and those involving structures**
- **Evaluate effectiveness of clinical and public health intervention strategies to reduce short-term exposures in those at highest-risk and long-term exposures in all**

Thank you

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- No conflicts of interest
- The presentation represents the opinions of the speaker and does not necessarily represent the policies of the US EPA