Where There's Wildfire, There's Smoke

John R. Balmes, MD

University of California,

San Francisco and Berkeley

Joint Medical Program

University of California Berkeley

University of California at San Francisco

Outline

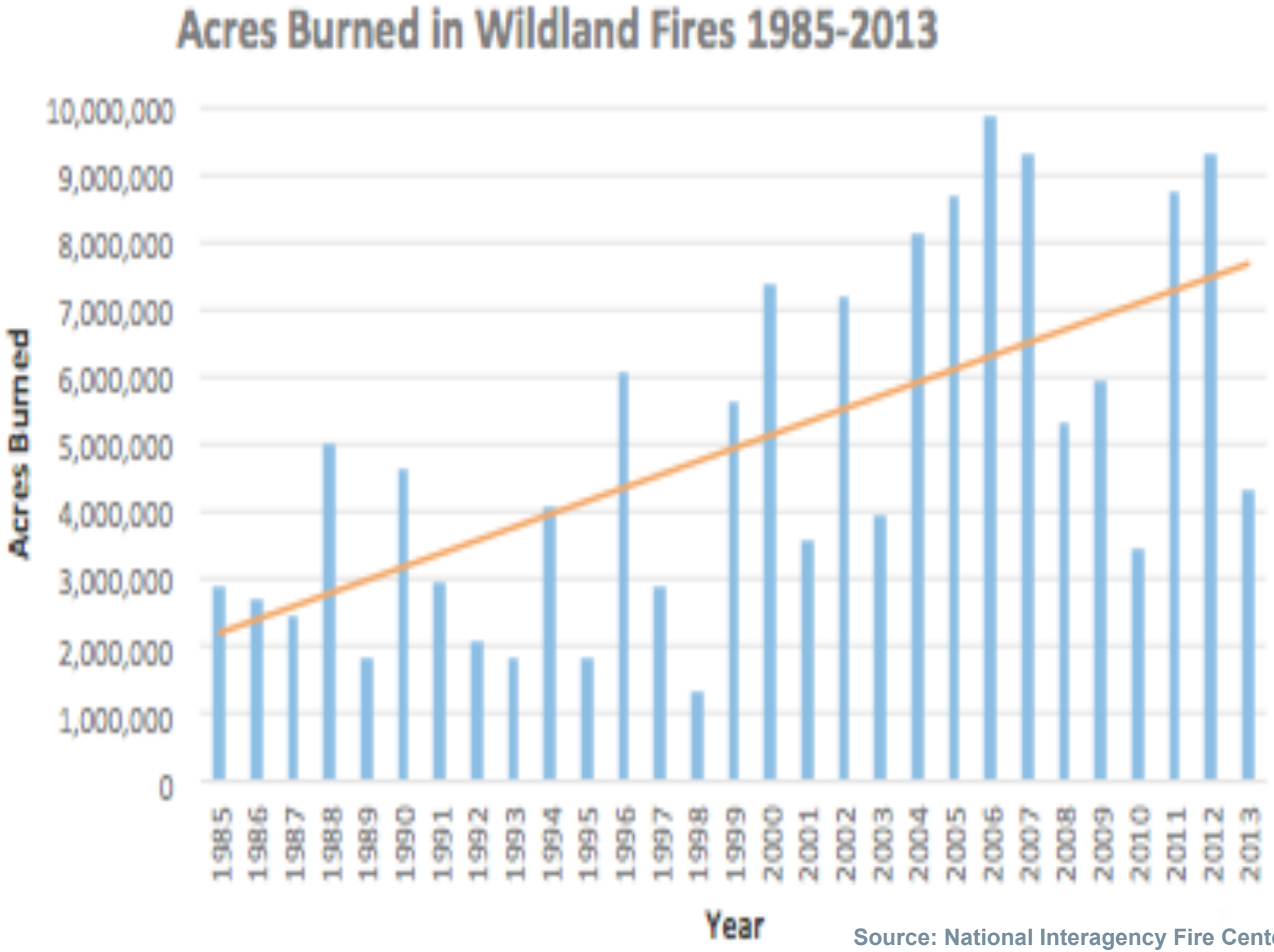
- Wildfire
- Climate Change
- What's in wildfire smoke
- Health effects
- Public health messaging
- Post-fire issues
- Prevention

Wildfire

Sonoma-Napa Wildfires – Oct. 2017

Southern CA Wildfires – Dec. 2017

Carr, Mendocino Complex, and Camp Fires - 2018



Source: National Interagency Fire Center

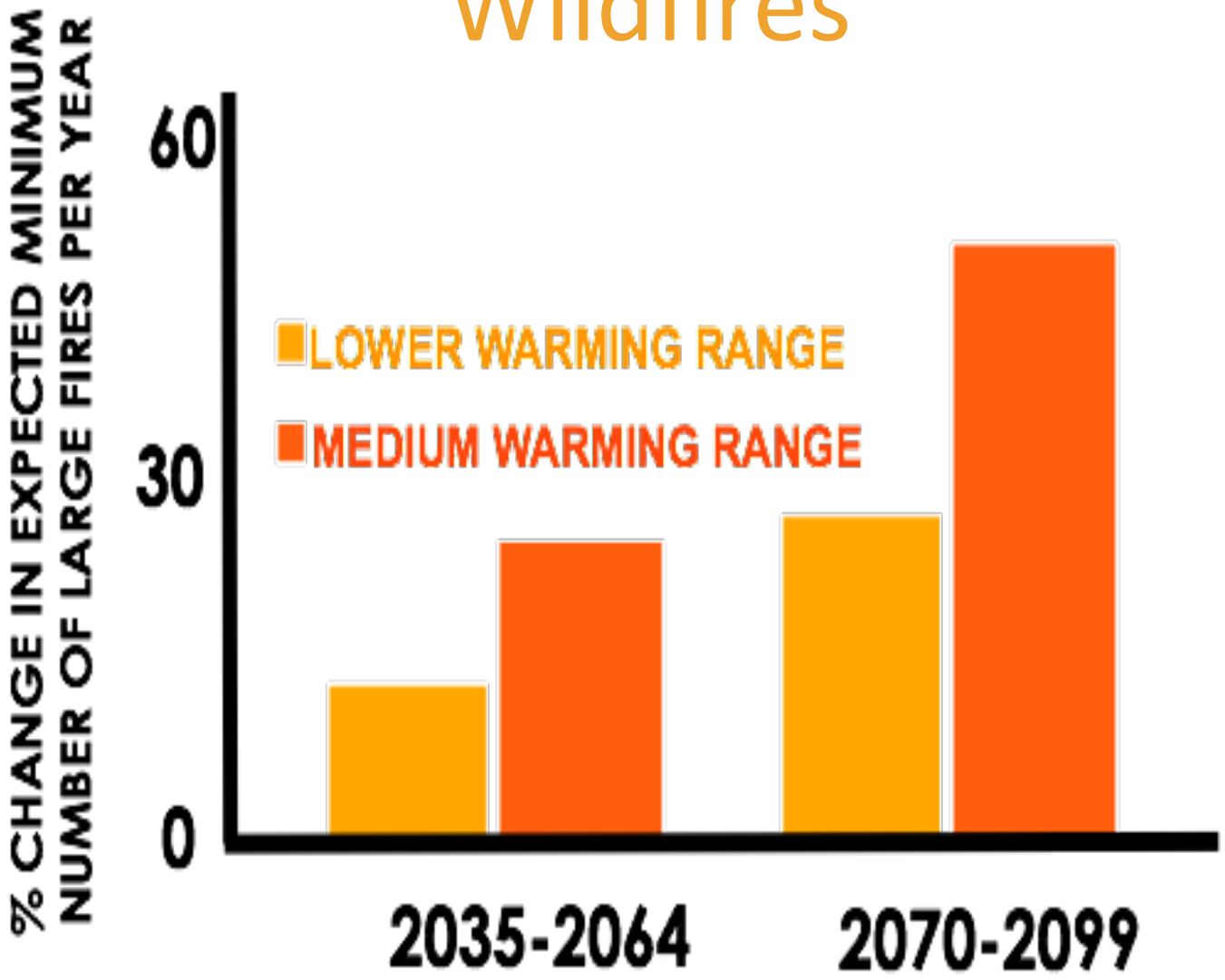
2017 and 2018 were Bad Wildfire Years - Why?

- 5 years of drought 2011-2016; many dead trees
- *El Nino w*inter of 2017 brought lots of rain, ending the drought
- Increased growth of vegetation in spring
- Normally dry and very hot summer weather generating lots of fuel
- Lack of rain in fall

2017 and 2018 were Bad Wildfire Years - Why?

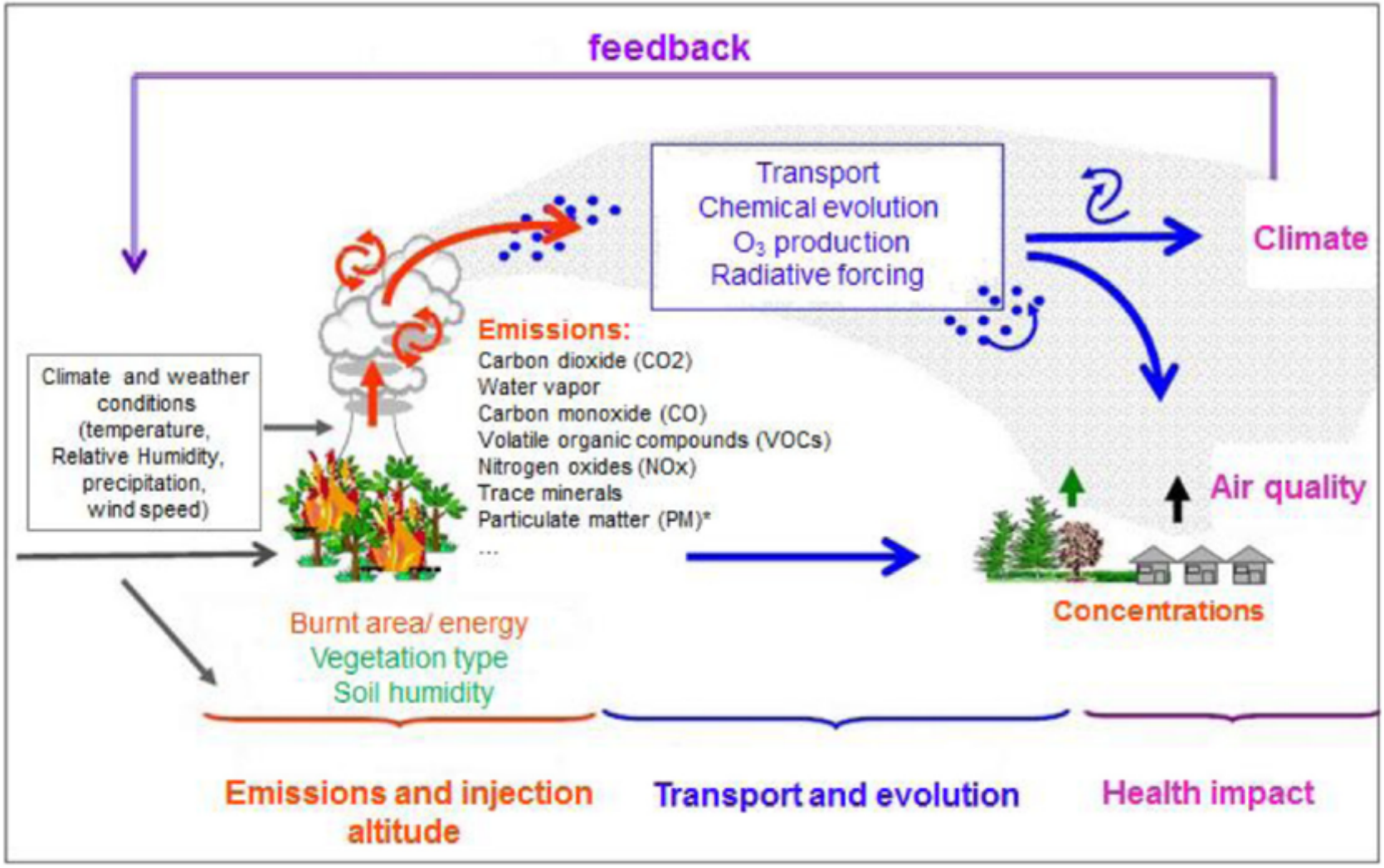
- 5 years of drought 2011-2016; many dead trees
- *El Nino w*inter of 2017 brought lots of rain, ending the drought
- Increased growth of vegetation in spring
- Normally dry and very hot summer weather generating lots of fuel
- Lack of rain in fall

Climate Change and Increase in Wildfires



Source of data : Westerling and Bryant, "Climate change and wildfire in and around California: Fire modeling and loss modeling" (2006), *www.climatechange.ca.gov*

Wildfire emissions and related health impacts

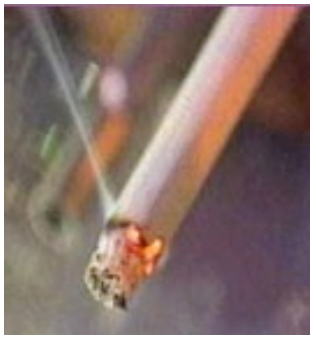


Youssouf et al. Atmospheric Environment 2014;97:239-251

Emissions from Wildfires

Primary air pollutants
- Particulate Matter (PM)
- CO
- NO_2
- Polycyclic aromatic hydrocarbons (PAHs)
- Volatile organic compounds (VOCs)

Secondary air pollutants
- Particulate Matter (PM)
- Ozone



Coffey Park neighborhood burning

When Buildings and Vehicles Burn

- Structural fire smoke contains other toxic air contaminants, including
  - HCN, HCl, phosgene, metals
  - toluene, styrene, dioxins

- The Sonoma-Napa, Thomas, and Camp fires caused many buildings and motor vehicles to burn
  - Local residents exposed to more than wood smoke

Australian Bush Fires

- 16 million acres have burned (8 times what burned in California in 2018
- Fires are in populated areas with more than 2500 homes destroyed
- Poor air quality in Sydney, Melbourne, Canberra, and New Zealand
- Climate-forcing emissions = 8 months from man-made sources

Acute health impacts of short-term community wildfire smoke exposures

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]

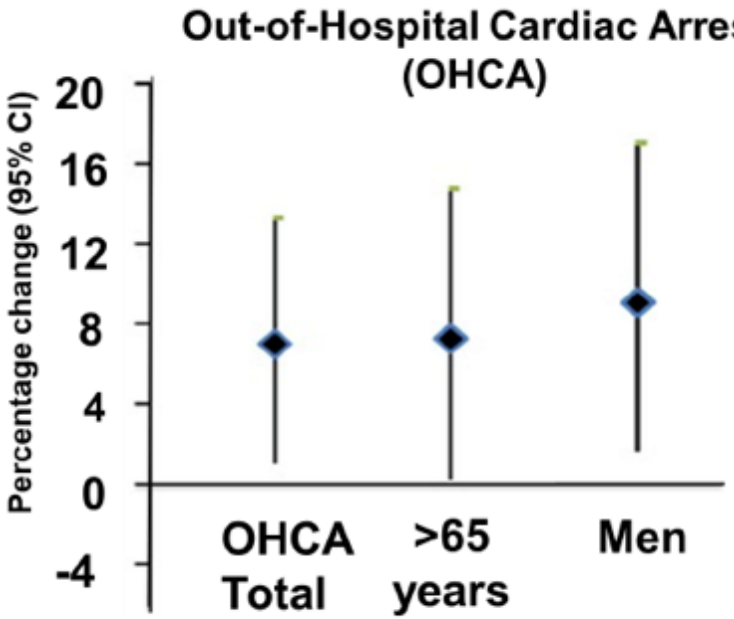
Environ Health Perspect 2016;124:1334–1343

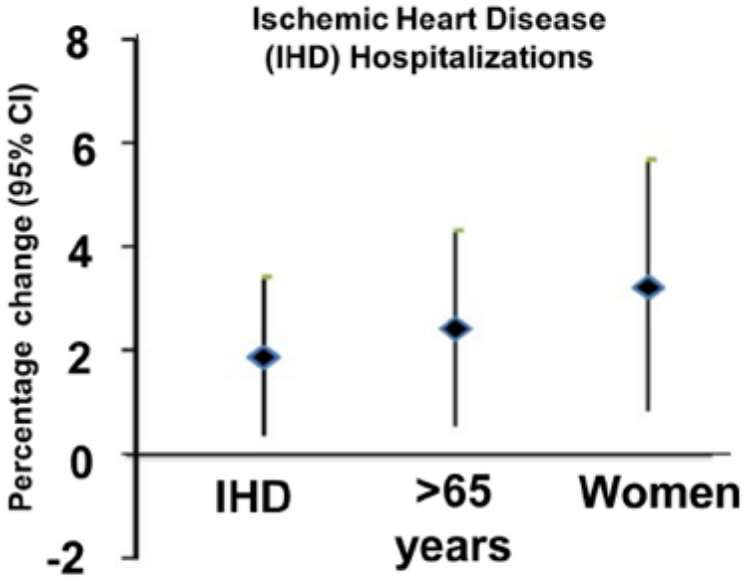
Clear evidence of an association between wildfire smoke and respiratory health

- Asthma exacerbations significantly associated with higher wildfire smoke ***in nearly every study***
- Exacerbations of chronic obstructive pulmonary disease (COPD) significantly associated with higher wildfire smoke in most studies
- Growing evidence of a link between wildfire smoke and respiratory infections (pneumonia, bronchitis)

Cardiovascular effects

Victoria, Australia - Dec 1, 2006 - Jan 31, 2007

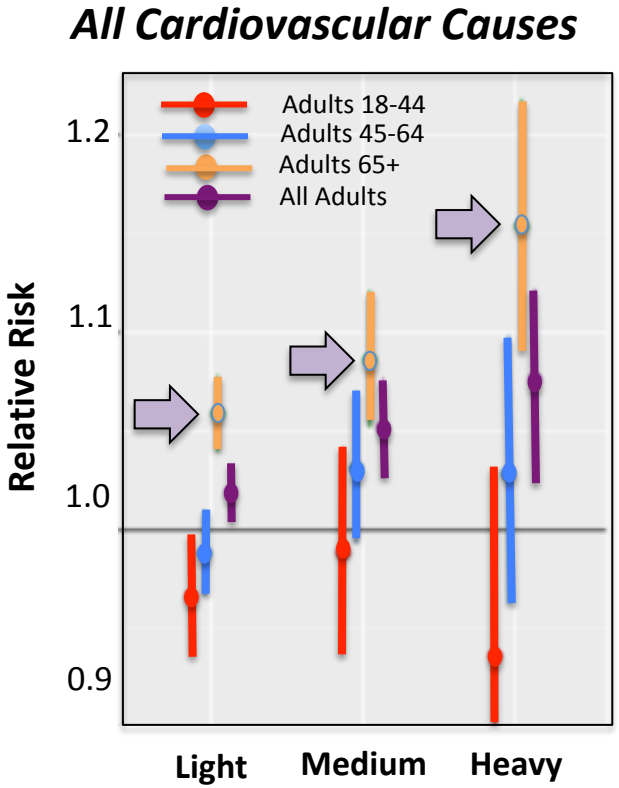




Haikerwal et al. 2015 J Am Heart Assoc

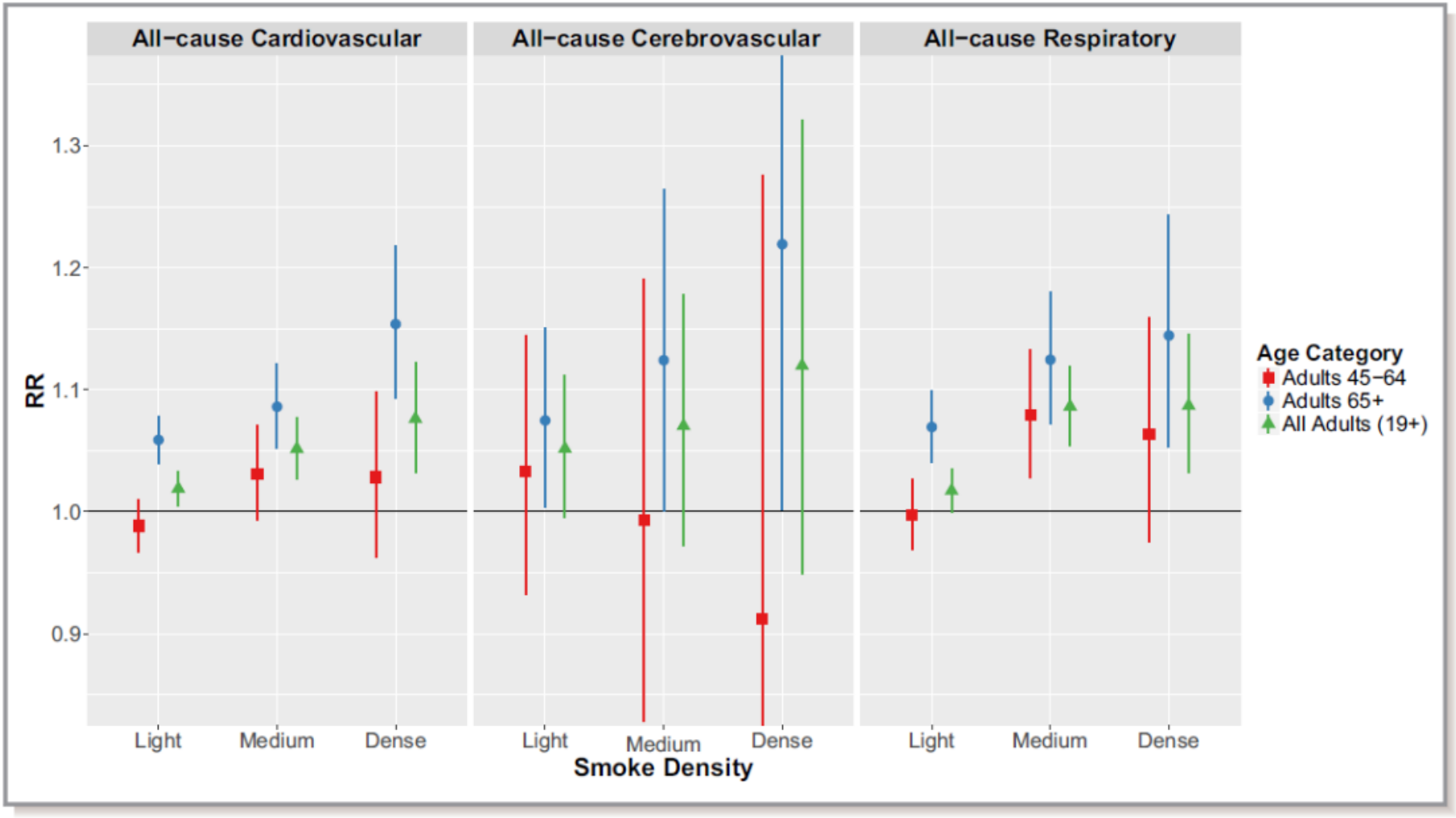
Wildfire-$PM_{2.5}$ Increases Heart Attack & Stroke

- ***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

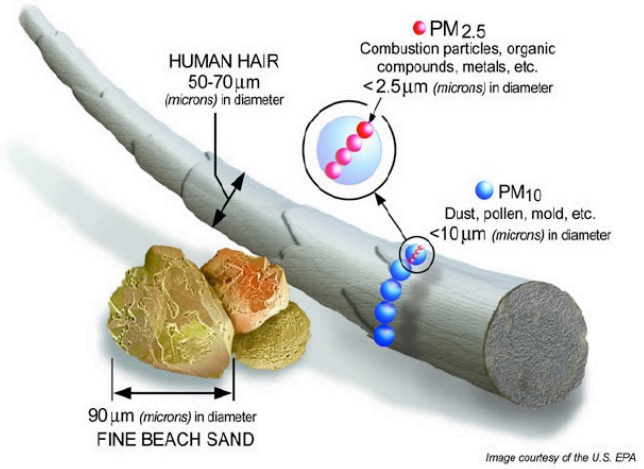
Slide credit: Wayne Cascio



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

Other Health Outcomes

- Adverse birth outcomes
  - Health of pregnant mothers
- Mental health
- ? Chronic effects from recurrent exposures based on the $PM_{2.5}$ literature
  - Metabolic outcomes
  - Cognitive decline
  - Child neurodevelopment
  - Health of pregnant mothers



Wildland Firefighter Health Effects

- Cross-shift changes in lung function, urinary biomarkers of exposure, and blood biomarkers of inflammation
- Pre-post season changes in lung function, airway responsiveness, and airway inflammation
- Do the fire season-associated changes persist?

Contents lists available at ScienceDirect

Environmental Research

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

Wildland firefighter smoke exposure and risk of lung cancer and cardiovascular disease mortality

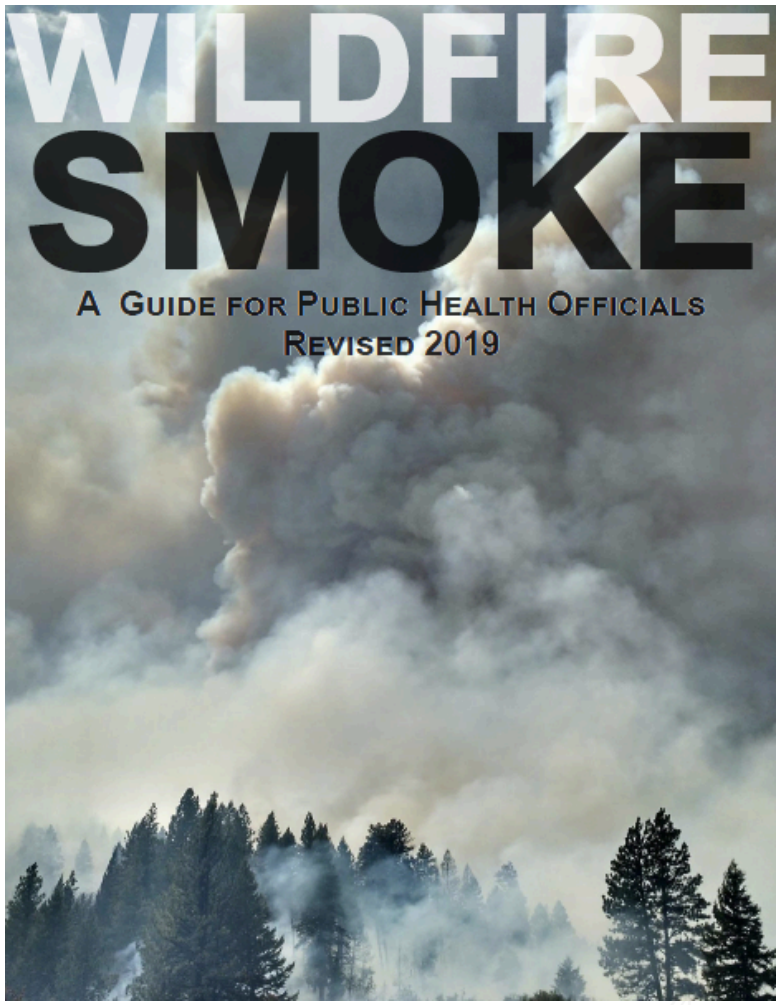
Kathleen M. Navarro[a], Michael T. Kleinman[b], Chris E. Mackay[c], Timothy E. Reinhardt[d], John R. Balmes[e], George A. Broyles[f], Roger D. Ottmar[g], Luke P. Naher[h], Joseph W. Domitrovich[i,*]

- Estimated the daily dose of wildfire smoke $PM_{2.5}$
- The daily dose for firefighters working 98 days per year of $PM_{2.5}$ ranged from 0.30 mg to 1.49 mg
- For career durations (5–25 years), wildland firefighters had an estimated increased risk of lung CA (8 percent to 43 percent) and CVD (16 percent to 30 percent) mortality

Environ Res 2019;173:462-468

Public Health Response

Improved planning and readiness on the part of the public health infrastructure and health care providers are necessary to reduce morbidity and mortality due to wildland fire smoke exposure



Public Health Advisories

Based on the U.S. EPA's Air Quality Index:

- "Good" 0-50
- "Moderate" 51-100
- "Unhealthy for sensitive groups" 101-150
- "Unhealthy" 151-200
- "Very Unhealthy" 201-300
- "Hazardous" >300

Wildland forest fire smoke: health effects and intervention evaluation, Hoopa, California, 1999

Joshua A Mott, Pamela Meyer, David Mannino, Stephen C Redd

- Large fire burned for 2 months with poor air quality (high PM_{10})
- CDC investigators documented increased health care utilization for lower respiratory illness
- Recollection of public service announcements was associated with a reduced odds of reporting adverse respiratory health effects

West J Med 2002;176:157-162

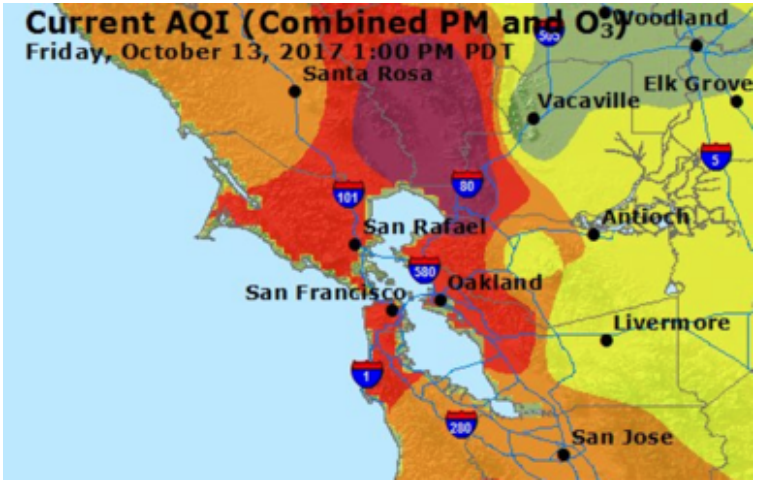
Wildland forest fire smoke: health effects and intervention evaluation, Hoopa, California, 1999

Joshua A Mott, Pamela Meyer, David Mannino, Stephen C Redd

- Increased duration of the use of HEPA air cleaners was associated with a reduced odds of reporting adverse respiratory health effects
- No protective effects were observed for use of masks or duration of evacuation

West J Med 2002;176:157-162

Case Study – UC Berkeley



24-hour $PM_{2.5}$ levels exceeded 200 µg/m^3 in Napa and 70 µg/m^3 in Oakland on October 13

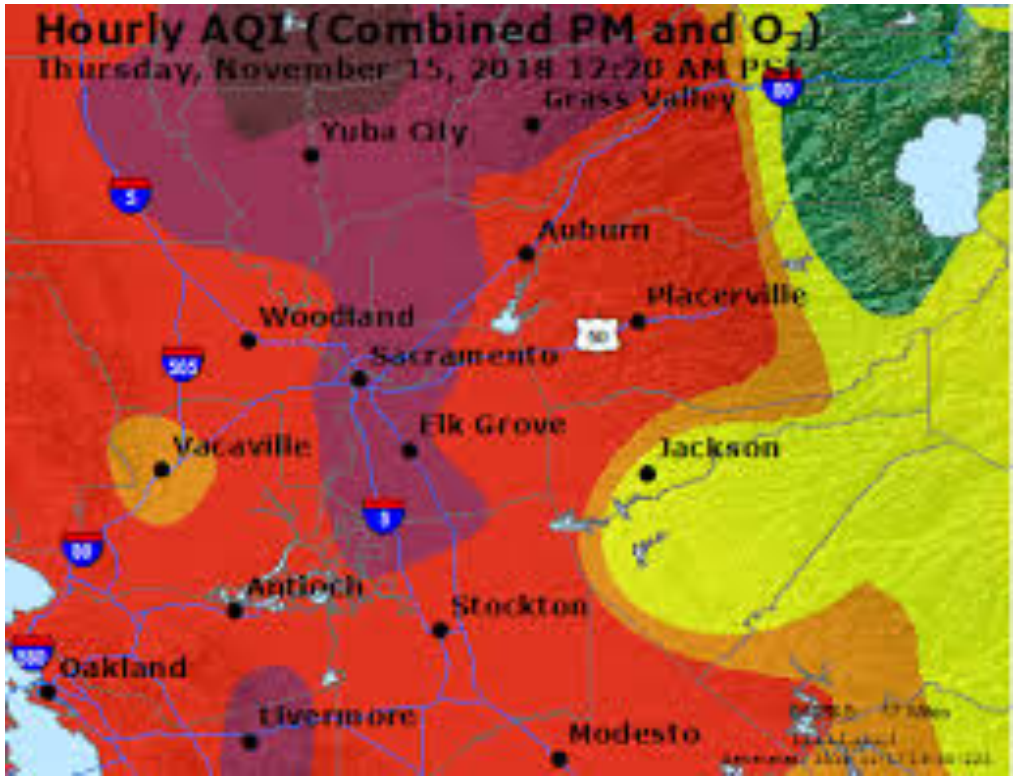
- Oct. 13, 2017 – the AQI goes over 200 during the day
  - UC Berkeley issues a health advisory to students, staff, and faculty (stay indoors, consider wearing N95 masks if you have to be outside); classes not cancelled
  - BAAQMD asks UC Berkeley to cancel the televised football game with Washington State
  - Game not cancelled because AQI <200 by kickoff

Camp Fire – Nov. 9, 2018

Poor Air Quality in Bay Area

- Nov. 14, 2018 – $PM_{2.5}$ goes over 200 µg/m^3 that Thurs. evening and is projected to stay high for days
  - UC Berkeley cancels classes, but does not close campus
  - UC Berkeley postpones the "Big Game" with Stanford scheduled for Sat. Nov. 16

Even Poorer Air Quality Closer to Fire



Nov. 15, 2018 – PM2.5 goes up to 250 µg/m^3 in Sacramento and over 300 µg/m^3 in Yuba City

Post-Wildfire Problems

- Post-traumatic stress
- Housing shortage, especially for low-income, immigrant renters
- Post-fire structural building clean-up
  - Much of the work done by day workers
- Mudslides

Fire suppression has increased fuel availability

Prevention

- Most of the U.S. Forest Service wildfire budget goes to suppression activities, leaving precious little for necessary forest-maintenance activities.
  - The 2013 Rim Fire started in Yosemite but mostly burned in the Stanislaus National Forest − why?
- Dead trees and excessive undergrowth need to be removed from our forests
- Communities near National Forests resist prescribed burns

Increased Development - Urban Wildland Interface

Community Protection

- At-risk communities can do more to prepare for wildfires
  - Bulldoze fuel breaks around neighborhoods
  - Install new smoke-detection cameras and sensors
  - Remove vegetation around homes
  - Improve escape routes in subdivisions
  - Train residents in initial fire suppression methods (i.e., watering down roofs)

Summary

- The duration of the wildfire season is longer and catastrophic wildfires are increasing in frequency due to climate change
- Acute respiratory effects are well documented, but new studies suggest acute cardiovascular effects as well
- Post-fire health effects are impactful
- Long-term effects of high and/or recurrent exposures need further study
- Need to invest heavily in forest management and community resilience

Thank you