Public Health Impact of Wildfire Emissions

Wayne Cascio, MD, FACC
Director, Environmental Public Health Division
National Health and Environmental Effects Research Laboratory
Office of Research and Development
US EPA

High Park Wildfire
June 27, 2012, USDA Photo
Wildland Fires and Emissions
A Global Public Health Issue

URL: lance-modis.eosdis.nasa.gov/cgi-bin/imagery/firemaps.cgi
Wildland Fire Smoke & Populations
Regional Impacts on At-Risk Populations

- Russia 2010
- Sydney Australia 1994
- Indonesia 1997
- Victoria Australia 2009
- Canada 2003
- California 2007

Locations and Years of Wildfires
- Sydney, Australia (1994)
- Indonesia (1997)
- Victoria, Australia (2009)
- Canada (2003)
- California (2007)
- Russia (2010)
Historical Legacy of Large Wildfires

19th Century Wildland Fires in the U.S.

- **Maine & New Brunswick, 1825**
- **The Great Fire, Oregon, 1845**
- **Hinckley Fire, Minnesota, 1894**
- **Peshtigo Fire, Wisconsin, 1871**
- **Silverton Fire, Oregon, 1865**
- **Yaquina Fire, Oregon, 1853**
Wildfire in the U.S.
Acreage Burned in the U.S. Annually

Present Concerns

- Increasing acreage burned
- Increased vulnerability of populations
- 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
    (Radeloff et al. 2005)

Adapted from https://www.nifc.gov/fireInfo/fireInfo_stats_totalFires.html
Why is Wildfire Important to the EPA
Protecting Public Health & Environment

- Increasing Fire Size & Intensity
- Community & Fire Fighter Health
  - PM, Toxics
  - Susceptible Subpopulations
- Ambient Air Quality
  - PM, O₃, NOₓ, NH₃, CO, VOCs
- Global Climate
  - CO₂, CH₄, Black & Brown carbon vs Blue carbon, Organic Aerosols, NOₓ, N₂O
Constituents of Wildfire Smoke

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

Cascade Complex, Idaho, 2007

doi:10.1038/ncomms3122

https://picasaweb.google.com/lh/photo/-ZF6POTn-Q0Dubaw7GCsktMTjNZETYmyPly0liipFm0?full-exif=true
Health Effects of Wildfire Smoke
Recent Review & Case Controlled Study


Air pollution events from forest fires and emergency department attendances in Sydney, Australia 1996–2007: a case-crossover analysis
Fay H Johnston1*, Stuart Purdie2, Bin Jalaludin3,4, Kara L Martin5,6, Sarah B Henderson7 and Geoffrey G Morgan8,9
Health effects known or suspected to be caused by wildfire smoke:

- All-cause mortality
- Asthma & COPD exacerbations
- Bronchitis & pneumonia
- Childhood respiratory disease
- Cardiovascular outcomes
- Adverse birth outcomes
- Anxiety
- Symptoms such as: eye irritation, sore throat, wheeze, cough, & chest pain

Elliott CT. Guidance for BC Public Health Decision Makers During Wildfire Smoke Events 2014
Air Pollution and Health Effects

Subclinical Effects with No Symptoms (e.g. asymptomatic decrease in lung function, heart rate variability or endothelial function)

Deaths

Hospitalization

ED, Urgent Care, & Physician Office Visits
Restricted Activity Days

Respiratory, Cardiovascular, Other Symptoms, and/or Medication Use

Public health impact & costs extends beyond deaths

Size of Population Affected by Exposure to Wildfire Smoke
Cardiovascular Health Effects
Australian Wildfire Smoke Health Effects

Victoria, Australia - December 1, 2006, to January 31, 2007

Out-of-Hospital Cardiac Arrest (OHCA)

Ischemic Heart Disease Hospitalizations

Adapted from Haikerwal et al. J Am Heart Assoc. 2015;4:e001653
### Who is at Risk from Wildfire Smoke

**NHANES 2007-2010, N=10,898**

<table>
<thead>
<tr>
<th>Susceptible category</th>
<th>N</th>
<th>Percent (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>7135</td>
<td>73.0 (71.4, 74.6)</td>
</tr>
<tr>
<td>Respiratory only</td>
<td>642</td>
<td>6.4 (5.5, 7.2)</td>
</tr>
<tr>
<td>Cardiovascular only</td>
<td>319</td>
<td>2.6 (2.3, 2.9)</td>
</tr>
<tr>
<td>&gt;65 years only</td>
<td>1713</td>
<td>10.9 (10.1, 11.8)</td>
</tr>
<tr>
<td>Respiratory and cardiovascular</td>
<td>136</td>
<td>1.0 (0.7, 1.3)</td>
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<td>Respiratory and &gt;65 years</td>
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<td>Cardiovascular and &gt;65 years</td>
<td>608</td>
<td>3.8 (3.3, 4.3)</td>
</tr>
<tr>
<td>All three groups</td>
<td>125</td>
<td>0.7 (0.5, 0.9)</td>
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*NHANES = National Health and Nutrition Education Survey*

### Who is at Risk from Wildfire Smoke

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27% fall into at least one susceptible group category!
Wildfire Smoke Information
Public Interest in AirNow

Locations for Fires > 50,000 Acres
Washington State for 2015

AirNow Sessions Hits in Washington State 2015
With Fires Burning >50,000 Acres

Acres Burned (thousands)

- (50, 70]
- (70, 76]
- (76, 100]
- (100, 150]
- (150, 220]

Fires
- CARPENTER RD.
- Chelan Complex
- COUGAR CREEK
- LimeBelt
- NORTH STAR
- Okanogan
- Reach
- STICKPIN
- TUNK BLOCK
- WOLVERINE

Courtesy of:
Ana Rappold NHEERL/ORD/US EPA
## Odds Ratio for Changing Activity due to Poor Air Quality

<table>
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<tr>
<th>Susceptible category</th>
<th>Unadjusted</th>
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<td>2.64 (2.06, 3.37)</td>
<td>2.61 (2.03, 3.35)</td>
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<tr>
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<td>1.16 (0.76, 1.77)</td>
<td>1.33 (0.86, 2.04)</td>
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<td>1.20 (0.93, 1.54)</td>
<td>1.22 (0.95, 1.57)</td>
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<td>Respiratory and cardiovascular</td>
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<td>3.64 (2.35, 5.64)</td>
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<td>1.38 (0.89, 2.13)</td>
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- **12% of the study population changed activities due to bad air quality**
- **25% of those with a respiratory condition changed activities**


Reproducibility of Health Effects
Eastern NC Pocosin (Peat) Wildfires

2008 Pocosin Lakes National Wildlife Refuge
Peat Bog Wildfire Smoke Exposure in Rural North Carolina is Associated with Cardiopulmonary Emergency Department Visits Assessed through Syndromic Surveillance
Environmental Health Perspective 119:1425, 2011

2008 Heart failure, COPD, asthma, pneumonia, bronchitis

- Increased regional focus on health effects of wildfire smoke
- State sponsored public health messaging

Total costs of the 45 day fire was:
- $20 million to suppress the fire
- $48 million in economic costs

2011 Pains Bay
Repeating cardiopulmonary health effects in rural North Carolina population during a second large peat wildfire
Melissa A. Tinling, J. Jason West, Wayne E. Cascio, Vasu Kilaru and Ana G. Rappold

Respiratory symptoms, upper respiratory infection, hypertension
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 $O_2$

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

Allen et al. AJRCCM 2011
Health Effects of Inhaled PM
Proposed Mechanisms

Circulating Constituents
Blood

PM or constituents in the circulation

Bronchioles/Alveoli

Pulmonary oxidative stress & inflammation

PM or constituents transmitted into blood

1. SYSTEMIC “SPILL-OVER”

2. Neural Response
ANS

PM

Activation of lung
ANS reflex arcs

3. Circulating Constituents
Blood

PM or constituents
in the circulation

Systemic Oxidative stress and Inflammation

Acute phase response
↑ Clotting factors
Fibrinogen, CRP

Activated or Inflamed liver

Direct actions

↑ Adipokines
(PAI-1)

Activated or Inflamed fat

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

CHRONIC: LV hypertrophy, Atherosclerosis, Arterial Stiffness, Metabolic Syndrome: HTN, Insulin resistance, Dyslipidemia
Protecting the Health of the Public
Interagency Cooperation

- National Interagency Fire Center (NIFC)
  - Coordination of Federal Agencies Efforts on National Fire Planning and Operations
  - USFS, BLM, NWS, NPS, BIA, FWS, NOAA, NBC, NASF, FEMA – U.S. Fire Administration

- Department of Agriculture
  - U.S. Forest Service
    - Fire Research – Pacific Northwest, Pacific Southwest, Rocky Mountain, Northern, & Southern Stations
      - BlueSky – Wildland Fire Emissions and Smoke Forecasting Model, Emission Factors, Fuel Research
    - Fire Management - Suppression, Fuels Management, Predictive Services
    - Burned Area Emergency Response – After Fire Support

- National Oceanic and Atmospheric Administration (NOAA)
  - National Weather Service
    - Fire Weather Planning Tools

- Department of Interior
  - National Park Service
    - Fire Management - Suppression, Fuels Management
  - Bureau of Land Management
    - Fire and Aviation Program – Suppression, Fuels Management, Predictive Services
  - U.S. Geological Survey

- National Aeronautics and Space Administration (NASA)
  - Satellite Products (Aqua, Aura, MODIS, Fire Information for Resource Management System)

- Centers for Disease Control & Prevention (CDC)

- Environmental Protection Agency
  - National Ambient Air Pollution Regulations
  - Fire Research & Human Health Assessment
EPA Expertise - Linking Air Pollution to Health Effects

- Source Emission to Exposure (NRMRL & NERL)
  - Emission Characterization
  - Atmospheric Chemistry
  - Ambient Monitoring Methods
  - Human Exposure

- Health Effects (NHEERL)
  - Mechanistic Toxicological Effects
  - Epidemiological Modeling

- Multi-pollutant Context (NHEERL)
  - Human & Animal Models

- Model Development & Assessment (NERL)
  - Deterministic Modeling (CMAQ)
  - Receptor Modeling (PMF, Unmix, CMB)

EPA Expertise - Climate Change & Health Risk Assessment

- Data Integration & Analysis
- Health Communication (AQI, Healthy Heart)
Aerial Sampling

- Onboard Computer with Data Transmission
- User-set CO$_2$ Triggering of Samplers
- GPS, CO$_2$, CO
- Semi-Volatile Organic Compounds (SVOCs)
- Volatile Organic Compounds (VOCs)
- Black Carbon (BC)
- Brown Carbon
- PM by Filter ($\text{PM}_{2.5}$, $\text{PM}_{10}$)
- Continuous $\text{PM}_{2.5}$, $\text{PM}_{10}$
- 3D-anemometer

Terrestrial Sampling

**Courtesy of Matt Landis NERL**
Research Goals:

1) Compare the relative cardiopulmonary toxicity and mutagenicity of PM emissions from different fuel types (e.g., pine, oak, peat, chaparral) and burning conditions (e.g., flaming, smoldering)

2) Provide a potency ranking matrix

Joint Fire Science Program
http://www.firescience.gov

Courtesy of Matt Landis NERL & Ian Gilmour NHEERL/ORD/EPA
Today's AQI Forecast
Monday, March 14, 2016

Fires: Current Conditions
Click to see map

Announcements
3/9/16: NEW: Spanish-language website for Air Quality Flag Program - NEUVO: En español—El sitio web de la program 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

Air Quality Basics
Air Quality Index | Ozone | Particle Pollution | Smoke from fires | What You Can Do

Health

Learning Center
Fires: Current Conditions

Click to see map
AirNow
Current Fire Conditions

Fires: Current Conditions

March 16, 2016
Fires: Current Conditions

- Latest PM$_{2.5}$ AQI from Temporary Monitors
- Latest PM$_{2.5}$ AQI from AirNow Monitors
- Incident Information System (InciWeb)
- Hazard Mapping System Fire Locations
- Hazard Mapping System Smoke Plumes

Explanation of Map Layers

- **Latest PM$_{2.5}$ AQI from Temporary Monitors** shows particle pollution observed at portable, temporary PM2.5 monitors near large, active wildfires. These monitors are deployed by US Forest Service and state and local agencies for measuring air quality during wildfires. They may be moved based on wildfire locations. Data are not fully verified and only intended for real-time air quality reporting.

- **Latest PM$_{2.5}$ AQI from AirNow Monitors** shows particle pollution observed at monitors operated by state, tribal, or local monitoring agencies using federal reference or equivalent monitoring techniques. Data are considered preliminary and non-regulatory.

- **Incident Information System (InciWeb)** shows the locations of active wildfires from the InciWeb website. Chrome and Firefox only.

- **Hazard Mapping System Fire Locations** are fire locations detected by satellites operated by the National Oceanic and Atmospheric Administration (NOAA) Hazard Mapping System.

- **Hazard Mapping System Smoke Plumes** are smoke plumes analyzed by the National Oceanic and Atmospheric Administration (NOAA) Hazard Mapping System. Darker colors indicate denser smoke concentrations. The plumes may be at ground-level or high up in the atmosphere.
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
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 be 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.

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, 285KB, 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
- Wildfire Guide for Health Officials

FOR KIDS - Follow Smoky Bear's advice when wildfires are in your area!
Emergency Preparedness and Response

Wildfires

More and more people make their homes in areas that are prone to wildfires. You can take steps to be ready for a wildfire and prepare your home and landscaping to reduce your risk. Learn how to protect yourself and your family from a wildfire, evacuate safely during a wildfire, and how to stay healthy when you return home.

Before a Wildfire

- Wildfire...Are You Prepared?
- Is your home Firewise
- Make a Plan

During a Wildfire
Wildfire Guide developed in 2001

- Response to 1999 fires on Hoopa reservation
- Meetings in 2000 (CA OEHHA) and 2001 (Univ. of Washington) initiated its development
- Recommendation based on limited health or air quality information
- The Guide - developed by EPA, CA and WA without any agency taking ownership. It was widely used by state/local agencies.

Revised in 2008

- Better information about health effects of PM & more continuous monitoring data was incorporated.
- Same partners made revisions. The guide is still widely used.

http://oehha.ca.gov/air/risk_assess/wildfire.html
Wildfire Smoke:
A Guide for Public Health Officials

- 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
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

Elliott CT. Guidance for BC Public Health Decision Makers During Wildfire Smoke Events. 2014
Wildfire Smoke Guide: Anticipated Upgrades

Why Revise It Now
✧ Stronger evidence base is available.
✧ Federal partners are now making revisions with input from state and local partners.

Writing Team Partners
✧ EPA Office of Air & Radiation (Lead) (Office of Air Quality Planning and Standards)
✧ EPA Office of Research & Development (National Health & Environmental Effects Research Lab)
✧ CDC – Natl Center for Environmental Health
✧ CDC - Pediatric Environmental Health Specialty Units
✧ US Forest Service

Anticipated Upgrades
✧ Better defined health effects
✧ Children’s health
# Expected Products and Timeline

### Draft and Final Wildfire Guide

**2016**

<table>
<thead>
<tr>
<th>Month</th>
<th>Activity Description</th>
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<tbody>
<tr>
<td>Early March</td>
<td>Writing of revision with partners underway</td>
</tr>
<tr>
<td>Late March</td>
<td>Complete initial revision</td>
</tr>
<tr>
<td>Early May</td>
<td>State comments provided to EPA as written comments</td>
</tr>
<tr>
<td>End of May</td>
<td>First Draft Revised Guide</td>
</tr>
<tr>
<td>Jun, Jul, Aug</td>
<td>Deliver Draft Revised Guide for use during 2016 fire season</td>
</tr>
<tr>
<td>Late Sept</td>
<td>EPA summarizes comments from States’ from wildfire season experience and needs into further revision</td>
</tr>
</tbody>
</table>

**2016-2017**

<table>
<thead>
<tr>
<th>Winter</th>
<th>EPA and writing team work to finalize the document based on state input</th>
</tr>
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<tr>
<td>Winter</td>
<td>Work with partners to develop communication and outreach strategy for the Final Guide</td>
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**2017**

|        | Release Final Guide prior to 2017 fire season |
For More Information Visit

• 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

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

Wayne E. Cascio, MD, FACC, FAHA
Environmental Public Health Division
ORD/National Health Environmental Effects Laboratory
U.S. Environmental Protection Agency
Email: cascio.wayne@epa.gov