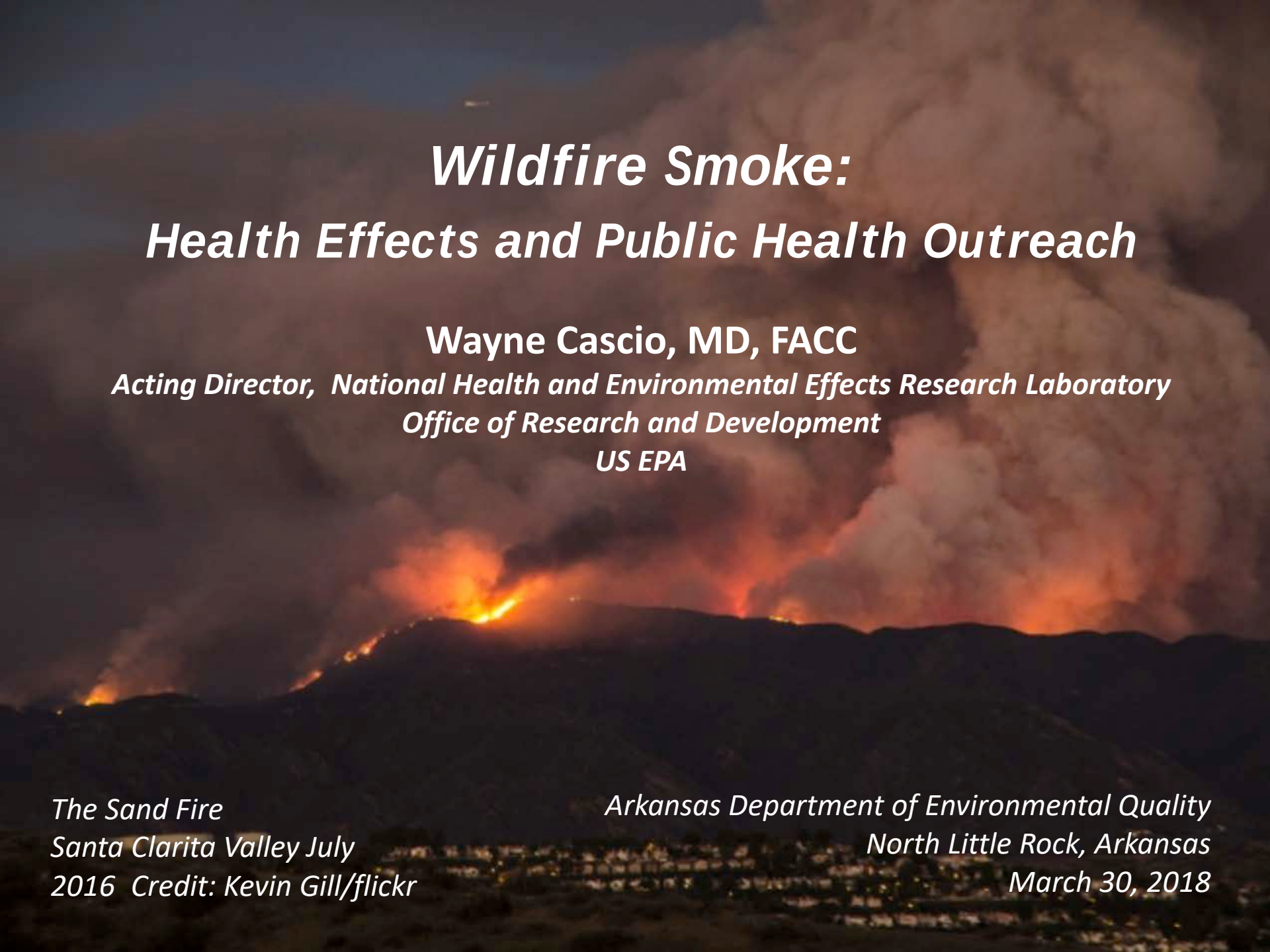


A large wildfire is burning on a hillside, with thick, dark smoke rising into the sky. The fire is visible as a bright orange and yellow glow against the dark landscape. The smoke is dense and billowing, filling much of the upper half of the image.

Wildfire Smoke: Health Effects and Public Health Outreach

Wayne Cascio, MD, FACC

***Acting Director, National Health and Environmental Effects Research Laboratory
Office of Research and Development
US EPA***

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

*Arkansas Department of Environmental Quality
North Little Rock, Arkansas
March 30, 2018*



Wildland Fires & Their Emissions

A Global Public Health Issue



Global mortality from wildfire smoke:
Estimated to be 339,000 persons/year

Johnson FH et al. *Environ Health Perspect* 2012



Wildland Fires & Their Emissions

Community Public Health Issue



*Brianna Paciorka
Knoxville News Sentinel*



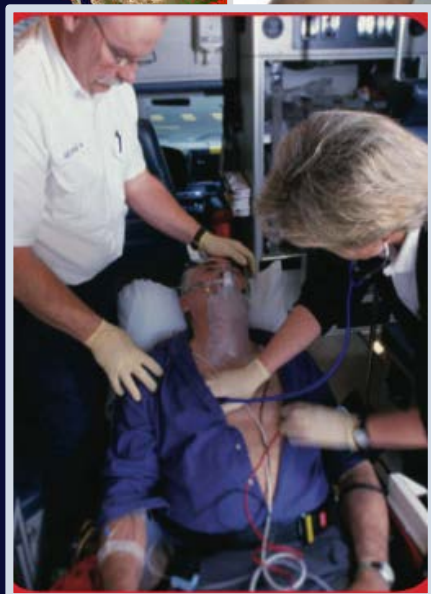
Wildfire spreads to Gatlinburg and Pigeon Forge

Photo: Bruce McCamish



Wildland Fires & Their Emissions

An Individual & Occupational Health Issue



Whitewater-Baldy Complex, Gila National Forest, NM, May, 2012

URL: lance-modis.eosdis.nasa.gov/cgi-bin/imagery/firemaps.cgi

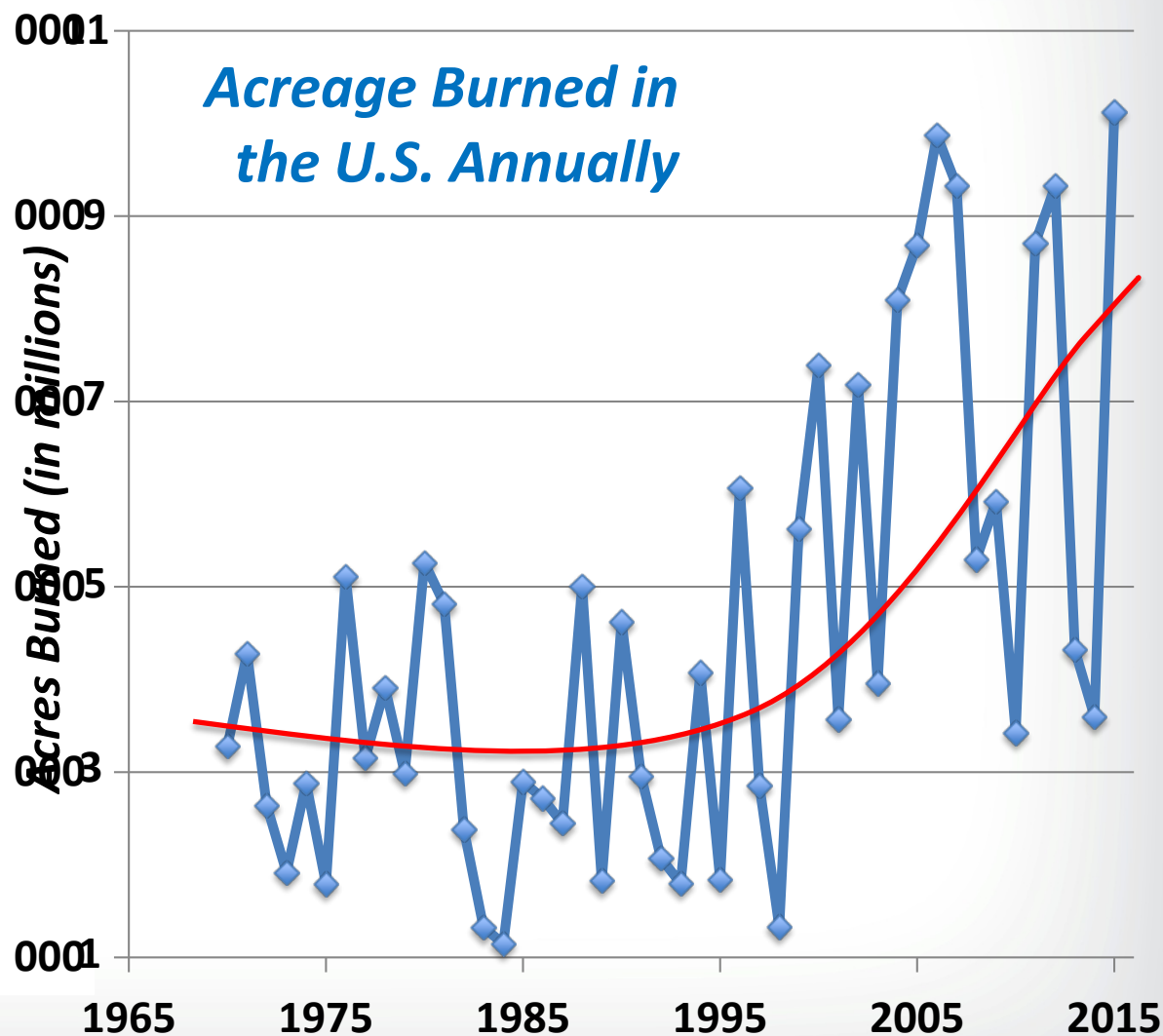


Wildfire Smoke is an Increasing Public Health Hazard in the U.S.

Present Concerns

- **Increasing acreage burned**
- **Increasing impact on urban areas**
 - 10% of all land with housing are situated in the wildland-urban interface
 - 38.5% of U.S. housing units
- **Increasing vulnerability of sensitive populations**

(Radeloff et al. 2005)





Changing U.S. Demographic Increases Risk to Wildfire Smoke

Changing US Demographic

- Median age of U.S. Population will continue to shift upward

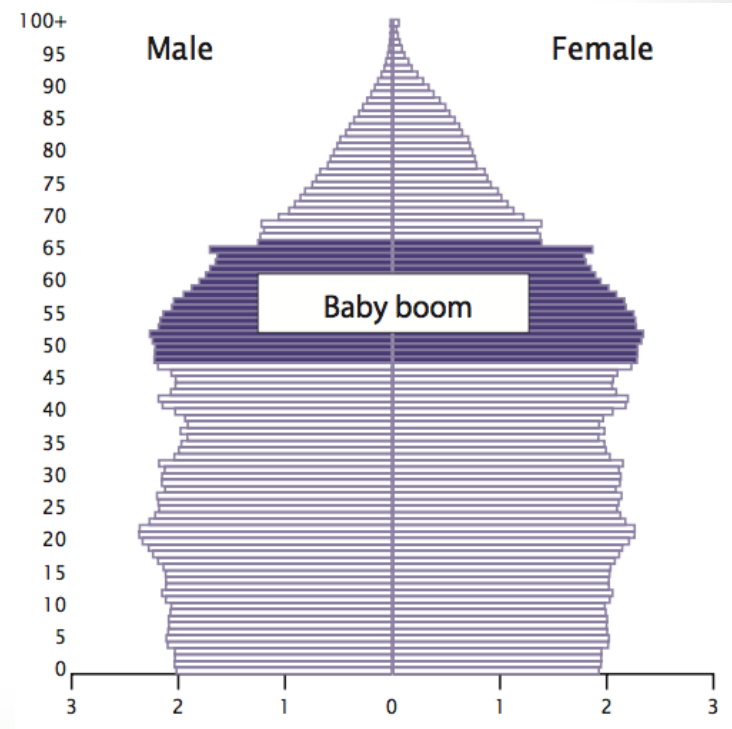
Higher Prevalence of Chronic Diseases Conferring Risk to Wildland Fire Smoke

- Aging U.S. population with increasing prevalence of:
 - Heart-lung disease, obesity, diabetes
 - 27% of U.S. population falls into a risk group

Increasing Population Living in WUI

- More than 2,000,000 acres/yr converted to WUI

US Population 2012





Changing U.S. Demographic Increases Risk to Wildfire Smoke

Changing US Demographic

- Median age of U.S. Population will continue to shift upward

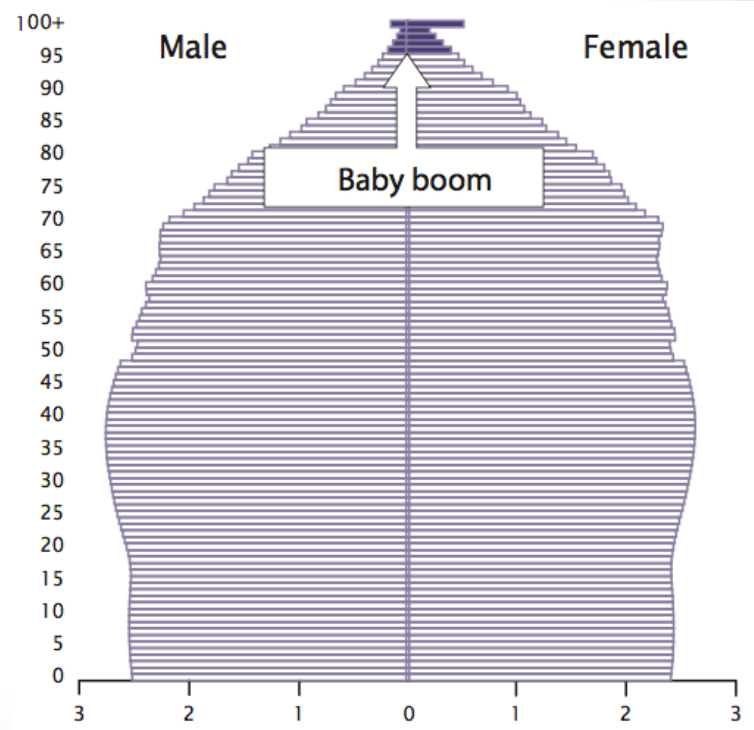
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Projected US Population 2060





Changing U.S. Demographic Increases Risk to Wildfire Smoke

Changing US Demographic

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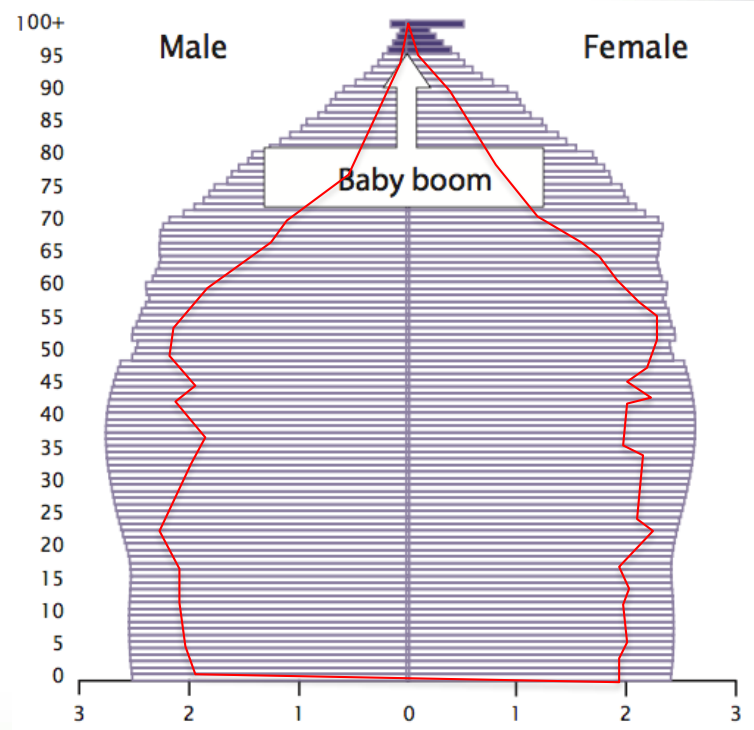
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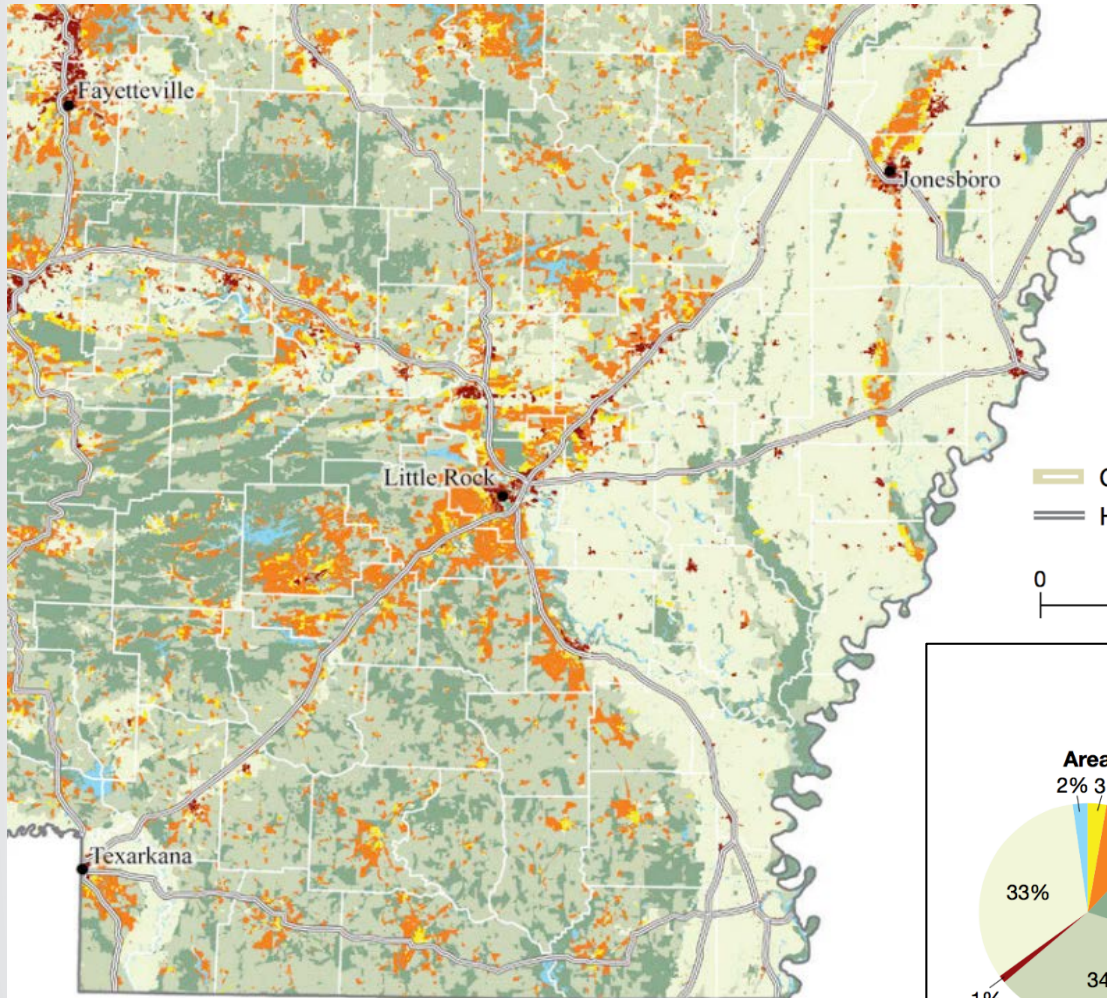
Projected US Population 2060





2010 Wildland-Urban Interface

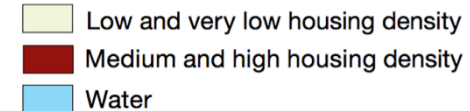
Arkansas



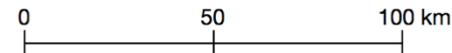
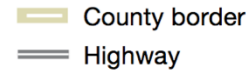
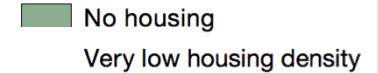
Wildland-Urban Interface (WUI)



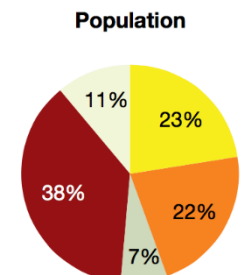
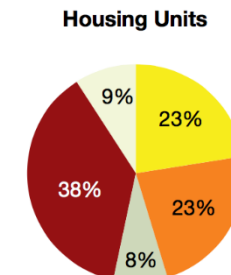
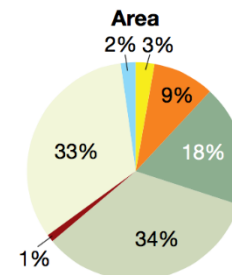
Non-vegetated or Agriculture



Non-WUI Vegetated



WUI in Numbers (see legend)



Air-Quality Impacts Extend Long Distances

Health Impacts Can Extend Hundreds of Miles and Affect Heavily Populated Urban Areas

- **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





Wildfire Smoke: A Complex Mixture

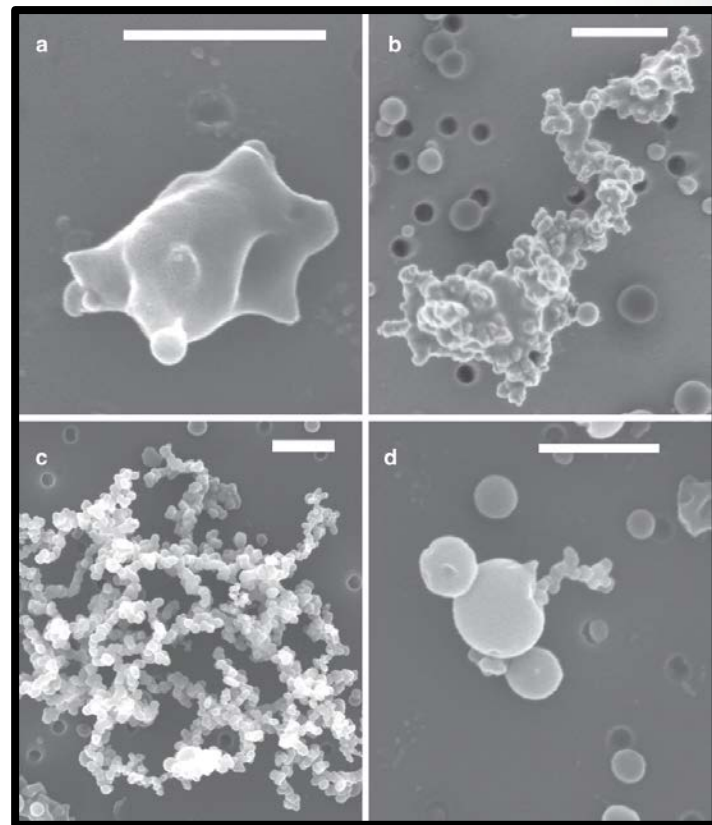
Depends on Fuel & Combustion Conditions



Cascade Complex, Idaho, 2007

Varies Spatially & Temporally

- Particulate matter
- CO
- VOCs
- Trace gases
- Air toxics
- Metals
- Ozone



China S, *et al.* *Nat Commun* 4,
No.: 2122
doi:10.1038/ncomms3122



Air-Quality Impacts

Urban Areas, at a Distance, High Exposures

2013 California Rim Fire



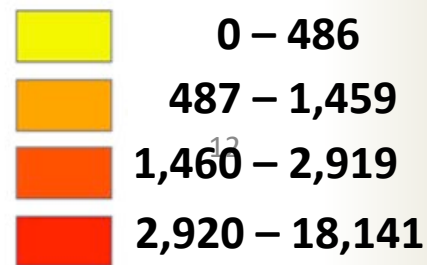
Daily mass intake breathing PM
at the EPA 24 hr $PM_{2.5}$ standard
($35\mu g/m^3$) = $486 \mu g PM_{2.5}/day$

Affected Californian Counties

Aug. 30 – Sep. 10



Daily Mass Intake
 $\mu g PM_{2.5}$ per Person



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



Understanding the Effects of Wildfire Smoke on Health

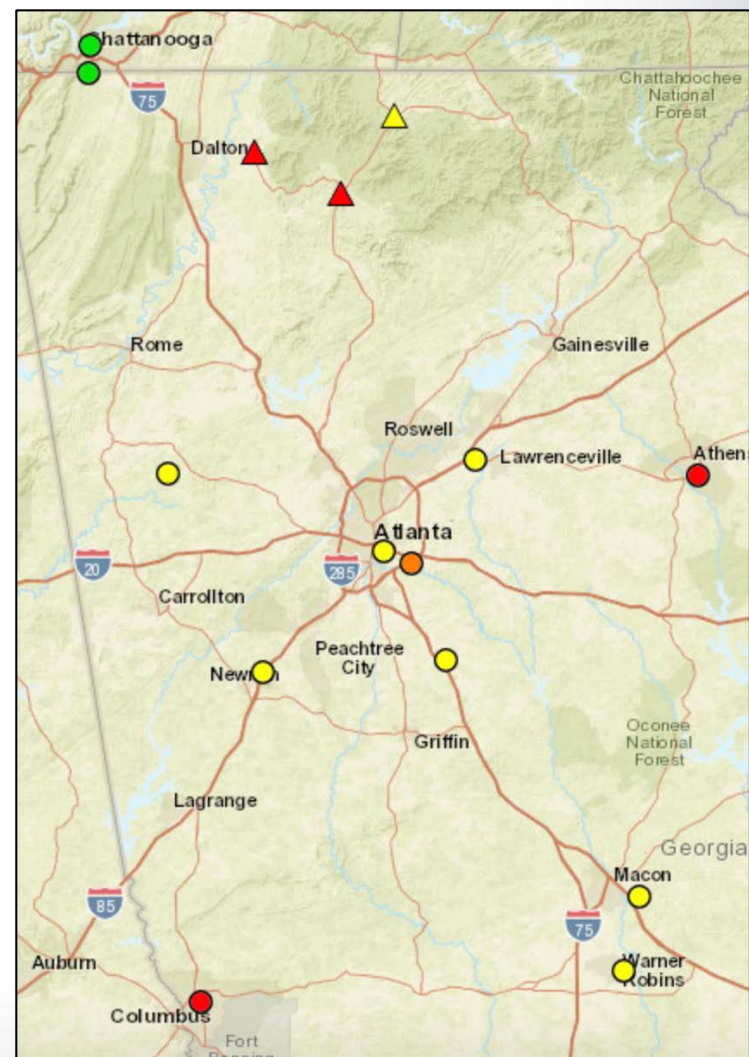
Key Requirements: Exposure Assessment & Health Outcome Data

- **Exposure Assessment**

- Location
- Pollutants and their concentration
- Duration of exposure
- Weather and other confounders

- **Health Outcomes**

- Administrative health data



Fires: Current Conditions



Understanding the Effects of Wildfire Smoke on Health

Key Requirements: Exposure Assessment & Health Outcomes

- **Exposure Assessment**

- Location
- Pollutants and their concentrations
- Duration of exposure
- Weather and other conditions

- **Health Outcomes**

- Administrative health data

Game Changers:

- Satellite imaging of spatial and temporal distribution of pollutants and exposure modeling
- GIS coding of residences
- Large health data sets



Fires: Current Conditions



Understanding the Effects of Wildfire Smoke on Health

Key Requirements: Exposure Assessment & Health Outcomes

- **Exposure Assessment**

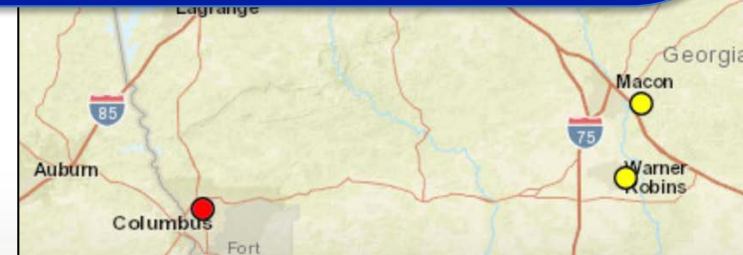
- Location
- Pollutants and their concentrations
- Duration of exposure
- Weather and other conditions

- **Health Outcomes**

- Administrative health data
- Syndromic surveillance data
- Electronic health records
- Pharmacy medication usage
- Health confounders

Game Changers:

- Satellite imaging of spatial and temporal distribution of pollutants and exposure modeling
- GIS coding of residences
- Large health data sets



Fires: Current Conditions



Health Effects of Wildfire Smoke

Systematic Reviews are Now Available



ELSEVIER

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,*}, Gavin Pereira ^b, Sarah A. Uhl ^a, Mercedes A. Bravo ^a, Michelle L. Bell ^a

 CrossMark

[Environ Res.](#) 2015
Jan;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}

¹Environmental Health Sciences Division, School of Public Health, University of California, Berkeley, Berkeley, California, USA; ²Harvard Center for Population and Development Studies, Harvard T.H. Chan School of Public Health, Cambridge, Massachusetts, USA; ³School of Population and Public Health, University of British Columbia, Vancouver, British Columbia, Canada; ⁴Menzies Institute of Medical Research, University of Tasmania, Hobart, Tasmania, Australia; ⁵Environmental Health Services, Department of Health and Human Services, Hobart, Tasmania, Australia; ⁶Department of Environmental Health Sciences, Fielding School of Public Health, University of California, Los Angeles, Los Angeles, California, USA; ⁷Department of Medicine, University of California, San Francisco, San Francisco, California, USA; ⁸Office of the Chief Medical Officer of Health, Yukon Health and Social Services, Whitehorse, Yukon, Canada



Health Effects of Wildfire Smoke

Systematic Reviews are Now Available



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

Review

Critical Review of Health

Colleen E. Reid,^{1,2} Michael Brauer,³ Fa

¹Environmental Health Sciences Division, Science and Technology Center for Population and Development Studies, University of British Columbia, Vancouver, Canada; ²Department of Population and Public Health, University of British Columbia, Vancouver, Canada; ³Environmental Health Sciences Division, University of Tasmania, Hobart, Tasmania, Australia; ⁴Department of Environmental Health Sciences, Fielding School of Public Health, University of California, Los Angeles, Los Angeles, California, USA; ⁵Department of Medicine, University of California, San Francisco, San Francisco, California, USA; ⁶Office of the Chief Medical Officer of Health, Yukon Health and Social Services, Whitehorse, Yukon, Canada

*Positive associations
between smoke exposure
and health outcomes
found in:*

- 70% of all mortality studies
- 90% of all respiratory health outcome studies

Known and Suspected Health Effects of Wildfire Smoke

Known

- **Respiratory morbidity**
 - *Asthma & COPD*
 - *Bronchitis & pneumonia*
- **Susceptible populations**
 - *Children, elders and those with chronic disease*

Suspected

- All-cause mortality
- Cardiovascular morbidity
- Adverse birth outcomes

More data needed

- Risk of mortality
- Cardiovascular morbidity
- Susceptible populations





Who's at Risk from Wildfire Smoke

NHANES 2007-2010, N=10,898

Susceptible category	N	Percent (95% CI)
None	7135	73.0 (71.4, 74.6)
Respiratory only	642	6.4 (5.5, 7.2)
Cardiovascular only	319	2.6 (2.3, 2.9)
>65 years only	1713	10.9 (10.1, 11.8)
Respiratory and cardiovascular	136	1.0 (0.7, 1.3)
Respiratory and >65 years	220	1.6 (1.3, 1.8)
Cardiovascular and >65 years	608	3.8 (3.3, 4.3)
All three groups	125	0.7 (0.5, 0.9)

NHANES = National Health and Nutrition Education Survey

Wells EM, Dearborn DG, Jackson LW (2012). PLoS ONE 7(11): e50526



Who's at Risk from Wildfire Smoke

NHANES 2007-2010, N=10,898

Susceptible category	N	Percent (95% CI)
None		73.0 (71.4, 74.6)
Respiratory only		1.1 (0.5, 2.2)
Cardiovascular only		1.5 (0.7, 2.9)
>65 years only		10.1 (8.1, 12.8)
Respiratory and cardiovascular		1.3 (0.7, 2.3)
Respiratory and >65 years		1.8 (1.3, 2.5)
Cardiovascular and >65 years		3.8 (3.3, 4.3)
All three groups	125	0.7 (0.5, 0.9)

27% fall into at least one susceptible group category

NHANES = National Health and Nutrition Education Survey

Wells EM, Dearborn DG, Jackson LW (2012). PLoS ONE 7(11): e50526



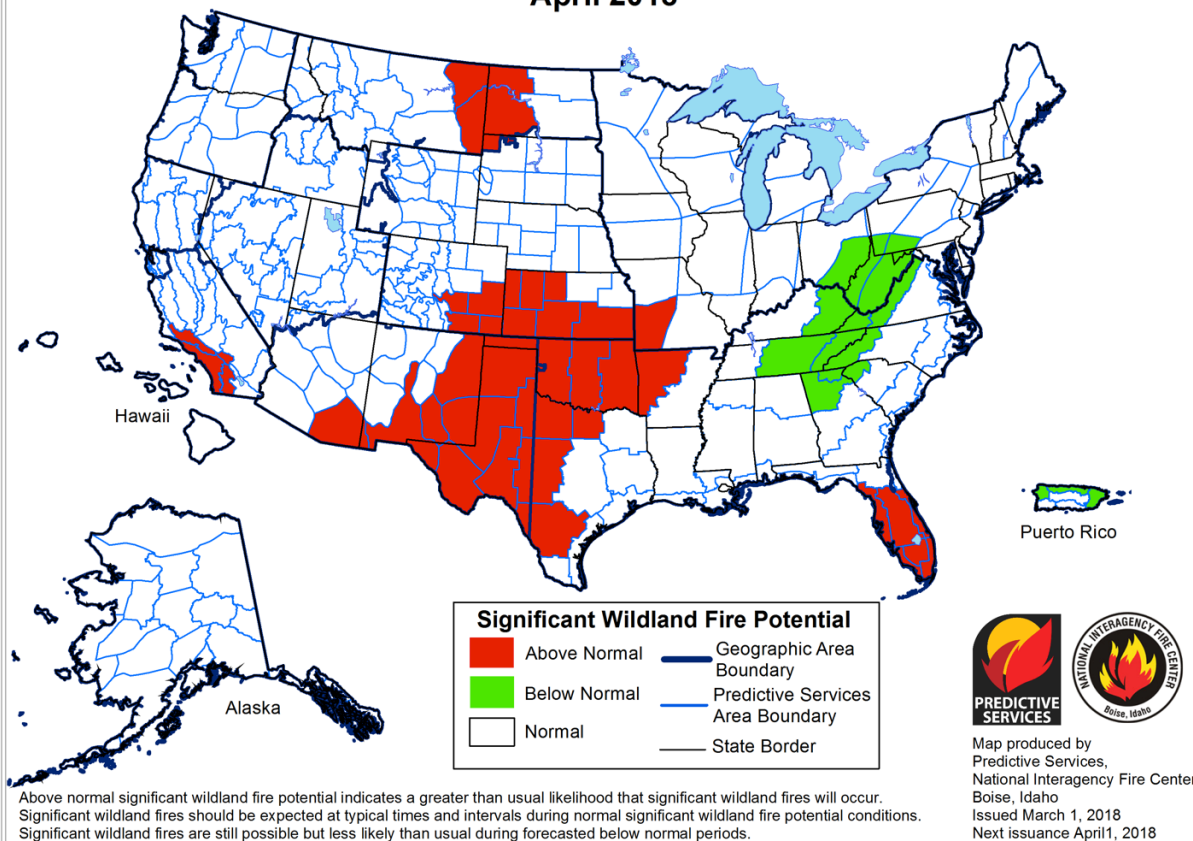
Wildland Fire Potential Outlook

April 2018

As drought conditions intensify large fire potential will expand:

- Warmer than average temperatures across the Southern Area
- Longer term dry areas of OK & TX along with warm temperatures are likely to keep fire potential above average
- Drier weather increasing potential for FL

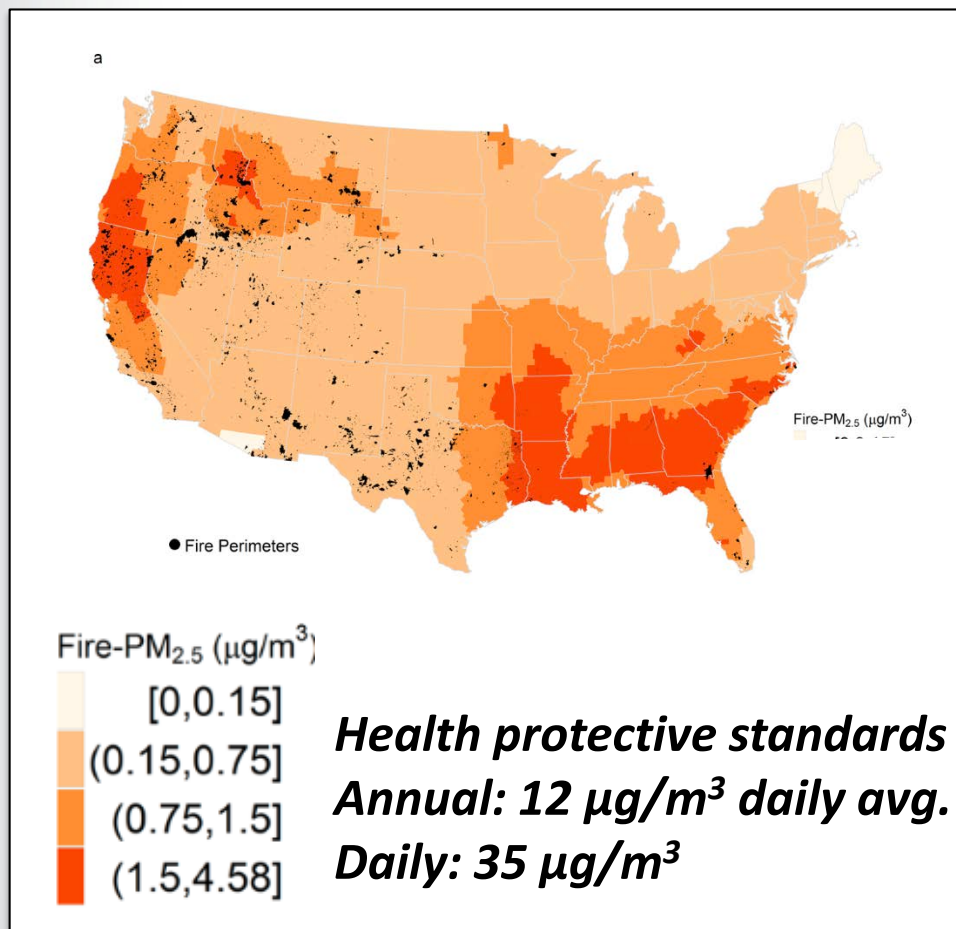
Significant Wildland Fire Potential Outlook
April 2018





Identifying Communities at Risk from Wildfire Smoke

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



Community Health-Vulnerability Index (CHVI)

- Based on health and social factors that increase the risks of adverse health effects from wildfire smoke exposures
- Factors included county prevalence rates for health conditions, age and socioeconomic conditions
- Characterized the population size at risk with respect to the level and duration of exposure to fire-originated fine PM (fire-PM_{2.5}) and vulnerability



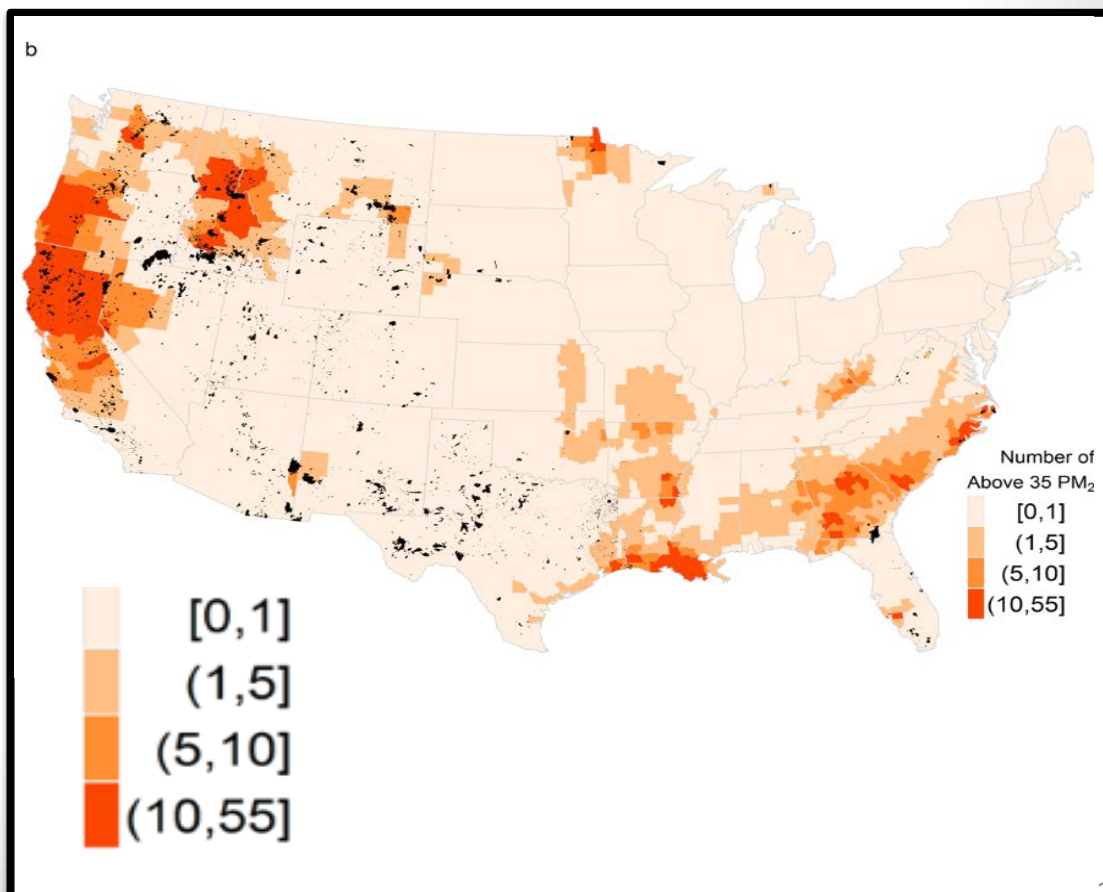
Identifying Communities at Risk from Wildfire Smoke

Factors of Vulnerability

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

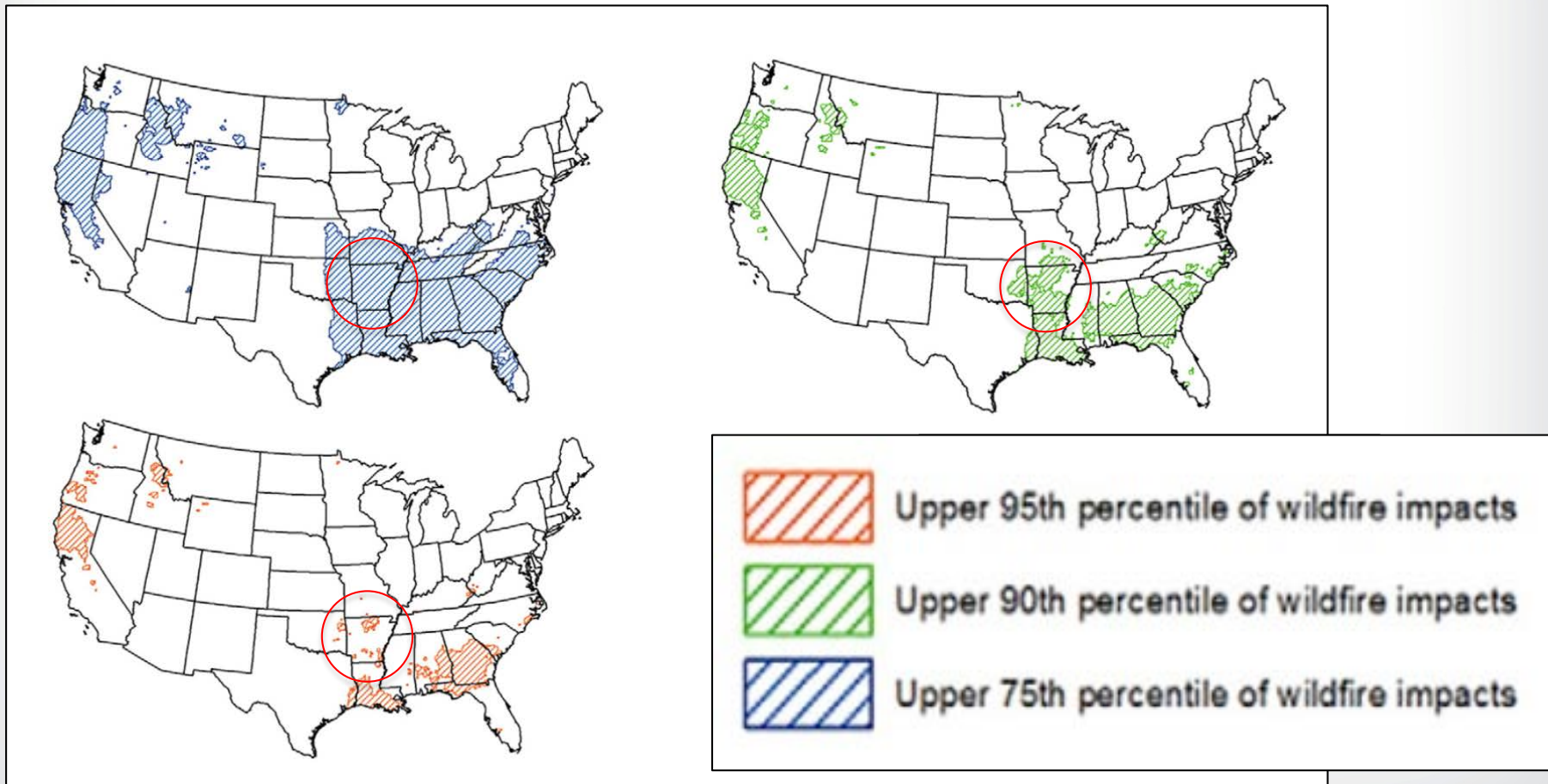
of days with fire- $PM_{2.5}$ above $35 \mu\text{g}/\text{m}^3$ by counties of continental US

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



Spatial Distribution of Elevated Wildfire-Related $PM_{2.5}$

Locations of the U.S. experiencing elevated wildfire-related $PM_{2.5}$ concentrations over a 5-year period





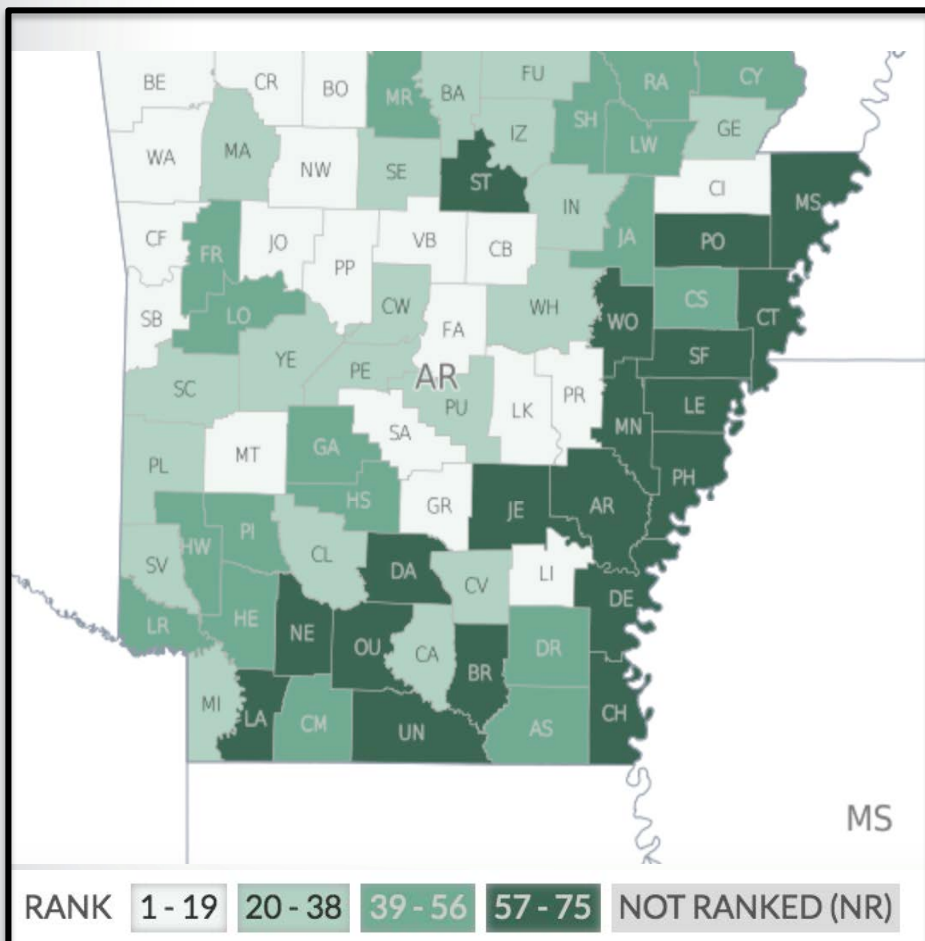
Arkansas 2018

County Health Rankings

HEALTH OUTCOMES

Overall Rank

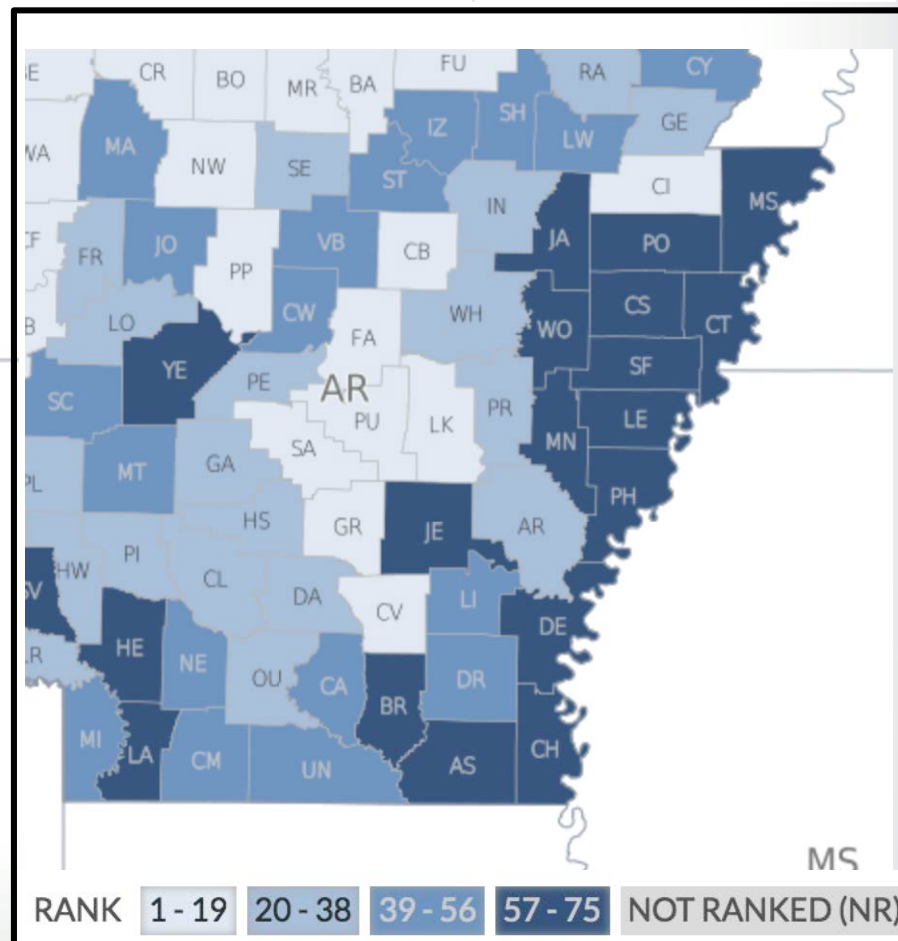
An overall ranking for all Health Outcomes combined.



HEALTH FACTORS

Overall Rank

An overall ranking for all Health Factors combined.





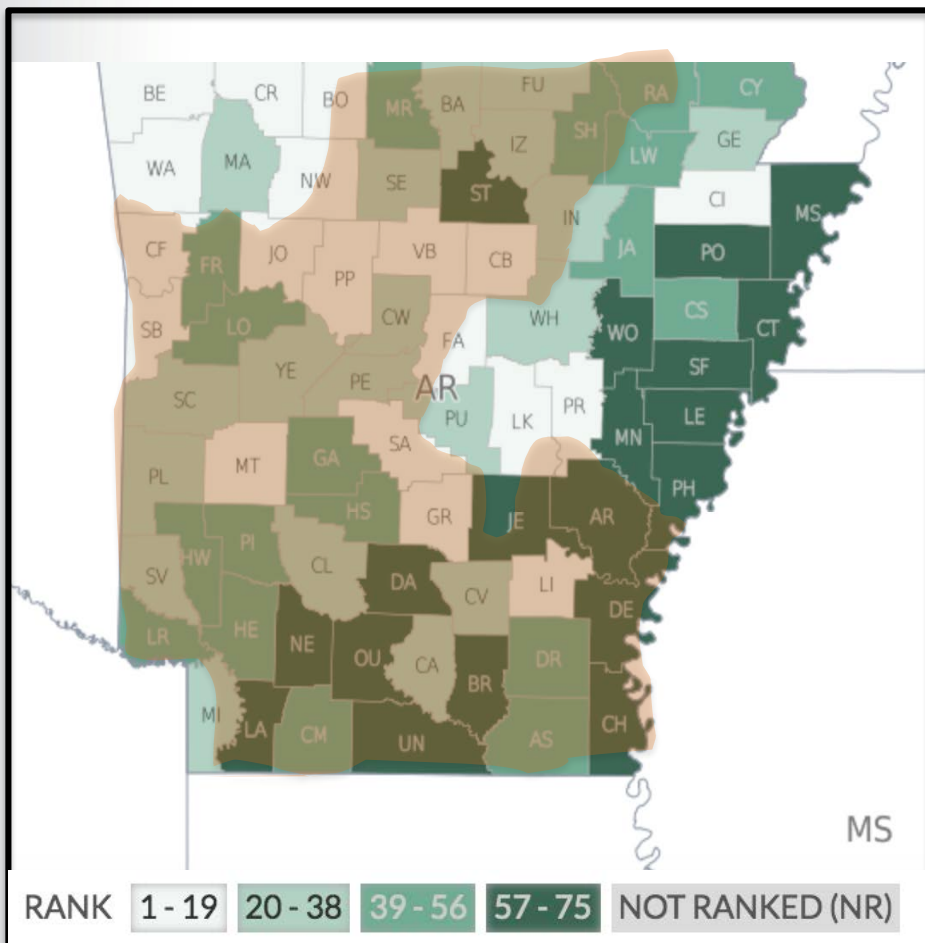
Arkansas County Health Rankings

Superimposed 90th Percentile Wildfire Impacts

HEALTH OUTCOMES

Overall Rank

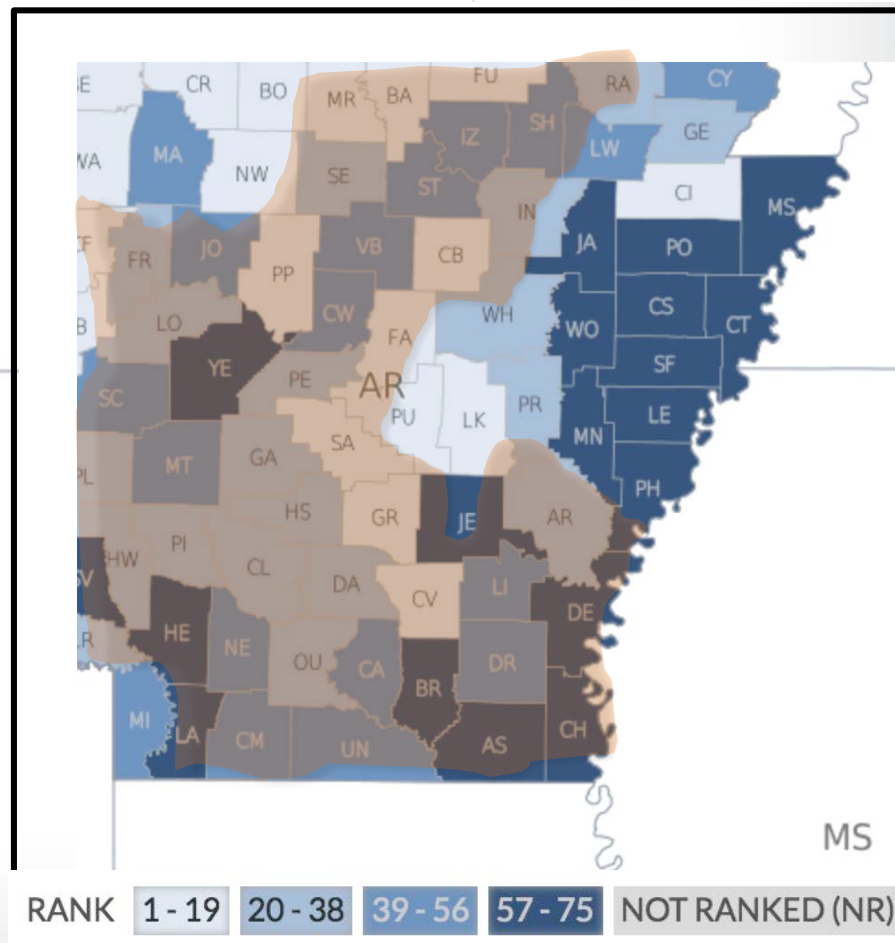
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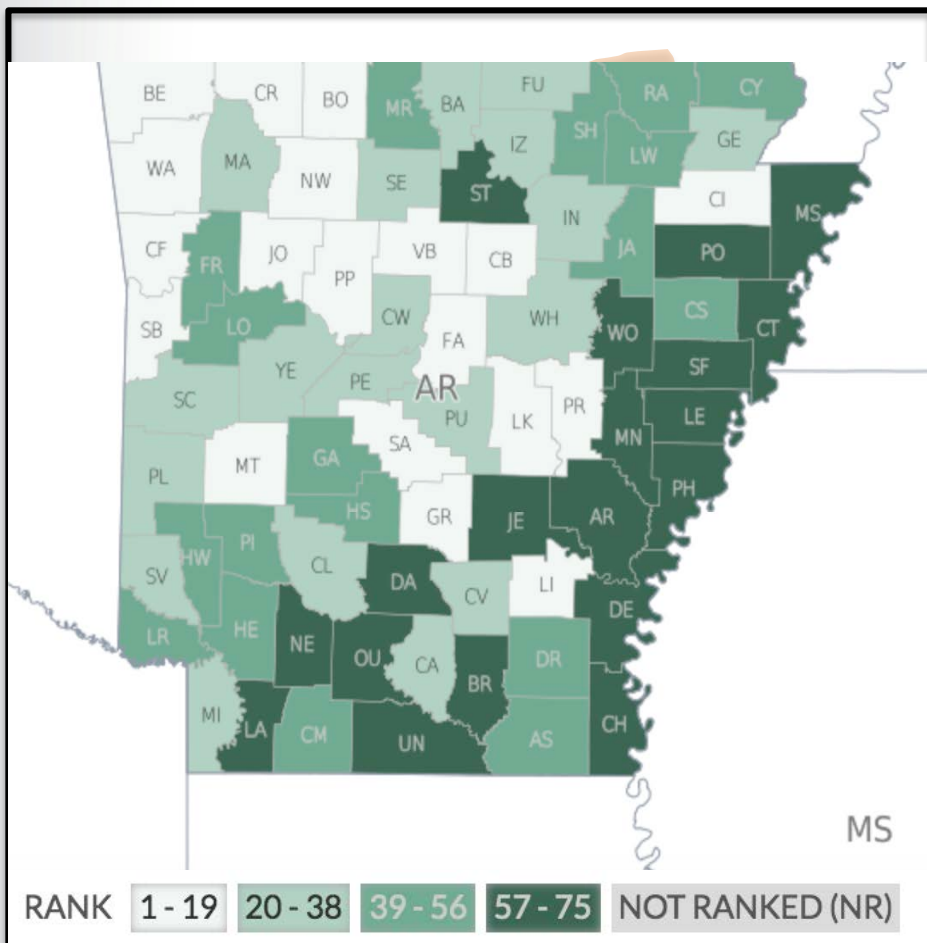
Arkansas County Health Rankings

Superimposed 90th Percentile Wildfire Impacts

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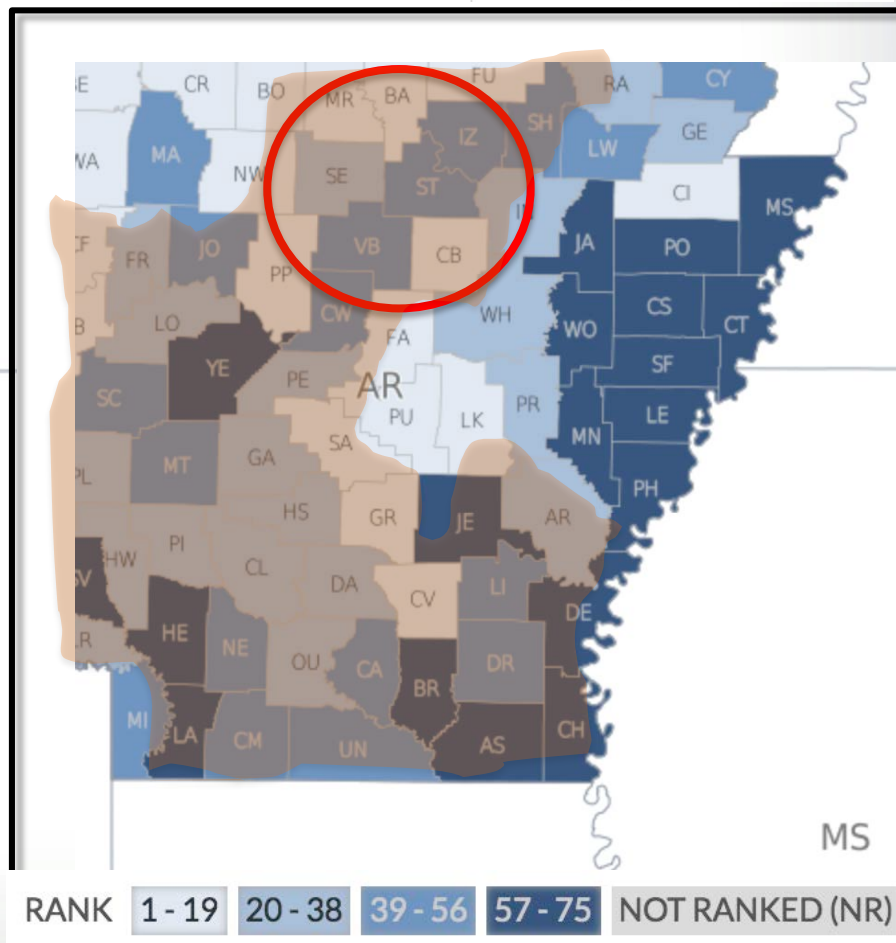
An overall ranking for all Health Outcomes combined.



HEALTH FACTORS

Overall Rank

An overall ranking for all Health Factors combined.

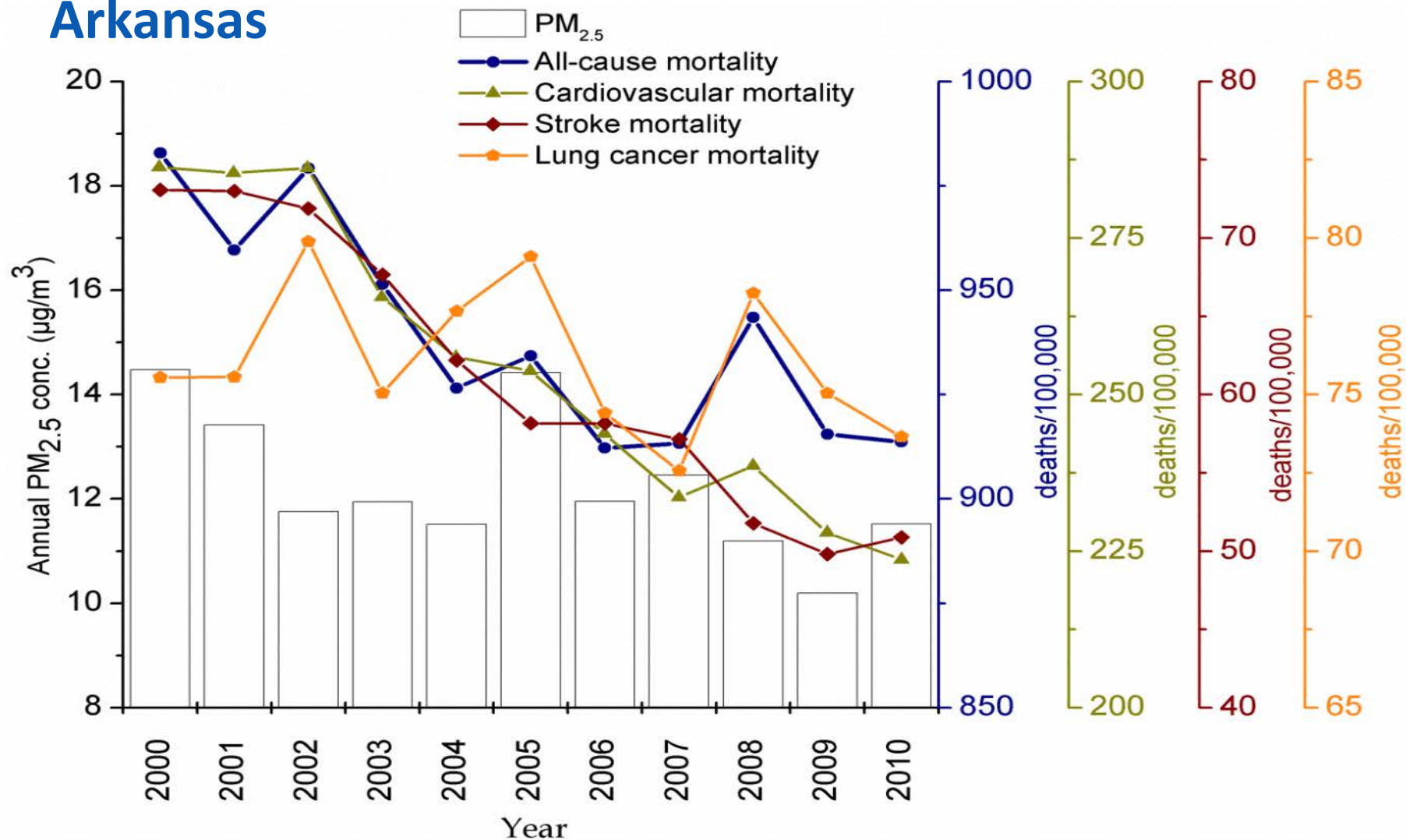




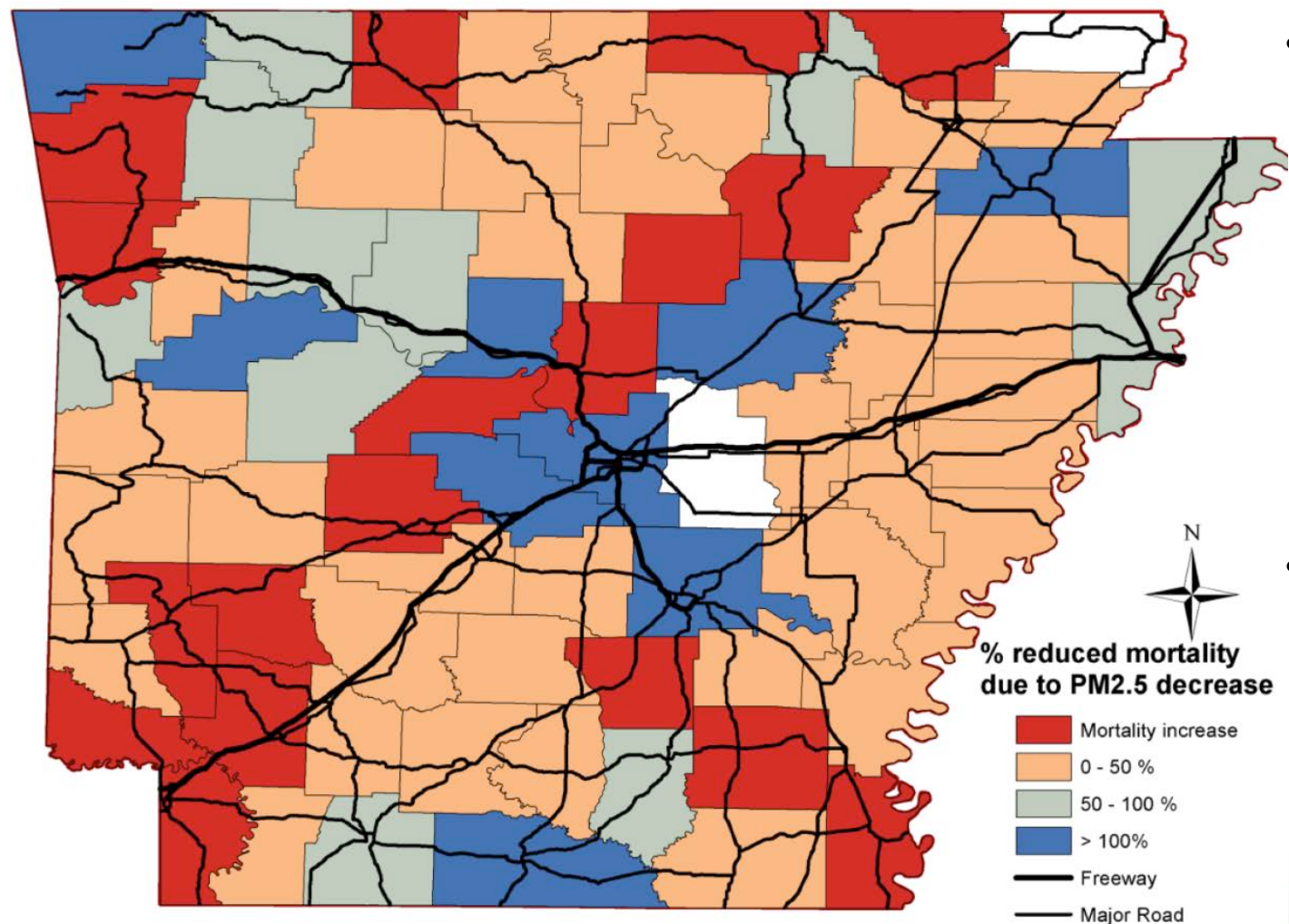
Annual $PM_{2.5}$ Mass Concentration

Non-accidental, CV, stroke & Lung Cancer Mortality

Arkansas



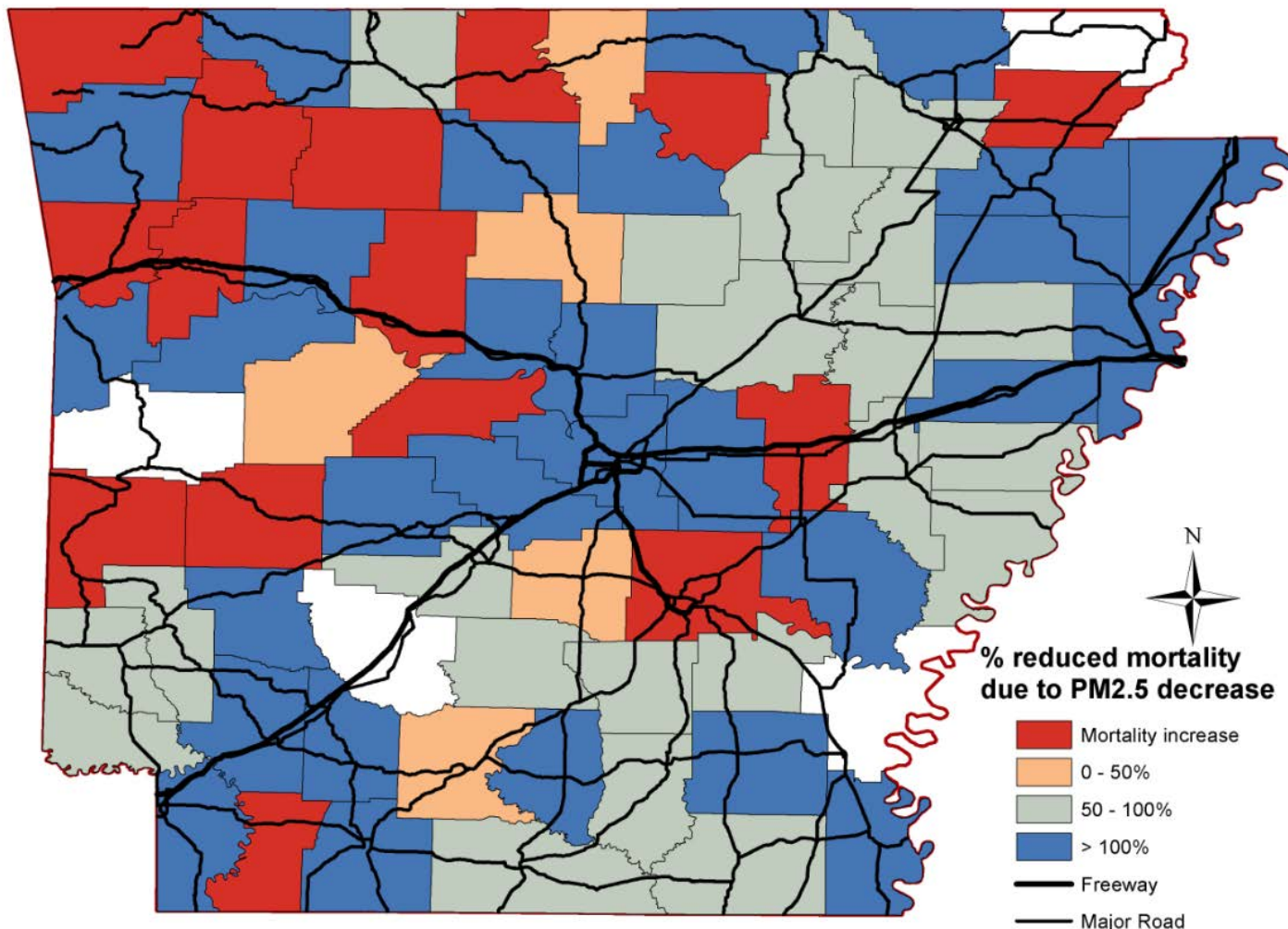
Cardiac Mortality Reductions Attributed to PM_{2.5} Reductions by County



- Reduction of PM_{2.5} in the Little Rock/North Little Rock, Jonesboro and Bentonville area fully accounted for the declining mortality rates
- Rural Arkansas and the Delta region, up to 50% of reduced premature cardiovascular deaths was due to PM_{2.5} reductions



Stroke Mortality Reductions Attributed to PM_{2.5} Reductions by County



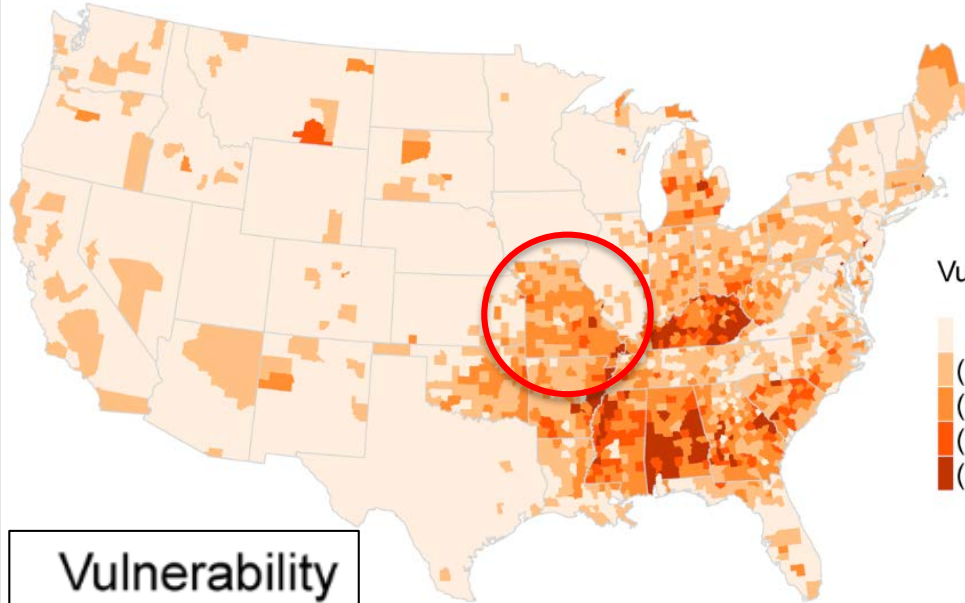
- Improvements in PM_{2.5} prevented the vast majority of premature deaths due to stroke
- In particular farming communities along the Delta region (eastern/south east Arkansas) benefited



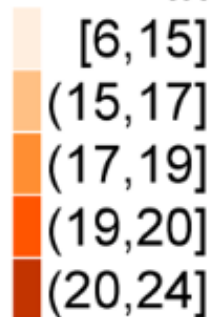
Community Health-Vulnerability

Community-Health Vulnerability Index

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



Vulnerability Index



Vuln



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

Estimating Health-Related Costs

2008 Pocosin Lakes National Wildlife Refuge

www.fws.gov/pocosinlakes/news/ERF/news-erf-out.html



Satellite image showing the location of Evans Road Fire in the Pocosin Lakes National Wildlife Refuge, NC

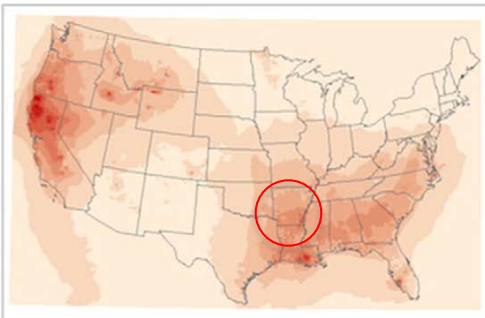
Rappold A et al. Environ Sci & Tech 2014

- *Burned 40K acres of peat bogs*
- *\$20M in suppression efforts, 2 billion gallons of water, 202 days*
- *Cost of excess ED visits for asthma and heart failure ~ \$1 million*
- *Additional estimates of health costs*
 - 4 to 5 premature deaths
 - 31 non-fatal heart attacks
 - 41 bronchitis, & 810 asthma attacks
 - 530 lower respiratory symptoms
 - 769 upper respiratory symptoms
 - 3,700 work days lost
- *Health & death-related costs \$48.4 million*



Annual U.S. Wildland Fire-Attributable $PM_{2.5}$ & Costs (2008-2012)

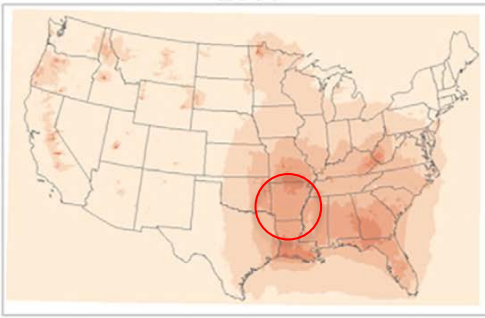
2008



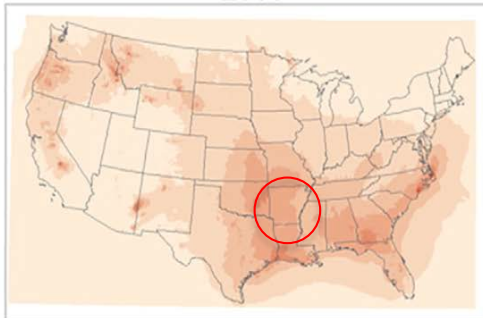
2009



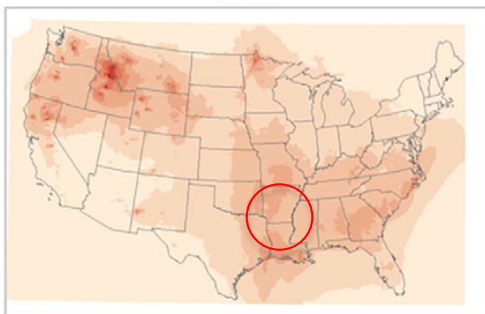
2010



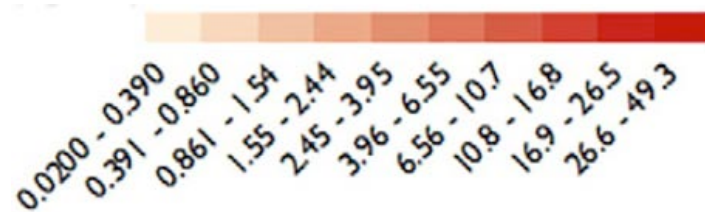
2011



2012



**Wildland Fire-Attributable
Annual Mean $PM_{2.5}$ ($\mu g/m^3$)**



**Estimated Economic Value of
Wildfire-Attributed $PM_{2.5}$ -
Premature Deaths &
Respiratory Admissions**

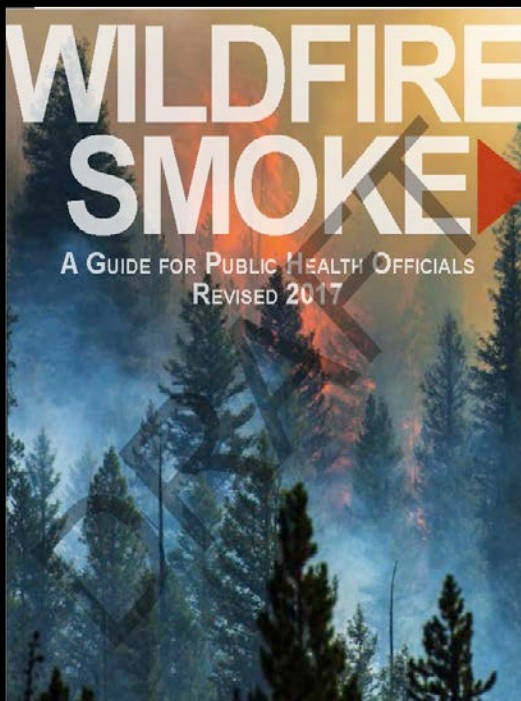
Short-term \$63 billion
(Range \$6 - \$170 billion)

Long-term \$450 billion
(Range \$42 – \$1000 billion)



Public Health Outreach

Mitigating the Health Effects of Wildfire Smoke



Environmental Topics Laws & Regulations About EPA

Particle Pollution and Your Patients' Health

An evidence-based training for healthcare professionals that:

- Describes the biological mechanisms responsible for the cardiovascular and respiratory health effects associated with particle pollution exposure.
- Provides educational tools to help patients understand how particle pollution exposure can affect their health and how they can use the Air Quality Index to protect their health.



This course is designed for family medicine physicians, internists, pediatricians, occupational and rehabilitation physicians, nurse practitioners, nurses, asthma educators, pulmonary specialists, cardiologists, and other medical professionals.

[Start the Course](#)

[Course developers](#)



Environmental Topics Laws & Regulations About EPA

Search EPA.gov

Related Topics: [Air Research](#)

CONTACT US SHARE

Wildland Fire Research to Protect Health and the Environment

Fires are increasing in frequency, size and intensity partly due to climate change and land management practices, yet there is limited knowledge of the impacts of smoke emissions—both short term and long term. EPA is using its expertise in air quality research to fill the gaps in scientific information and to develop tools to prevent and reduce the impact of wildfires and controlled or prescribed burns. The wildland fire research has three main goals:

- Provide new science to understand the impacts of smoke on health, and how this knowledge can instruct smoke management practices and intervention strategies to reduce health impacts.
- Provide essential novel data on smoke emissions to construct the national emission inventory used to understand air quality across the country.
- Improve understanding of how smoke from fires affects air quality and climate change.



Researchers lift a monitoring balloon to track smoke from a prescribed fire in Camp Lejeune, N.C.

Research Areas

- [Health Effects](#)
- [Tools and Technology Development](#)
- [Water Supply and Ecosystem Protection](#)

Research Publications and Other Resources

- [Health Risk Communication Workshop Report and Presentations](#)
- [EPA Wildland Fire Research Publications: 2010-2017](#)
- [Other Resources](#)
- [Key Links](#)

Public Health Information

- [Local air quality conditions](#)
- [Current fire conditions and advisories](#)
- [Fires and health](#)
- [Burn Wise program](#)
- [Other Resources](#)



[Learn more](#)

Wildland Fire Sensors Challenge



"Turnkey real-time air pollutant measurement platform to support public health messaging during large wild and prescribed fire events"

Do you have ideas on new air pollution measurement strategies for wildfire events?

Wild fires often produce significant air pollution, which poses health risks to first responders, residents in nearby communities and other populations that are impacted by smoke as it travels downwind. In contrast, prescribed fires are typically managed to minimize downwind impacts on populated areas, however those in close proximity may be exposed to smoke. Wildland fire refers to both wild and prescribed fires.

Quickly deploying air pollution measurement stations has, to date, been limited by the cost and complexity of implementation. However, emerging technologies including miniaturized direct-reading sensors, compact micro-processors, and wireless data communications provide new opportunities to detect air pollution. U.S. EPA and collaborating partners are preparing a challenge opportunity to develop a prototype multi-node measurement system capable of rapid deployment and continuous real-time monitoring of highly



Local Air Quality Conditions

Zip Code: Go State: Alabama My Current Location

Fires: Current Conditions





Local Air Quality Conditions

Zip Code:

Go

State :



Go

[National Summary](#)

[Forecast](#)

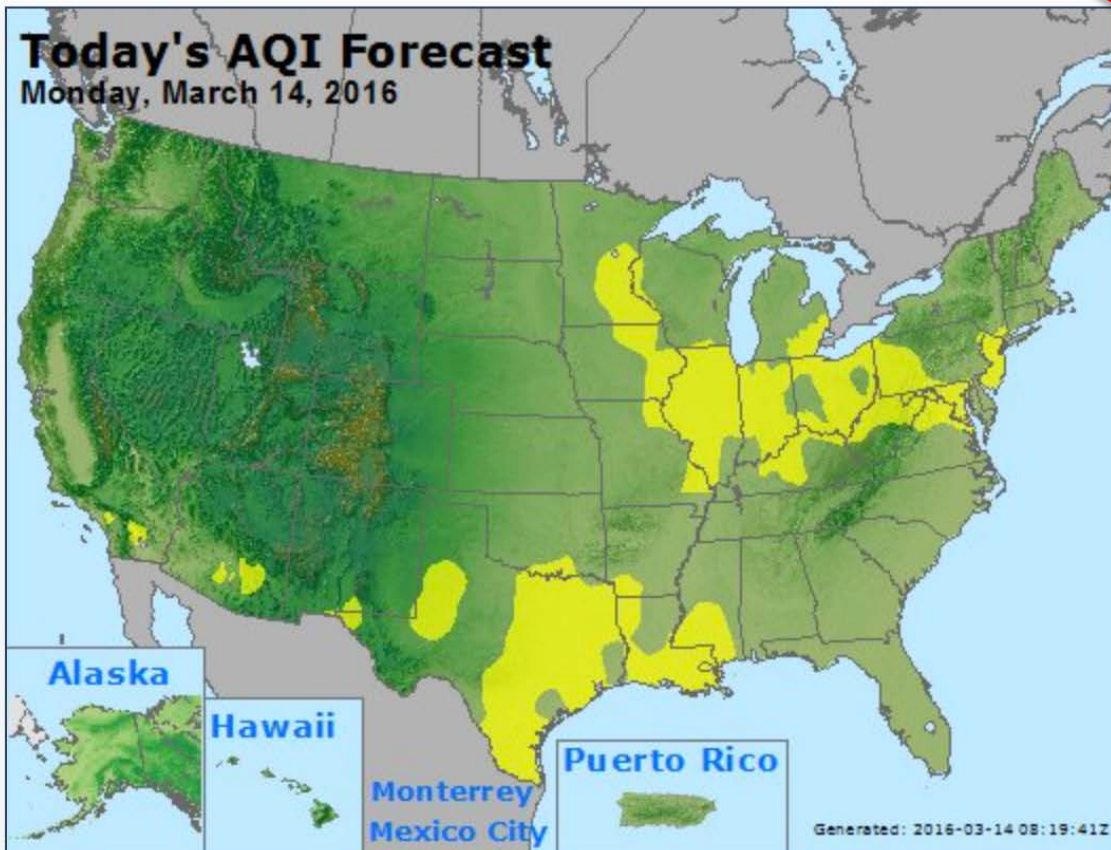
[Current AQI](#)

[AQI Loop](#)

[More Maps](#)

Today's AQI Forecast

Monday, March 14, 2016



Alaska

Hawaii

Monterrey
Mexico City

Puerto Rico

Generated: 2016-03-14 08:19:41Z

Good

Moderate

USG

Unhealthy

Very
Unhealthy

Hazardous

! Action Day

Fires: Current Conditions

[Click to see map](#)



U.S. Embassies and Consulates

Data from air quality monitors at select U.S. embassies and consulates around the world

Announcements

3/9/16: NEW: [Spanish-language website](#) for Air Quality Flag Program - NEUVO: [En español—El sitio web](#) de la programa de banderines sobre la calidad del aire

03/03/16: Now available! Heart Disease, Stroke, and Outdoor Air Pollution (en Español) - [Enfermedades del corazón, ataques cerebrales y contaminación del aire](#)

[more announcements](#)

Air Quality Basics

[Air Quality Index](#) | [Ozone](#) | [Particle Pollution](#) | [Smoke from fires](#) | [What You Can Do](#)

▶ [Health](#)

▶ [Learning Center](#)



Apps



EnviroFlash Email



Local Air Quality Conditions

Zip Code:

Go

State : Alabama



Go

[National Summary](#)

[Forecast](#)

[Current AQI](#)

[AQI Loop](#)

[More Maps](#)

Fires: Current Conditions

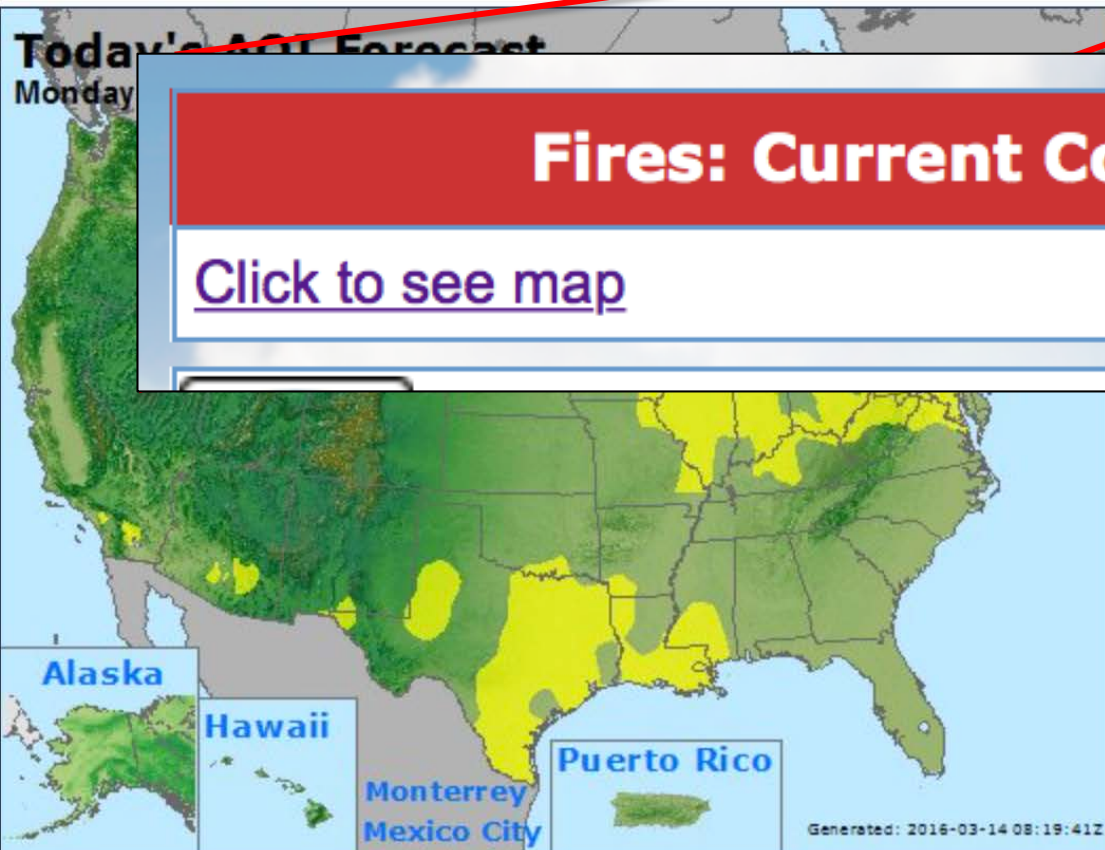
[Click to see map](#)



[U.S. Embassies and Consulates](#)

Fires: Current Conditions

[Click to see map](#)



[corazón, ataques cerebrales y contaminación del aire](#)

[more announcements](#)

Air Quality Basics

[Air Quality Index](#) | [Ozone](#) | [Particle Pollution](#) | [Smoke from fires](#) | [What You Can Do](#)

[Health](#)

[Learning Center](#)

Good

Moderate

Unhealthy for Sensitive Groups

Unhealthy

Very Unhealthy

Hazardous

! Action Day



Apps



EnviroFlash Email



Fires: Current Conditions Page

- **Current Smoke Map generated by NOAA HMS**
- **Current Advisories – State/Local/Tribal agency blogs and Wildland Fire Air Quality Response Program**

Current Conditions Map - May 9, 2016

The screenshot displays the AirNow website interface. At the top, there's a search bar for 'Local Air Quality Conditions' with fields for Zip Code, State (Alabama), and a Go button. Below this, the 'Fires: Current Conditions' map shows a large area of smoke and fire in the western United States, specifically in California and Nevada. The map includes labels for various cities and states.

Below the map, there's a section titled 'Smoke Advisories and Forecasts' with a list of advisories for various states including Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, and North Carolina. Each state has a link to its respective advisory page.

On the right side, there's a section titled 'Wildland Fire Air Quality Response Program' with a sub-header 'The Wildland Fire Air Quality Response Program'. It includes a brief description of the program and a link to 'Air Resource Advisors'. Below this, there's a table titled 'Current Advisories' with columns for Site, Yesterday, Today, Tomorrow, and Comments. The table lists several sites including Johnsenville, Kennedy Meadows, Kernville, Lone Pine, Porterville, Springville, and Three Rivers, with their respective advisory levels (e.g., Good, Moderate, USG).

At the bottom right, there's a section titled 'Air Resource Advisors' with a brief description of their role and a link to 'Learn more about Air Resource Advisors and what they do'.

Current Advisories

CA Smoke Blog
USFS Wildland Fire Air Quality Response Program



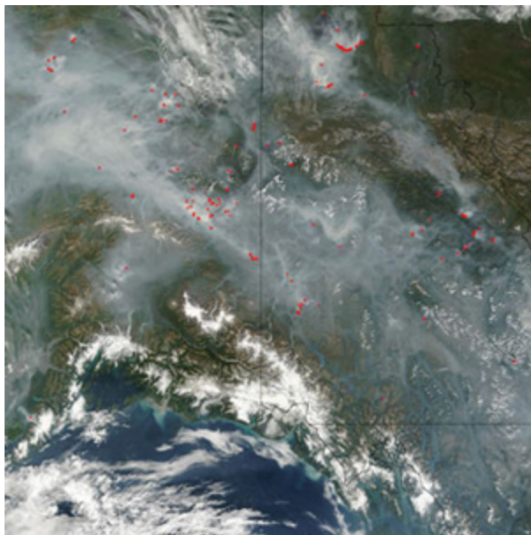
AirNow

Fires and Your Health

Fires and Your Health

Smoke is made up of a complex mixture of gases and fine particles produced when wood and other organic materials burn. The biggest health threat from smoke is from fine particles. These microscopic particles can get into your eyes and respiratory system, where they can cause health problems such as burning eyes, runny nose, and illnesses such as bronchitis. Fine particles also can aggravate chronic heart and lung diseases - and even are linked to premature deaths in people with these conditions.

If you are healthy, you're usually not at a major risk from short-term exposures to smoke. Still, it's a good idea to avoid breathing smoke if you can help it. Everyone should take the steps below when wildfires are present.



Fires and smoke across Alaska and Northern Canada
[Archive Image courtesy of NASA Modis](#)

Use common sense. If it looks smoky outside, it's probably not a good time to mow the lawn or go for a run. And it's probably not a good time for your children to play outdoors.

Pay attention to local air quality reports. Stay alert to smoke-related news coverage or health warnings.

Visit [AirNow](#) to find out the Air Quality Index in your area. As smoke gets worse, the amount of particles in the air changes - and so do the steps you should take to protect yourself. AirNow recommends precautions you can take to protect your health when air pollution gets bad.

If you are advised to stay indoors, take steps to keep indoor air as clean as possible. When smoke levels are high, try to avoid using anything that burns, such as wood fireplaces, gas logs, gas stoves - and even candles! Don't vacuum. That stirs up particles already inside your home. And don't smoke. That puts even more pollution in your lungs, and in the lungs of people around you.

If you have asthma or other lung disease, make sure you follow your doctor's directions about taking your medicines and following your asthma management plan. Call your doctor if your symptoms worsen.

Run your air conditioner if you have one. Keep the fresh air intake closed and the filter clean to prevent bringing additional smoke inside. Note: If you don't have an air conditioner, staying inside with the windows closed may be dangerous in extremely hot weather. In these cases, seek alternative shelter.

Health Resources

- [How Smoke from Fires Can Affect Your Health](#) - Learn steps you can take to protect your health.
- [Particle Pollution and Your Health](#) - Find out if you are at risk from exposure to particle pollution, and what health effects can be caused by particles. (PDF, 2 pp, 280KB, [about PDF](#)),

Health Resources

- [How Smoke from Fires Can Affect Your Health](#) - Learn steps you can take to protect your health.
- [Particle Pollution and Your Health](#) - Find out if you are at risk from exposure to particle pollution, and what health effects can be caused by particles. (PDF, 2 pp, 280KB, [about PDF](#)),

Educational Resources

- [CDC Wildfire Fact Sheet](#) - Information on emergency preparedness and response.
- [California Air Resources Board SMP Public Outreach Protocol - Tools and Materials](#)
[EXIT AIRNOW ►](#)
- [Wildfire Guide for Health Officials](#)
[EXIT AIRNOW ►](#)

- FOR KIDS- Follow [Smoky Bear's advice](#) when wildfires are in your area!

Educational Resources

- [CDC Wildfire Fact Sheet](#) - Information on emergency preparedness and response.
- [California Air Resources Board SMP Public Outreach Protocol - Tools and Materials](#)
[EXIT AIRNOW ►](#)
- [Wildfire Guide for Health Officials](#)
[EXIT AIRNOW ►](#)

How Smoke from Fires Can Affect Your Health

Updated January 2017

Smoke may smell good, but it's not good for you

While not everyone has the same sensitivity to wildfire smoke, it's still a good idea to avoid breathing smoke if you can help it. And when smoke is heavy, such as can occur in close proximity to a wildfire, it's bad for everyone.

Smoke is made up of a complex mixture of gases and fine particles produced when wood and other organic materials burn. The biggest health threat from smoke is from fine particles. These microscopic particles can penetrate deep into your lungs. They can cause a range of health problems, from burning eyes and a runny nose to aggravated chronic heart and lung diseases. Exposure to particle pollution is even linked to premature death.

Some people are more at risk

It's especially important for you to pay attention to local air quality reports during a fire if you are

- **a person with heart or lung disease**, such as heart failure, angina, ischemic heart disease, chronic obstructive pulmonary disease, emphysema or asthma.
- **an older adult**, which makes you more likely to have heart or lung disease than younger people.
- **caring for children, including teenagers**, because their respiratory systems are still developing, they breathe more air (and air pollution) per pound of body weight than adults, they're more likely to be active outdoors, and they're more likely to have asthma.
- **a person with diabetes**, because you are more likely to have underlying cardiovascular disease.
- **a pregnant woman**, because there could be potential health effects for both you and the developing fetus.



How to tell if smoke is affecting you

High concentrations of smoke can trigger a range of symptoms.

- **Anyone** may experience burning eyes, a runny nose, cough, phlegm, wheezing and difficulty breathing.
- **If you have heart or lung disease**, smoke may make your symptoms worse
 - **People with heart disease** might experience chest pain, palpitations, shortness of breath, or fatigue.
 - **People with lung disease** may not be able to breathe as deeply or as vigorously as usual, and may experience symptoms such as coughing, phlegm, chest discomfort, wheezing and shortness of breath.



AirNow

Current Advisories



Local Air Quality Conditions

Zip Code: Go

State : Go

National Summary

[AirNow Home](#) >> [Headline](#)

Smoke Advisories and Forecasts

[Fires and Your Health](#)

[Fires: Current Conditions](#)

Advisories and Forecasts

United States

Alaska

[Alaska DEC Wildfire Information](#)

Arizona

[Arizona Wildfire Information](#)

California

[Butte County Air Quality Management District](#)

[Northern Sierra Air Management District](#)

[Shasta County Air Quality Management District](#)

[Shasta County \(Redding\) Air Quality Webcam](#)

[South Coast Air Quality Management District](#)

[Ventura County Air Pollution Control District](#)

Colorado

[Colorado Wildfire Smoke Health Advisories](#)



AQI Categories and Health Messages

Level of Health Concern	Index Value	Message
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health alert: everyone may experience more serious health effects.
Hazardous	301 to 500	Health warnings of emergency conditions. The entire population is more likely to be affected by serious health effects.



Downloadable Factsheets for Heart and Lung Disease

Asthma



ASTHMA AND OUTDOOR AIR POLLUTION



1 Air pollution can make asthma symptoms worse and trigger attacks.

If you or your child has asthma, have you ever noticed symptoms get worse when the air is polluted? Air pollution can make it harder to breathe. It can also cause other symptoms, like coughing, wheezing, chest discomfort, and a burning feeling in the lungs.

Two key air pollutants can affect asthma. One is *ozone* (found in smog). The other is *particle pollution* (found in haze, smoke, and dust). When ozone and particle pollution are in the air, adults and children with asthma are more likely to have symptoms.

2 You can take steps to help protect your health from air pollution.

► **Get to know how sensitive you are to air pollution.**

- Notice your asthma symptoms when you are physically active. Do they happen more often when the air is more polluted? If so, you may be sensitive to air pollution.

► **Also notice any asthma symptoms that begin up to a day after you have been outdoors in polluted air.** Air pollution can make you more sensitive to asthma triggers, like mold and dust mites. If you are more sensitive than usual to indoor asthma triggers, it could be due to air pollution outdoors.

► **Know when and where air pollution may be bad.**

- Ozone is often worst on hot summer days, especially in the afternoons and early evenings.
- Particle pollution can be bad any time of year, even in winter. It can be especially bad when the weather is calm, allowing air pollution to build up. Particle levels can also be high:
 - Near busy roads, during rush hour, and around factories.
 - When there is smoke in the air from wood stoves, fireplaces, or burning vegetation.

Cardiovascular Disease – February 2016



Enfermedades del corazón, ataques cerebrales y contaminación del aire

1 ¿Sabía que la contaminación del aire puede provocar ataques al corazón, ataques cerebrales y otros problemas de salud?

Según estudios médicos, la contaminación del aire puede provocar ataques al corazón, ataques (derrames) cerebrales y arritmia, sobre todo en personas que están en situación de riesgo de padecer estas afecciones. Además, en las personas con una afección llamada insuficiencia cardíaca, la contaminación del aire puede reducir aún más la capacidad del corazón de bombear la sangre de la forma que necesita hacerlo. Las partículas muy pequeñas son los contaminantes más preocupantes que provocan estos efectos. La contaminación por partículas se encuentra en la neblina, el humo y el polvo, y a veces en el aire que parece limpio. Esta hoja informativa le explica cómo puede:

- Conseguir información actualizada sobre la calidad local del aire
- Proteger su salud cuando la contaminación por partículas se encuentra en niveles insalubres

2 ¿Tiene usted un riesgo más elevado?

Los adultos mayores y las personas con factores de riesgo de padecer enfermedades del corazón o un ataque cerebral pueden tener un riesgo más elevado. Tiene un riesgo mayor si:

- Ha sufrido un ataque al corazón, angina de pecho, bypass coronario (derivación vascular), angioplastia con o sin estent, obstrucciones en las arterias del cuello o de las piernas, insuficiencia cardíaca, arritmia, diabetes o enfermedad pulmonar obstructiva crónica.

Puede tener mayor riesgo de padecer enfermedades del corazón o ataques cerebrales (y, por lo tanto, ser más susceptible a la contaminación por partículas) si le corresponden cualquiera de estas condiciones:

- Es hombre de 45 años o más, o mujer de 55 años o más.
- En su historial familiar existen ataques cerebrales o enfermedades del corazón tempranas (en padre o hermano antes de cumplir 55 años; en madre o hermana antes de cumplir 65 años).



- Padece de presión arterial alta o colesterol alto.
- Tiene sobrepeso o no está físicamente activo.
- Fuma cigarrillos.

3 ¿Cómo puede proteger su salud?

Hacer ejercicio con regularidad es importante para tener buena salud, sobre todo si padece de enfermedades del corazón. Ajustar cuándo y dónde hace ejercicio le permitirá llevar un estilo de vida más saludable y reducir su riesgo de padecer problemas del corazón o ataques cerebrales provocados por la contaminación del aire. Además:

- Si padece de enfermedades del corazón o ha sufrido un ataque cerebral, consulte con su proveedor de atención médica sobre las mejores formas de proteger su salud cuando la calidad del aire es insalubre.
- Hable con su proveedor de atención médica si corre el riesgo de padecer de enfermedades del corazón o un ataque cerebral y planea hacer más ejercicio físico del habitual.

► **Sepa dónde y cuándo los niveles de contaminación por partículas pueden ser insalubres.**

Los niveles de contaminación por partículas pueden ser elevados en cualquier época de año. También pueden ser elevados:

- Cerca de vías muy transitadas, en zonas urbanas (sobre todo en horas pico) y en zonas industriales.
- Cuando hay humo en el aire proveniente de cocinas de leña, chimeneas, quema de vegetación o incendios forestales.



Coming This Fall

AirNow Redesign

- Look will be different: focus on local conditions
- Mobile-friendly web site
- Same great information
 - Health Care Provider page
 - Fires: Current Conditions page
- Better display of temporal changes in air quality



Wildfire Smoke:

A Guide for Public Health Officials

Wildfire Smoke
A Guide for Public Health Officials
Revised July 2008
(With 2012 AQI Values)



- ***Composition of smoke***
- ***Characteristics of wildfire smoke***
- ***Health effects of smoke***
- ***Sensitive populations***
- ***Specific strategies to reduce smoke exposure***
- ***Estimating particulate matter levels***
- ***Recommendations for public health actions***
 - Preseason public service announcements
 - Public advisories and protective measures
- ***Bibliography***



Wildfire Guide2016

- *Revised by EPA/CDC/USFS/California - on AirNow.gov*
- *Updated air quality and health information*
- *Evidenced-based exposure reduction measures*
- *Entirely new section on communicating air quality using:*
 - “Current PM” levels from AirNow
 - Satellite information on Fires: Current Conditions page
 - Update visual range information
- *New fact sheets about children's health*

Wildfire Smoke

A Guide for Public Health Officials

Revised May 2016



U.S. Environmental Protection Agency * U.S. Forest Service * U.S. Centers for Disease Control and Prevention * California Air Resources Board



Simple Steps to Lower Exposure

Concentration – Ventilation Rate – Time

Rationale for the public health messaging to decrease exposure to air pollution

Dose = Concentration x Ventilation rate x Time

C - be active
outdoors when air
quality is better

V - take it easier
when active
outdoors

T - spend less time
being active
outdoors





Public Health Recommendations

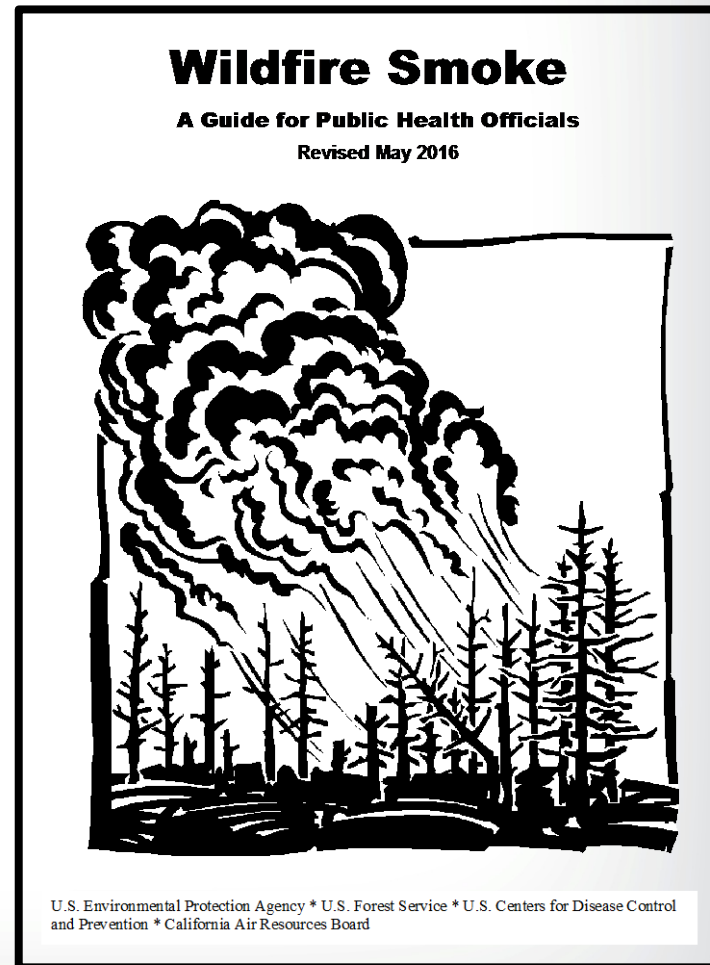
Exposure Reduction Measures

An individual can be advised to:

- Stay indoors
- Reduce outdoor physical activity
- Respirators (e.g., N-95) can help in the short-term
- Activate asthma/COPD action plans
- Use a home clean air shelter

A community can be advised to:

- Cancel outdoor events
- Provide community clean air shelters
- Increase air filtration in institutions
- Evacuate





Wildfire Smoke Guide 2018

To be Released before Next Wildfire Season



- *Updated look*
- *Smoke vs urban particles*
- *Addition of ozone*
- *Add sections*
 - *PM web course* - *Sensors*
 - *Ash clean-up*
- *Stand-alone fact sheets*
 - *Children* - *Older adults*
 - *Older adults* - *Respirator use*
 - *Pets/livestock* - *Ash clean-up*
 - *Preseason preparedness*
 - *Exposure reduction*
 - *Know when to evacuate*



Wildfire Smoke Guide 2018

Example of Draft Fact Sheets



WILDFIRE SMOKE FACTSHEET

Children and Families

Background

- **Wildfires** expose children and women of reproductive age to a number of environmental hazards, e.g., fire, smoke, psychological stress, and the byproducts of combustion of wood, plastics, and other chemicals released from burnings structures and furnishings.
- **During the acute phase** of wildfire activity, the major hazards are fire and smoke.
- **Children, Pregnant Women**, individuals with pre-existing lung or cardiovascular diseases (e.g. asthma), impoverished populations are especially vulnerable to hazards due to wildfires.

Environmental Hazards

- **Wildfire Smoke:** Consists of very small organic particles, liquid droplets, and gases such as carbon monoxide (CO), carbon dioxide (CO₂) and other volatile organic compounds (VOCs), such as formaldehyde and acrolein. The actual content of the smoke depends on the fuel source.

Health Effects from Smoke

- Symptoms from smoke inhalation can include chest tightness, shortness of breath, wheezing, coughing, respiratory tract and eye irritation and burning, chest pain, dizziness, or lightheadedness and other symptoms.
- Underlying conditions such as allergies and asthma symptoms may be exacerbated.
- The risk of developing cancer from short-term exposures to smoke is vanishingly small.

Recommendations

Prepare Before Wildfire Season

- **Stock up** so you don't have to go out when it's smoky. Have several days of medications on hand. Buy groceries that do not need to be refrigerated because cooking can add to indoor PM levels.
- **Create a "clean room"** in your home. Choose a room with as few doors as possible, such as a bedroom. Use a portable air cleaner and avoid indoor sources of pollution.
- **Buy a portable air cleaner** before there is a smoke event. High-efficiency (HEPA) filter air cleaners, and electrostatic precipitators that do not produce ozone help reduce indoor particle levels.
- **Organize** your important items ahead of time and know where to go in case you have to evacuate.



WILDFIRE SMOKE FACTSHEET:

Indoor Air Filtration

Exposure to Particle Pollutants

Indoor sources of particulate matter (PM) come from combustion events such as smoking, candle burning, cooking and wood-burning. During a wildfire event, outdoor PM can increase indoor PM levels well above the levels normally found. As outlined in the Guide, reducing indoor sources of pollution is a major step to lower the concentrations of PM indoors. Further reductions in indoor PM can be achieved using one of the filtration options discussed below.

Filtration Options

There are two effective options for improving air filtration in the home: upgrading the central system filter, or using high efficiency portable air cleaning appliances. Before discussing filtration options, it is important to understand the basics of filter efficiency.

Filter Efficiency

The most common industry standard for filter efficiency is known as the Minimum Efficiency Reporting Value, or MERV rating. The MERV scale for residential filters ranges from 1-20. The higher the MERV rating the greater the percentage of particles captured as the air passes through the filter media. Higher MERV (higher efficiency) filters are especially effective at capturing very small particles that can most affect health.

Central Air System Filter

The filter used in the central heating/cooling system of the home can effectively reduce indoor PM. A home typically will have a low MERV (1-4)

fiberglass filter that is 1" thick. Replacing this filter with a medium efficiency filter can significantly improve the air quality. Higher efficiency filters (MERV 11-16) in the central system can reduce indoor PM as a 95%. However, these filters have more resistance to air flow, which increases energy used by the blower. You may wish to consult a technician or the manufacturer to confirm that the system can handle the more efficient filter. If you are unsure, switching "Auto" to "On" has been shown to reduce concentrations by as much as 50%.

Portable Air Cleaner

Portable air cleaners are stand-alone appliances that can be used in addition to or instead of enhanced central filtration. Their effectiveness depends on several factors: air cleaner type, filter efficiency, and whether the unit is turned on and at what indoor PM concentrations more.

Portable Air Cleaner: Choose

There is a wide variety of air cleaners ranging in price from about \$20 to \$200. The air well and would not be a good choice.

Types of Air Cleaners: Most air cleaners fall into two categories: mechanical and electronic.

WILDFIRE SMOKE FACTSHEET

Prepare for Fire Season



If you live in an area that is regularly affected by smoke or where the wildfire risk is high, take steps to prepare for fire season. Know how to get ready before a wildfire. Know how to protect yourself from smoke exposure during a wildfire.

Being prepared for fire season is especially important for the health of children, older adults, and people with heart or lung disease.

Prepare Before a Wildfire

- **Stock up** so you don't have to go out when it's smoky. Have several days of medications on hand. Buy groceries that do not need to be refrigerated or cooked, because cooking can add to indoor particle levels.
- **Create a "clean room"** in your home. Choose a room with as few windows and doors as possible, such as a bedroom. Use a portable air cleaner and avoid indoor sources of pollution.
- **Buy a portable air cleaner** before there is a smoke event. High-efficiency particulate air (HEPA) filter air cleaners, and electrostatic precipitators that do not produce ozone, can help reduce indoor particle levels.
- **Understand** how you will receive alerts and health warnings, including air quality reports and public service announcements, from local officials.

- **If you have heart or lung disease**, check with your doctor about what you should do during smoke events.
- **If you have asthma or another lung disease**, update your respiratory management plan.
- **Have a supply of N95 masks** and learn how to use them. They are sold at many home improvement stores and online.
- **Organize** your important items ahead of time and know where to go in case you have to evacuate.





EPA's Healthy Heart Program Increasing Environmental Health Literacy



EPA's Healthy Heart program aims to prevent heart attacks and strokes by:

- Raising public awareness about the role outdoor air pollution plays in cardiovascular health, and
- Steps individuals can take to reduce their pollution exposure



Healthy Heart Toolkit

www.epa.gov/air-research/healthy-heart-toolkit-and-research

The screenshot shows the EPA website's 'Healthy Heart Toolkit and Research: Steps You Can Take' page. The header includes the EPA logo, navigation links for 'Environmental Topics', 'Laws & Regulations', and 'About EPA', and a search bar. Below the header, there's a 'Related Topics: Air Research' link and social media sharing icons. The main heading is 'Healthy Heart Toolkit and Research: Steps You Can Take'. Below this, a sub-heading reads 'Steps You Can Take to Reduce Health Effects from Air Pollution'. A paragraph states: 'Studies show that air pollution can trigger heart attacks, strokes and worsen heart failure in people who are at risk for these conditions. If you have a heart condition, you could benefit by reducing your exposure to high levels of air pollution.' To the right, there's a 'Daily Air Quality' section with links for 'Check Pollution Forecasts' and 'Get Free Email Alerts', and an 'EXIT' button. Below this is a 'Resources' section with links for 'Be Smart, Protect Your Heart video', 'Heart Disease, Stroke and Outdoor Air Pollution', and 'Million Hearts Initiative'. On the left, under the heading 'When are air pollution levels high?', there is a list of conditions: 'Any time of year', 'When weather is calm', 'Near busy roads', 'In urban areas', 'In industrial areas', and 'When there is smoke'. An image of a city skyline is also present.

When are air pollution levels high?

- Any time of year
- When weather is calm
- Near busy roads
- In urban areas
- In industrial areas
- When there is smoke

- *When are air pollution levels high?*
- *Are you at risk?*
- *Steps to Protect Your Heart*
- *How to Reduce your Risk?*
- *Warning Signs of a Heart Attack*
- *Warning Signs of a Stroke*



Particulate Matter Web Course

Designed for Healthcare Professionals and Educators

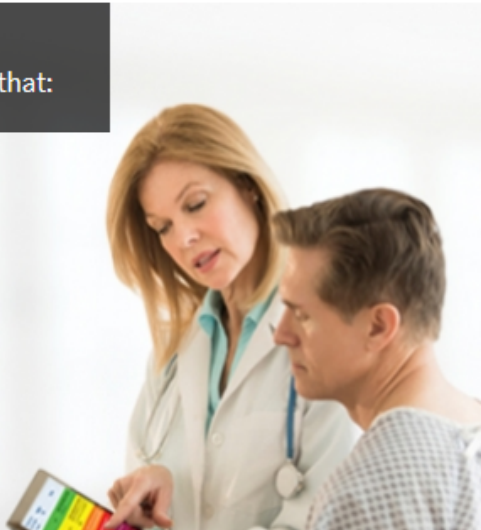
[Environmental Topics](#) [Laws & Regulations](#) [About EPA](#)

[Share](#) [Contact Us](#)

Particle Pollution and Your Patients' Health

An evidence-based training course for healthcare providers that:

- Describes the biological mechanisms responsible for the cardiovascular and respiratory health effects associated with particle pollution exposure.
- Provides education tools to help patients understand how particle pollution exposure can affect their health and how they can use the Air Quality Index to protect their health.



This course is designed for family medicine physicians, internists, pediatricians, occupational and rehabilitation physicians, nurse practitioners, nurses, asthma educators, pulmonary specialists, cardiologists, and other medical professionals.

[Start the Course](#)

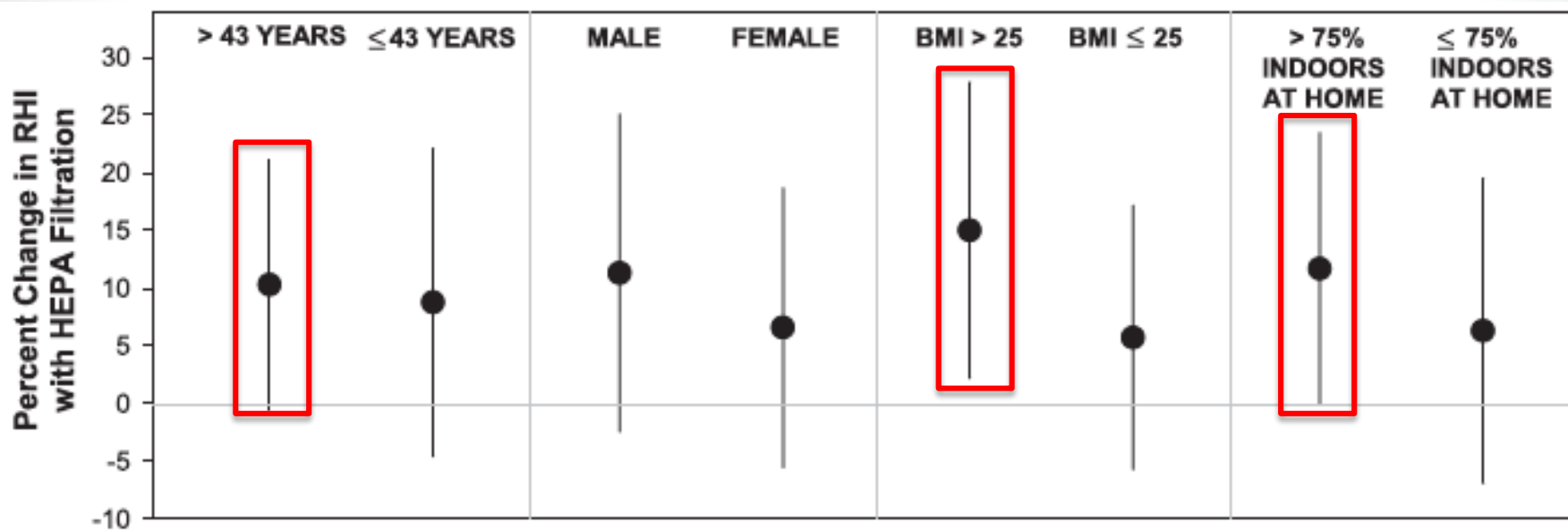
CME credit from CDC to physicians, nurses and health educators



HEPA Filters & Vascular Function

HEPA Filtration Improves Vascular Function

Wood smoke impacted community – British Columbia



RHI = Reactive hyperemia index, a measure of an artery's capacity to respond to low O₂

HEPA filtration improved blood vessel function in people older than 43 years, having BMIs >25, and spending more than 75% of their time indoors

HEPA filtration improved biomarkers of inflammation in men and in people having BMIs >25



HEPA Filter & Vascular Function

HEPA Filtration Improves Vascular Function Wood smoke impacts vascular function in Columbia



Portable air cleaners should be at the forefront of the public health response to landscape fire smoke

Barn PK et al. Environ Health. 2016
Nov 25;15:116

RHI = Reactive hyperemia index, a measure of arterial blood flow capacity, respond to low O₂

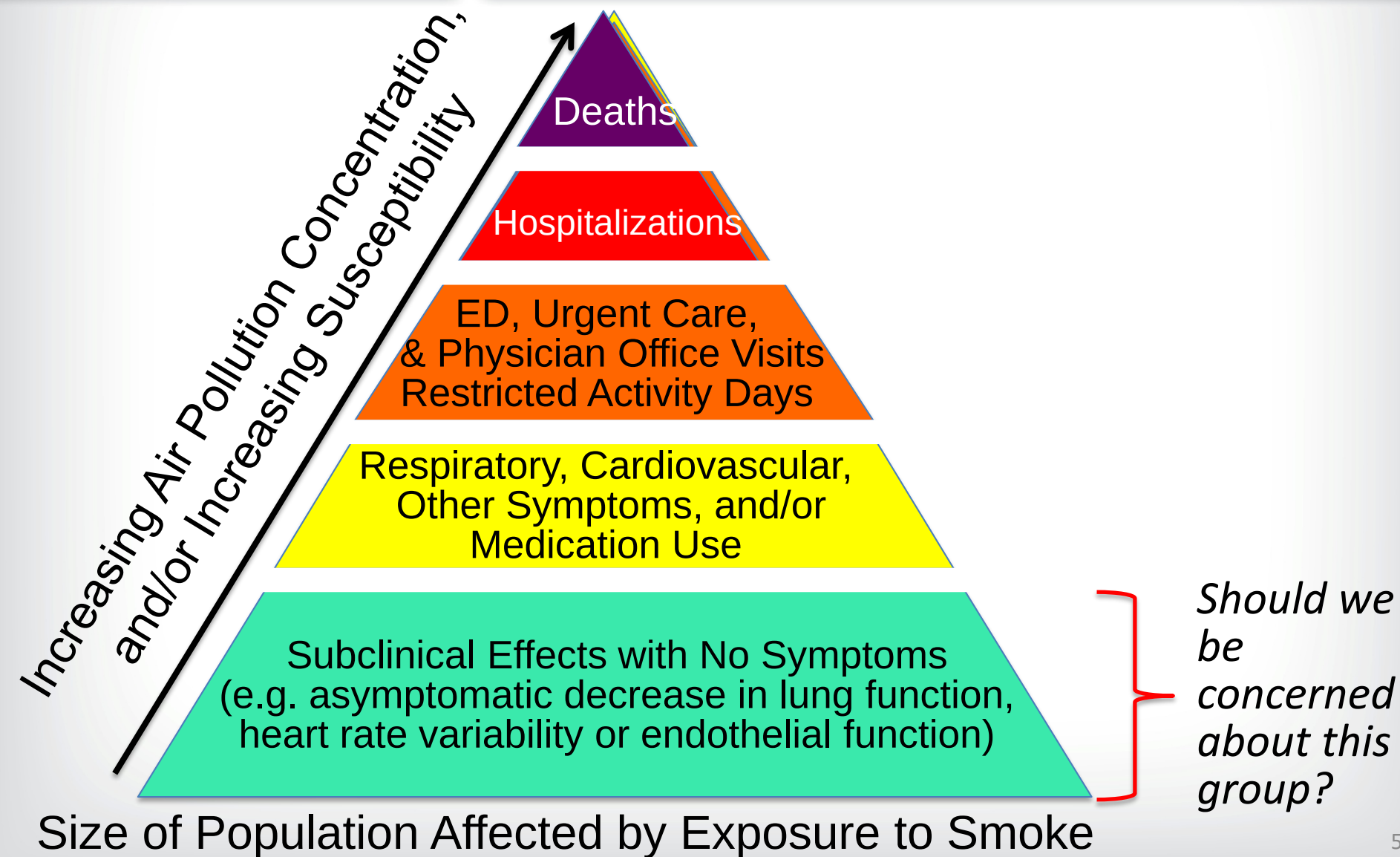
HEPA filtration improved blood vessel function in people older than 43 years, having BMIs >25, and spending more than 75% of their time indoors

HEPA filtration improved biomarkers of inflammation in men and in people having BMIs >25



Health Effects of Wildfire Smoke

Aggregated effects at a Population Level

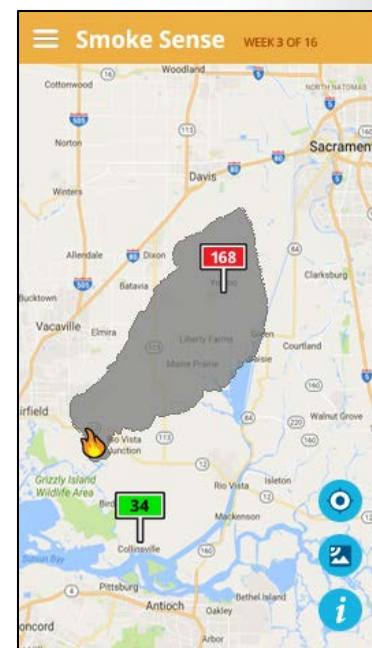




Air Quality & Smoke Plume Info



- *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, & 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*





Odds Ratio for Changing Activity due to Poor Air Quality

Susceptible category	Unadjusted	Adjusted
None (referent)		
Respiratory only	2.64 (2.06, 3.37)	2.61 (2.03, 3.35)
Cardiovascular only	1.16 (0.76, 1.77)	1.33 (0.86, 2.04)
>65 years only	1.20 (0.93, 1.54)	1.22 (0.95, 1.57)
Respiratory & CV	4.06 (2.31, 7.15)	4.36 (2.47, 7.69)
Respiratory and >65 years	3.64 (2.35, 5.64)	3.83 (2.47, 5.96)
Cardiovascular and >65 yrs	1.23 (0.78, 1.91)	1.38 (0.89, 2.13)
All three groups	2.80 (1.94, 4.04)	3.52 (2.33, 5.32)

• 12% of the study population changed activities due to bad air quality

• 25% of those with a respiratory condition changed activities

• People with CV disease did not change their activity

Million Hearts® 2022

Aim: Prevent 1 Million Heart Attacks and Strokes in 5 Years

Keeping People Healthy

Optimizing Care

COMMUNITY



Priority Populations

Million Hearts[®] 2022

Priorities and Objectives

Keeping People Healthy

Reduce Sodium Intake

Decrease Tobacco Use

Increase Physical Activity

Optimizing Care

Improve ABCS*

Increase Use of Cardiac Rehab

Engage Patients in
Heart-healthy Behaviors

Improving Outcomes for Priority Populations

Blacks/African Americans

35- to 64-year-olds

People who have had a heart attack or stroke

People with mental illness or substance use disorders



*Aspirin use when appropriate, Blood pressure control, Cholesterol management, Smoking cessation

Optimizing Care

Goals	Effective Health Care Strategies
Improve ABCS* Targets: 80%	<i>High Performers Excel in the Use of...</i> • Teams—including pharmacists, nurses, community health workers, and cardiac rehab professionals • Technology—decision support, patient portals, e- and default referrals, registries, and algorithms to find gaps in care • Processes—treatment protocols; daily huddles; ABCS scorecards; proactive outreach; finding those with undiagnosed high BP or cholesterol, tobacco use, particulate matter exposure • Patient and Family Supports—training in home blood pressure monitoring; problem-solving in medication adherence; counseling on nutrition, physical activity, tobacco use, risks of particulate matter; referral to community-based physical activity programs and cardiac rehab
Increase Use of Cardiac Rehab Target: 70%	
Engage Patients in Heart-healthy Behaviors Targets: TBD	



*Aspirin use when appropriate, BP control, Cholesterol management, Smoking cessation

Improving Outcomes for Priority Populations

Priority Population	Objectives	Strategies
Blacks/African Americans	Improving hypertension control	- Implement tailored protocols - Problem-solve in med adherence
35-64 year olds	- Improving HTN control and statin use - Increasing physical activity	- Implement tailored protocols - Increase access to and participation in community-based activity programs
People who have had a heart attack or stroke	- Increasing cardiac rehab referral and participation Avoiding exposure to particulate matter	- Use opt-out referral and CR liaison visits at discharge; ensure timely enrollment post-discharge Increase use of Air Quality Index
People with mental illness or substance abuse disorders	Reducing tobacco use	- Integrate tobacco cessation into behavioral health treatment - Institute tobacco-free policy at mental health and substance use treatment facilities - Tailored quitline protocols

Improving Outcomes for Priority Populations

- ✓ Disparate outcome
- ✓ Effective interventions
- ✓ Well-positioned partners

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Key Actions to Protect Your Health From Air Pollution

- Know when and where particle pollution levels may be unhealthy
 - Busy roads
 - Rush hour traffic
 - Smoke from fires
- Plan activities when and where pollution levels are lower
 - Delay activity until air is cleaner or move activity indoors

- Check the Air Quality Index, which provides forecasts of daily air quality



- Change your activity level
 - Reduce activity (ex: walk instead of jog)
- Reduce overall risk of heart disease or stroke
- Know the warning signs of heart attack or stroke



Million Hearts Family Priority Actions

- Raise awareness among those at-risk, their families, and **the clinicians who care for them**
- Encourage health professionals to take EPA's web-based course: [Particle Pollution and Your Patients' Health](#)
- Educate at-risk patients about mitigation behaviors
- Incorporate messages about air quality into cardiac rehab program curriculum
- Encourage adoption of EPA's Air Quality Flag Program among hospitals, employers, health systems, others
- Disseminate PM_{2.5} content via Million Hearts channels



Take Home Messages

Wildfire Smoke and Health

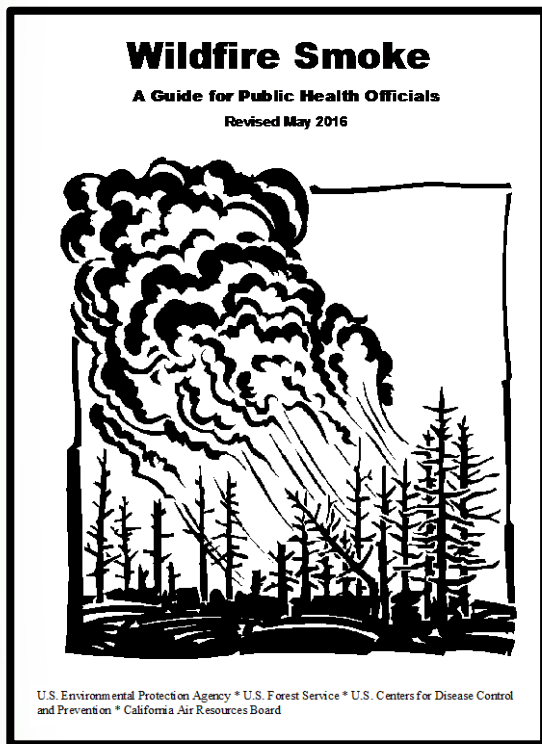
- ***Exposure to wildfire emissions is an important public health issue***
 - *Size of vulnerable & sensitive populations is increasing*
 - *Drought and poor forest health is increasing risks of wildland fire and risks of co-morbidity*
- ***Relevant health data is now available to provide guidance for public health action and to aid decision-making***
- ***Knowledge gaps persist and require ongoing research***





For More Information Visit

WILDFIRE GUIDE - A GUIDE FOR PUBLIC HEALTH OFFICIALS, UPDATED JUNE 2016



http://oehha.ca.gov/air/risk_assess/wildfire.html

Contact information: Wayne Cascio, MD
email: cascio.wayne@epa.gov

- www.airnow.gov
 - EPA AirNow
- www.usfs.gov
 - U.S. Forest Service
- www.cdc.gov
 - Wildfire
- www.nasa.gov
 - Satellite imaging
- www.noaa.gov
 - Forecasting
- www.nifc.gov
 - National Interagency Fire Center
- www.firescience.gov
 - Joint Fire Science Program

Thank you

Wayne E. Cascio, MD, FACC

Acting Director

National Health and Environmental Effects Research Laboratory

Office of Research and Development

U.S. Environmental Protection Agency

Email: cascio.wayne@epa.gov

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



Research Needs and Opportunities



Health Impacts of Wildfire Smoke Merit Our Attention & Action

- *Population & clinical health impacts are real and costly*
- *Intensity of wildland fires is increasing*
- *Size of vulnerable & sensitive populations is Increasing*
 - *Increasing area of the Wildland-Urban Interface*
 - *contains 60% of new homes built in the U.S. after 1990*
 - *contains 46 million single family homes, thousands of businesses, & a population greater than 120 million*
 - *Increasing size of the sensitive population*
 - *aging U.S. population with high prevalence of heart & lung disease*
 - *increasing prevalence of obesity and diabetes*
- *Drought and poor forest health are increasing risks of wildland fire and risks of co-morbidity*

Develop, Harmonize, Implement and Evaluate Impact Public Health Communication on Health Effects

- **Link wildfire smoke forecasts to public health messaging to decrease exposure**
- **Evaluate the effectiveness of:**
 - interventions to decrease wildfire smoke exposures and associated adverse health outcomes
 - PSAs (public service announcements) and other communication methods



Acquire a better understanding of the toxicology of wildfire emissions alone and co-mingling with urban pollutants

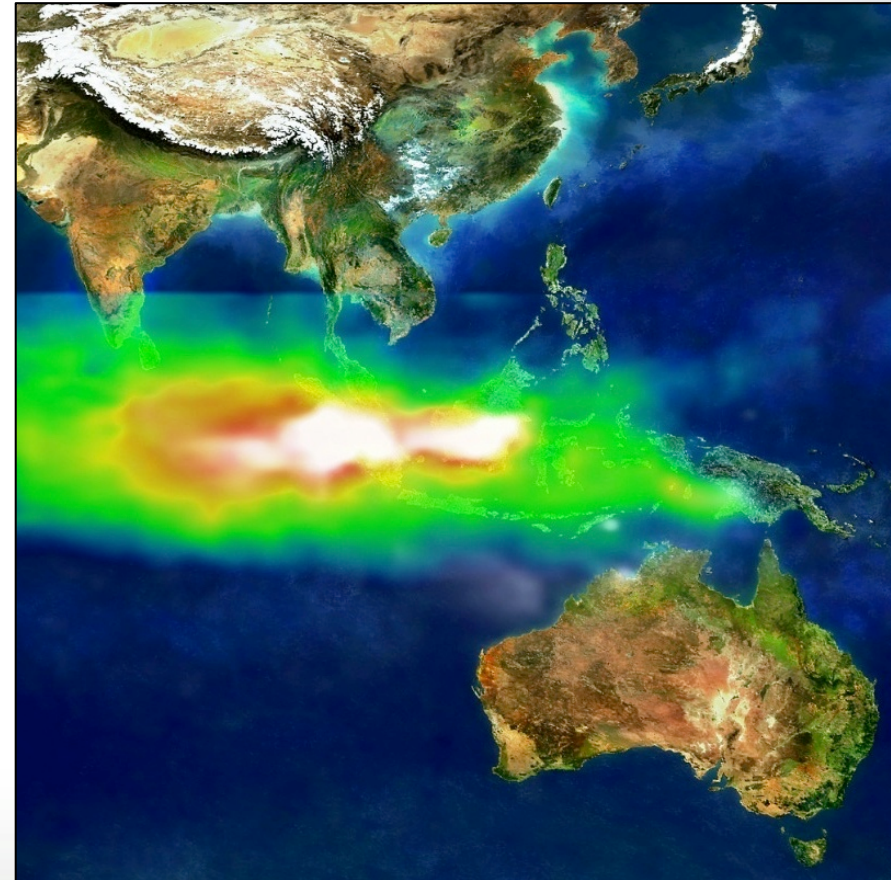
- Differential toxicity of fuel types and combustion conditions
- Relative contributions of the pollutant mix: PM, gases, VOCs, ...
- Interaction with urban co-pollutants
- Mechanisms for adverse health effects

Adapt new technologies to advance smoke surveillance, forecasting & exposure assessment

- Satellite-based models, chemical transport and dispersion models

Studies in wildfire-affected Areas and Estimates of Future Wildfire-Related Health Impacts

- **Develop models of communities at-risk that:**
 - Integrate the probability and severity of wildfire events with health characteristics and resilience of communities likely to be affected
 - include changes in parameters sensitive to climate-change



Large-scale studies are needed to:

- establish more reliable estimates on health impact of wildfires
- identify intrinsic factors that increase an susceptibility to wildfire smoke
- Identify socio-demographic factors increasing a community's susceptibility to wildfire smoke-related health responses
- Identify at-risk communities and populations for policy assessment



Multiple-episode fire events are needed to:

- Identify consistency of an association over time
- Change in vulnerability or behavioral adaptation (e.g., remaining indoors) to wildfire smoke exposure

Estimates of health effects of short-term exposures

- Need health and short-term exposure data (<24 hrs) to guide public health policy and decision-making

Estimates of health effects of long-term exposures

- Need health and long-term exposure data (annual averages) to guide public health policy and decision-making



Health Impacts of Wildfire Smoke

Mechanisms

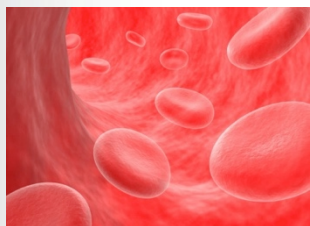


Health Effects of Inhaled PM

Proposed Mechanisms

Circulating Constituents

Blood



PM or constituents in the circulation

UFP, soluble metals, organic compounds

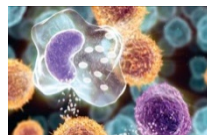
3

PM and/or constituents transmitted into blood

Bronchioles/Alveoli

PM
Pulmonary oxidative stress & inflammation

1



SYSTEMIC "SPILL-OVER"

Systemic Oxidative stress and Inflammation

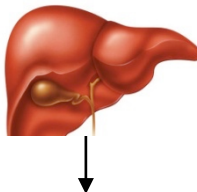
CELLS: ↑ activated WBCs, platelets, myeloperoxidase, Plt-MΦ

CYTOKINES: ↑ IL-1β, IL-6, TNF-α

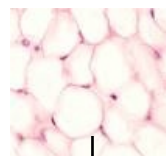
OTHER: ↑ ET, histamine, ? Microparticles, ox-LDL, dysF_x HDL

Acute phase response
↑ Clotting factors
Fibrinogen, CRP

Activated or Inflamed liver



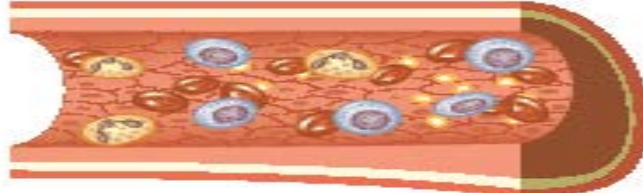
Direct actions



Activated or Inflamed fat

↑ Adipokines
(PAI-1, Resistin)

CARDIOVASCULAR INFLAMMATION + ROS/RNS



Neural Response

ANS



ANS imbalance

↑SNS / ↓PSNS

2
Activation of lung
ANS reflex arcs

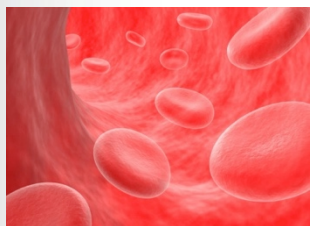


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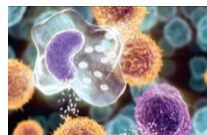
Bronchioles/Alveoli

PM

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Systemic Oxidative stress and Inflammation

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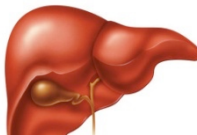
CYTOKINES: ↑ IL-1β, IL-6, TNF-α

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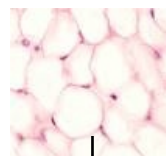
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Neural Response

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ANS imbalance

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Activation of lung ANS reflex arcs

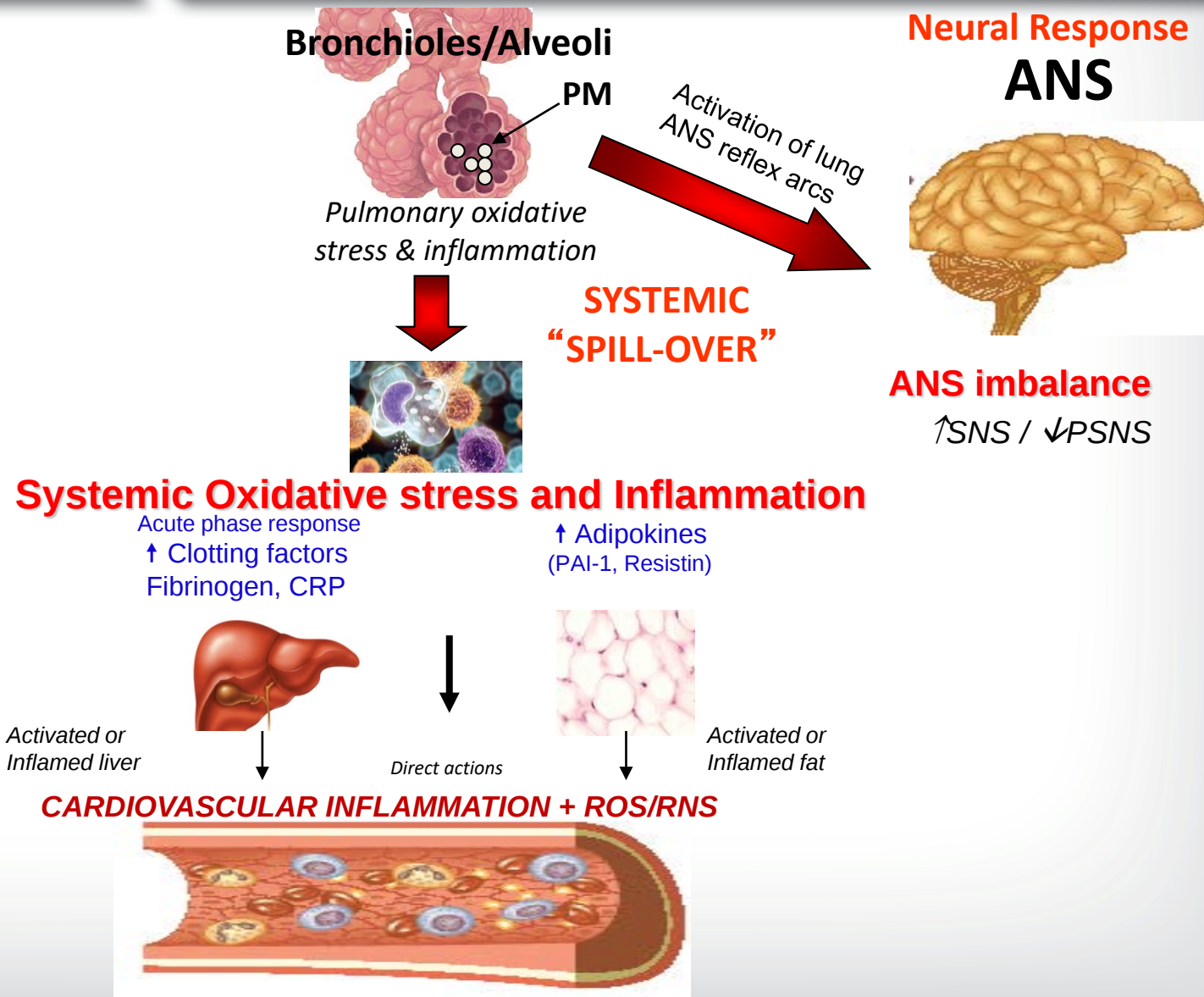
CARDIOVASCULAR INFLAMMATION + ROS/RNS

ACUTE: Endothelial dysfunction, Vasoconstriction, Plaque instability, Coagulation, Thrombosis, Arrhythmias

CHRONIC: LV hypertrophy, Atherosclerosis, Arterial Stiffness, Metabolic Syndrome: HTN, Insulin resistance, Dyslipidemia

Effects of Inhaled Wood Smoke

Controlled Human Exposure Studies





Effects of Inhaled Wood Smoke

Controlled Human Exposure Studies

Ghio A, et al.

Occ Health Med 2011

PM 485 $\mu\text{g}/\text{m}^3$ for 2 hrs with exercise

- At 20hr Increase in systemic & lung inflammation

Barregard L, et al. *Occup Environ Med* 2008; & *Inhal Tox* 2006

PM 260 $\mu\text{g}/\text{m}^3$ for 4-hr

- malondialdehyde & NO & levels in breath
- Oxidant stress
- serum amyloid A
- factor VIII in plasma
- factor VIII/vWF ratio

Bronchioles/Alveoli

PM

Pulmonary oxidative stress & inflammation

Activation of lung ANS reflex arcs

Neural Response
ANS



SYSTEMIC
"SPILL-OVER"

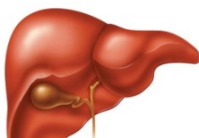
ANS imbalance

$\uparrow$ SNS $\downarrow$ PSNS

Systemic Oxidative stress and Inflammation

Acute phase response
 $\uparrow$ Clotting factors
Fibrinogen, CRP

$\uparrow$ Adipokines
(PAI-1, Resistin)



HunterAL, et al. *P&FT* 2014

- No evidence of increased thrombus formation or impaired:
- vascular vasomotor function
 - fibrinolytic function

Unosson et al. *P&FT* 2013

PM 314 $\mu\text{g}/\text{m}^3$ for 3 hr intermittent exercise

- Decrease in HRV
- Increase in central arterial stiffness



Subclinical Effects of Wood Smoke

Controlled Human Exposure Studies

Bønløkke JH et al. JOEM 2014
and *Hunter AL, et al. J Occup PFT 2014*

Woodsmoke 1 to 3-hr exposure. No changes:

- Pneumoproteins,
- adhesion factors,
- coagulation, cytokines, platelet activation,
- vasomotor function

of limited changes after a 3-hour wood smoke exposure.

Bronchioles/Alveoli

PM

Pulmonary oxidative stress & inflammation

Activation of lung ANS reflex arcs

Neural Response
ANS



**SYSTEMIC
"SPILL-OVER"**

ANS imbalance

↑SNS / ↓PSNS

Systemic Oxidative stress and

Acute phase response
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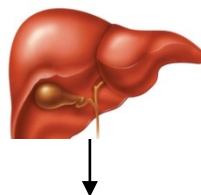
Hejl AM, et al. J Occup Environ Hygiene 2013

Firefighters working at prescribed burns.

Inflammatory biomarkers, PM_{2.5}, CO. Cross-work shift differences: IL-1β, IL-8, CRP, SAA, ICAM-1, and VCAM-1.

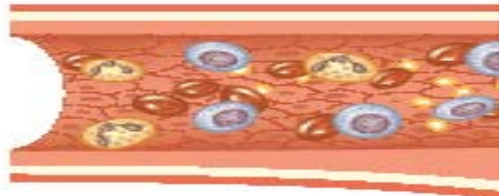
Lighting fires had the largest cross-work shift increase in IL-8

Activated or inflamed liver



Direct actions

CARDIOVASCULAR INFLAMMATION



Muala et al. Particle and Fibre Toxicology 2015

Wood smoke exposure from incomplete combustion with PM₁ (314 µg/m³) for 3 h

- **decreased** macrophage, neutrophil and lymphocyte numbers in bronchial wash
- **decreased** lymphocytes in BAL fluid;
- **decreased** sICAM-1, MPO and MMP-9;
- **increases** in submucosal and epithelial CD3+ cells, epithelial CD8+ cells and submucosal mast cells