United States
Environmental Protection
Agency

ORD Wi

Wayne E. Ca

Region 4 State
August 30, 201

Office of Research and Development

ldfire Research

scio, MD, FACC

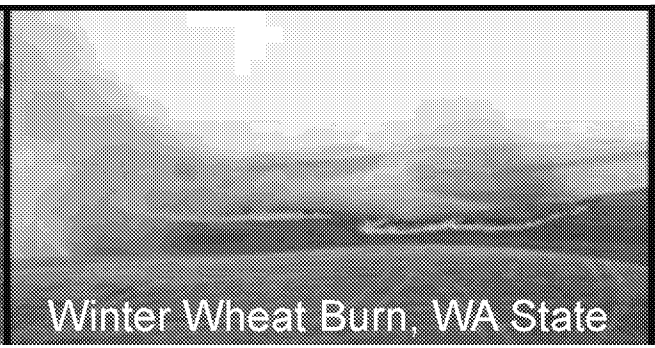
Commissioner's Visit

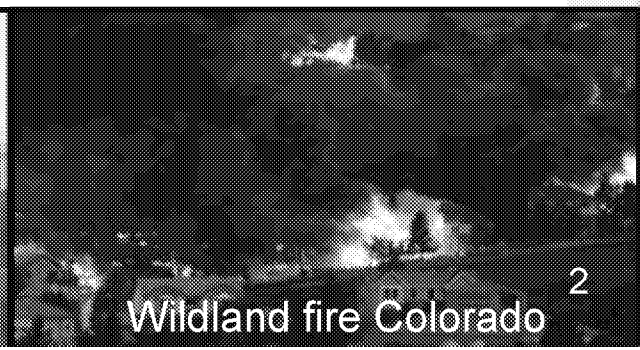
-7

The Challenges of Fire on the Landscape

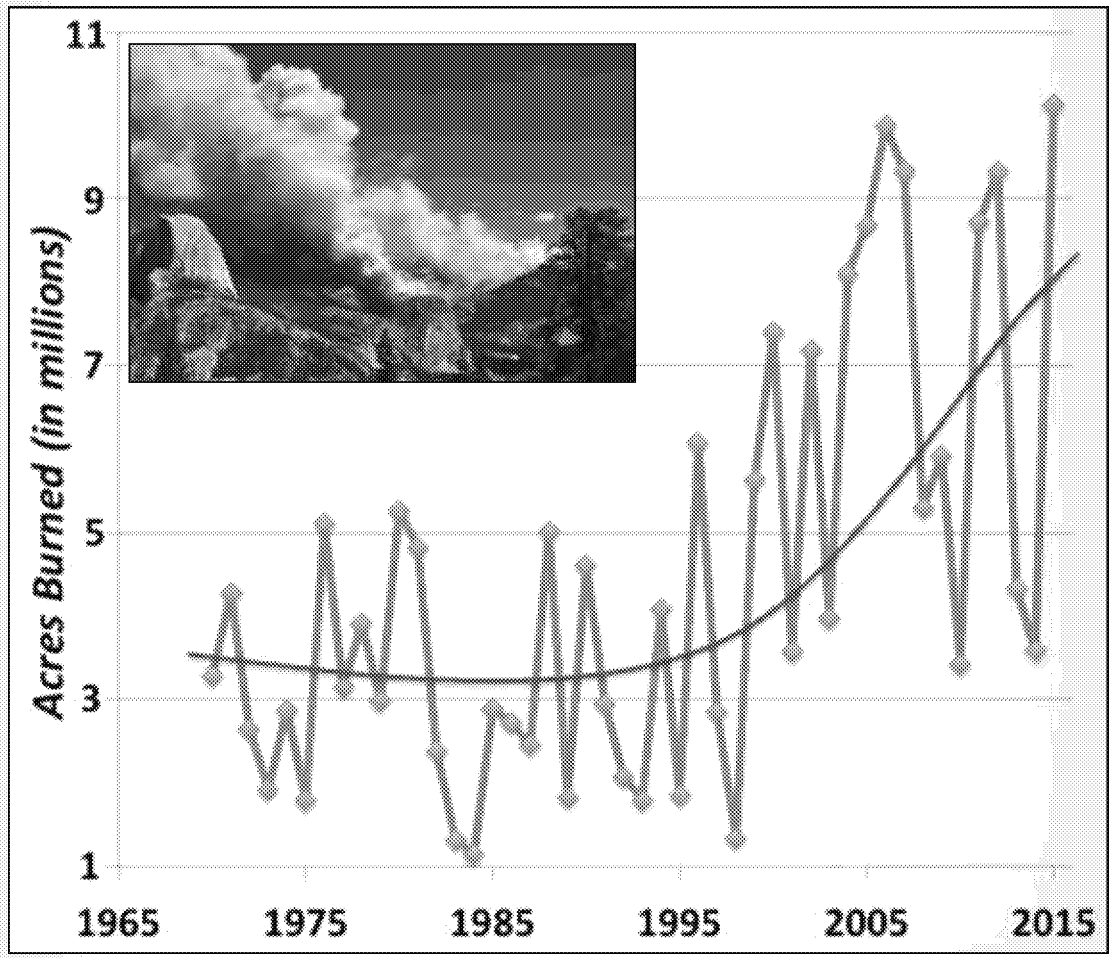
- ***Wildland fires are a national challenge** impacting population health **and** ecological health **through complex multi-media pathways***
- *Uncontrolled wildfires, prescribed fire **and** agricultural cycling **are raising questions related to potential impacts on:***
  - Ambient air quality
  - Public health
  - Water quality
  - Land management
  - Effects of ecosystem services
  - Local economic growth
- ***2014 National Emissions Inventory: ~38% of particulate matter $(PM)_{2.5}$ emissions resulted from wildland fires***


"Wildfire" SC State


Winter Wheat Burn, WA State


Wildland fire Colorado

An Issue of Concern for the States
Impacts of Local and National Importance



- ***Between 2001 - 2010 over 40% of the country's large wildfires occurred in the Southeast***
- ***Wildland fires burn all year in the southeast stressing firefighting capacity and resources***
- ***U.S. spends more than $1 billion each year to fight wildfires***

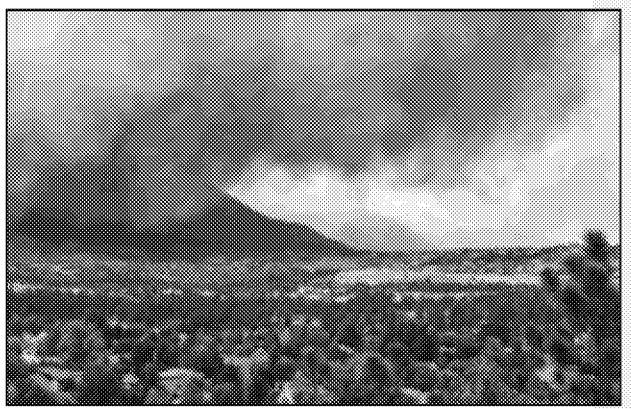
Adapted from
https://www.nifc.gov/fireInfo/fireInfo_stats_totalFires.html

Health Effects Linked to Smoke from Wildland Fires

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

(Source: Studies reviewed in Liu et al 2015)

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



Present Day Challenges are Only Expected to Get Worse

Wildland-Urban Interface

- **Growing by 4,000 acres/day**

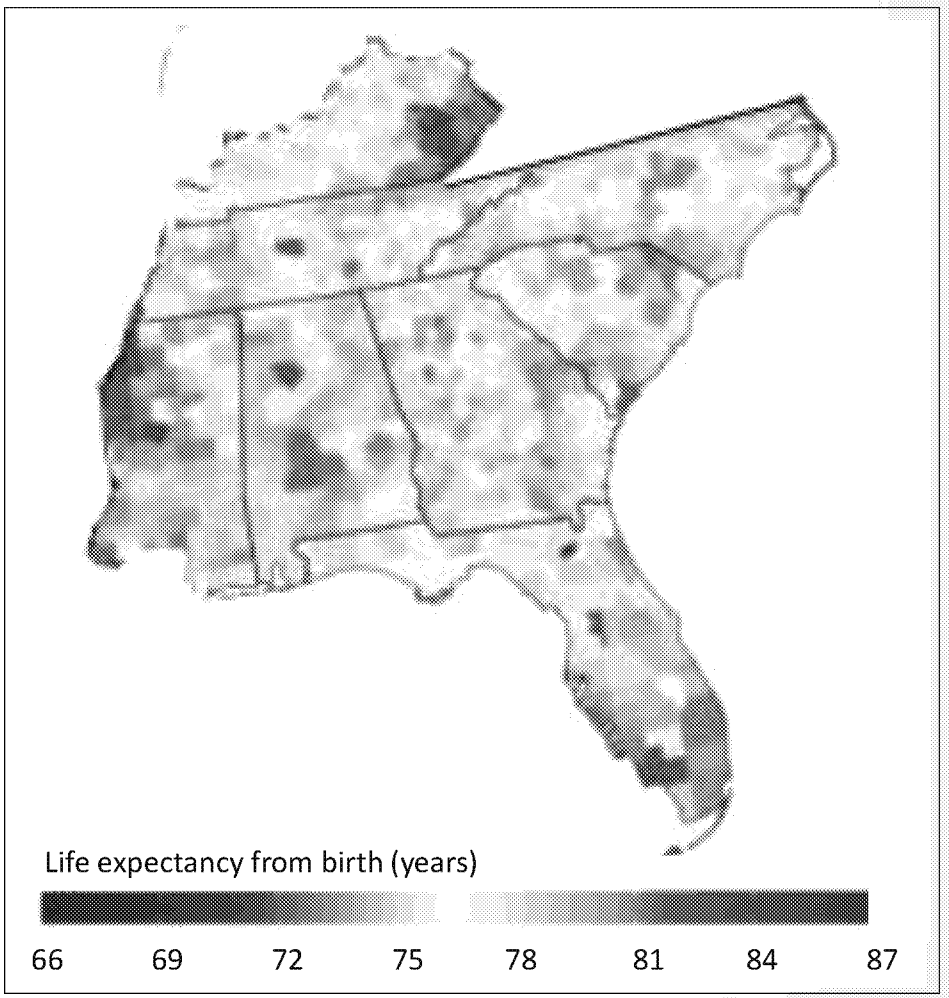
Changing U.S. Demographic

- **U.S. population will continue to:**
  - *Grow*
  - *Median age will shift upward*

Higher Prevalence of Chronic Diseases Conferring Risk to Wildland Fire Smoke

- **Aging U.S. population with increasing prevalence of:**
  - *Heart-lung disease, obesity, diabetes*

Region 4 Life Expectancy at Birth



Source: Xu J, Murphy SL, Kochanek DK, Arias E. NCHS Data Brief No. 267, 2016

Dwyer-Lindgren L et al. AMA Intern Med. 2017

Defining the Health Effects of Wildfire Smoke

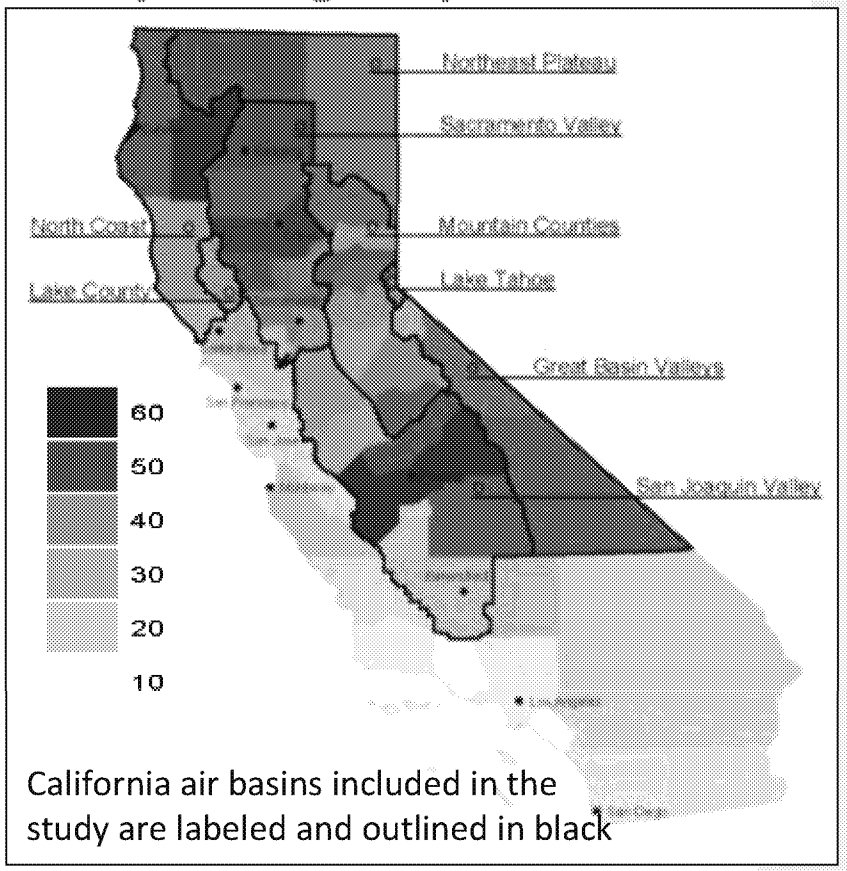
California 2015 Wildfire Study

Problem: Cardiovascular health effects of wildfire smoke are uncertain

Approach:

- Epidemiology study of health effects during the 2015 California wildfire season
- Associate wildfire-$PM_{2.5}$ exposure with emergency department visits for cardiovascular and respiratory diagnoses
- Collaborative study partners:
  - *California Dept. of Public Health*
  - *Univ. of California at San Francisco*
  - *ORD/NHEERL/EPHD*

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



California air basins included in the study are labeled and outlined in black

Hoshiko S, Wettstein Z, Cascio WE, Rappold AG

California 2015 Wildfire Study

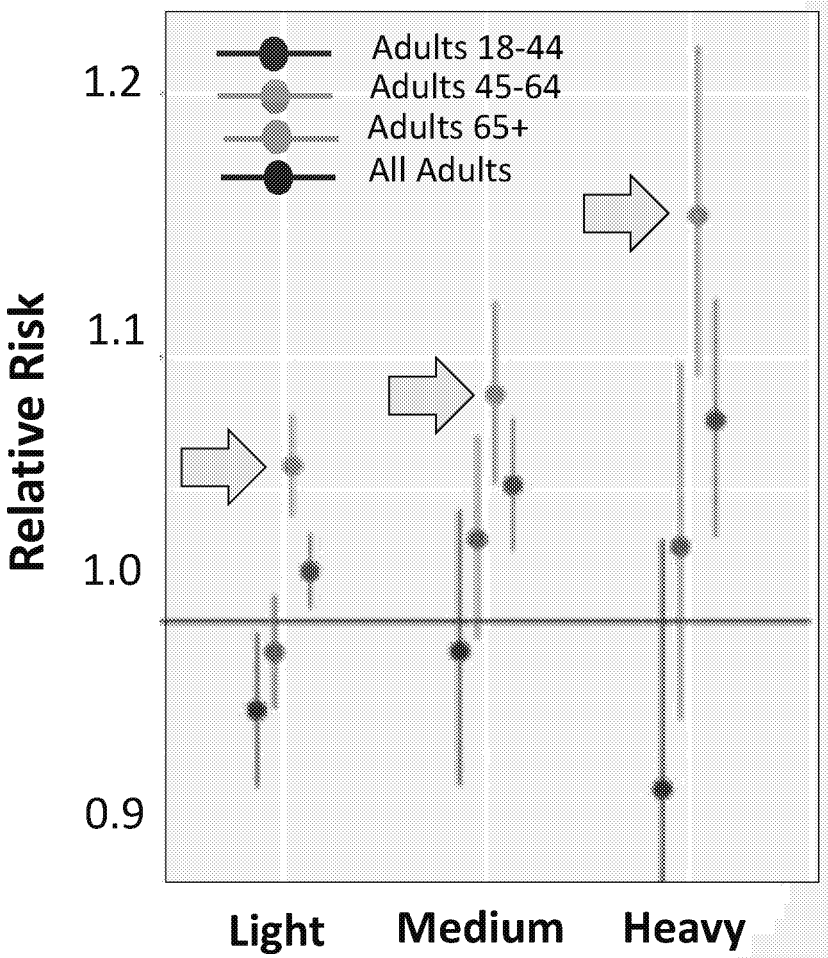
Wildfire-$PM_{2.5}$ Increases Heart Attacks & Strokes

Results: 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%
  - Abnormal heart rhythm, 24% (same day)
  - Heart failure 16%
  - Stroke 22%
  - All respiratory causes 18%
- ***Impact:*** Highlights the importance of decreasing exposure in at-risk populations

Data to be presented as a Late-Breaking Study at the *American Public Health Association* Conference in Atlanta - November 2017

All Cardiovascular Causes



Hoshiko S, Wettstein Z, Cascio WE, Rappold AG

Identifying US Counties at Risk for Health Effects from Wildfire Smoke

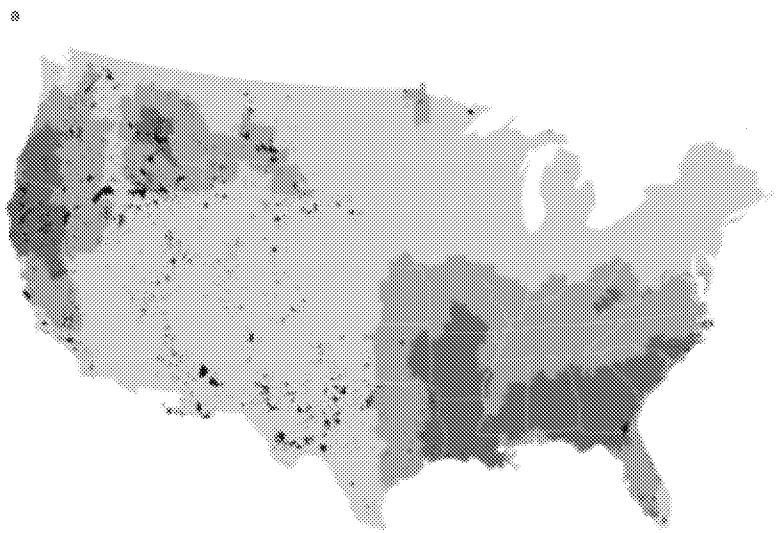
Problem:

- Are some communities more vulnerable to health effects of wildfire smoke?

Approach:

- Develop a Community Health-Vulnerability Index (CHVI) based on factors known to increase the risks of health effects from wildfire smoke exposures.
- Simulated Air quality between 2008 - 2012 over the U.S.
- Characterized the population size at risk based on the level and duration of exposure to fine particulate matter (fire-$PM_{2.5}$) and CHVI.

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



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

Rappold AG, et al Environ Sci Technol 2017

Identifying Communities at Risk from Wildfire Smoke

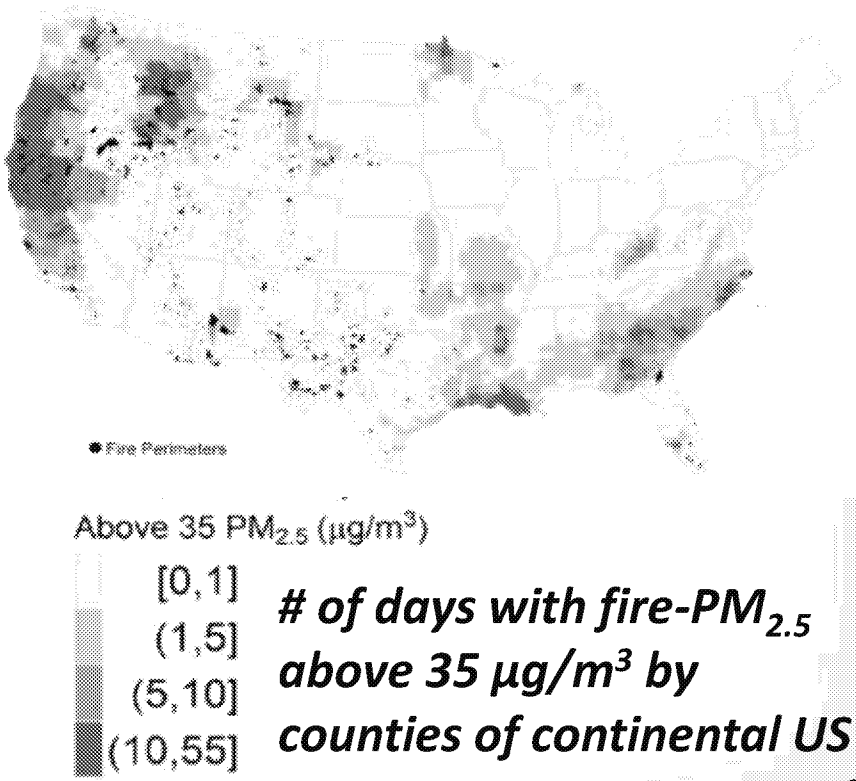
Approach (continued):

- Factors included county prevalence rates for health conditions, age and socioeconomic conditions

Factors of Vulnerability

- Child & Adult Asthma
- COPD
- Obesity
- Diabetes
- High blood pressure
- % population age 65+
- Income, education, poverty, unemployment

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

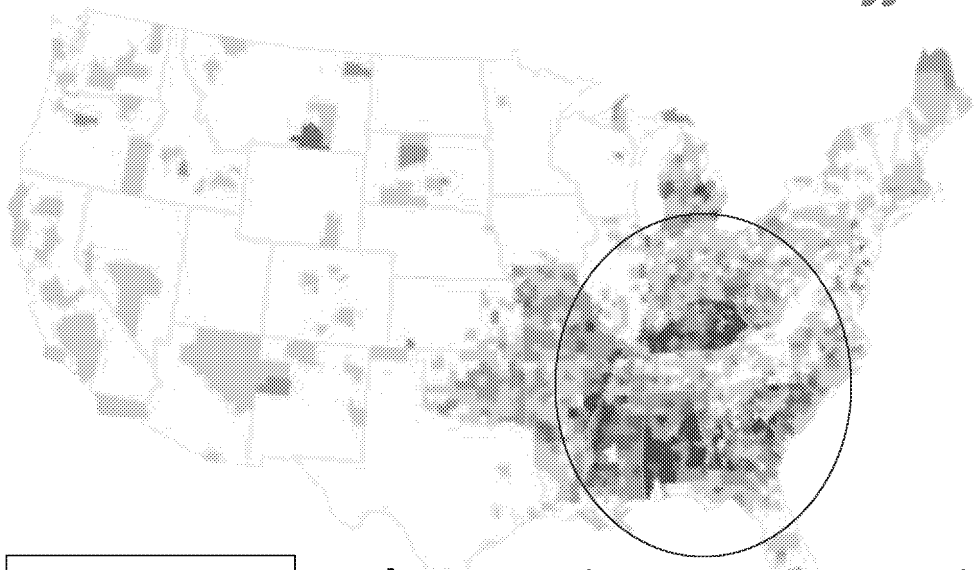


# of days with fire-$PM_{2.5}$ above 35 µg/m³ by counties of continental US

Community Health-Vulnerability

Community-Health Vulnerability Index

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



Results:

- 30.5 million lived in the areas where the contribution of fire-$PM_{2.5}$ to annual average ambient $PM_{2.5}$ was high (>1.5 $\mu g/m^3$)
- 10.3 million people experienced unhealthy air quality levels for >10 days due to smoke

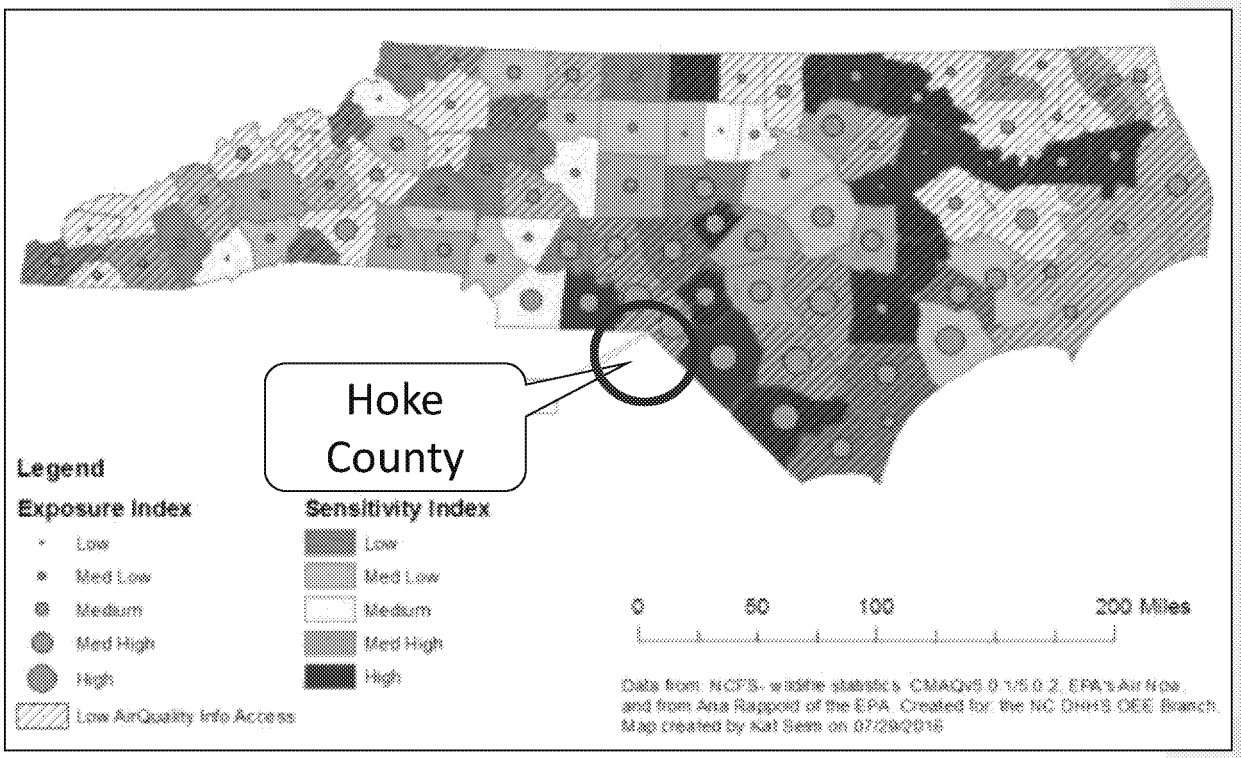
Impact: The Community Health-Vulnerability Index

- 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

Community-Health Vulnerability Index Used in NC
CDC-funded North Carolina Health Program

- *Community-Health Vulnerability Index was adapted for use in North Carolina*
- *Utilized CHVI to identify a NC community most at risk to smoke health impacts*
- *Used CHVI to identify & add NC-specific layers (e.g., NC Forestry data)*
- *Engaged Hoke County stakeholders (e.g., local fire departments) with CHVI to discuss vulnerability to smoke health impacts*



- *CHVI discussion has given way to implementing prevention efforts, e.g. Smoke Sense*

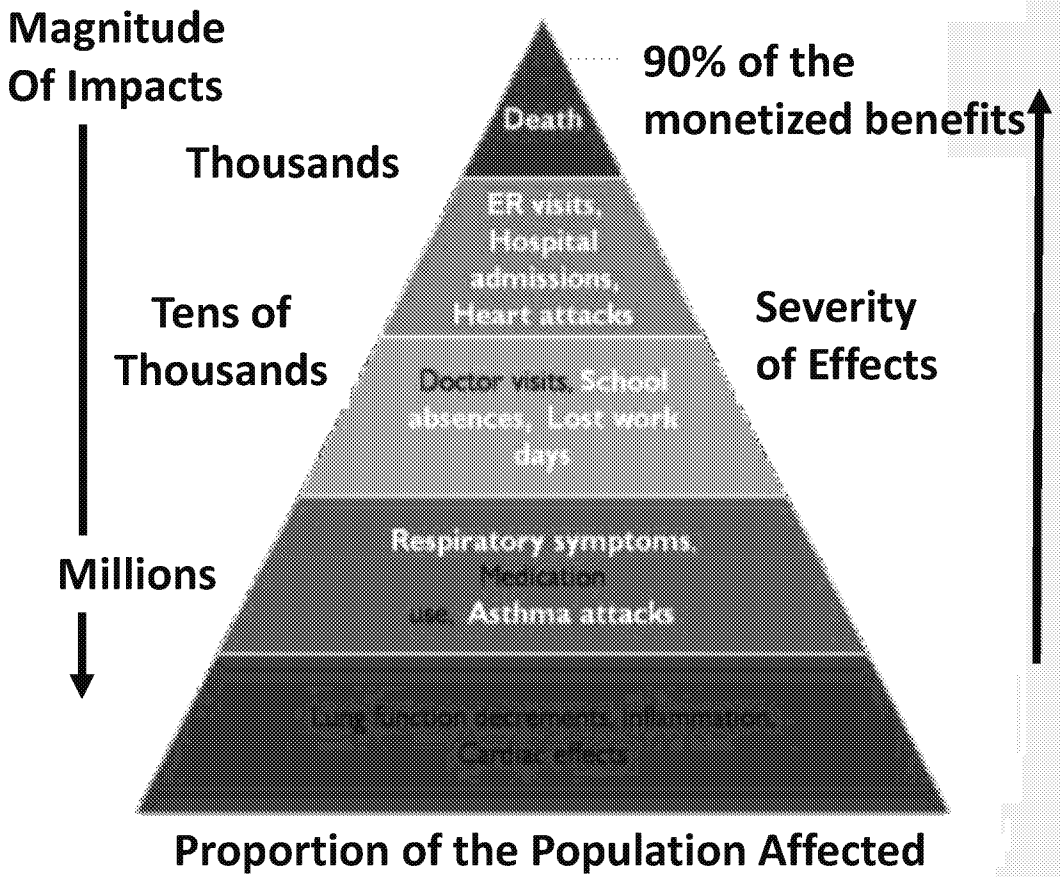
Courtesy of Lauren Thie NC Department of Public Health

Subclinical Effects Outnumber Clinical Effects

Problem:

- ***Insufficient information on subclinical symptoms*** *(less severe symptoms)* ***from exposure to wildfire smoke***
- ***More people experience these subclinical effects than those who go to the hospital***
- ***Effects include decreased lung & heart function, worsened asthma, & lost days of school and work***

A "Pyramid of Effects" from Air Pollution

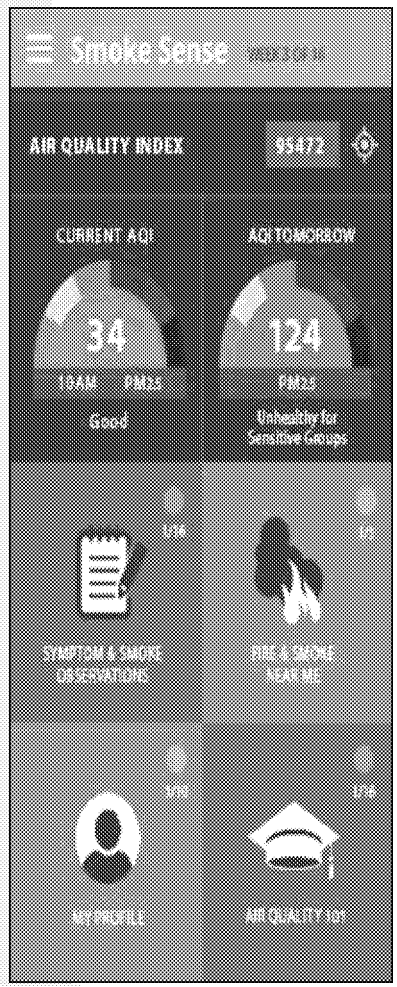


Smoke Sense Project
Improving Public Health Outcomes

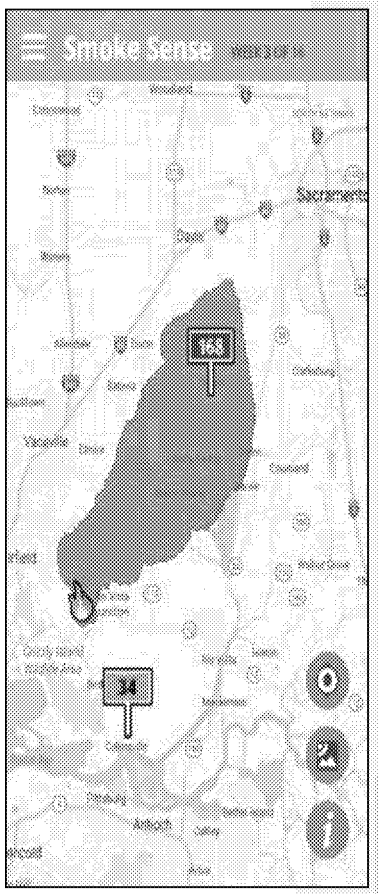
Approach:

- *Aims of Smoke Sense:*
  - Measure the effect of wildfire smoke exposure on health and productivity
  - Develop health risk communication strategies to improve public health outcomes
- *As part of this, researchers have developed a Smoke Sense mobile phone application to:*
  - Collect user input on how smoke events impact their health and daily activities
  - Provide information about the smoke exposure and recommended health risk messages

Air Quality & Smoke Plume Info



- *Smoke Sense provides information about current and future air quality*
- *Forecasted smoke plumes can be visualized*
- *Less time outside during smoke episodes to decrease exposure, and protect health*
- *Smoke Sense helps collect information about who, when, and how frequently people are impacted by smoke*
- *Information about smoke in the air and symptoms experienced in the past week will be logged*



Network of Smoke Sense Partners

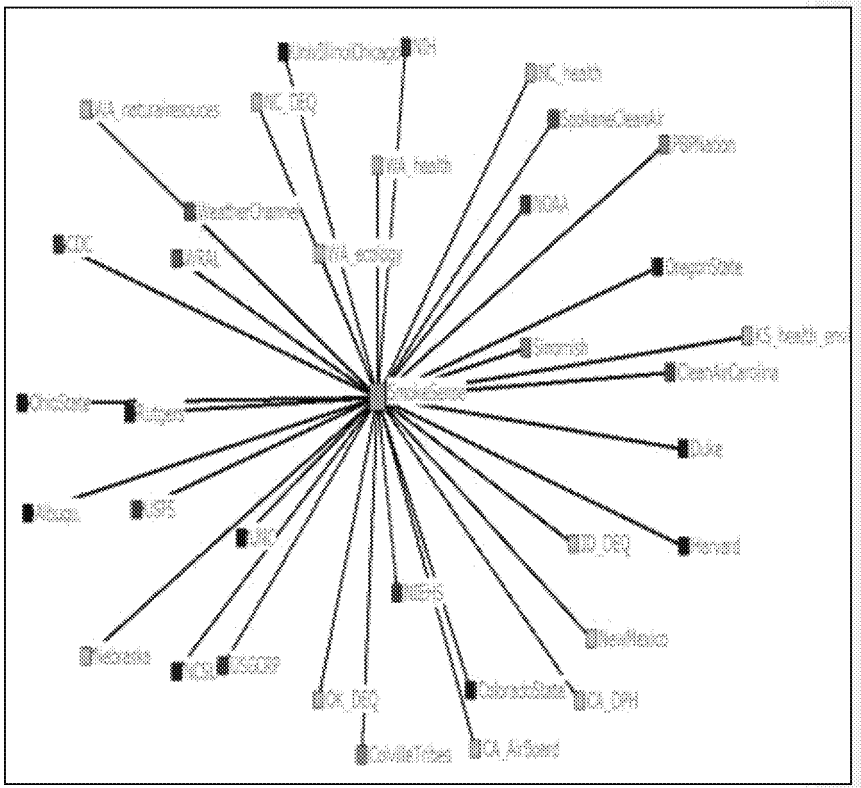
Beta Testers & Pilot Community Representatives

Results:

- Partner agencies provided diverse perspectives for the development of Smoke Sense as beta-testers and pilot community representatives
- Distributed nationally; over 1,300 users.
- Well-developed pilot community engagement
- North Carolina & Washington most active

Impact:

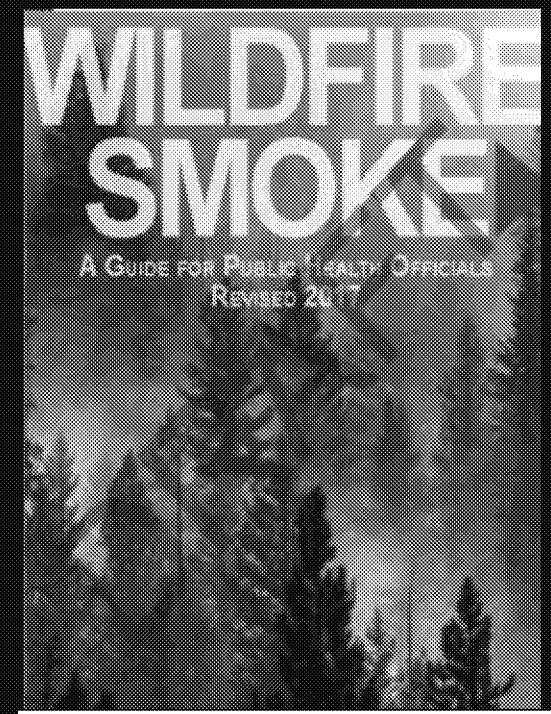
- Stakeholders are committed to advancing knowledge of wildland fire smoke & through public engagement in science
- Partner agencies have the opportunity to promote health protective behaviors within their communities to reduce the impact on health from unavoidable smoke exposure

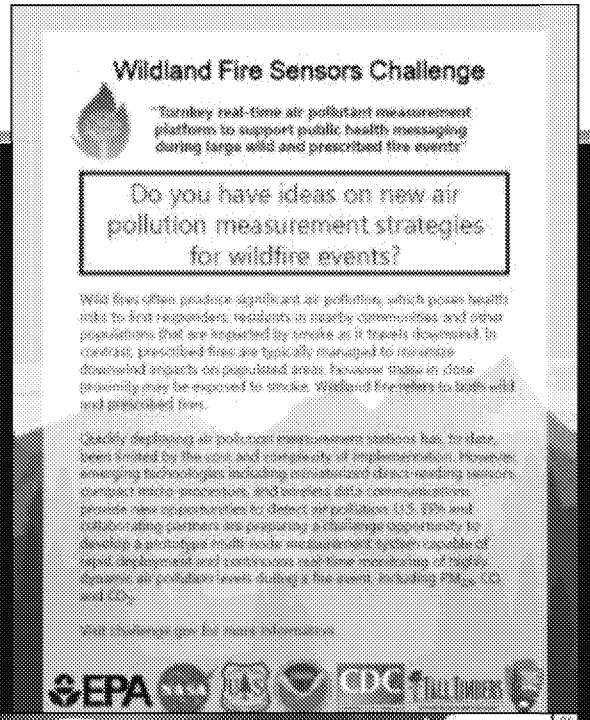


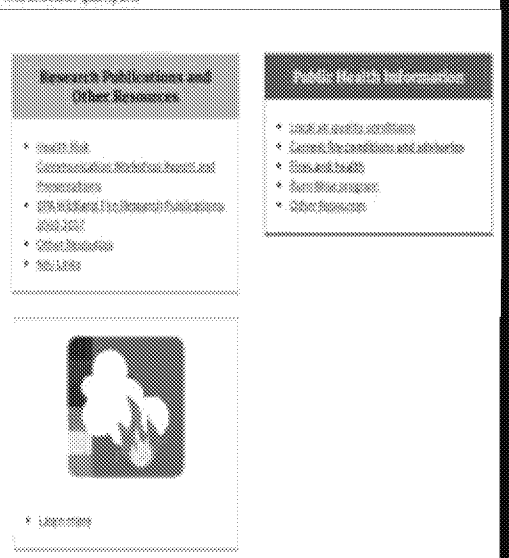
LEGEND

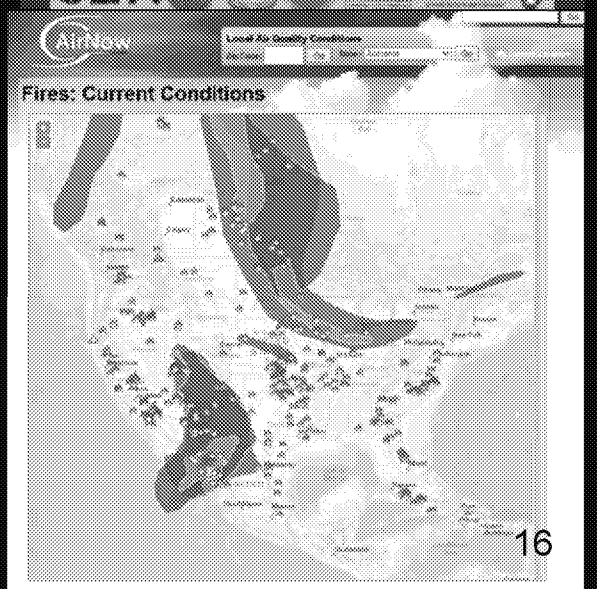
Local Gov.	Tribal Org.
State Gov.	Academia
Federal Gov.	Non-Profit Org.
	Private Org.

Mitigating the Health Effects of Wildfire Smoke









Impact of ORD Wildfire Research

Take Home Messages

- Exposure to wildfire smoke increases healthcare utilization for cardiopulmonary conditions particularly among older persons, and those with heart and lung disease.

- ORD is actively translating science into actionable information and tools to limit the adverse public health impact of emissions from wildland fire and prescribe fire.

- The *Community Health Vulnerability Index* might help States identify at-risk communities, prepare responses, increase the resilience to smoke and improve public health outcomes during smoke days.

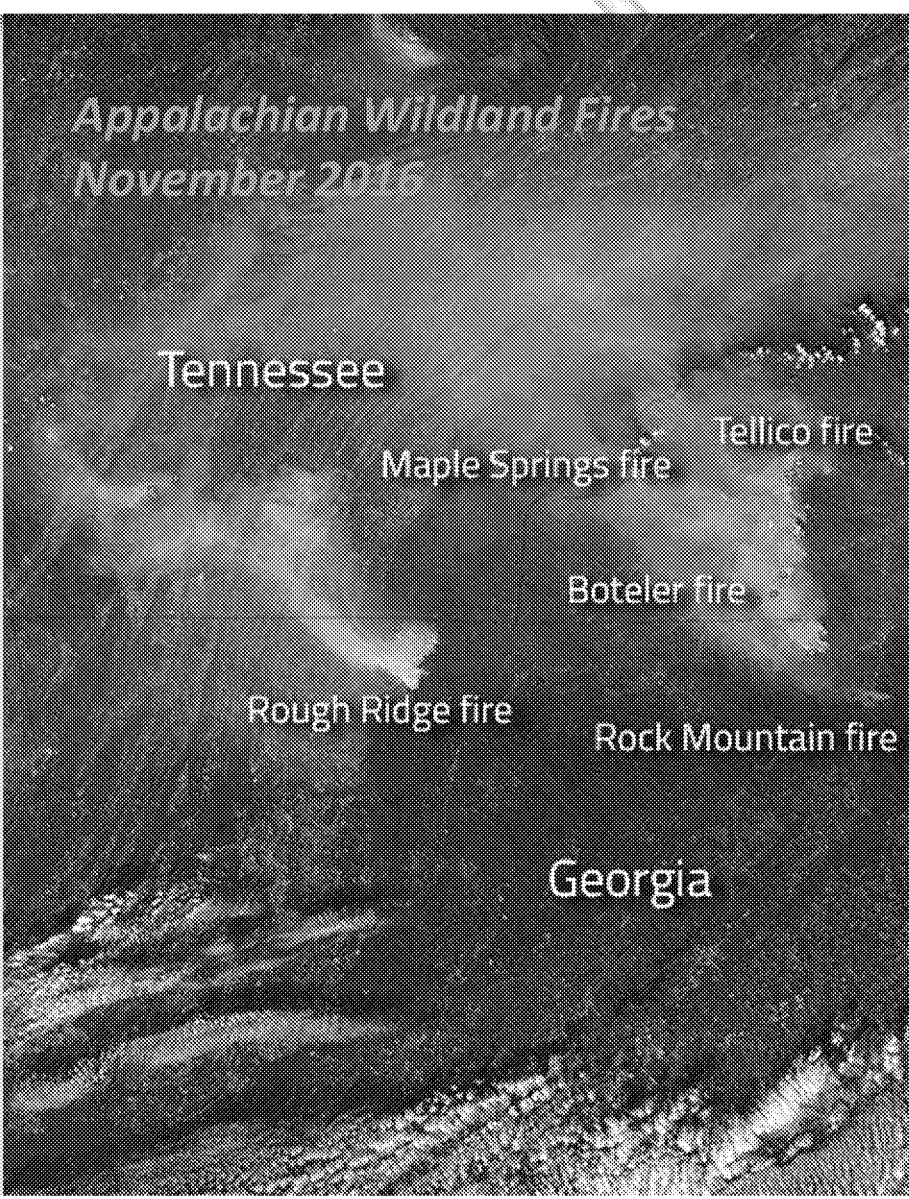
- The Smoke Sense app provides a means to engage partners and the public to increase knowledge and share experiences related to smoke for the purpose of reducing exposures to smoke.

Contact Information

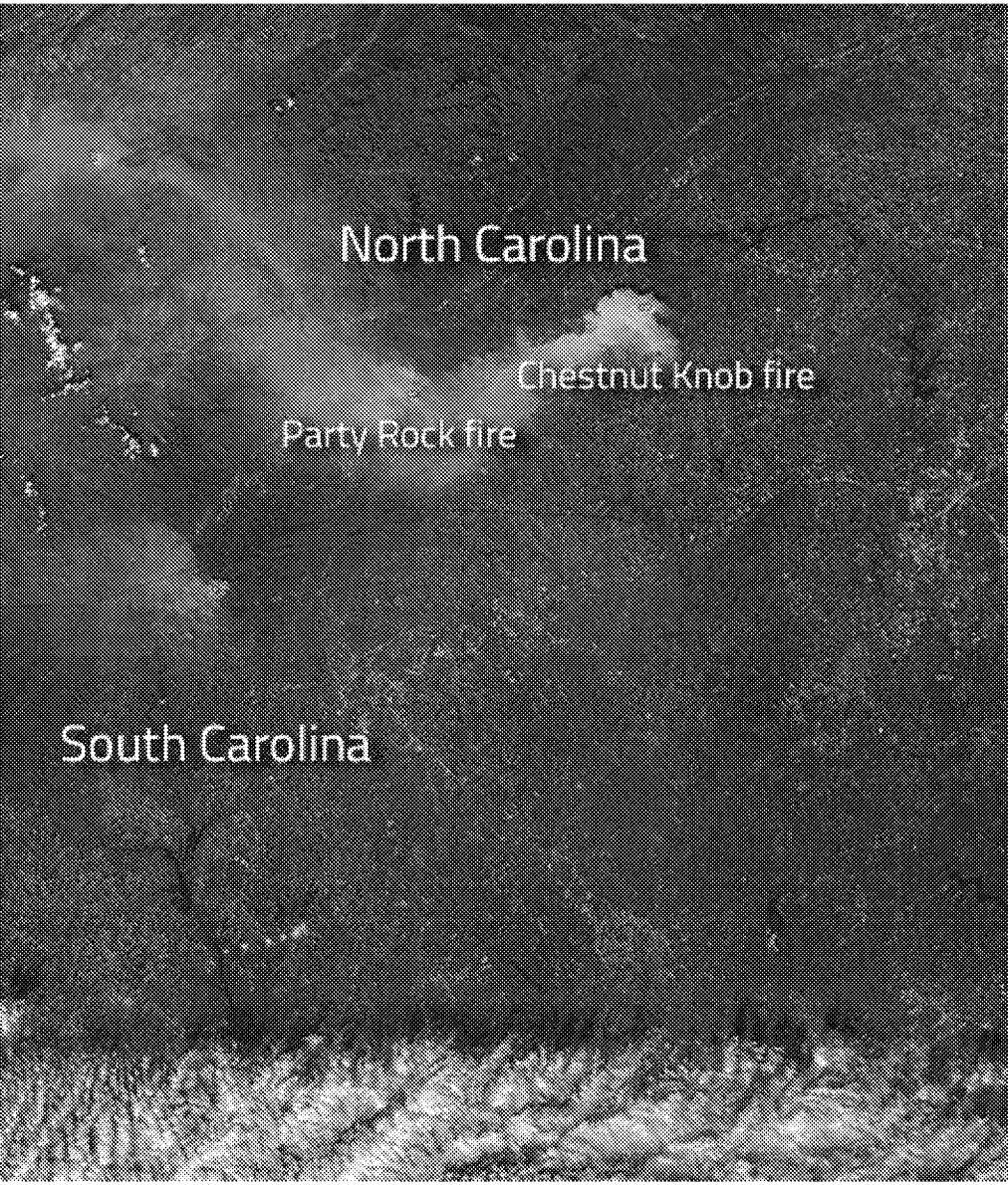
Wayne E. Cascio, MD, FACC

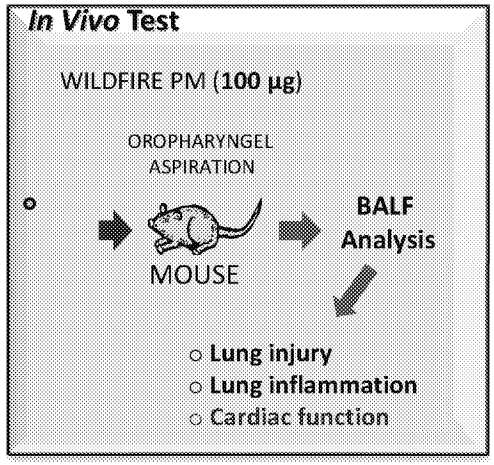
US EPA Office of Research and Development
National Health and Environmental Effects Research Laboratory
Environmental Public Health Division
Chapel Hill, NC and Research Triangle Park, NC

919-966-0617
cascio.wayne@epa.gov

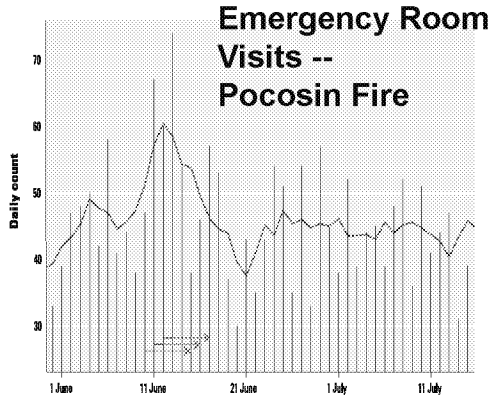

Appalachian Wildland Fires
November 2016
Tennessee
Tellico fire
Maple Springs fire
Boteler fire
Rough Ridge fire
Rock Mountain fire
Georgia

Wildfire Research





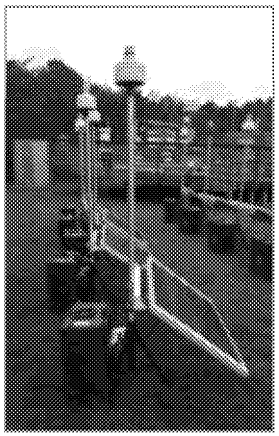
Smoke Toxicology
Ian Gilmour, NHEERL
David DeMarini, NHEERL
Andy Ghio, NHEERL



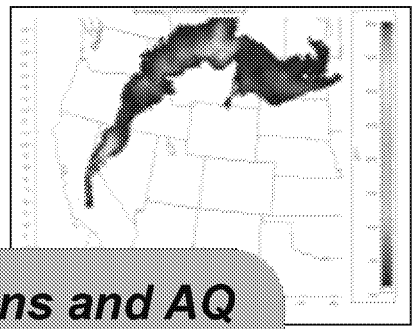
EPA ACE Wildland Fire Research

Smoke Exposure (Monitors/Sensors)
Matt Landis, NERL
Amara Holder, NRMRL
Gayle Hagler, NERL

Smoke Epidemiology
Ana Rappold, NHEERL
Wayne Cascio, NHEERL
Susan Stone, OAQPS
Public Health



FASMEE Initiative w/ OAR-OAQPS

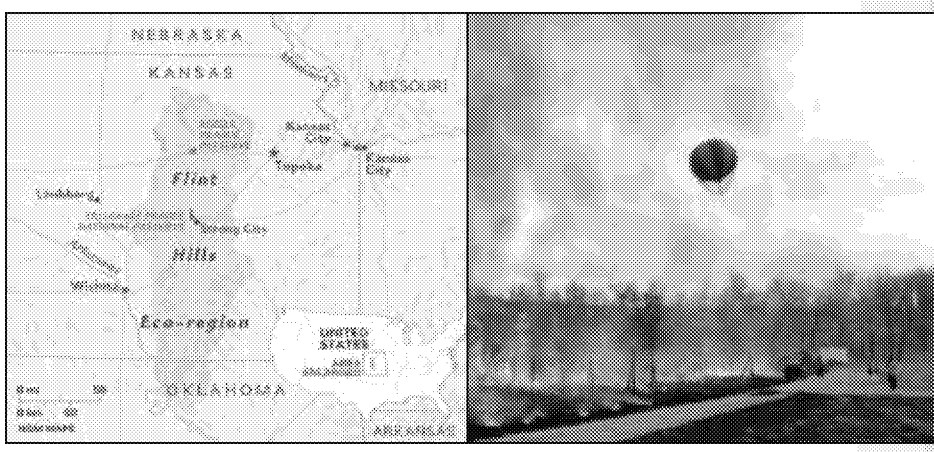


Biomass Emissions Factors & Speciation
Brian Gullett, NRMRL
Mike Hays, NRMRL
Amara Holder, NRMRL
Venkatesh Rao, OAR-OAQPS

Smoke Emissions and AQ Impacts Modeling
George Pouliot, NERL
Tom Pierce, NERL
Kirk Baker, OAR-OAQPS

Region 7 – RARE Project
Flint Hills Prescribed Fires

- Annual grass/rangeland prescribed burning in Flint Hills region of central Kansas
  - Intended to minimize invasive woody species on the prairie and stimulate new grass growth for cattle grazing
- This practice can lead to elevated O_3 and PM regionally
  - Kansas developed an exceptional event demonstration for O_3 impacts in Kansas City & Wichita from Flint Hills burning in 2011
- Field work at Konza Prairie Biological Station conducted to evaluate and improve emission estimates (March 2017)
  - Also working to better understand plume rise and dispersion to improve air quality model representation of these fires
- Related Coop efforts in MD with DOD – advanced monitoring technologies (sensors) associated with Unmanned Aerial Vehicles (UAVs)



Ord Lead – Bryan Gullett, NRMRL

ORD - Measuring Smoke Toxicity

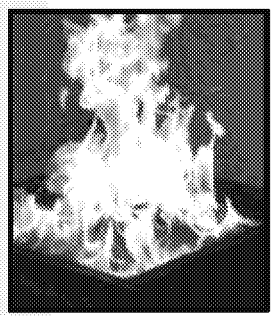
JFSP Research Plan FY 2015-2017

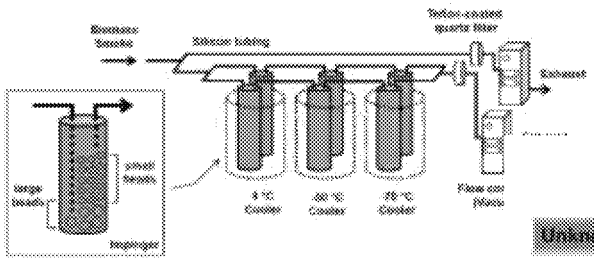
Research Goals:

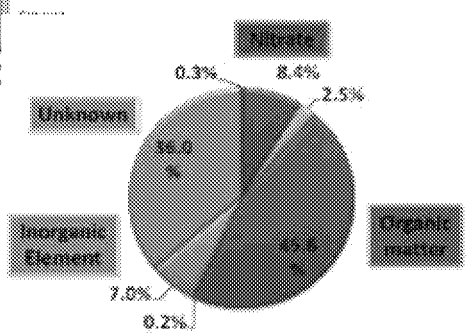
- Compare the relative cardiopulmonary toxicity and mutagenicity of PM emissions from different fuel types (e.g., pine, oak, peat, chaparral) & burning conditions (e.g., flaming, smoldering)
- Provide a potency ranking matrix

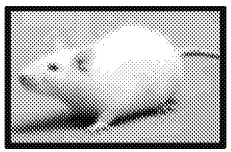
Combustion | **Collection/ Analysis** | **Toxicity Test**

Fire Emissions → Cryotrap System → Particle and Gas Phase Chemistry & Mass Balance → WT & K/O Mice → Toxicity Ranking Matrix

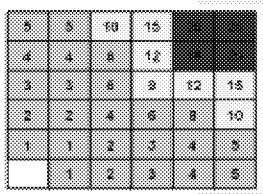


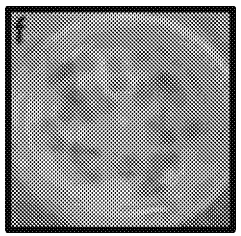






Cells, Tissue Slices





Joint Fire Science Program

http://www.firescience.gov

Courtesy of Matt Landis NERL & Ian Gilmour NHEERL/ORD/EPA

Combustion and Smoke Sampling System