Air and Energy (A-E)

Science of Wildland Fires

A-E BOSC Subcommittee Meeting, February 17-19, 2021

Bryan Hubbell, A-E National Program Director

Motivation

Wildland fires impact:

- Air quality and human health
- Water quality and quantity
- Ecosystems and habitats
- Climate

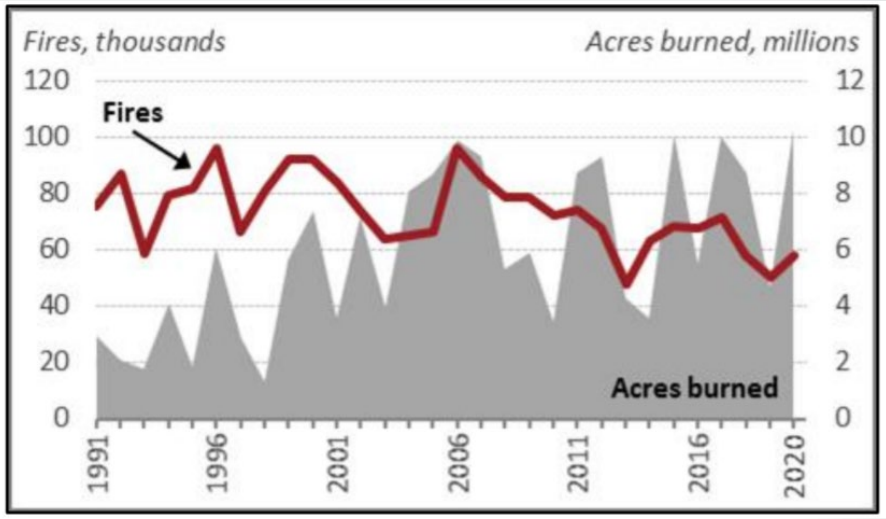
Impacts extend both near and far and are increasing as a result of climate change.

Autumn Complex Fire, 2020 Photo credit: Roy Jones, USFS

Leaburg Fish Hatchery, OR 2020
Photo credit: Oregon Department of Fish and Wildlife

Concern is Growing Over Wildfires in the U.S.

- In the past 10 years, an average of 6.8 million acres burned annually in the U.S.
- Since 1960, 4 of the top 5 years with largest acreage burned have occurred in the last decade.
- In 2020, over 10 million acres burned.
- In 2020, a single fire burned more than one million acres (the August Complex Fire in California).
- Washington and Oregon also experienced record setting fires and damages in 2020.

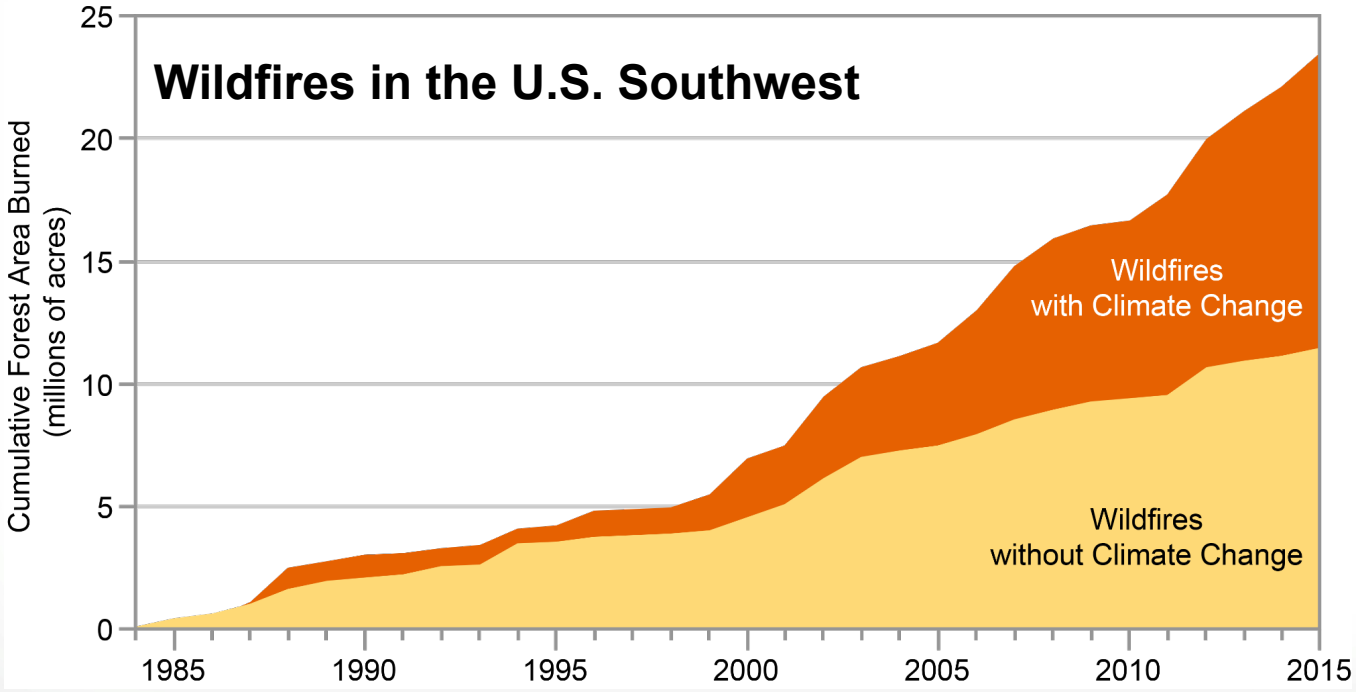


Source: National Interagency Fire Center, Congressional Research Service

Source: NASA Earth Science Applied Sciences

Climate Change is Increasing the Acreage Burned by Wildfires

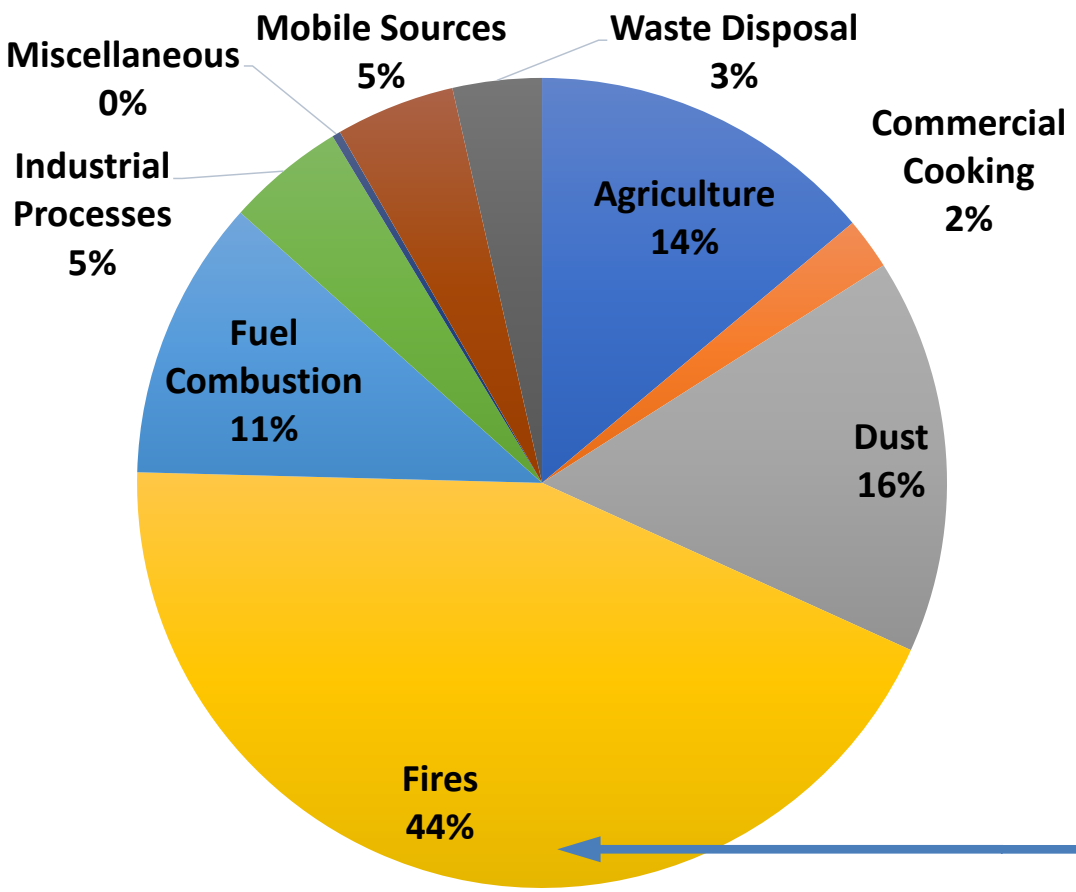
- Models show increases in acres burned due to climate change.
- The 4th National Climate Assessment reports that climate change approximately doubled the cumulative acreage burned by wildfires in the Southwestern U.S. from 1985 to 2015.



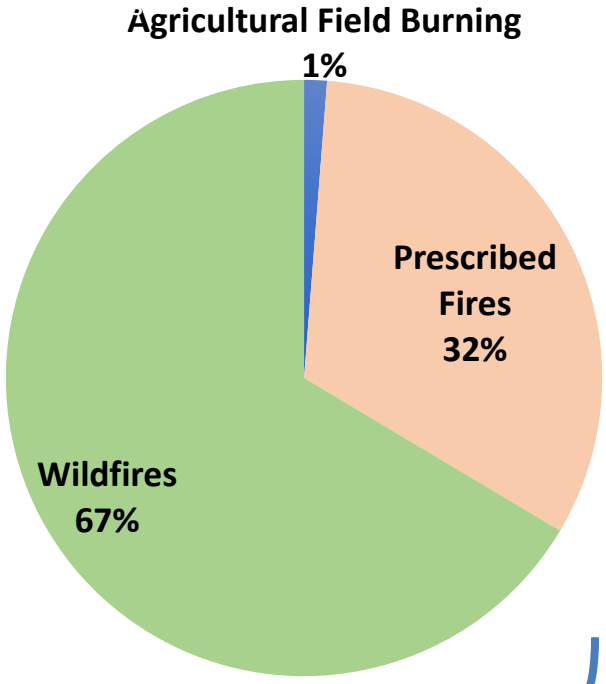
Source: Fourth National Climate Assessment (NCA4) - Figure 25.4, adapted from Abatzoglou and Williams 2016

2017 National $PM_{2.5}$ Emissions Inventory

Total $PM_{2.5}$ Emissions (5.7 million tons)



$PM_{2.5}$ Emissions from Fires (2.5 million tons)



https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data

Wildland Fire Impacts on Human Health

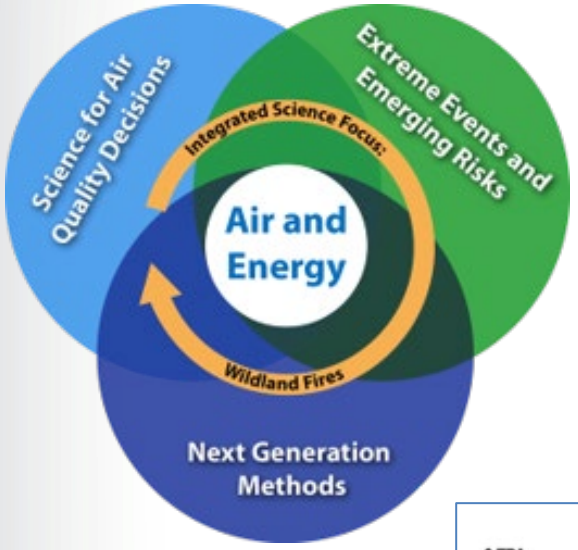
- Associated Press analysis showed smoke affected millions of people downwind from the 2020 wildfires
- Concentrations of PM2.5 and other air pollutants such as ozone are increased
- Known or suspected health effects specific to smoke from wildland fire includes:
  - Asthma and COPD exacerbation
  - Bronchitis and pneumonia
  - All-cause mortality
  - Cardiovascular morbidity
  - Adverse birth outcomes
- Fann et al (2018) estimated economic value of wildfire smoke health effects:
  - Short term exposures, $11 to $20 billion per year
  - Long-term exposures, $76-$130 billion per year

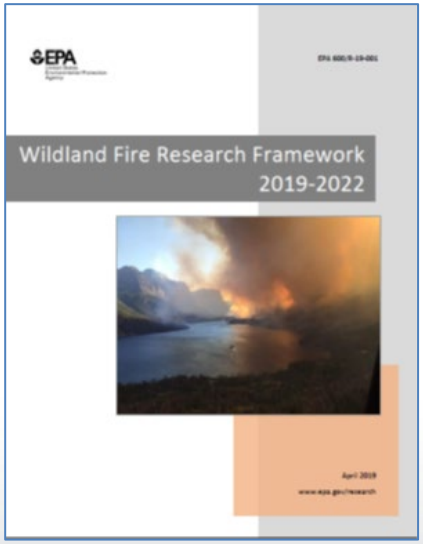
Wildland Fire Impacts on Water

- About two-thirds of western US municipalities rely on water from forested watersheds.
- Healthy forests maintain water quality by stabilizing the soil, reducing nutrient and sediment transfer to streams.
- Wildfires can abruptly and adversely impact these watersheds.
  - Soil disturbance results in runoff of nutrients, metals, etc. to water bodies, as well as ash deposition.
- Impacts may last for years following a wildland fire.

Courtesy of Jeff Peterson (Retired-Office of Water, EPA)

Increasing Emphasis on Wildland Fires





- Multiple efforts led to the Wildland Fires integrated science focus in the 2019-2022 A-E StRAP.
- Internal EPA wildland fires summit in 2016
- Wildland Fire Research Framework published in 2019
- Regional Applied Research Effort (RARE) wildland fire projects including emissions from prescribed fires, sensors, DIY air cleaners
- Wildfire ASPIRE solutions-driven research project focused on evaluating clean air spaces during wildfire smoke episodes

Our Science is...

- Improving ability to identify and mitigate the health and environmental impacts of wildfires by
  - Improving measurement methodologies and models to assess emissions from different types of fires, types of fuels and burn conditions
  - Assessing performance of lower cost air quality sensors, deployed to characterize air quality during smoke events
  - Improving models to determine impacts on air and water quality and ecosystems
  - Assessing implications of sustained use of prescribed fires for air and water quality
  - Measuring impacts of fires on water quality, including drinking, surface and ground water

Our Science is.... (continued)

- Studying health effects of wildland fire smoke from both short-term and repeated exposures
- Assessing susceptibility and vulnerability of ecosystems and human populations to wildland fires
- Evaluating strategies to mitigate risk to humans and ecosystems and to reduce exposure to wildland fire smoke
- Assessing effectiveness of different risk communication strategies to promote health-protective behaviors, especially within at-risk populations

Charge Question 3

- Recent increases in wildland fires activity have highlighted the challenges associated with protecting public health and environmental quality during these events.
- The A-E program is working to improve understanding of wildland fire impacts and to develop knowledge and tools to inform strategies aimed at decreasing negative effects.

➢ **What suggestion(s) or recommendation(s) does the Subcommittee offer on the progress of the research aimed at identifying and mitigating the health and environmental impacts of wildfires? [RA2, RA3, RA7, RA8, RA9]**

➢ CQ3 is addressed in the panel discussions and Meet the Scientists session on Day 2

Program Implementation

- ORD scientists from the Center for Environmental Measurement (CEMM) and Modeling and the Center for Public Health and Environmental Assessment (CPHEA) are addressing these scientific challenges.

- Next, Wayne Cascio will provide an overview of the Centers' scientific approaches to deliver outputs and products related to wildland fires.

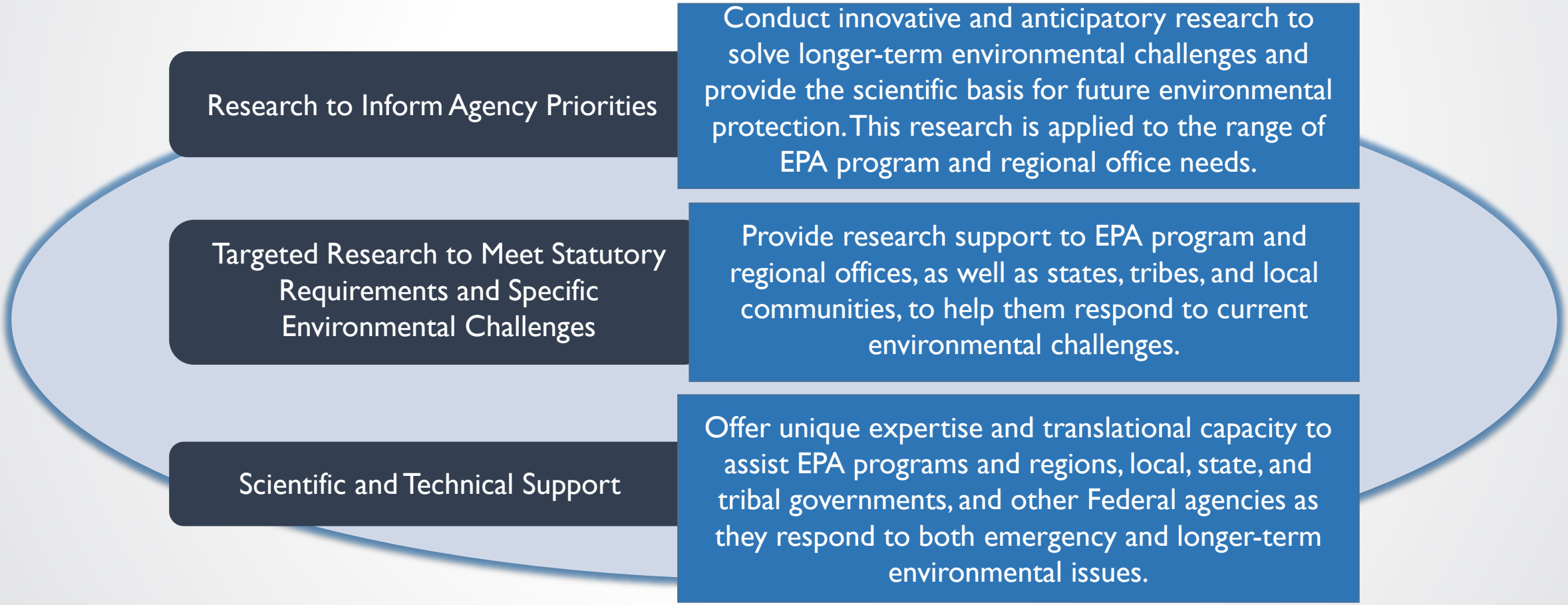
Approaches to Address Current Challenges Posed by Wildfires

Wayne E. Cascio, MD, FACC
Director, CPHEA

Office of Research and Development
Center for Public Health and Environmental Assessment

EPA Research

ORD provides the scientific foundation for EPA to execute its mandate to protect human health and the environment.



Wildland Fire Research Across the A-E Portfolio

Modeling of background air pollution

Measurements

Health impacts

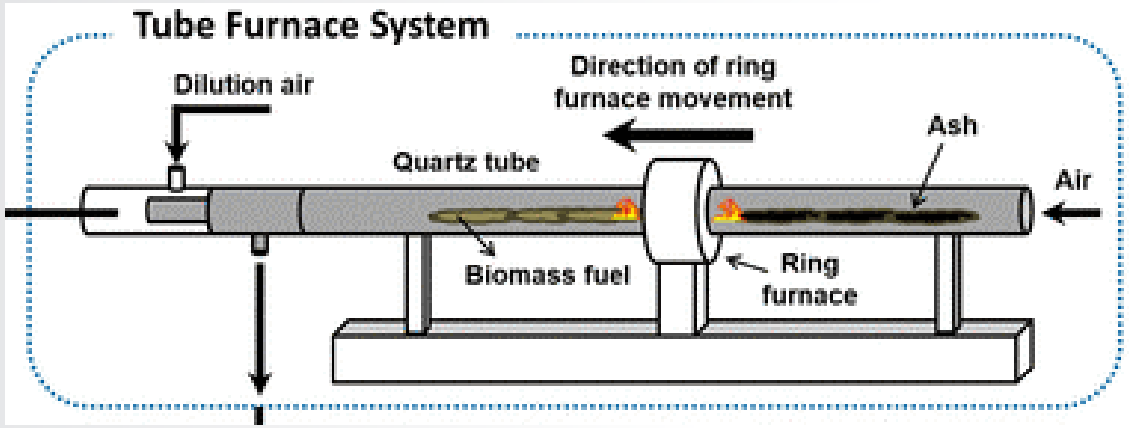
Climate change impacts

Sensors

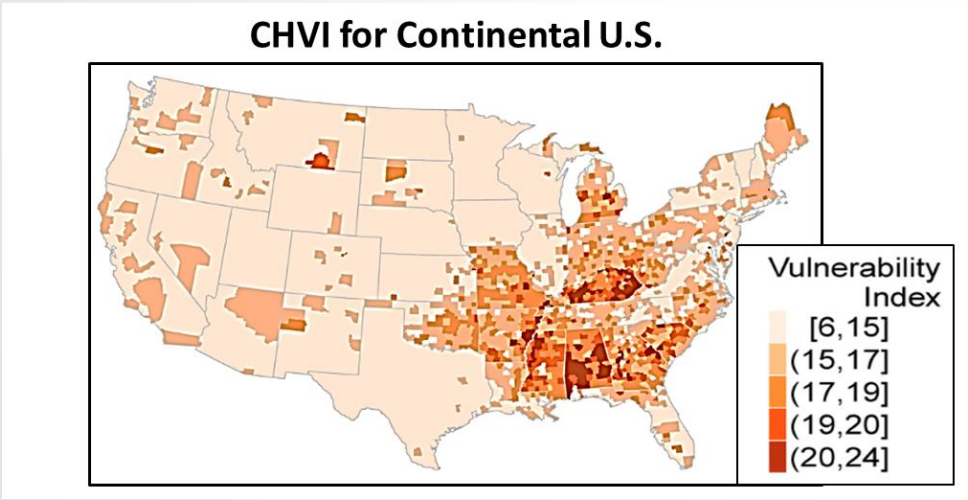
Topic	Research Areas	
Science for Air Quality Decisions	#1: Approaches to support air quality management programs for multiple pollutants at multiple scales	#9: Wildland Fires (Integrated Science Focus) Synthesis or literature review and cross-Research Area products
	#2: Approaches for characterizing source emissions, air quality, exposure, and mitigation strategies	
	#3 Public health and environmental responses to air pollution	
Extreme Events and Emerging Risks	#4: Public health and ecosystem exposures and responses to emerging air pollutants and sources	
	#5: Methods to evaluate environmental benefits and consequences of changing energy systems	
	#6: Methods to enable resilience to future environmental stressors	
Next Generation Methods to Improve Public Health and the Environment	#7: Emerging approaches to improve air quality and exposure characterization	
	#8: Novel approaches to assess human health and ecosystem impacts and risks	

Integration of atmospheric, fire emissions, and ecosystem models

Research to Understand Fire Emission Impacts on Public Health

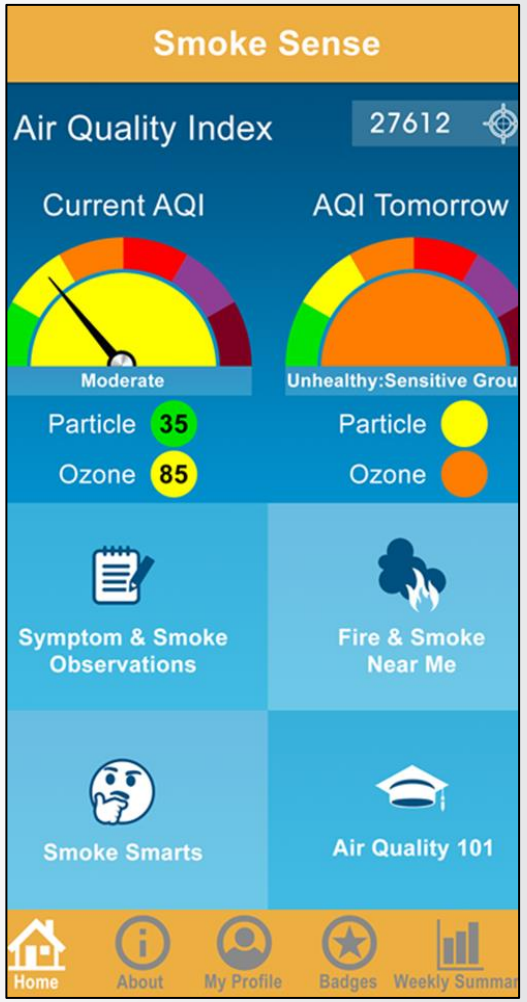


Toxicology



Epidemiology

Interventions

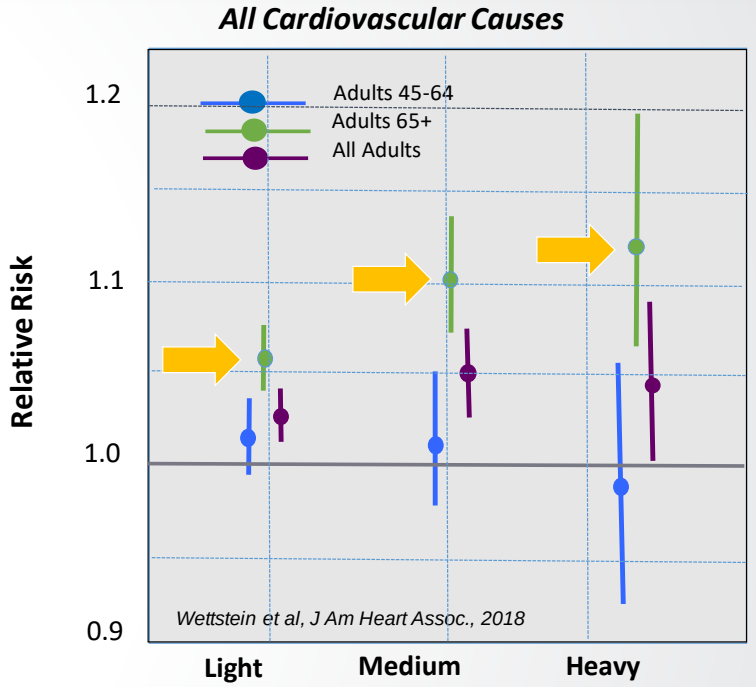


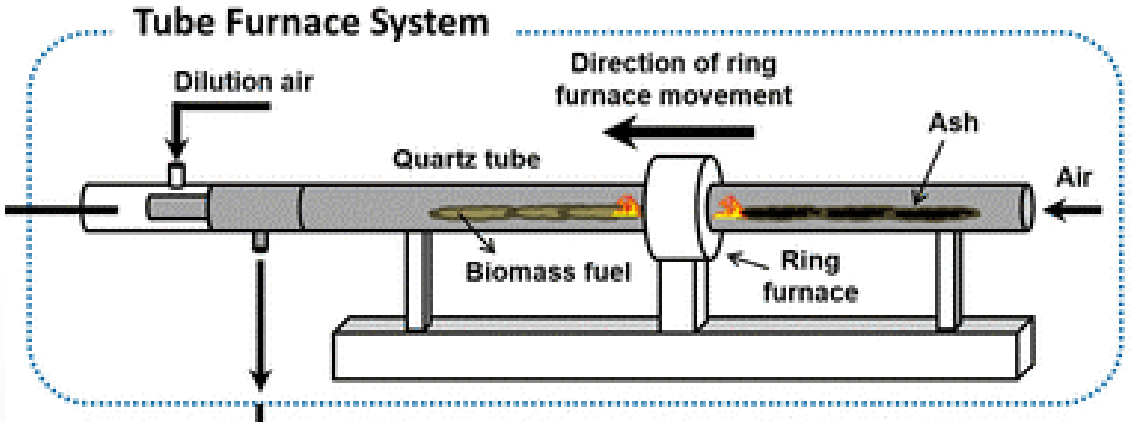
Social Science and Risk Communication

Wildland Fire Smoke Health Studies

- Epidemiology: evidence of increased cardiovascular emergency department visits, especially in those 65 and older

- Toxicology: PM from different wood burned (e.g., red oak, peat, pine, and eucalyptus) and wildfire combustion phases (e.g., flaming vs. smoldering) had appreciable differences in lung toxicity and mutagenic potency



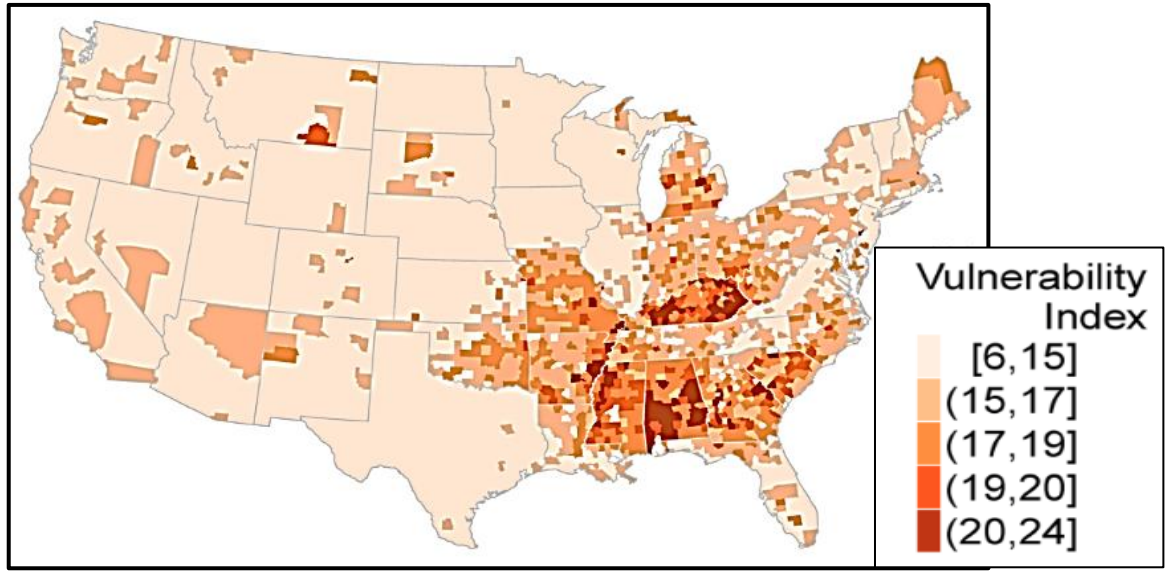


Community Health-Vulnerability Index

A tool for public health officials to identify vulnerable populations at risk from wildland fire smoke exposure

- Considers factors known to define susceptibility to air pollutant-related health effects
- Can be combined with air quality forecast data generated by models to develop maps of counties, regions, or other designated areas where at-risk populations live

CHVI for Continental U.S.



Factors of Vulnerability

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

Rappold AG, et al Environ Sci Technol 2017

Smoke Sense Citizen Science Initiative

1. Provides participants with smoke and health information through a mobile app when and when it is needed
2. Advances the state of the science on health risk communication related to actions that individuals take to protect their health during a wildfire

- Available since summer 2017 on both iOS and Android, in English and Spanish, currently more than 44,000 users from across the U.S. participate
- Current Emphasis
  - Exploring the role of risk perception in adopting recommended exposure reducing behaviors by leveraging models of health behavior including theory of planned behavior, theory of reasoned action, health belief model, and stages of change models.
  - Further developing innovative research methods through continued collaboration with partners like researchers at Washington State University to adapt the research design in a range of contexts

Respirator/Face Mask Study

- This year EPA will test effectiveness of a range of devices, including:
  - NIOSH-approved N95 or P100 respirators
  - Surgical masks
- Results will expand our understanding of the health benefits provided by these exposure-reducing devices during a wildland fire event and inform risk communication approaches

Measurements of Wildfire Smoke

Mobile Ambient Smoke Investigation Capability (MASIC)

- Provide enhanced ambient monitoring capability to evaluate smoke impacts and inform air quality modeling
- Evaluate performance of various instruments and sensors during wildfire smoke conditions

EPA trailer with enhanced measurement capabilities

Measurements: Evaluations and Development

- Evaluation of low cost and commercially available PM samplers
- Ozone measurement methods in smoke plumes
- Performance of multi-pollutant sensor pods from the EPA Wildland Fire Air Sensor Challenge
- Vehicle add-on mobile monitoring system (VAMMS)

Sensor pod evaluation at USFS Missoula Fire Science Lab

The Effect of Fuel Characteristics and Fire Dynamics on Emissions, Dispersion, and Air Quality Impacts (SERDP funded)

- Determine how prescribed burning emissions can be reduced by studying the effects of fuel structure, wind conditions, and ignition methods on fire dynamics

Wildfire ASPIRE Study: Advancing Science Partnerships for Indoor Reductions of Smoke Exposures

- Targeted research questions based on discussions with stakeholders:
  - How effective are air filtration systems during smoke events?
  - How effective are portable air cleaners in reducing $PM_{2.5}$ concentrations?
  - What innovative approaches can help reduce wildfire exposures?
- Study Components:
  - Web Summit on Clean Air Spaces (Jun. 2019)
  - Field studies in Missoula, MT and Hoopa, CA (Jul. 2019-present)
  - Lab studies on effectiveness of air cleaning technologies (Oct. 2020-present)
  - Prize-based challenge (under development)

- Partners include
  - USFS Fire Sciences Laboratory
  - Missoula City-County Health Department
  - Climate Smart Missoula
  - University of Montana
  - Hoopa Valley Tribe

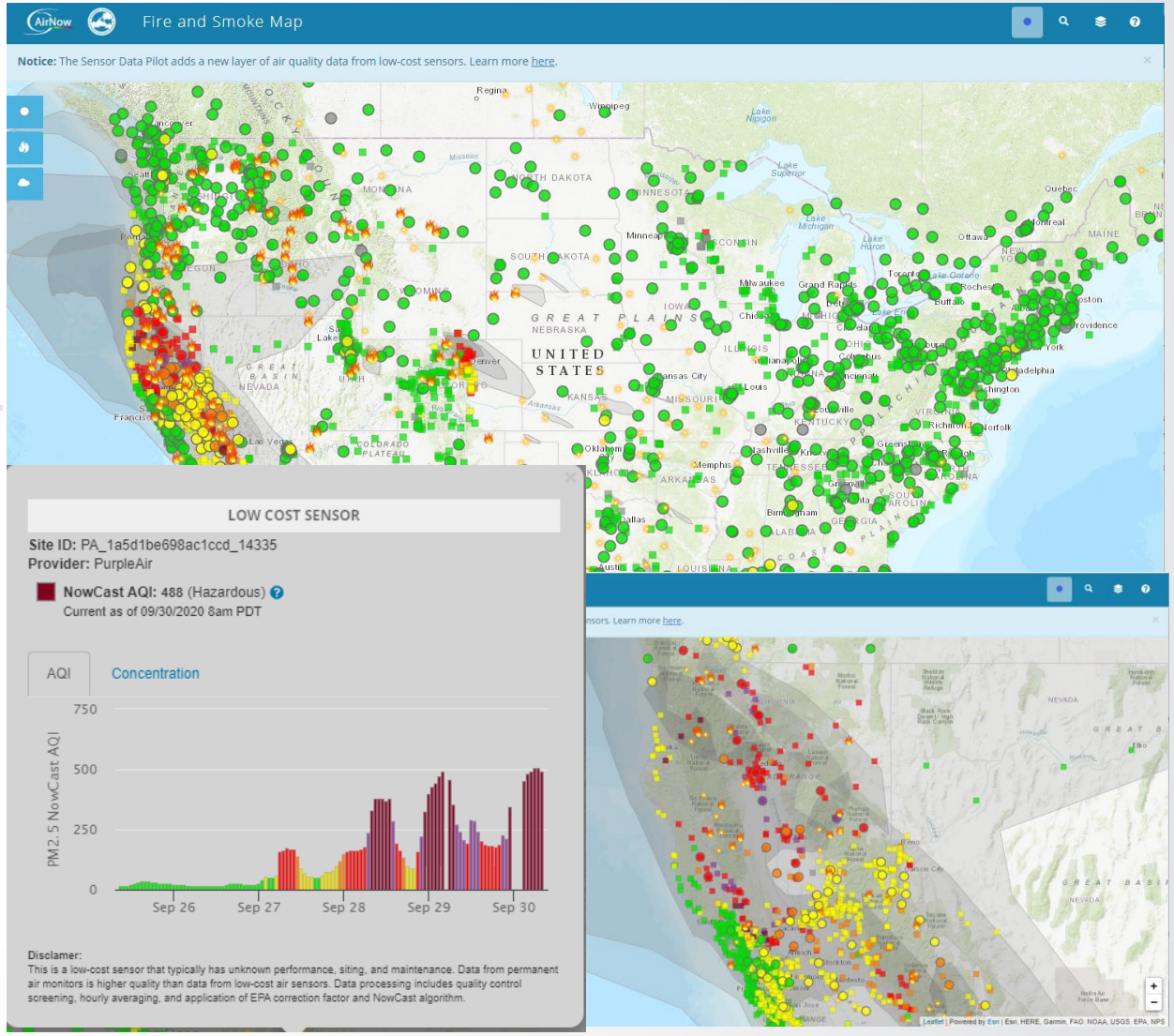
Collocation of PurpleAir sensors with reference monitors at the USFS Missoula Fire Science Lab

https://wcms.epa.gov/air-research/wildfire-study-advance-science-partnerships-indoor-reductions-smoke-exposures

AirNow Fire and Smoke Map - Sensor Data Pilot

To provide the public with additional air quality information they can use to protect their health during wildfires.

- EPA developed correction equation for low-cost PurpleAir Sensors
- Corrected data from PurpleAir Sensors have been added as a layer to the AirNow Fire and Smoke Map
- Improves coverage of air quality information where there are no regulatory grade monitors



https://fire.airnow.gov/

Smoke Ready Communities Research

- Goals
  - To support communities in their efforts to reduce the public health burden of wildfire smoke events
- Objectives
  - Conduct applied research that
    1. Aids local communities in their smoke event preparedness efforts
    2. Characterizes the relationship between interorganizational collaborative planning processes, community capacity, and overall resilience to wildland fire smoke events
    3. Identifies actionable strategies that EPA and partner agencies can take to improve tools and resources in this context

Two Phases

1. Examining local smoke planning processes.
2. Exploring the relationship among collaborative planning and community capacity/resilience

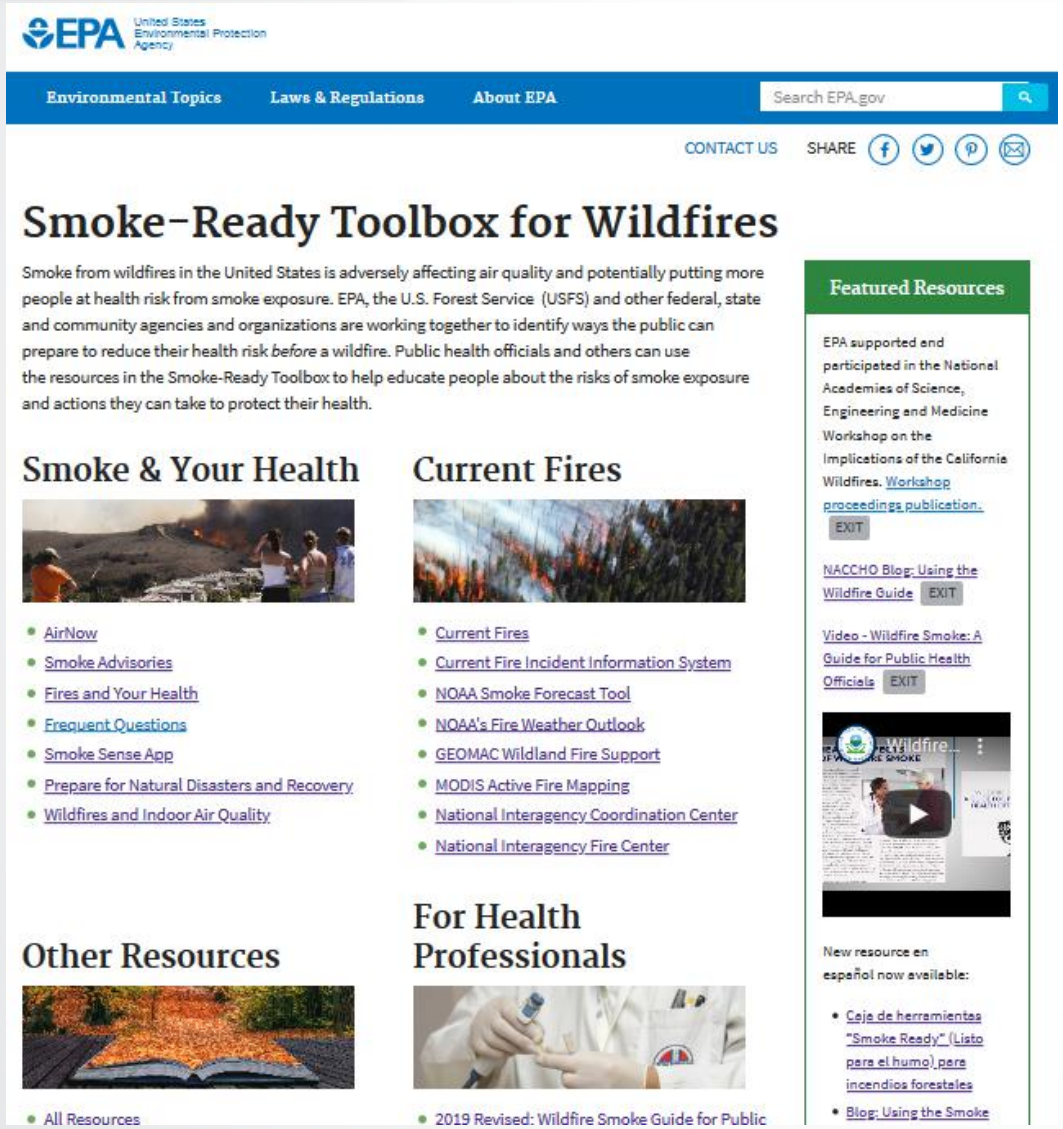
Thank You!

Wayne E. Cascio, MD, FACC
Director
Center for Public Health and Environmental Assessment

Supplemental Slides

Tools and Education

Visit the Smoke-Ready Toolbox for Wildfires



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Smoke-Ready Toolbox for Wildfires

Smoke from wildfires in the United States is adversely affecting air quality and potentially putting more people at health risk from smoke exposure. EPA, the U.S. Forest Service (USFS) and other federal, state and community agencies and organizations are working together to identify ways the public can prepare to reduce their health risk *before* a wildfire. Public health officials and others can use the resources in the Smoke-Ready Toolbox to help educate people about the risks of smoke exposure and actions they can take to protect their health.

Smoke & Your Health

- AirNow
- Smoke Advisories
- Fires and Your Health
- Frequent Questions
- Smoke Sense App
- Prepare for Natural Disasters and Recovery
- Wildfires and Indoor Air Quality

Current Fires

- Current Fires
- Current Fire Incident Information System
- NOAA Smoke Forecast Tool
- NOAA's Fire Weather Outlook
- GEOMAC Wildland Fire Support
- MODIS Active Fire Mapping
- National Interagency Coordination Center
- National Interagency Fire Center

Other Resources

- All Resources

For Health Professionals

- 2019 Revised: Wildfire Smoke Guide for Public

Featured Resources

EPA supported and participated in the National Academies of Science, Engineering and Medicine Workshop on the Implications of the California Wildfires. Workshop proceedings publication. EXIT

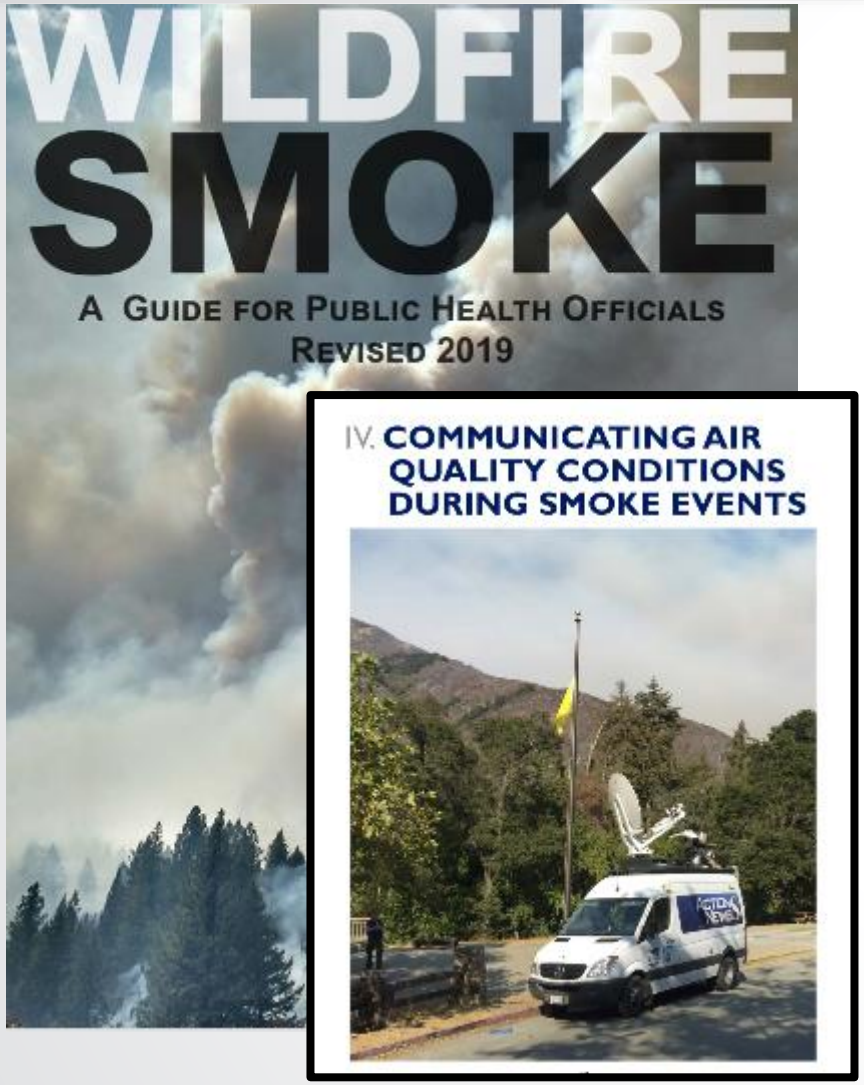
NACCHO Blog: Using the Wildfire Guide EXIT

Video - Wildfire Smoke: A Guide for Public Health Officials EXIT

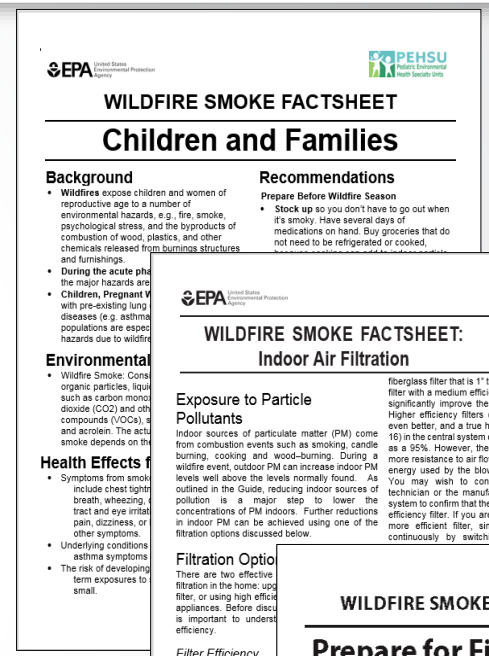
New resource en español now available:

- Caja de herramientas "Smoke Ready" (Listo para el humo) para incendios forestales
- Blog: Using the Smoke

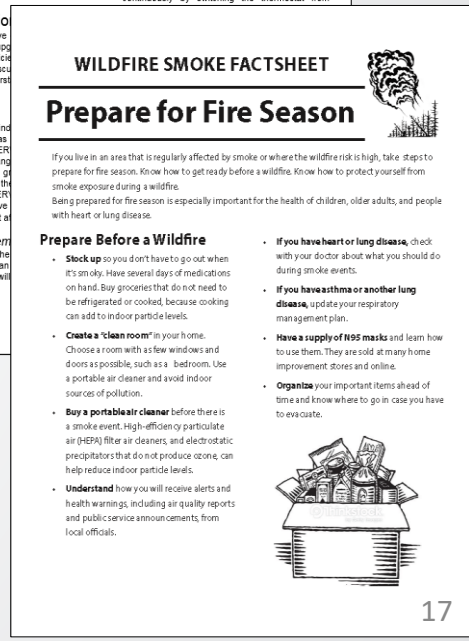
QR code takes you to the Toolbox webpage.



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


EPA PEHSU
WILDFIRE SMOKE FACTSHEET
Children and Families
Background
Recommendations
Prepare Before Wildfire Season


EPA
WILDFIRE SMOKE FACTSHEET:
Indoor Air Filtration
Exposure to Particle Pollutants
Health Effects
Filtration Optio
Filter Efficiency
Central Air System


WILDFIRE SMOKE FACTSHEET
Prepare for Fire Season
Prepare Before a Wildfire

https://airnow.gov/index.cfm?action=topics.smoke_wildfires_guide_factsheets

Wildfire Smoke

Patient Exposure and High Particle Pollution Events

On this page:

Introduction

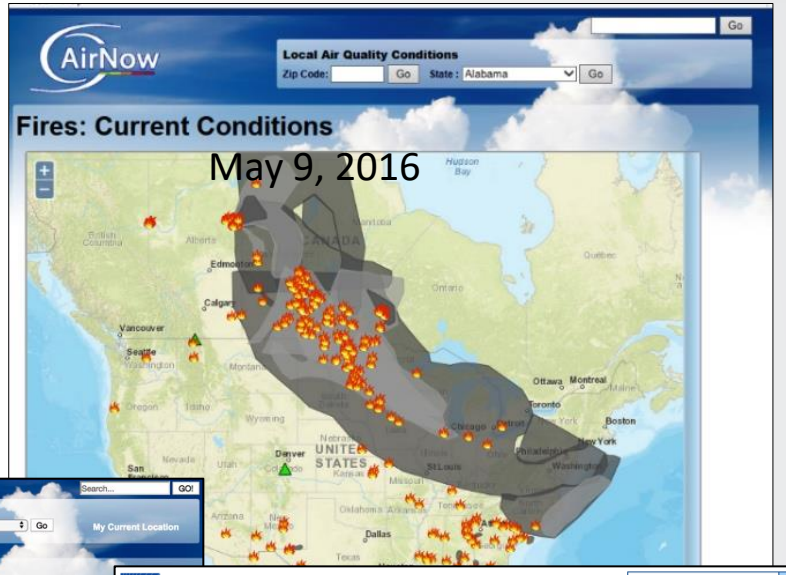
Ozone and the other common pollutants rarely reach very high levels in the U.S. But almost every year, in many parts of the country, particle pollution levels reach the ver
ranges of the AQI. These events are usually associated with fires or dust
wildfires, but on a smaller spatial and temporal scale high particle pollu
other types of fires or combustion. Examples of these high particle even
wood burning in valleys during winter-time inversions, or transport of u
for reducing exposure to particle pollution, discussed below, are similar
particles are wildfires, other fires, transport of particles, or dust storms
needed with some fires depending on hazards of the chemicals that bur

Portions of the text in the following sections is adapted from the docum
for Public Health Officials (May 2016)," which is designed to help local p
for smoke events, to take measures to protect the public when smoke is
with the public about wildfire smoke and health. The 2016 Wildfire Guid
assistance and expertise of a number of federal and state agencies, inclu
Control and Prevention, National Institute of Occupational Safety and H

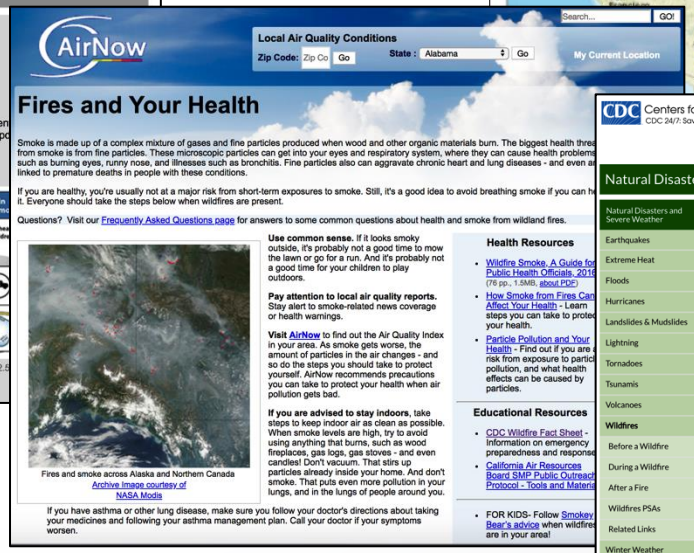
Consistent with Wildfire Smoke: Guide for Public Health Officials

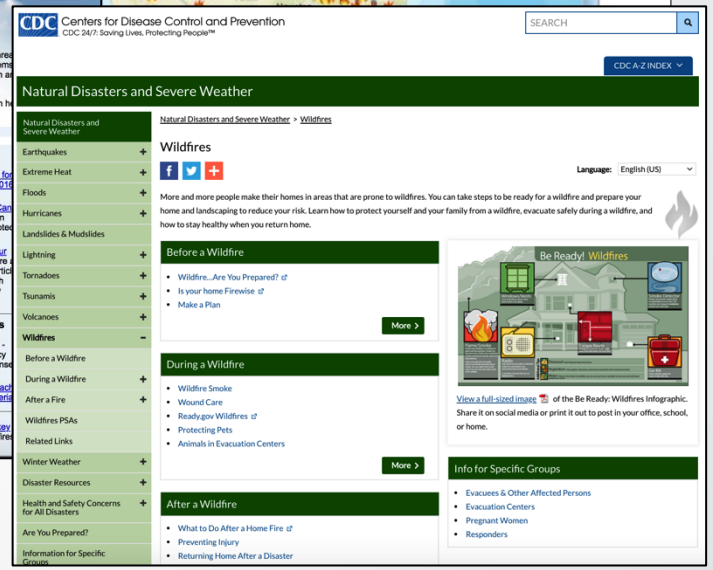
AirNow

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



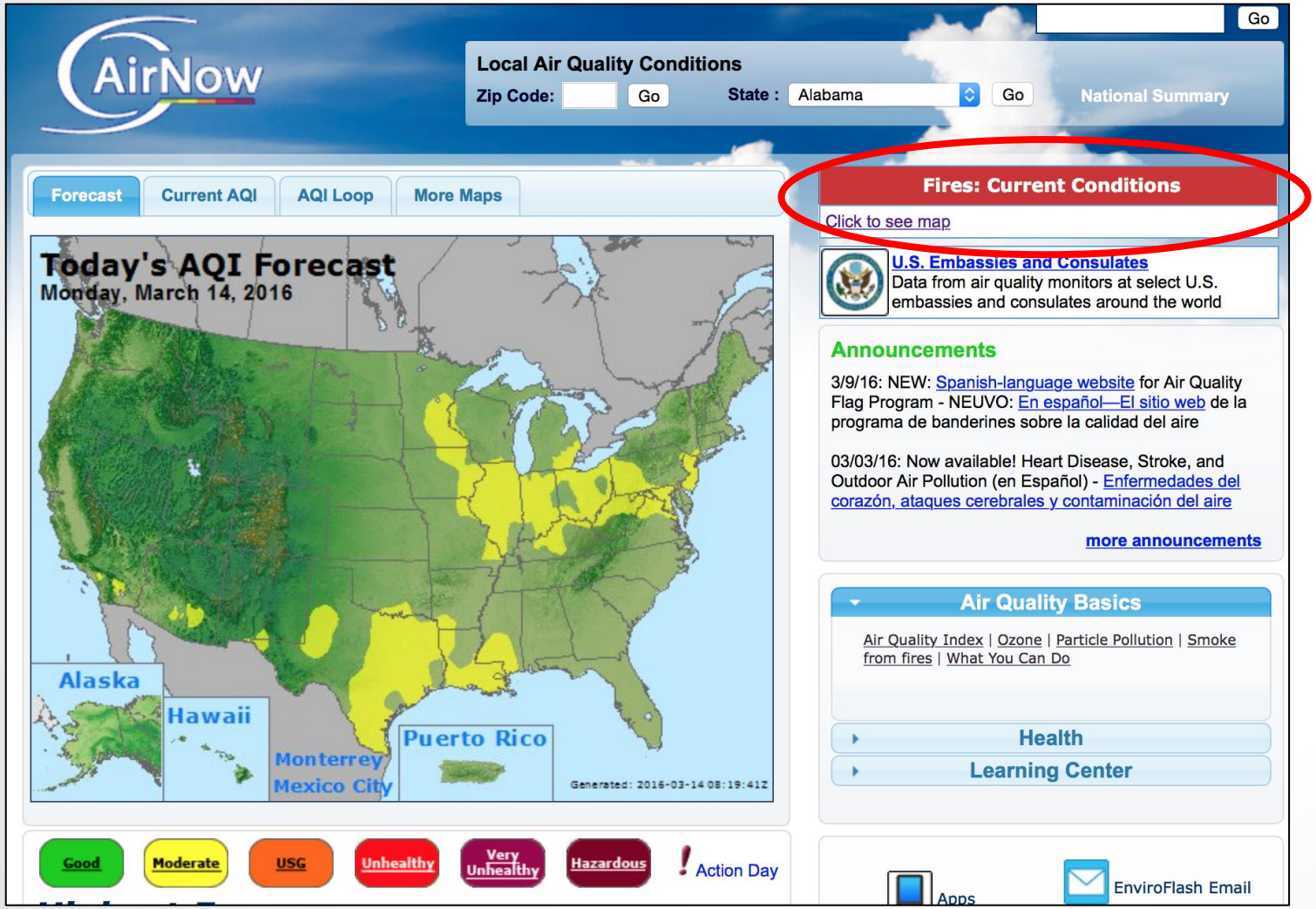
Fires and Your Health





CDC: Before, During and After a Wildfire

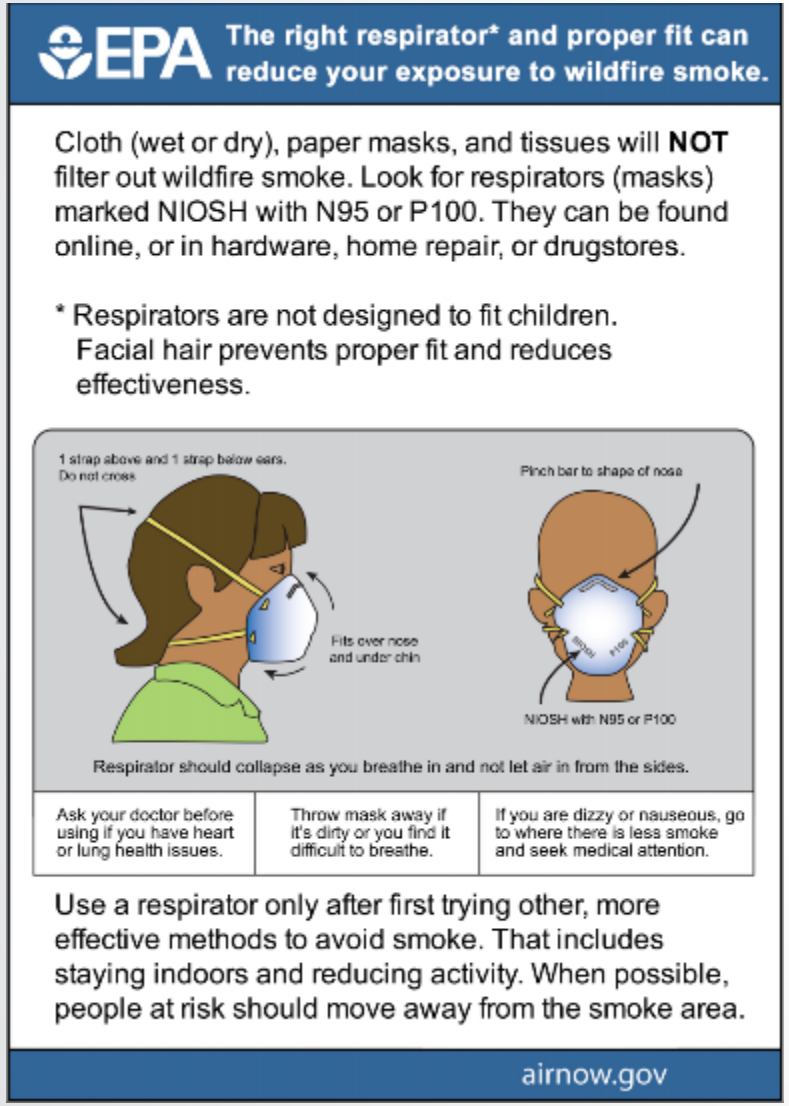
Finding the Wildfire Smoke: Guide for Public Health Officials

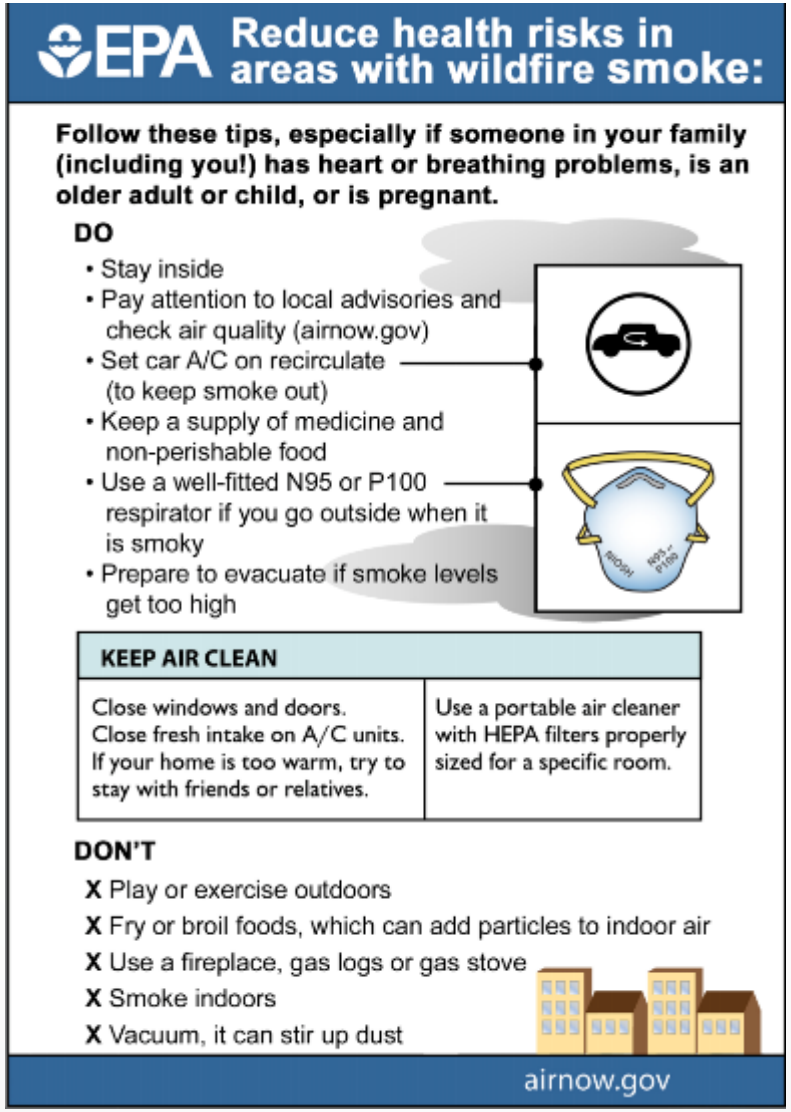


Fires: Current Conditions

- **Includes the -**
  - ***Wildfire Guide***
  - ***Factsheets***
  - ***Infographics***
  - ***Wildland Fire Air Quality Resource Program***
  - ***NOAA Smoke Forecast Tool***
  - ***NOAA's Fire Weather Outlooks***
  - ***MODIS Active Fire Mapping***

Infographic Available for Download on AirNow





Challenges:

- **Inconsistent public health messaging across cities and states**
- **Of value only if used correctly**
- **Not designed or recommended for children**
- **Increases work of breathing that might increase risk among those with cardiopulmonary impairment**

Research Opportunity:

- **ORD plans to investigate these issues**

Collaboration/Partnerships

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***

http://www.epa.gov/healthyheart/

Provides Educational Tools on Particle Pollution

Connect with us:

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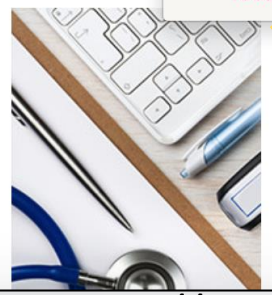
- Undiagnosed Hypertension
- Self-Measured Blood Pressure
- Medication Adherence
- Treatment Protocols
- Action Guides
- Tools
  - Health IT
  - Particle Pollution
  - Physical Activ
  - Tobacco



Tools & Protocols

Find treatment protocols, action guides, and other tools to help educate, motivate, and monitor your patients.

Data & Reports

Access the latest data and published research on heart disease and stroke.

Learn more >

https://millionhearts.hhs.gov

Million Hearts® millionhearts.hhs.gov — e-update

Tools You Can Use

- **New Million Hearts® website on physical activity promotes community programs and resources.** Physical activity is one of the most effective ways to prevent and manage heart disease, but just half of U.S. adults get enough. Take advantage of resources and information about community-based programs to boost physical activity in your community.
- **Vermont Department of Health releases Hypertension Management Toolkit.** The toolkit uses Lean quality improvement tools and methods to support evidence-based strategies that improve blood pressure control. A new statewide peer learning collaborative will share best practices to keep the toolkit updated.
- **Million Hearts® Tobacco Cessation Protocol now available on the go.** Find the CDC Protocol for Identifying and Treating Patients Who Use Tobacco on Epocrates, a free website and app for clinicians. (Registration may be required.)
- **A visual air quality alert makes air awareness easy.** The EPA's Air Quality Flag Program provides instructions on using physical and digital flags at your business or online to alert people to daily air quality.
- **New EPA toolkit details the link between heart problems and air pollution.** Use the Healthy Heart Toolkit to take steps to protect yourself and your community, sign up for air alerts, and download public education materials.

Million Hearts® in the Community

- **The District of Columbia Department of Health's Million Hearts® program builds a framework for success.** Learn how D.C.'s Million Hearts® program's strong partnerships, data monitoring, and targeted interventions have reduced CV disease morbidity and mortality in the nation's capital.
- **Find your niche when partnering with Million Hearts®.** Hospitals, employers, and clinical care teams in communities across the nation have tailored unique approaches to keeping people healthy, optimizing care, and helping priority populations. Learn how they did it—and then craft your own plan.
- **Million Hearts® continues engagement to find patients with hypertension "hiding in plain sight."** How many people in your practice have undiagnosed high blood pressure? Learn how to establish criteria for finding people with hypertension, implement evidence-based strategies to treat them, and improve their CV outcomes.
- **Pilot program with National Association of Community Health Centers (NACHC) shows progress in fighting hypertension.** In honor of National Health Center Week (Aug. 13-19), take the time to learn how Million Hearts® partner NACHC is making strides in blood pressure control.

The Science of Million Hearts®

- **Physicians experienced in health information technology are more likely to achieve 70% blood pressure control.** (*Journal of the American Medical Informatics Association*)
- **Lowering prices of fruits and vegetables could reduce the number of deaths from CV disease.** (*PLOS Medicine*)
- **A cost-benefit analysis shows how indoor air filtration may reduce mortality due to particulate matter.** (*International Journal of Indoor Environment and Health*)

You are receiving this newsletter because you are a Million Hearts® supporter.

Air quality as a risk factor for heart attack? It may sound strange, but worsening air quality puts people at risk for heart attacks and other cardiovascular (CV) conditions, especially among people who are already vulnerable. More than 1.5 million people in the United States suffer from heart attacks and strokes each year. Millions more have high blood pressure or heart rhythm disorders, putting this priority population especially at risk from particle pollution's effects.

Million Hearts® is dedicated to driving implementation of evidence-based public health and clinical strategies that help prevent CV events. With that in mind, we recently **launched a webpage** to spread awareness about particle pollution and CV health, with resources to help track local air quality. Use the resources in this newsletter to learn about the connection between heart health and particle pollution to help keep people healthy this summer and beyond.

—**Janet Wright, MD, FACC**
Executive Director, Million Hearts®

Do This!
Share the EPA Air Quality Index with networks and people at risk.
Particle pollution puts people with CV conditions at higher risk for heart problems or stroke. Post this tool on your websites and social media so people can check air quality before they go outside for physical activity. Those at risk should avoid going outside on days ranked "orange" or worse and instead choose indoor versions of their favorite activities.

Quick Fact
One in three American adults has heart or blood vessel disease and is at higher risk from air pollution, which can trigger heart attacks

Healthy Heart Toolkit and Research

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

- *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*

https://www.epa.gov/air-research/healthy-heart-toolkit-and-research-steps-you-can-take

Protecting Pets, Farm Animals and Livestock

WILDFIRE SMOKE FACTSHEET

Protect Your Pets from Wildfire Smoke

Your pets can be affected by wildfire smoke. If you feel the effects of smoke, they probably do, too! Smoke can irritate your pet's eyes and respiratory tract. Animals with heart or lung disease and older pets are especially at risk from smoke and should be closely watched during all periods of poor air quality.

Know the Signs

If your animals have any of these signs, call your veterinarian:

- Coughing or gagging
- Red or watery eyes, nasal discharge, inflammation of throat or mouth or reluctance to eat hard foods
- Trouble breathing, including open-mouth breathing, more noise when breathing, or fast breathing
- Fatigue or weakness, disorientation, uneven gait, stumbling
- Reduced appetite or thirst

Recommended Actions

Even if the fire danger is not imminent, high levels of smoke may force you to stay indoors for a long time or even to evacuate. Reduce your pet's exposure to smoke as you would reduce your own.

Before the fire season:

- Whether you have a central air conditioning system or a room unit, buy high efficiency filters you can use to capture fine particles from smoke.
- Think about creating a clean room in your house with a portable air cleaner.

When smoke is present:

- **Keep pets indoors** as much as you can, with doors and windows closed. Bring outdoor pets into a room with good ventilation, like a utility room, garage, or bathroom. Move potentially dangerous products, such as pesticides, out of the reach of pets.
- **Smoke is especially tough on your pet birds.** Keep them inside when smoke is present.
- **Keep indoor air clean:** do not fry or broil foods, vacuum, burn candles, use a fireplace or woodstove, or smoke tobacco products. These activities add particles to your home.
- **Spend less time outdoors and limit physical activities when it is smoky.** For example, when it's smoky, it's not a good time for you and your pet to go for a run. Let dogs and cats outside only for brief bathroom breaks if air quality alerts are in effect.

https://www3.epa.gov/airnow/smoke_fires/protect-your-pets-from-wildfire-smoke.pdf

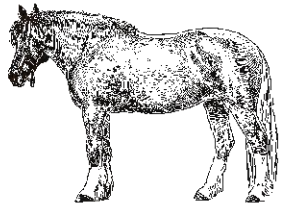
WILDFIRE SMOKE FACTSHEET

Protect Your Large Animals and Livestock from Wildfire Smoke

Your animals can be affected by wildfire smoke. If you feel the effects of smoke, they probably do too! High levels of smoke are harmful. Long exposure to lower levels of smoke can also irritate animals' eyes and respiratory tract and make it hard for them to breathe. Reduce your animals' exposure to smoke the same way you reduce your own: spend less time in smoky areas and limit physical activity. Animals with heart or lung disease and older animals are especially at risk from smoke and should be closely watched during all periods of poor air quality. Take the following actions to protect your large animals and livestock against wildfire smoke.

Protect Your Animals During Smoke Episodes

- ☐ Limit strenuous activities that increase the amount of smoke breathed into the lungs.
- ☐ Provide plenty of fresh water near feeding areas.
- ☐ Limit dust exposure by feeding low-dust or dust-free feeds and sprinkling or misting the livestock holding areas.
- ☐ Consider moving outdoor birds to a less smoky environment, such as a garage or basement.
- ☐ Give your livestock 4 to 6 weeks to recover fully from smoky conditions before resuming strenuous activity.
- ☐ Protect yourself, too! Think about wearing an N95 or P100 respirator while taking care of your animals.



Prepare Before a Wildfire

Know where to take your livestock if smoke persists or becomes severe, or if you need to evacuate. Good barn and field maintenance can reduce fire danger for horses and other livestock.

Record Keeping

- ☐ Make sure your animals have permanent identification (ear tags, tattoos, electronic microchips, brands, etc.).
- ☐ Keep pictures of animals, especially high-value animals, such as horses, up-to-date.
- ☐ Keep a list of the species, number and locations of your animals with your evacuation supplies.
- ☐ Note animals' favorite hiding spots. This will save precious rescue time!
- ☐ Keep vaccination records, medical records and registration papers with your **Evacuation Kit.**

Preparing for Evacuations

- ☐ Assemble an **Evacuation Kit.**
- ☐ Know where you can temporarily shelter your livestock. Contact your local fairgrounds,

https://www3.epa.gov/airnow/smoke_fires/protect-your-large-animals-and-livestock-from-wildfire-smoke.pdf

Federal and Professional Partners

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DEPARTMENT OF HEALTH & HUMAN SERVICES · USA

CDC Centers for Disease Control and Prevention

FOREST SERVICE US DEPARTMENT OF AGRICULTURE

AVMA American Veterinary Medical Association

CME credit from CDC to physicians, nurses and health educators

Combating Wildland Fire Impacts

Lara Phelps, Director

US EPA, Office of Research and Development,
Center for Environmental Measurement and Monitoring,
Air Methods and Characterization Division

A-E BOSC Subcommittee Meeting

February 17 – 19, 2021

Outline

- Wildland Fire Measurement & Characterization

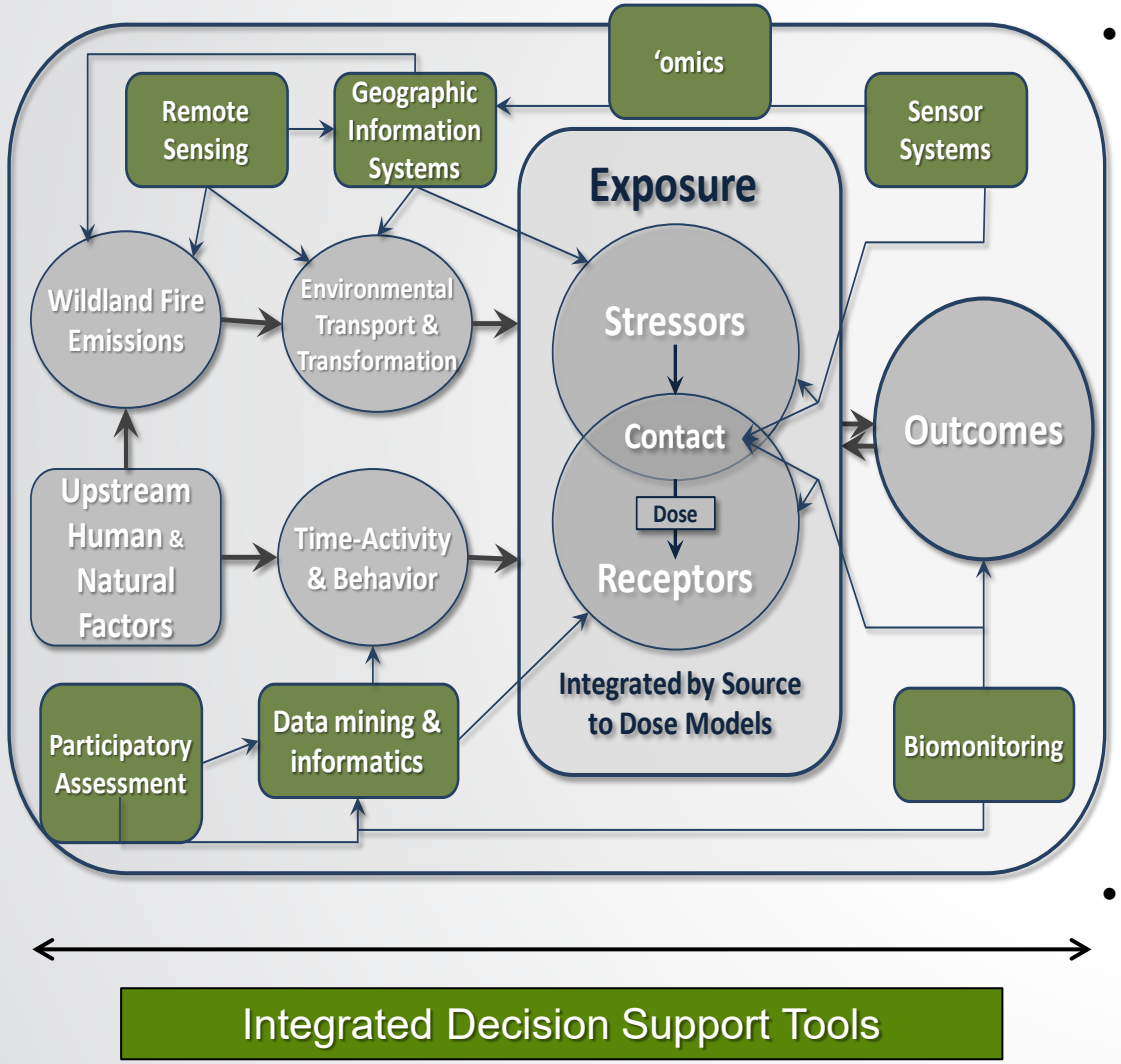
- Research Snapshot
  - Mobile Ambient Smoke Investigation Capability (MASIC); FireX-AQ Ground Measurement Support; and the AQUARIUS Study Sensor Programs
  - Multi-pollutant Sensor Pod Evaluation
  - Small Form Factor Filter Based PM Samplers
  - Wildland Urban Interface Emissions
  - Lead (Pb) Emissions
  - PurpleAir Correction Factor

- Research Challenges

Why are Smoke Emissions Important?

- Increasing Fire Size & Intensity
- Community & Fire Fighter Health
  - PM, Toxics
  - Susceptible Subpopulations
- Ambient Air Quality
  - PM, O_3, NOx, NH_3, CO, VOCs
- Global Climate
  - CO_2, CH_4, BC, Organic Aerosols, NOx, N_2O

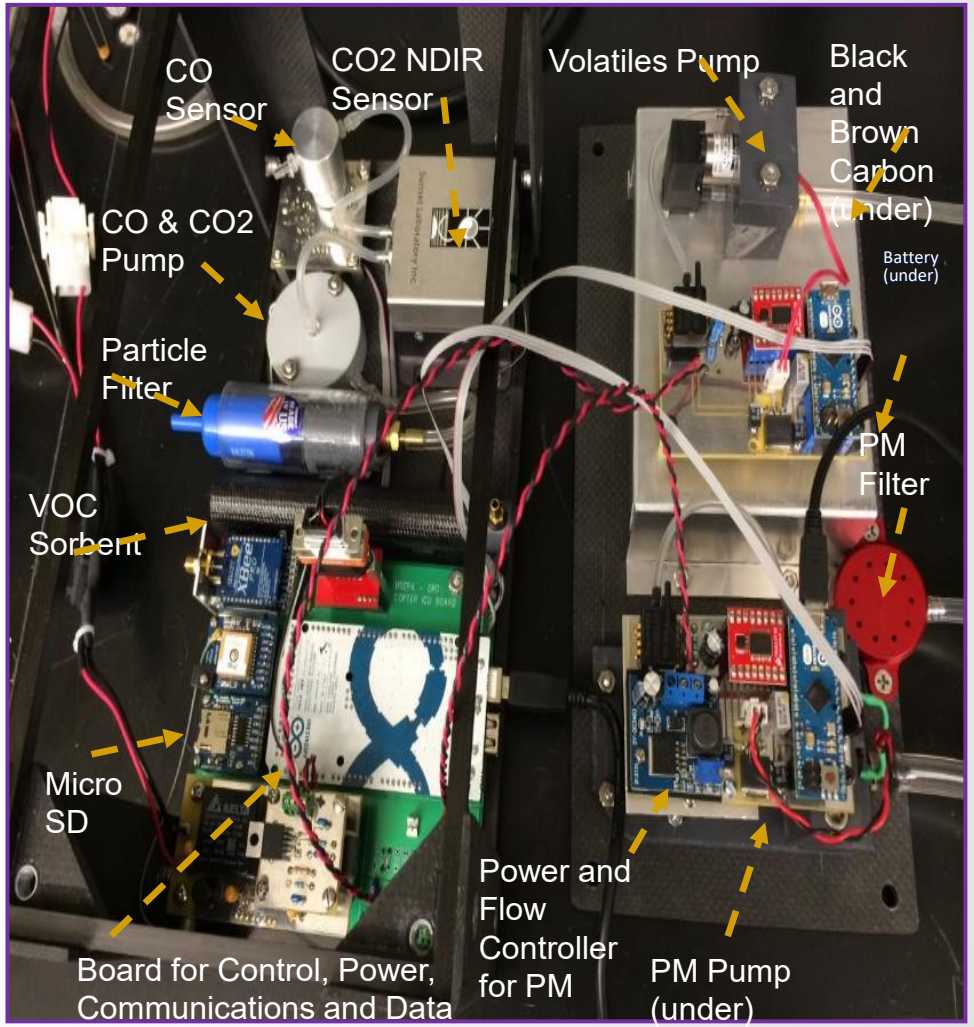
Measurements



- Elucidating Wildland Fire Smoke Impacts on Public Health
  - Source Emission to Exposure
    - Emission Characterization
    - Transport
    - Atmospheric Chemistry
    - Community Monitoring (NAAQS)
    - Human Exposure
  - Model Development & Assessment
    - Deterministic Modeling (CMAQ)
    - Receptor Modeling (PMF, Unmix)
  - Health Effects
    - Epidemiological Modeling
    - Mechanistic Toxicological Effects
- Public Health Communication
  - Data Integration & Risk Assessment
  - Health Communication (AirNow, AQI, SmokeSense)

Methods Characterization

- Development/Integration of Methods to Better Quantify Impact of Smoke
  - Required to Investigate Health Effects & Create Effective Public Health Messaging
  - Required to Elucidate Wildland Fire Impacts on NAAQS Compliance (e.g., Natural *versus* Anthropogenic Sources; Data to Inform Exceptional Event Determination)
- Development of Portable Multi-pollutant Sensors
  - Support Emission Characterization Using Unmanned Aerial Vehicles & Aerosonde for Plume Measurements; Tower & Forest Burn-over (*In Situ* Measurements)
  - Support Incident Response Activities (Local Scale)



An Integrated Approach

Mobile Ambient Smoke Investigation Capability (MASIC); FireX-AQ Ground Measurement Support; and the AQUARIUS Study – Matthew Landis, Russell Long, et al

- Prior to MASIC - No Ambient Monitoring Sites for Smoke Assessment
  - EPA (CSN, NCOR, PAMS, SLAMS, NAPS, Near Road, O_3, SO_2, FRM) or NPS (IMPROVE) Monitoring Network
  - No Sites Measuring CO & CO_2 Required to Calculate Modified Combustion Efficiency (MCE)
  - No Sites Routinely Analyzing FRM Filters for Definitive Smoke Tracers
  - Limited Sites Measuring Optical Carbon (EC/UVPM) or OC/EC (TOT/TOR)
- No Formal Evaluation of Existing Network Sites for Comprehensive Smoke Impacts
  - Limited Exceptional Event Designation Investigations
  - Lack of Definitive Tools/Data for Assessment (Many Inferential Approaches - Satellite Products)
  - Handicaps Health Effects (Epidemiology) Modeling & Understanding Impacts on NAAQS Compliance
- No Dedicated Mobile Monitoring Capabilities for Wildland Fire Events
  - Support Incident Response Activities (e.g., Air Resource Advisors)
  - Opportunity for Valuable Research Data: Emission Characterization, Plume Aging Characterization, Health Effects

Evaluation of Multi-Pollutant Sensor Pods

Matthew Landis, Russell Long, et al

EPA Wildland Fire Sensor Challenge (2016 – 2018 Testing) Performance Evaluation of Multi-Pollutant Sensor Pods in Biomass Combustion Smoke

Shared Vision by Partnering Organizations:

A desire to advance air measurement technology to be **easier to deploy**, suitable to use for **high concentrations observed during wildland fire events**, **durable** to withstand difficult field conditions, and report data **continuously and wirelessly**.

Partnering Federal Organizations:

Significance of Burn Conditions on Performance

Instrument	MCE	MMAD	BC	Temp	RH
2B PAM	✓				
Ambilabs-Neph	✓	✓	✓	✓	
AQMesh	✓		✓		✓
Duke Sensors	✓	✓	✓	✓	
Kunak	✓	✓	✓	✓	✓
Purple Air	✓				✓
Met-One EBAM			✓		
Met-One Esampler	✓	✓	✓	✓	
Sensivere RAMP	✓		✓	✓	
Thermo PDR	✓	✓	✓	✓	
Vaisala			✓		

MMAD – Mass Median Aerodynamic Diameter

- Calculate $D_{Instrument}$ (Instrument - Ref)
- Multivariate Analysis Testing the Influence of Burn Conditions
  - Modified Combustion Efficiency (MCE)
  - Aerosol Size Distribution (MMAD)
  - Black Carbon (BC)
  - Temperature (Temp)
  - Relative Humidity (RH)

Conclusions:

- **Factors Significantly Impacting Instrument Accuracy**
  - **Burn Conditions**
  - **Aerosol Density Assumptions**
  - **Sensor Implementation/ Power Management**

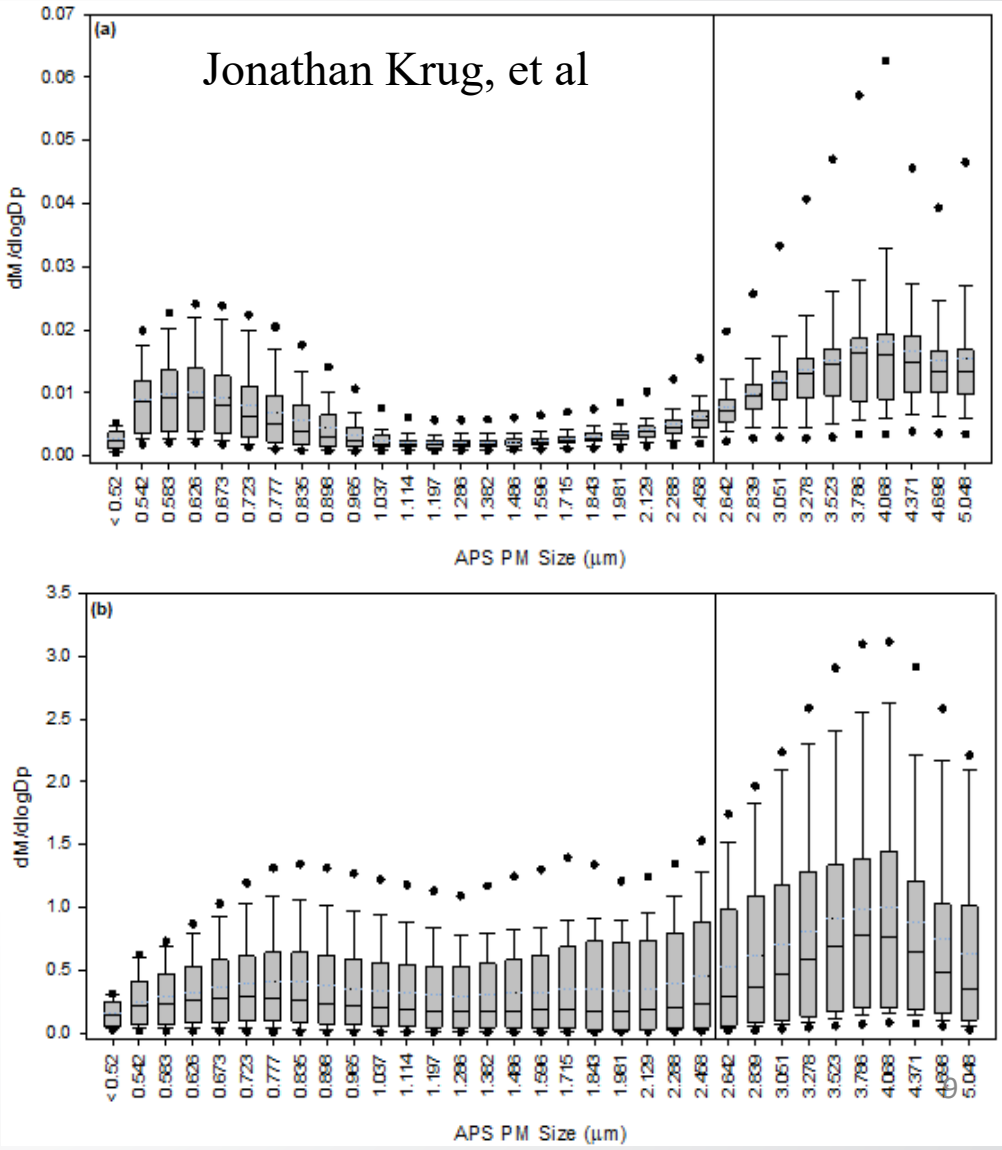
Evaluation of Small Form Factor Filter Based PM Samplers in Wildland Fire Conditions

EPA Air Innovative Research Site, RTP

- Ambient sampling for 32 days
- 23.75-hour sample days
- Collocated $PM_{2.5}$ Tisch FRMs
- 3-Collocated small form factor filter sampler pairs: nFRM, MiniVol, and Omni

USFS Missoula Fire Science Lab

- Fuel: Ponderosa Pine Needles & Mixed Woody Debris
- Combustion: Flaming & Smoldering, Control Variables: Fuel Moisture & Load
- 31 burns under varying loading and combustion efficiencies
- Higher concentration, larger particles in low MCE conditions
- 5 sampler pairs: nFRM, MiniVol, Omni, LFR-6, nFRM+URG inlet compared against Tisch FRM



Selected Small Form Factor Filter Sampler Evaluation Results

		AIRS			Chamber		
Sampler	**Unit**	**n**	**Mean ± StdDev $PM_{2.5}$ (µg m^{-3})**	**Accuracy (%)**	**n**	**Mean ± StdDev $PM_{2.5}$ (µg m^{-3})**	**Accuracy (%)**
Tisch FRM	**Ave**	32	7.62 ± 2.60	-	31	598.7 ± 637.0	-
nFRM	**Both**	32	7.49 ± 2.70	97.3 ± 1.9	31	605.7 ± 648.5	98.2 ± 1.4
Omni FT	**Both**	32	7.98 ± 2.80	93.1 ± 9.1	31	594.3 ± 622.1	96.3 ± 3.8
MiniVol	**Both**	32	7.76 ± 2.69	94.2 ± 5.5	31	575.7 ± 618.9	94.1 ± 5.0
LFR-6	**Both**	-	-	-	31	595.3 ± 637.2	97.5 ± 2.6
nFRM URG Variant	**Both**	-	-	-	31	611.7 ± 654.1	96.4 ± 4.5

- nFRM best overall accuracy in Ambient and Chamber testing compared to FRM
- LFR-6 (6 Lpm version of nFRM) second in overall accuracy in chamber testing
- nFRM's slope (1.036), intercept (-0.412), and r^2 (0.993) in ambient environment testing indicate able to provide data quality similar to FRM in a rapid deployment scenario

Wildland Urban Interface (WUI)

Estimate of pollutant emissions from fires in the WUI – Amara Holder

What are the chemical constituents of smoke from fires in the WUI and how much are emitted?

Assess the relative importance of structures and vehicles to wildfire emissions by developing an emissions inventory for a single fire in the WUI

"Humans and their development meet or intermix with wildland fuel"

WUI Take Away

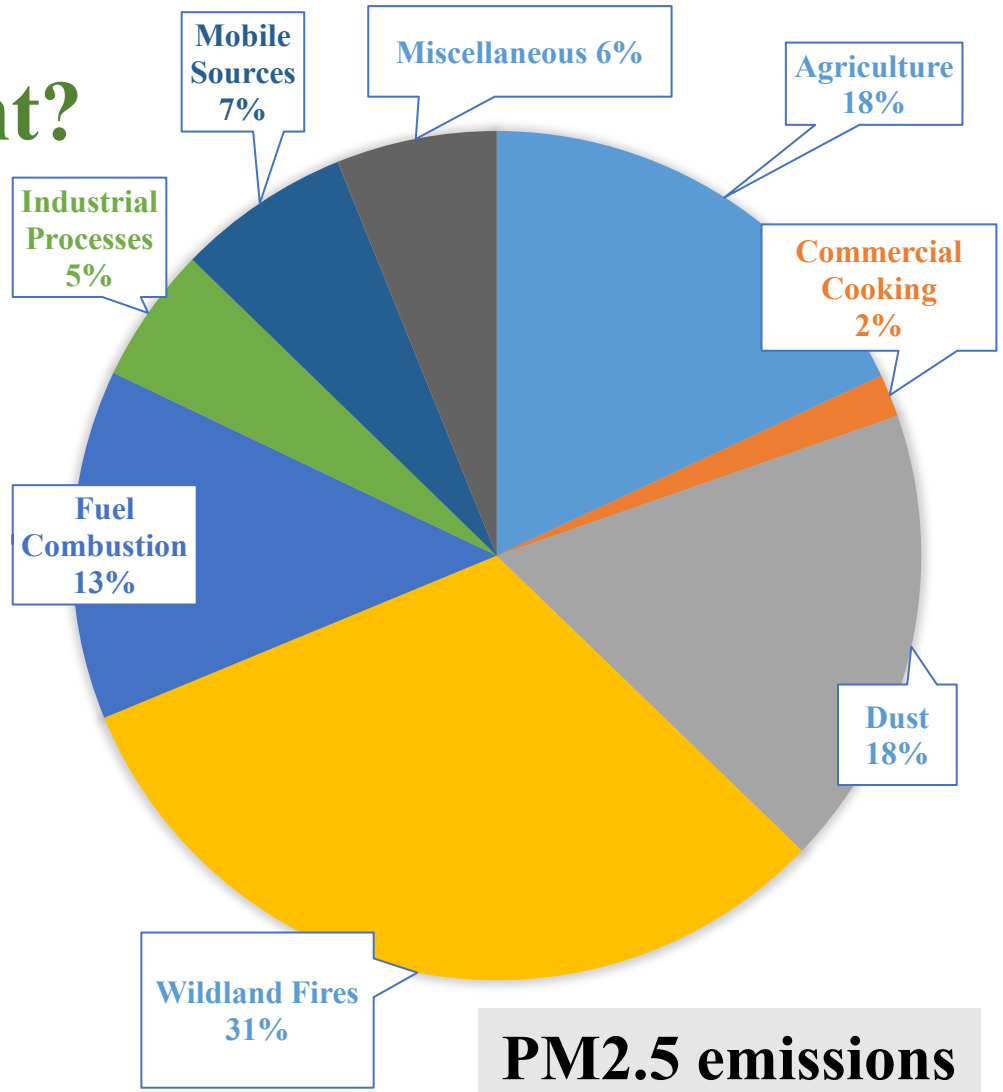
- Key Points:
  - Emissions of criteria pollutants from structures in the WUI are miniscule compared to those from the natural fuels for the Thomas Fire
  - Some air toxics (e.g., benzene, styrene, Pb) are emitted in amounts many times larger than those from the natural fuels and are comparable to other point sources on a county wide basis
  - Importance of WUI emissions depends on the individual wildfire/WUI fire, but exposure may be higher to WUI fire emissions due to the close-proximity of the public
- Method Comments:
  - Methods used for municipal fires are not applicable to WUI fires
  - Emission factors are needed to fill in the data gaps in the literature, especially for PM and its composition

Amara Holder

Lead (Pb) Emissions from Wildland Fires

Why are Pb emissions from fires important?

- Pb is an EPA criteria air pollutant with numerous health risks
- Fires are the largest source of fine particulate matter ($PM_{2.5}$ or PM) in US
- PM from fires are primarily carbonaceous, but contain many other elements at low concentrations, including Pb
- Given significant PM emissions from numerous fires, these trace level elements may be emitted in substantial concentrations, in aggregate
- We have never inventoried Pb from fires, but the risk assessment research community requested more information



PM2.5 emissions in the 2014 NEI

Measuring Pb Emission Factors (EFs) from Fires

- PM sampled from a series of prescribed (Rx) fires and laboratory simulations
- Increased sample mass and analytical sensitivity to optimize Pb limit of detection
- More robust and complete results coming from inductively coupled plasma – mass spectroscopy soon
- More samples from wider geographic areas are still needed to capture the variability of Pb in the environment

Biomass Type	Fire Type	Location
Tallgrass Prairie	Rx	Flint Hills, KS
Grassland	Rx	Sycan Marsh, OR
Loblolly Pine/Hardwood	Lab	RTP, NC
Lodgepole/Ponderosa Pine	Lab	Missoula, MT
Moss/Peat	Lab	Boundary Waters, MN

AirNow Sensor Data Pilot

Evaluation of Air Sensor Technologies and Development of Correction Equation and QA/QC Approach for Crowdsourced $PM_{2.5}$ Data – Andrea Clements, Amara Holder, Karoline Barkjohn

Secondary Data Project

Team: EPA ORD, partner local air agencies
Objective: Evaluate collocated PurpleAir sensors deployed by local agencies

Long Term Performance Project (and LTPP+)

Team: EPA ORD, partner local air agencies
Objective: Evaluate multiple sensors across the U.S. (LTPP+ PurpleAir only)

Smoke-Impacted Projects

Team: EPA ORD, Regions 9 & 10, USFS
Objective: Evaluate multiple sensors in smoke

24-hr U.S. Correction Development

Method: Collocations with FEM and FRM measurements
Objective: Build a correction model that improves sensor performance across the U.S.

1-hr Evaluation of Ambient and Smoke-Impacted Data

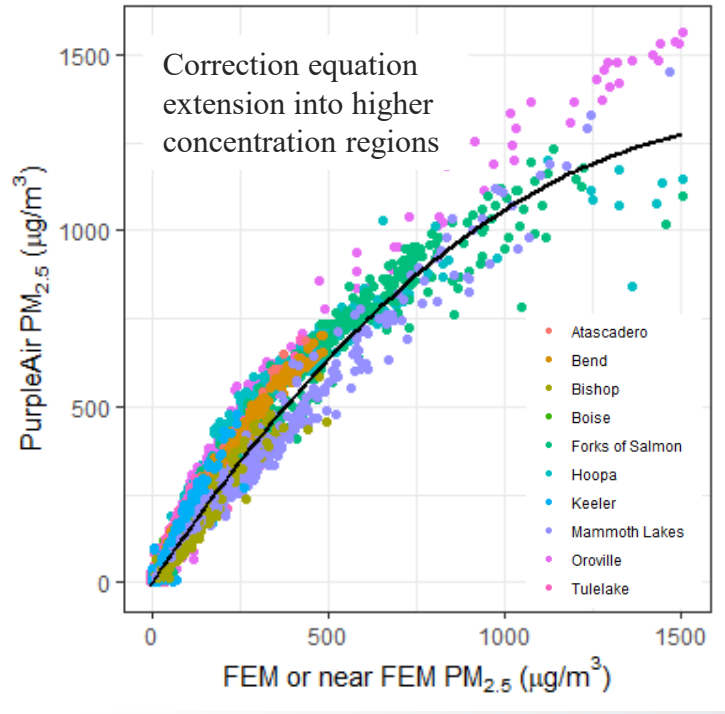
Method: Collocations with FEM and near FEM measurements
Objective: Evaluate correction model for 1-hour ambient and smoke-impacted datasets

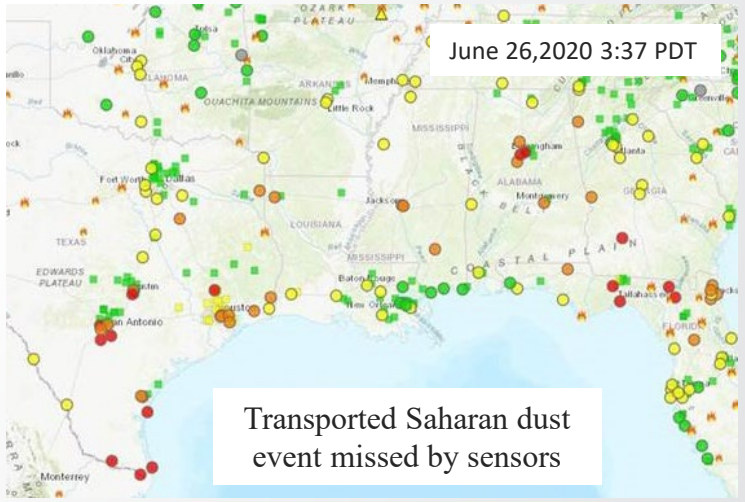
AirNow Sensor Data Pilot

Method: Apply data cleaning methodology and U.S. correction to sensor data before inclusion on the map
Objective: Provide more spatially-resolved air quality data, especially during wildfire episodes

Impact & Next Steps

- Characterizing PurpleAir sensors over a wide geographic area, under a variety of conditions (ambient and smoke-impacted) and has expanded understanding of using this sensor as a data source
- ORD's work allowed the sensor data pilot to be conducted in a scientifically credible way and allowed AirNow to communicate more spatially-resolved air quality information to the public at a critical time (i.e., peak fire season)
  - **Finalize and apply an updated correction equation** to extend the applicable concentration range using newly available data.
  - **Assist in developing methodologies** to address identified crowdsourced data/correction issues.
  - **Assist in developing testing and performance criteria** and a process to potentially add other sensors to the AirNow Fire and Smoke Map in the future.





Research Challenges

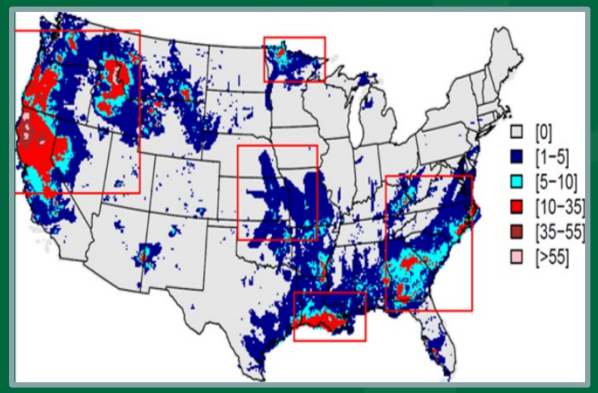
- Wildfires are Transient Events – Low probability of smoke impacts at fixed sites over short time scales (1 – 2 years)
- Nearfield Smoke Impacts Can Be High Magnitude Events
  - Outside gas monitoring calibration range
  - Filter sampler shutdown
  - Sampling artifacts
- Downwind Smoke Impacts May Not Be Obvious
  - Emissions may impact criteria pollutants without perceivable smoke or odor
  - Site measurements may not be adequate to identify biomass impact events

AESMD's wildland fire-related research: emissions and modeling

Tom Pierce
Associate Director
Atmospheric and Environmental Systems Modeling Division

Meeting of the BOSC Subcommittee for the
Air and Energy Research Program

February 18, 2021

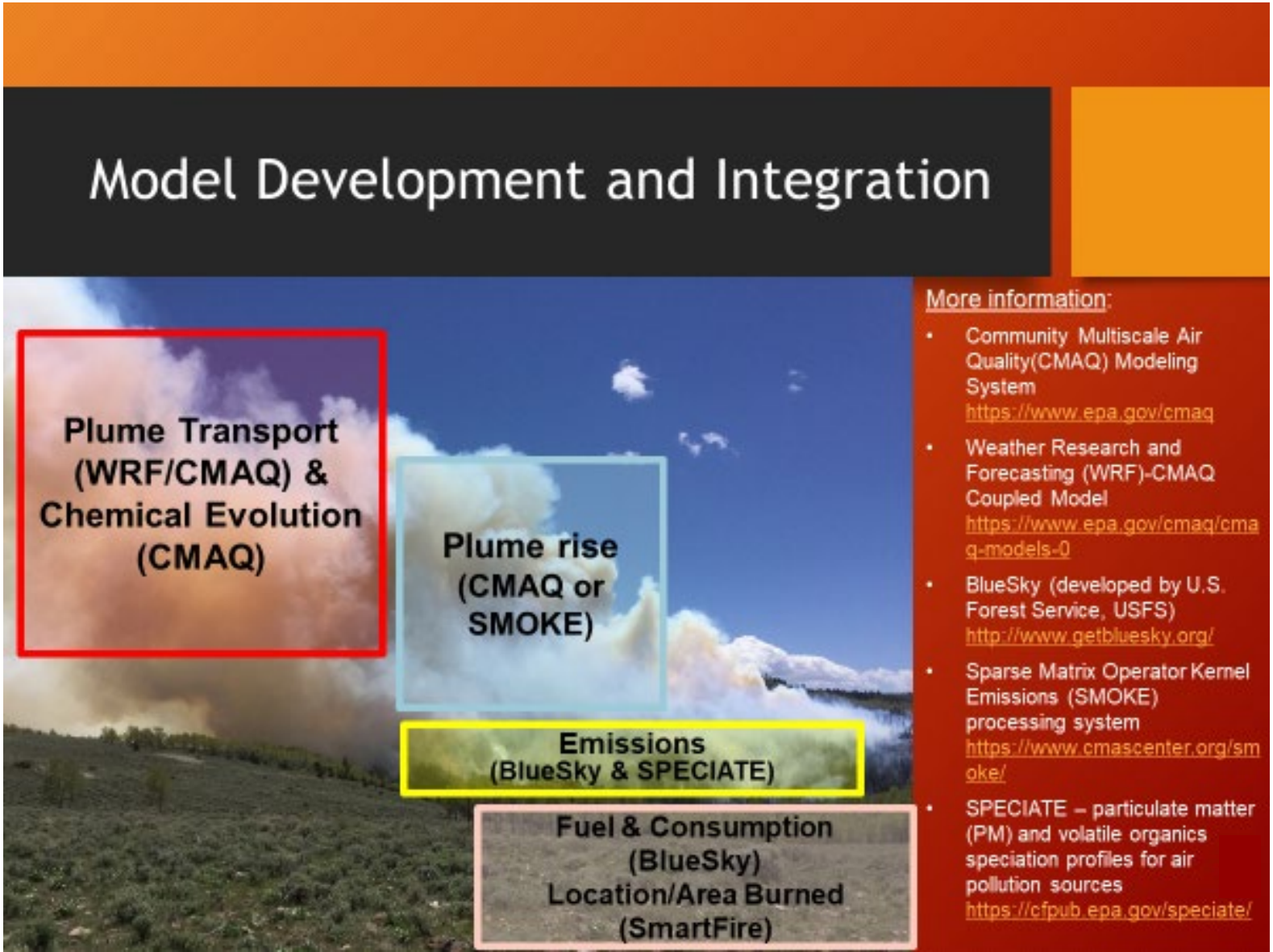


Office of Research and Development
Center for Environmental Measurement and Modeling
Atmospheric and Environmental Systems Modeling Division

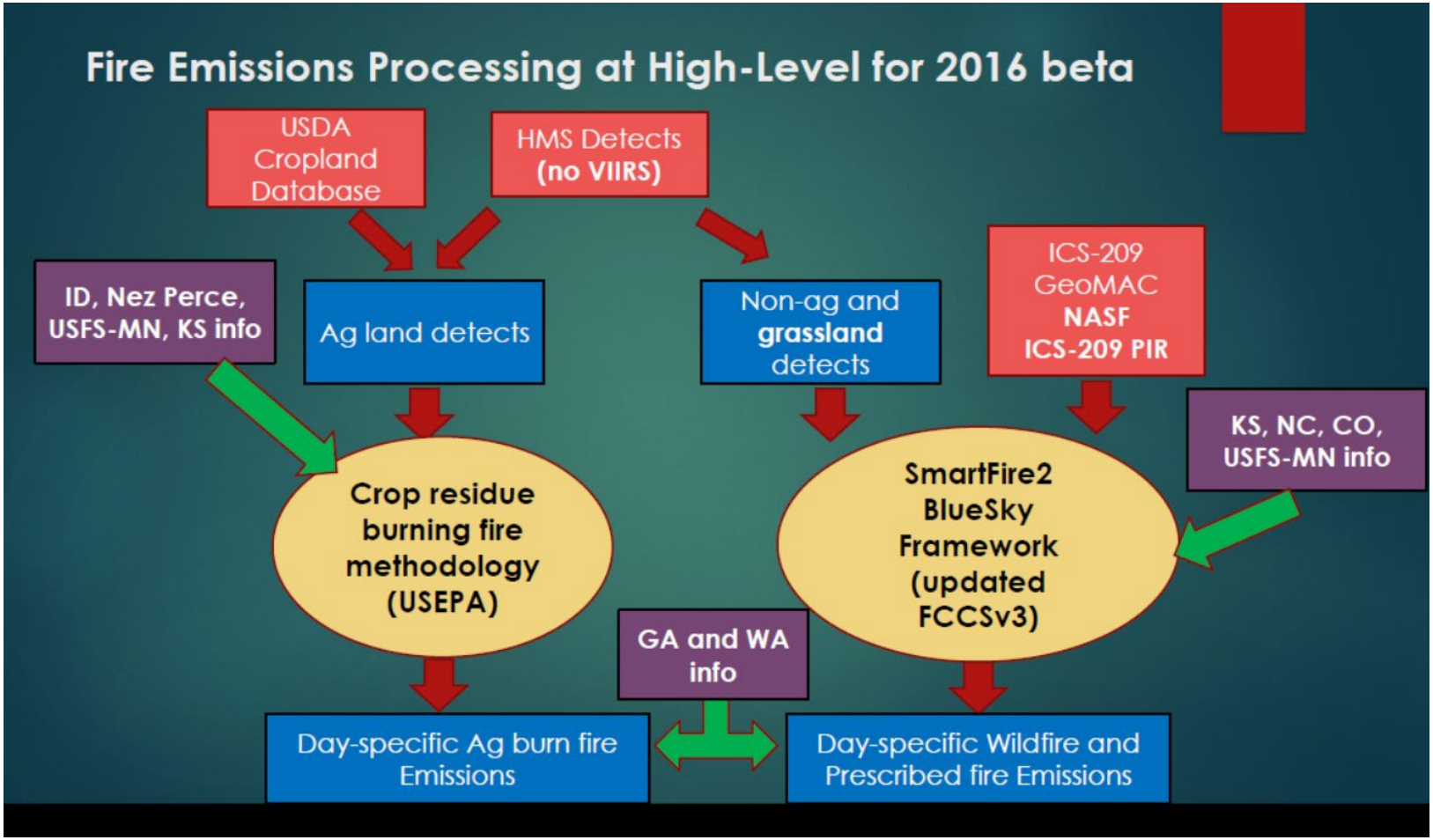
Outline

- Components of AESMD's research program
- Past and ongoing collaborations
- AESMD relevant research products in the StRAP
- Future directions/challenges

Improving wildland fire emission and air quality modeling components



Work with USFS to adapt the BlueSky emissions algorithm for AQ modeling



Work with NASA to improve plume injection heights in CMAQ

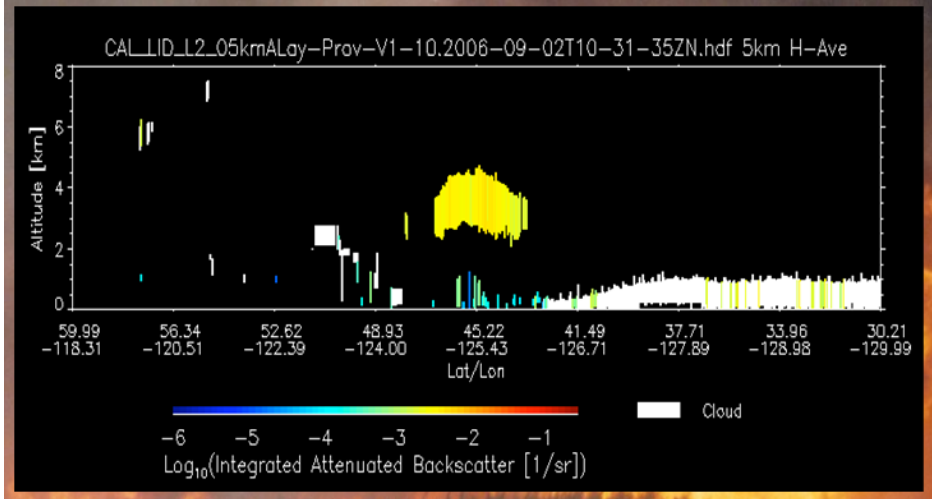
Characterizing the vertical distribution of smoke is very difficult, often resulting in poor predictions of air pollution from wildland fires.

Recent activities:

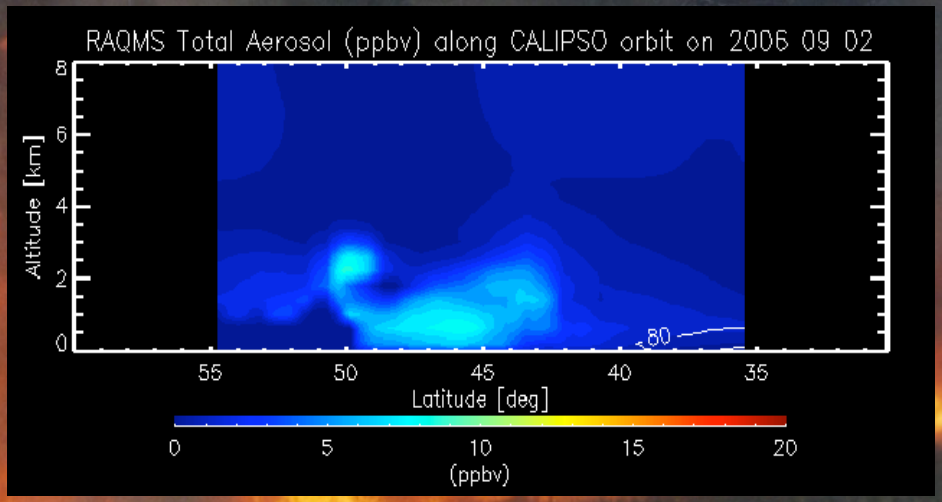
- **Collaborative ROSES project with NASA-Langley**
- **Federal post-doc (ended 2020)**
- **Ongoing collaboration with OAR-OAQPS and NOAA**

Work with NASA to use CALIPSO satellite imagery to measure smoke injection height

CALIPSO plume height



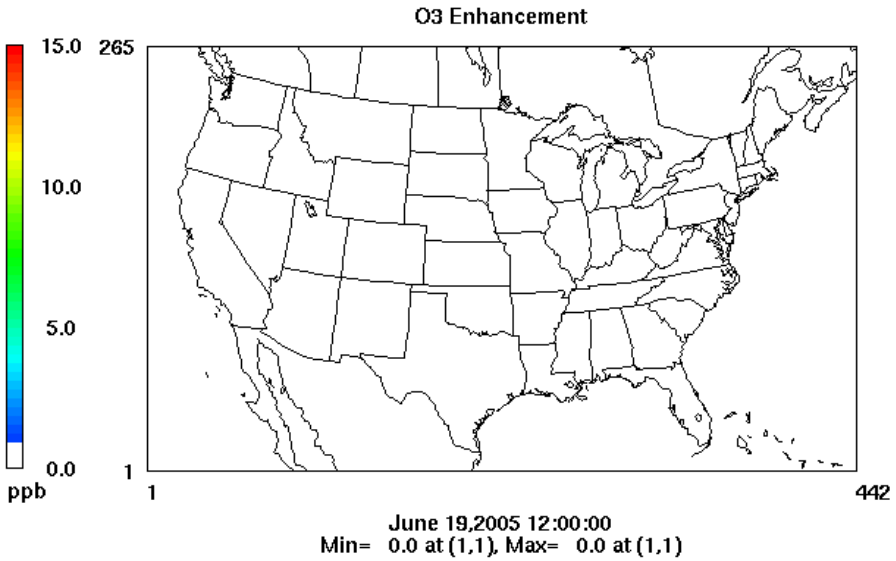
Chemical transport model

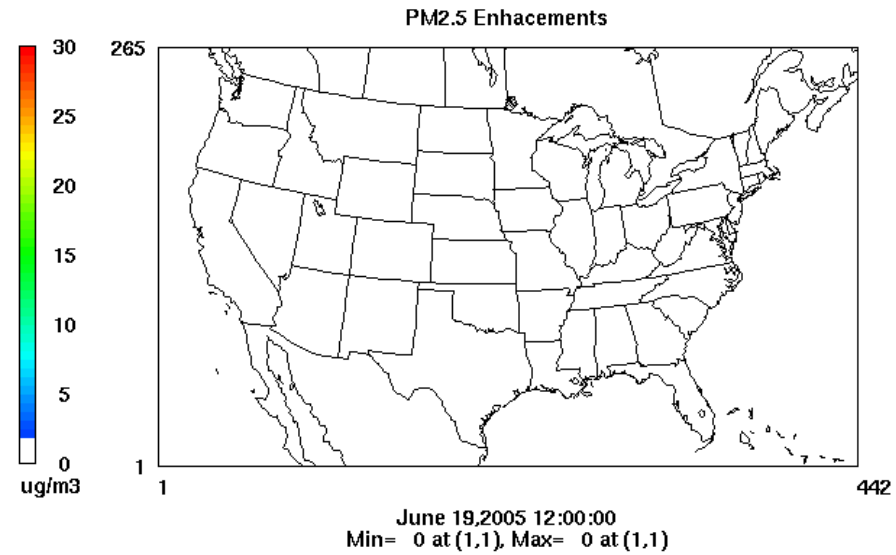


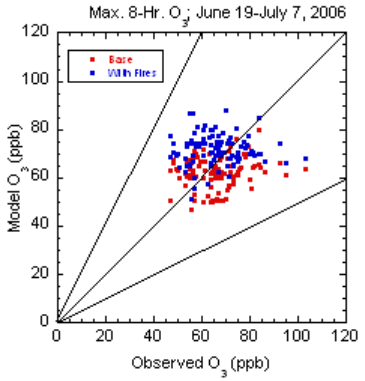
NASA model underestimates plume height by about 1/3 for this western fire.

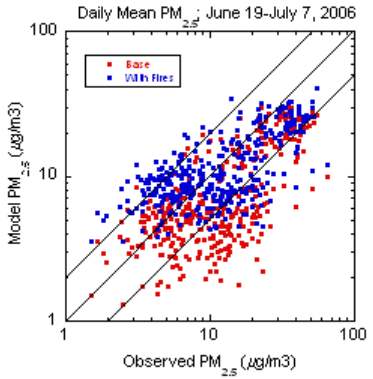
If plume height is misplaced, then the incorrect transport of smoke will impact air quality model performance.

Work with NOAA on fire emissions in the National Air Quality Forecast modeling system







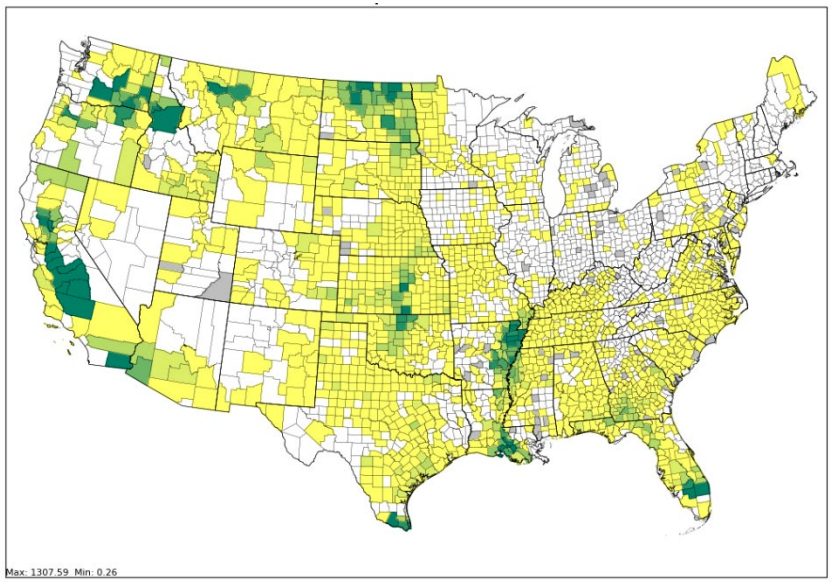


Accurate representation of wildfire emissions is important for both O_3 and PM forecasts

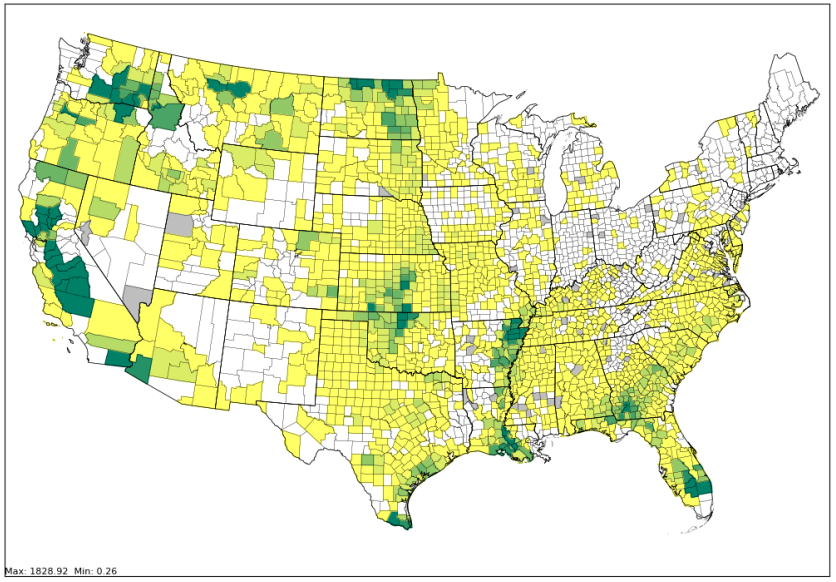
Work with OAR-OAQPS on fire emissions

Example shown for crop residue burning in EPA's National Emissions Inventory (NEI)

2016 – County-level $PM_{2.5}$ emissions (tons)



2017 – County-level $PM_{2.5}$ emissions (tons)



Pouliot G et al. 2017. Development of the crop residue and rangeland burning in the 2014 National Emissions Inventory using information from multiple sources. Journal of the Air & Waste Management Association, https://doi.org/10.1080/10962247.2016.1268982.

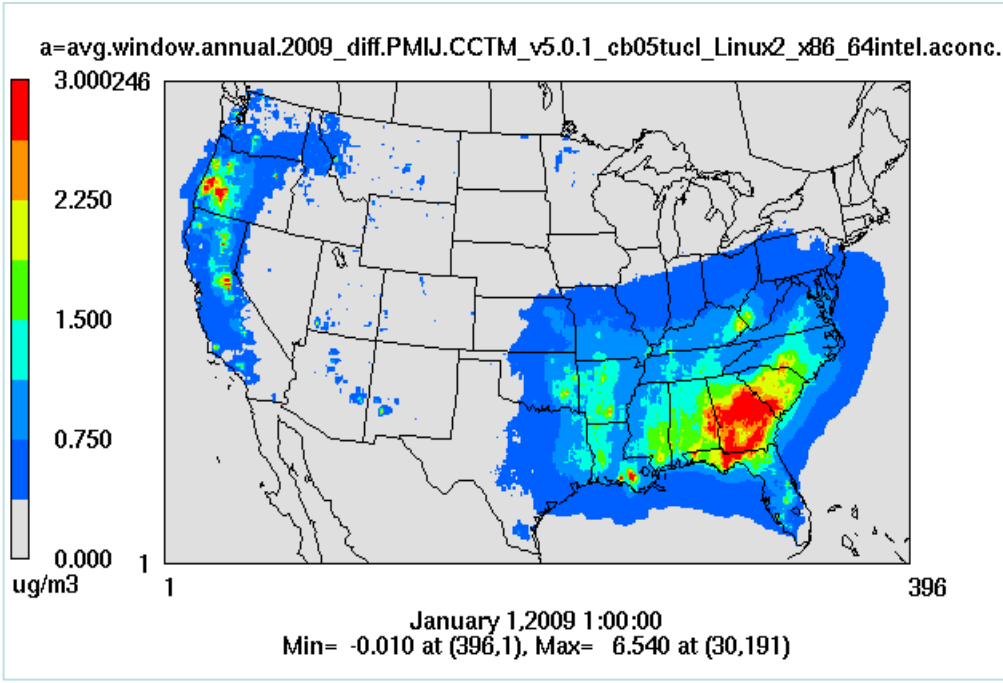
Work across EPA to assess the impact of wildland fire smoke on human health

Rappold AG et al. 2017. Community vulnerability to health impacts of wildland fire smoke exposure. Environ Sci Technol, https://doi.org/10.1021/acs.est.6b0620.

Fann N et al. 2018. The health impacts and economic value of wildland fire episodes in the U.S.: 2008–2012. Sci Total Environ, https://doi.org/10.1016/j.scitotenv.2017.08.02.

DeFlorio-Barker S et al. 2019. Cardiopulmonary effects of fine particulate matter exposure among older adults, during wildfire and non-wildfire periods, in the United States 2008-2010. Environ Health Perspectives, https://doi.org/10.1289/ehp3860.

CMAQ simulation – contribution of fires to $PM_{2.5}$ in 2009

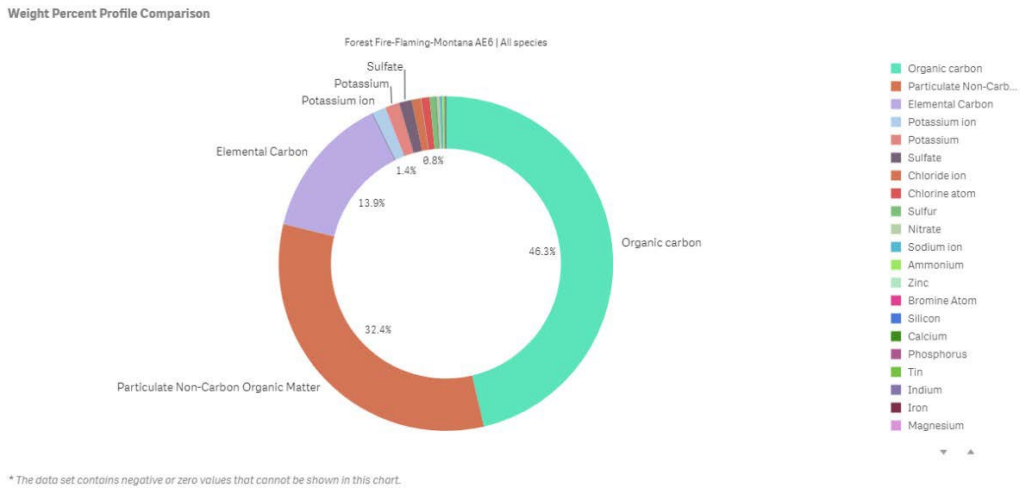


AESMD's involvement in wildland fire related research in the A-E StRAP

- AE 1.2.4: Improved model representation of local, regional, and global distribution of atmos aerosols (B Murphy)
- AE 1.3.3: Development and application of a modeling testbed for improving the characterization of the natural atmosphere (D Kang)
- AE 2.1.6: Development of the SPECIATE 5.2 Database (G Pouliot)
- AE 3.5.1: Estimates of the effect of changing environmental conditions on the chemistry and health impact of air pollution mixtures (M Gilmour, CPHEA)
- AE 6.2.1: Summary of changes in air quality and health impacts in the U.S. at 2050 and 2090 projected using multiple earth systems models and emission scenarios (C Nolte)
- AE 6.2.3: Summary of estimated relationship between national temperatures and AQ air quality based on multiple models (C Nolte)
- AE 8.2.1 Integrated modeling platform to assess the multimedia effects of wildfire and potential benefits and costs of management action (J Johnston, CEMM/EPD)
- AE 9.1.3: Multi-year fire activity and emissions inventory using the best available data and reconciliation techniques (G Pouliot)
- AE 9.1.5: Advanced individual-level air pollution exposure models for improving exposure assessments for wildland fires (M Breen, CPHEA; collaborator, V Isakov, AESMD)
- Output 9.3: Synthesis of wildland fire research findings related to improved modeling
  - Comparative Assessment of the Impacts of Prescribed Fire Versus Wildfire (CAIF): A Case Study of the Western U.S. *** Not in the original StRAP; currently in review ***

Research Product AE 2.1.6 (FY22)
SPECIATE 5.2 Database

- Supports AE 2.1 (Characterization … of key combustion sources).
- SPECIATE is a database of elements, compounds, PM, and other emissions (it provides an emissions profile for each source).
- SPECIATE supports EPA's National Emissions Inventory (NEI).
- Many groups inside and outside EPA use SPECIATE along with NEI, to provide spatial-, temporal-, and source-resolved emissions estimates of individual VOCs, PM components, and other modeled species.
- Speciation of wildland fires has been a recent focus of SPECIATE as shown by this example:



Research product AE 6.2.1 (FY22)

United States Environmental Protection Agency

Changes in air quality and health impacts in the U.S. at 2050 and 2090 using multiple earth systems models and emission scenarios

Koplitz S, C Nolte, et al. (2021) The contribution of wildland fire emissions to nitrogen and sulfur deposition in the contiguous U.S.: implications for tree growth and survival in the Northwest, Environ Res Letters, https://doi.org/10.1088/1748-9326/abd26e.

=> Based on 5 years of CMAQ simulations, N emissions from wildland fires "may affect the survival and growth rates of 16 tree species across 4.2 million hectares, with the most concentrated impacts occurring in Oregon, northern California, and Idaho."

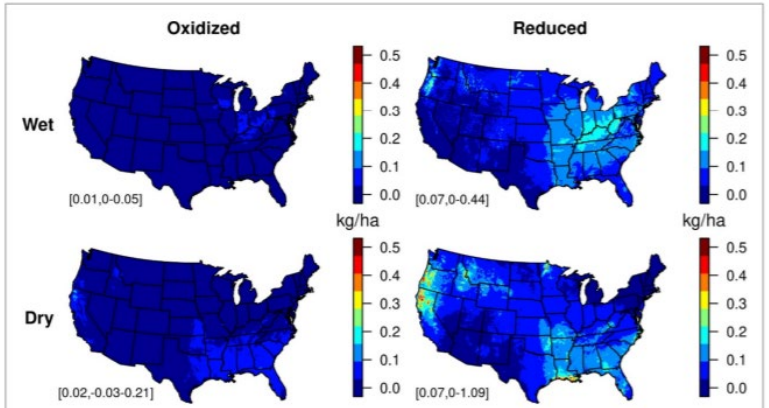


Figure 2. Contributions of wildland fires to CMAQ modeled wet (top) and dry (bottom) deposition of oxidized (left) and reduced (right) N during 2008–2012. Oxidized species include nitrogen oxides, nitrate, nitric acid, PAN, and organic nitrates; reduced species include ammonium and ammonia. Domain means and ranges are shown in the bottom left of each panel.

IOP Publishing Environ. Res. Lett. 16 (2021) 024028 https://doi.org/10.1088/1748-9326/abd26e

ENVIRONMENTAL RESEARCH LETTERS

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LETTER

The contribution of wildland fire emissions to deposition in the U S: implications for tree growth and survival in the Northwest

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[2] Center for Public Health and Environmental Assessment, US EPA, Washington, DC, United States of America
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Keywords: wildland fires, N deposition, ecosystem impacts

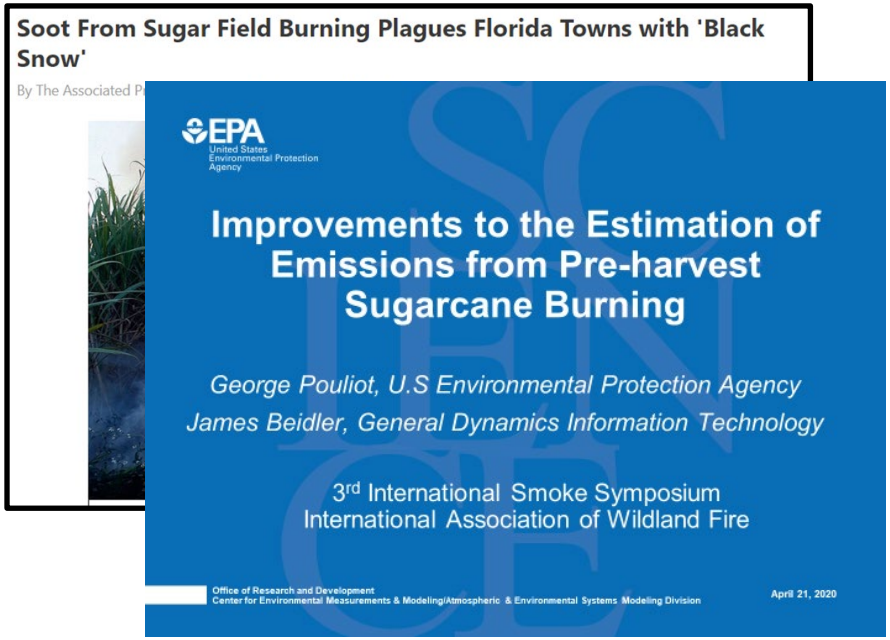
Supplementary material for this article is available online

Abstract

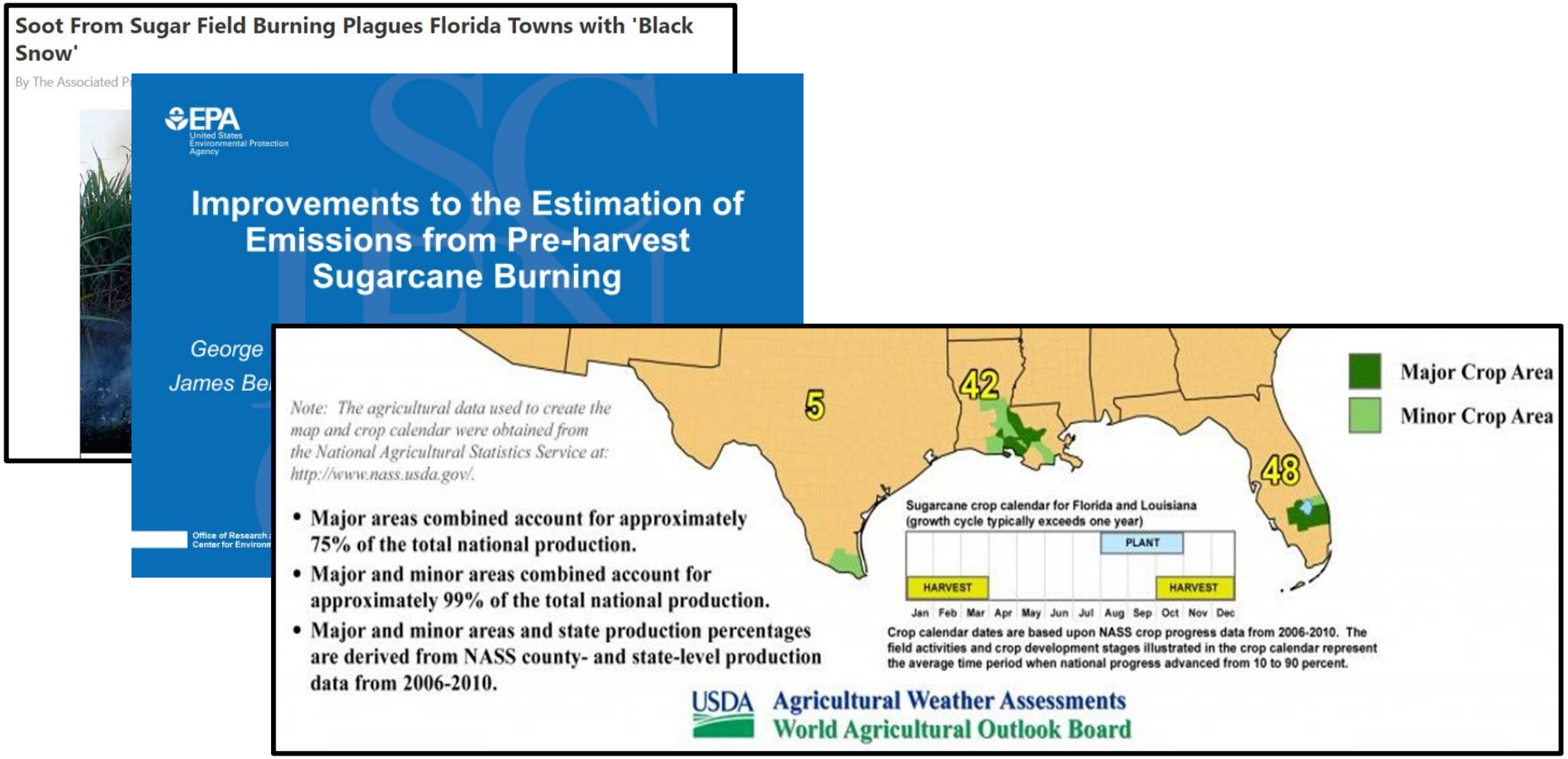
Ecosystems require access to key nutrients like nitrogen (N) and sulfur (S) to sustain growth and healthy function. However, excessive deposition can also damage ecosystems through nutrient imbalances, leading to changes in productivity and shifts in ecosystem structure. While wildland fires are a known source of atmospheric N and S, little has been done to examine the implications of wildland fire deposition for vulnerable ecosystems. We combine wildland fire emission estimates, atmospheric chemistry modeling, and forest inventory data to (a) quantify the contribution of wildland fire emissions to N and S deposition across the U S, and (b) assess the subsequent impacts on tree growth and survival rates in areas where impacts are likely meaningful based on the relative contribution of fire to total deposition. We estimate that wildland fires contributed 0.2 kg N ha^{-1} yr^{-1} and 0.04 kg S ha^{-1} yr^{-1} on average across the U S during 2008–2012, with maxima up to 1.4 kg N ha^{-1} yr^{-1} and 0.6 kg S ha^{-1} yr^{-1} in the Northwest representing over ~30% of total deposition in some areas. Based on these fluxes, exceedances of S critical loads as a result of wildland fires are minimal, but exceedances for N may affect the survival and growth rates of 16 tree species across 4.2 million hectares, with the most concentrated impacts occurring in Oregon, northern California, and Idaho. Understanding the broader environmental impacts of wildland fires in the U S will inform future decision making related to both fire management and ecosystem services conservation.

Research Product -- AE 9.1.3 (FY22)
Towards a multi-year fire activity and emission inventory
Improved emissions from sugarcane burning

Research Product -- AE 9.1.3 (FY22)
Towards a multi-year fire activity and emission inventory
Improved emissions from sugarcane burning



Research Product -- AE 9.1.3 (FY22)
Towards a multi-year fire activity and emission inventory
Improved emissions from sugarcane burning



Research Product -- AE 9.1.3 (FY22)
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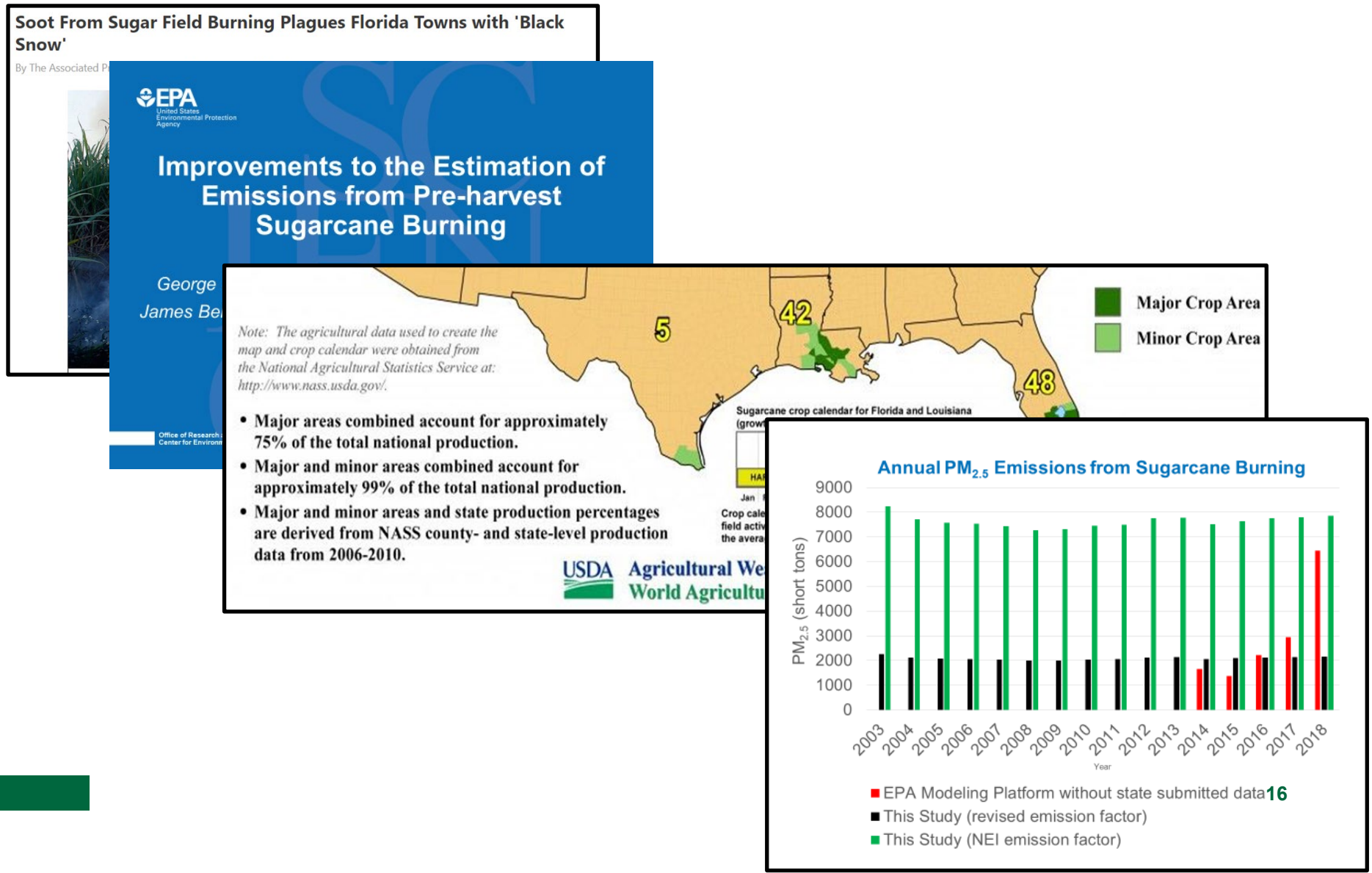
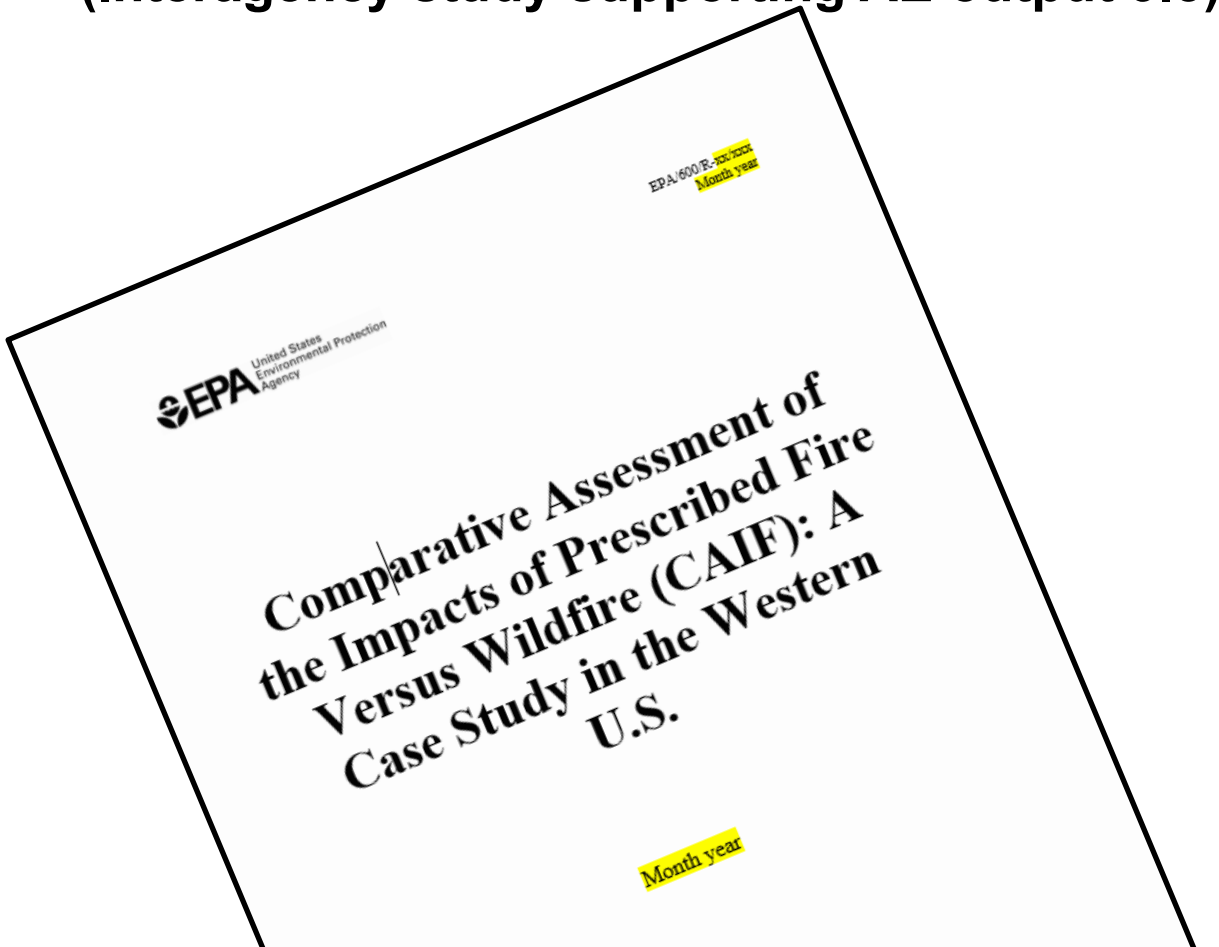


Responding to research needs not in the original 2019-2022 StRAP

Significant emission/AQ modeling contributions to the "Comparative assessment of the impacts of prescribed fire v wildfire: a case study of the western U.S" (Interagency study supporting AE output 9.3)



AESMD's wildland fire-related research: future directions and challenges

- Adapt to changing needs (like the CAIF report)
- Respond to an increased emphasis on climate change and environmental justice
- Continue to build off collaborations with other EPA and non-EPA partners
- Explore personnel and funding opportunities

Wildfire Research: Understanding Health Impacts and Potential Mitigations

John Vandenberg Ph.D., Director

Health and Environmental Effects Assessment Division, CPHEA

Board of Scientific Counselors Subcommittee for the

Air and Energy Research Program

February 18, 2021

Assess and Minimize Human Health Impacts from Wildland Fire Smoke

Assessment

- Impacts on Air Quality and Water Quality
- Efforts to Understand Fire Emissions (RA 2, 7, 9 - in previous talk)

Exposure & Health Effects

- Understanding Potential Exposures
- Cardiovascular Health Impacts
- Impacts in Vulnerable Populations

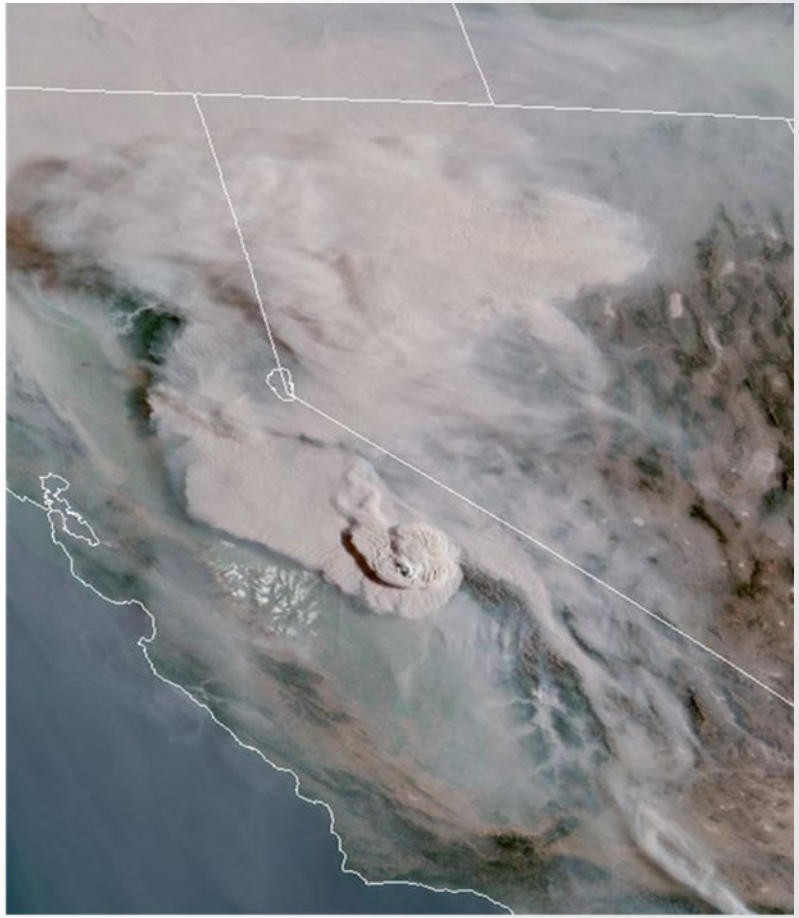
Interventions

- Air Filtration Effectiveness
- Research Grants and Challenge Competition

Health Risk Communication

Comparative Assessment of the Impacts of Prescribed Fire Versus Wildfire

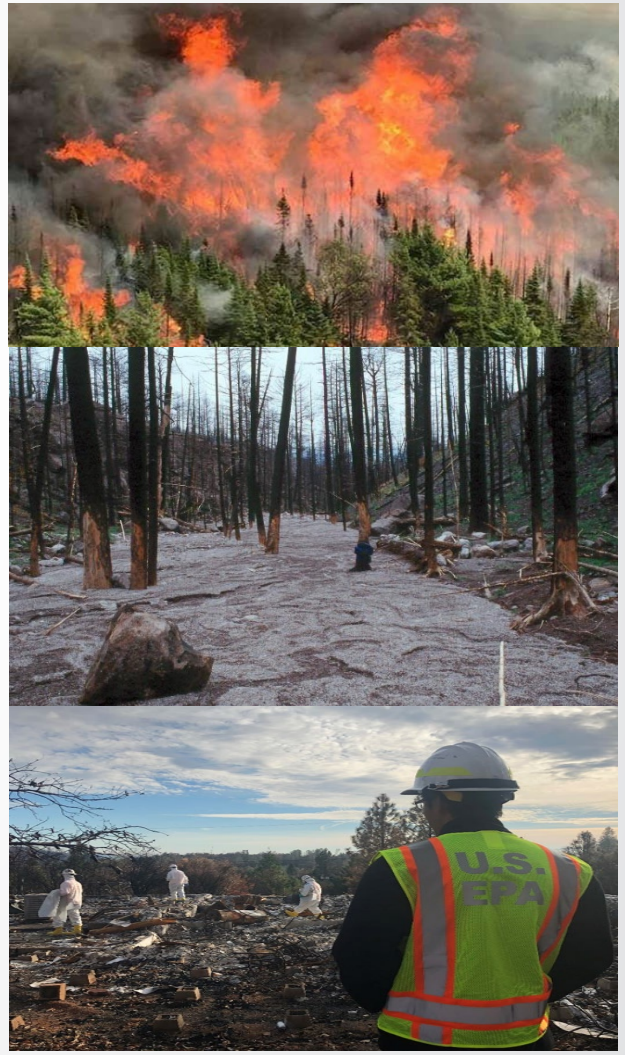
- The Wildland Fire Leadership Council (US Depts of Ag and Interior) requested that EPA conduct an assessment of the health impacts of prescribed fire versus wildland fire
- Interagency group of expert scientists [including EPA (Jason Sacks, ORD Lead), USFS, DOI, and NIST] developing a report that will include:
  - Framework for evaluation of fire management strategies
  - Air quality monitoring of wildfire smoke
  - Epidemiologic evidence of health effects
  - Ecological impacts of wildfire smoke
  - Overview of costs/benefits of different fire regimes



September 9, 2020

Assessment of Wildland Fire Effects

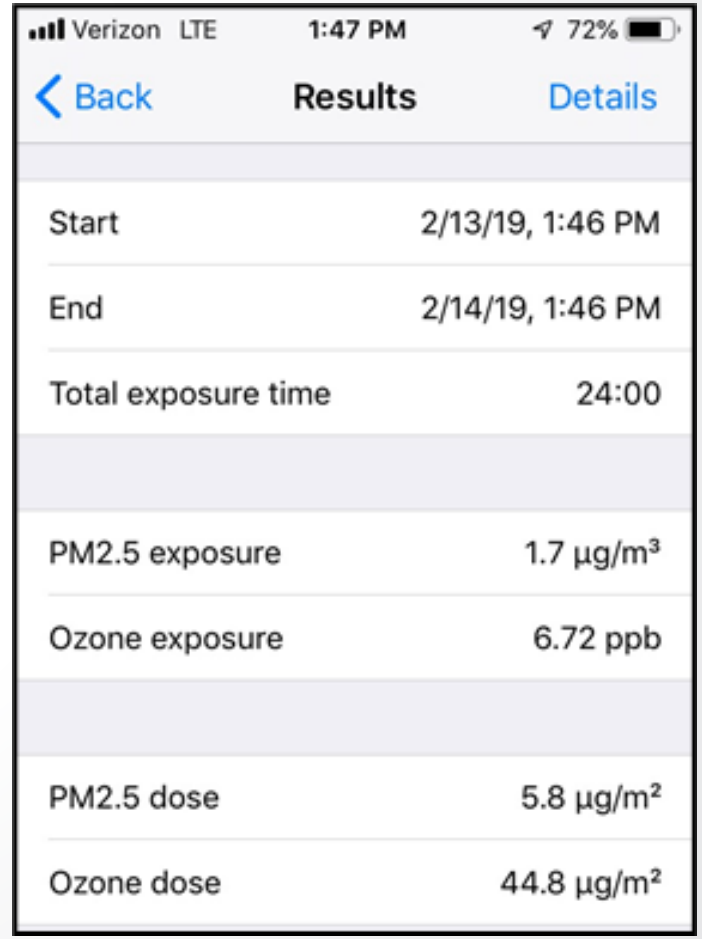
- Literature assessment of wildland fire effects on air quality, water quality, and human health (Product 9.1.2- Steve LeDuc)
  - Initial work focused on drinking water and water quality impacts
  - Preliminary results show that exceedances of drinking water standards can occur for nitrate, arsenic, benzene, and disinfection by-products following fire
- Synthesis of wildland fire research findings (Output 9.3 - Steve LeDuc)
  - State of the science will capture the main findings from ORD's research
    - Air quality
    - Water quality
    - Human health
  - Results will inform EPA and other decision-makers on issues such as ecosystem and smoke management, reducing emissions from prescribed burning, and public health interventions.



Exposure: Advanced Individual-Level Air Pollution Exposure Models for Wildland Fires

- Advanced Individual-Level Air Pollution Exposure Models for Improving Exposure Assessments for Wildland Fires (Product 9.1.5)
  - TracMyAir mobile application estimates real-time individual-level exposures and inhaled doses of $PM_{2.5}$
  - Learn more in **Michael Breen's Meet the Scientist** presentation

TracMyAir mobile app
Real-time exposure estimation

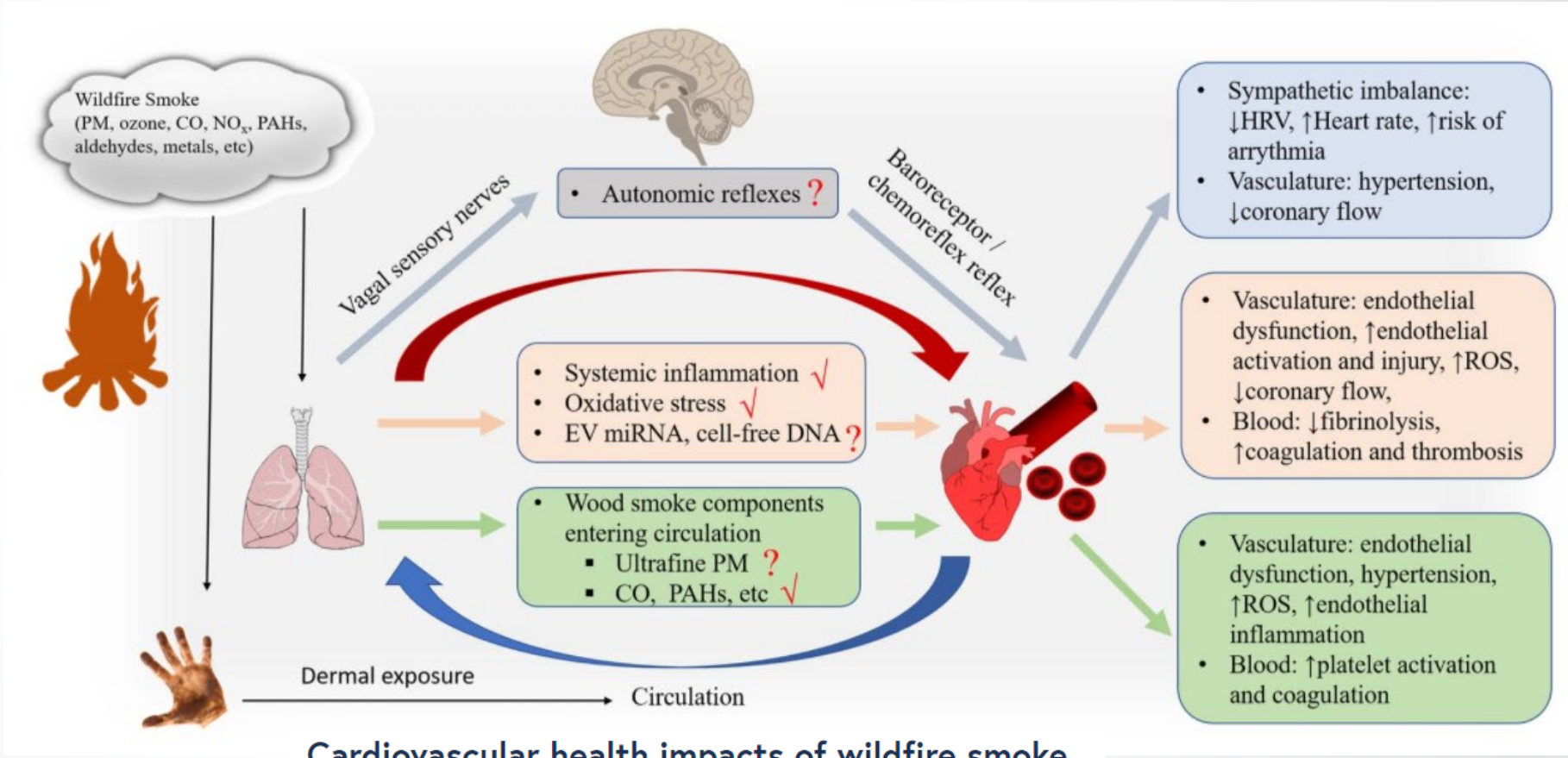


Health Effects:
Cardiovascular Health Impacts of Wildfire Smoke Exposure

Evaluate health impacts from wildfire smoke and identify mitigation strategies (Product 3.3.3- Haiyan Tong)

- Published review on cardiovascular health impacts of wildfire smoke exposure
- Includes data from populations with lower socio-economic status

Mechanisms of cardiovascular impacts of wildfire smoke



Cardiovascular health impacts of wildfire smoke exposure

Hao Chen, James M. Samet, Philip A. Bromberg & Haiyan Tong

Particle and Fibre Toxicology **18**, Article number: 2 (2021) | Cite this article

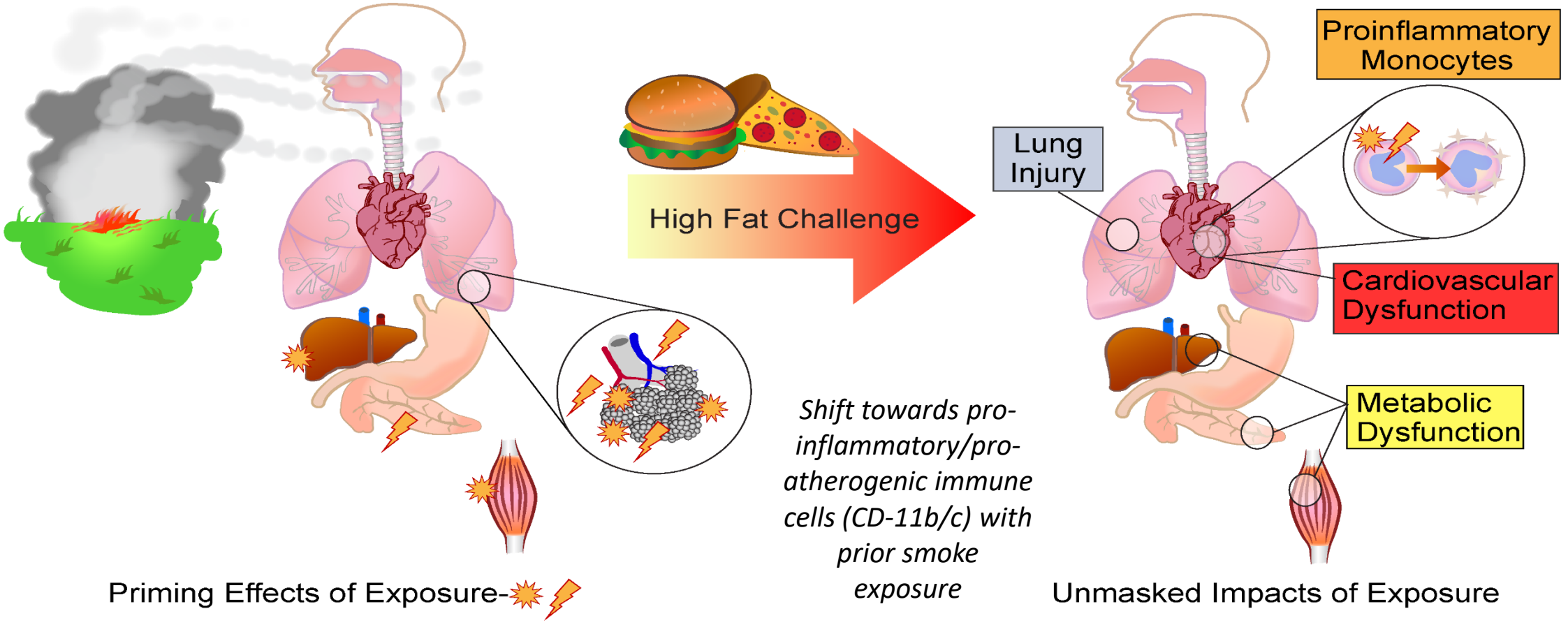
Health Effects:
Health Impacts in Vulnerable Populations

- Epidemiological studies - **Meet the Scientist presentation by Ana Rappold** (Product 3.3.2)
  - Health effects of multi-day peak exposures in population-based studies
  - Risks from short- and long-term exposures in vulnerable populations
  - Identify susceptible factors (e.g., SES & pre-existing diseases)

- Estimates of modifying effects of air pollution on subsequent responsiveness to air pollutant exposure (Product 3.5.3, Kristen Rappazzo,)
  - Using electronic health records data (CARES dataset) for individuals with COPD, using respiratory related hospitalizations and visits as the outcome
    - Exposure modelling includes CMAQ and wildfire models
  - Also pursuing birth registry data in Colorado, which would allow us to examine air pollution effects during wildfire seasons versus non-wildfire seasons

Health Effects of Short-Term Exposures

Peat smoke primes body to exaggerated responses to day-to-day stressors

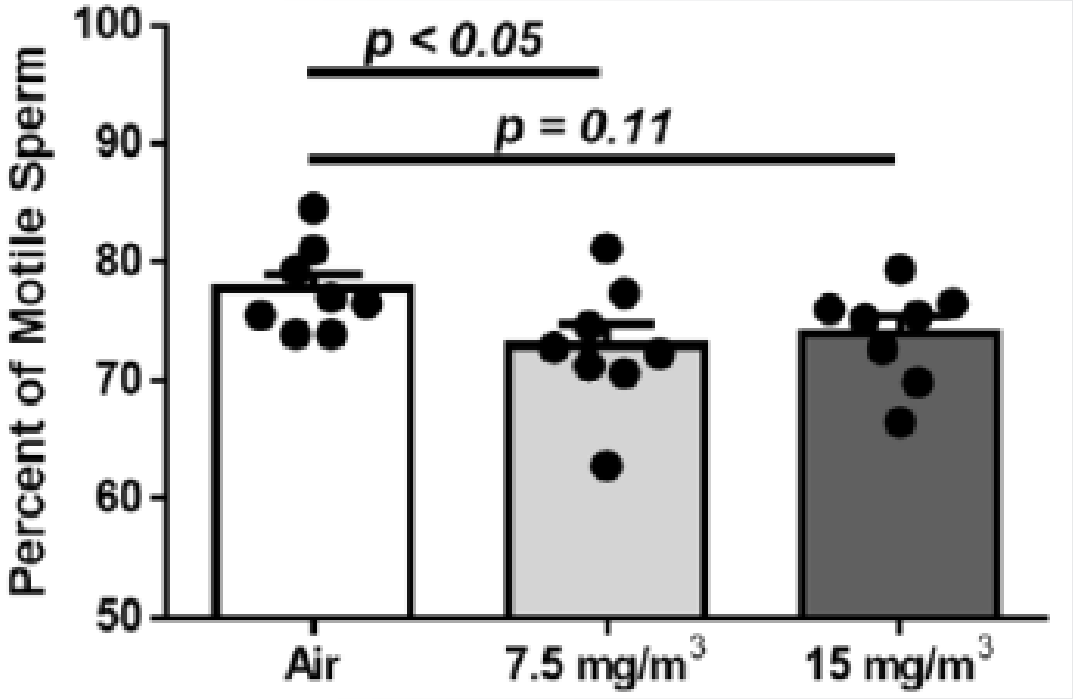


Aimen Farraj

Martin et al. Science of the Total Environment 643 (2018) 378–391

Health Effects - Paternal Exposures to Wildfire Smoke

- Subacute exposures impair sperm motility and the epigenome
- Current studies are using smoke from different scenarios

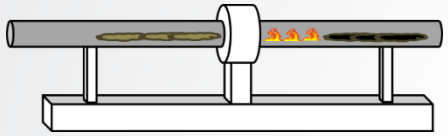


Product 3.5.2 - Colette Miller and Urmila Kodavanti

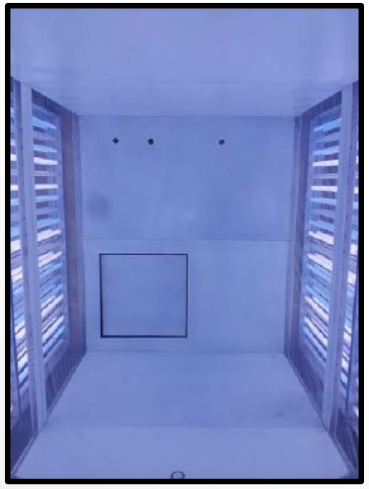
Pathfinder Innovation Project (2018 & 2019)

Effects of Changing Conditions on Aerosol Chemistry and Health Impacts

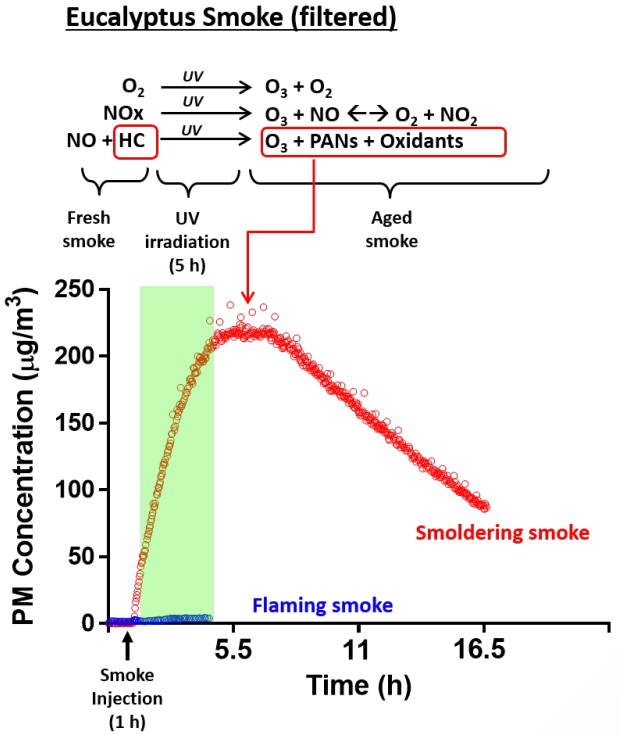
Biomass smoke Generated by Tube furnace



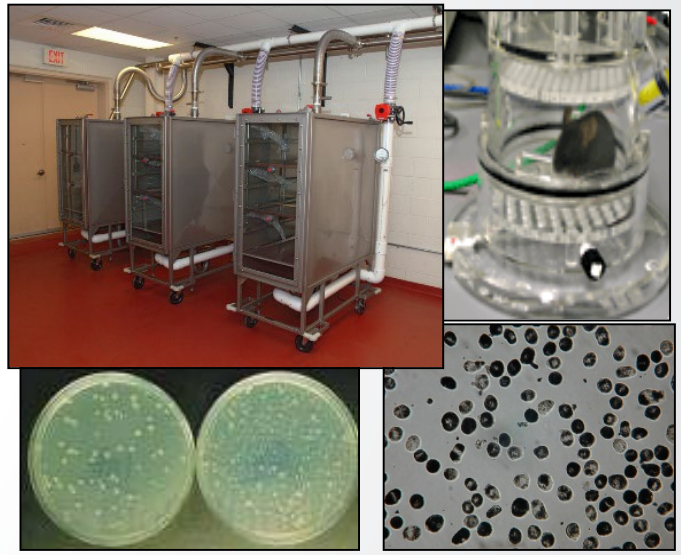
Photochemical Aging in Smog Chamber



Generation of Secondary Organic Aerosol (SOA)



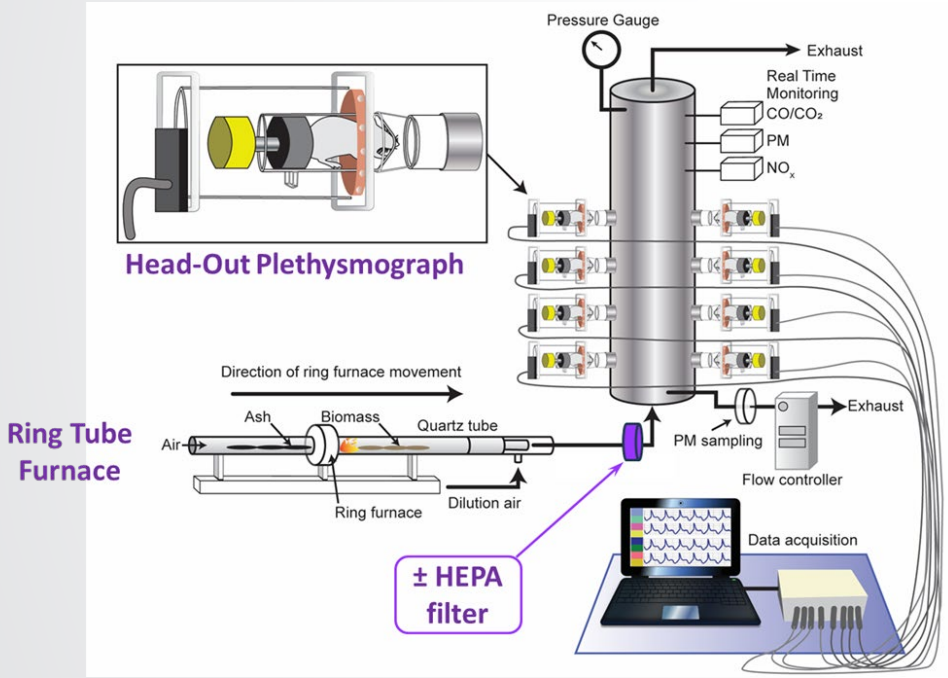
Health Testing using In Vivo and In Vitro Models including Susceptibility



Product 3.5.1 – Ian Gilmour

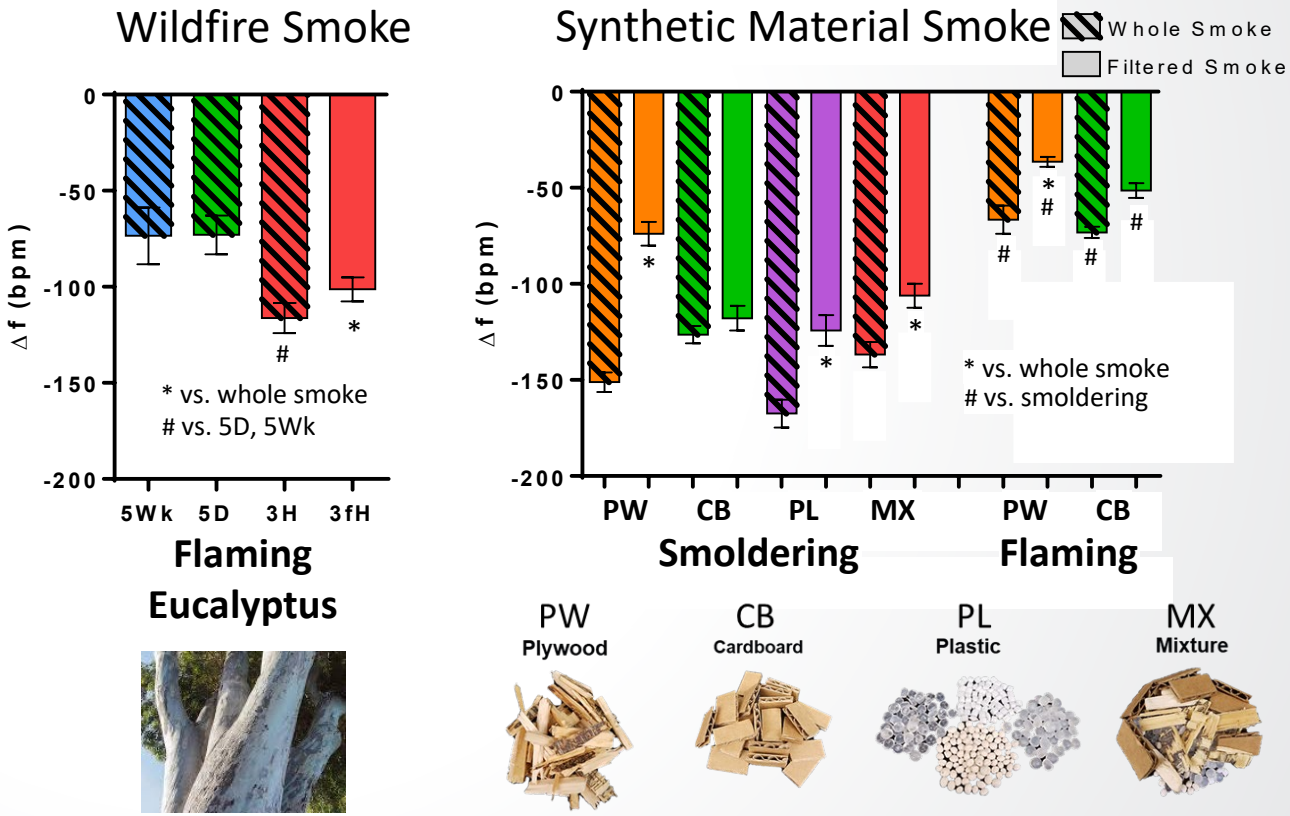
Health Effects of Exposures to Wildfire or Synthetic Material Smoke & Benefits of Air Filtration Interventions

Integrated Tube Furnace, Nose-Only Exposure, Real-Time Physiology



Hargrove et al. 2019; Vance et al., 2021

Reduction in Breathing Frequency During Smoke Exposures



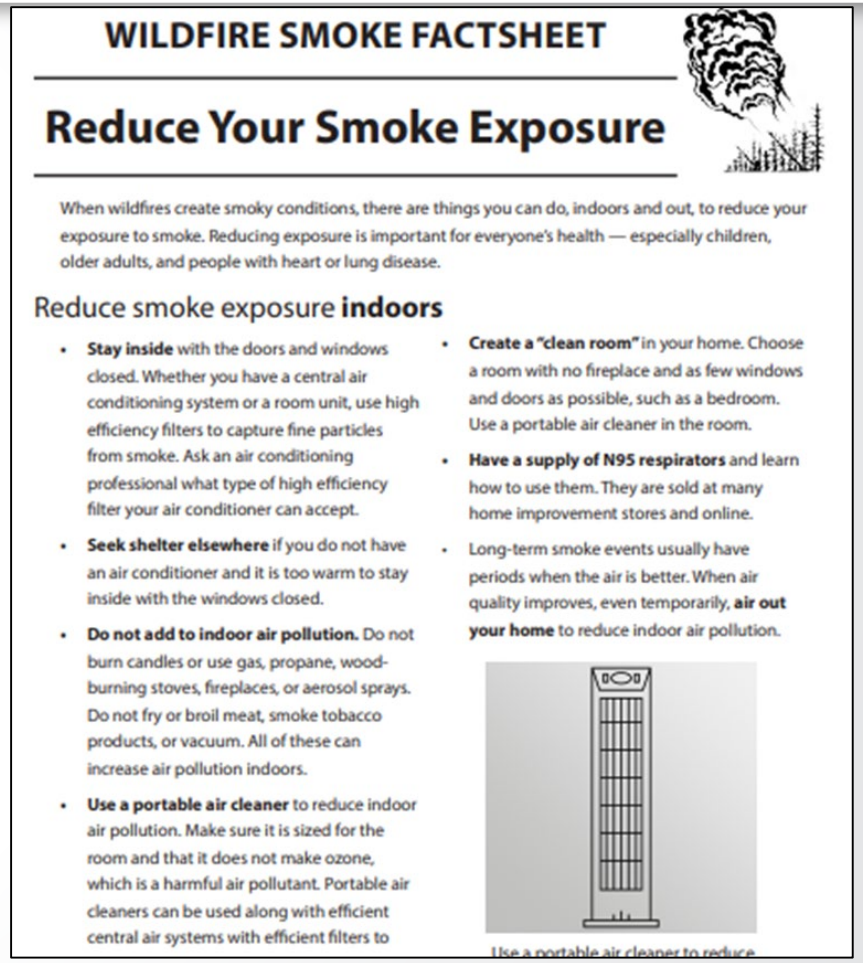
C x T, filtration study

Material type, burn condition, filtration study

Product 3.3.1 - Stephen Gavett and Yong Ho Kim

Mitigating Exposure to Wildfire Smoke

- Current public health recommendations
  - Stay indoors (close windows and doors) and use portable air cleaners
  - N95 respirators
  - Local agencies to designate cleaner air shelters to protect some at-risk groups
- See **Meet the Scientist presentation by Amara Holder** for details on HVAC and $PM_{2.5}$ monitoring research related to creating these spaces and evaluations of the performance of existing portable air cleaners (Product 9.2.1)
- Examining if physical barriers (e.g., face masks) can mitigate the adverse health effects (Product 3.3.1)



WILDFIRE SMOKE FACTSHEET

Reduce Your Smoke Exposure

When wildfires create smoky conditions, there are things you can do, indoors and out, to reduce your exposure to smoke. Reducing exposure is important for everyone's health — especially children, older adults, and people with heart or lung disease.

Reduce smoke exposure **indoors**

- **Stay inside** with the doors and windows closed. Whether you have a central air conditioning system or a room unit, use high efficiency filters to capture fine particles from smoke. Ask an air conditioning professional what type of high efficiency filter your air conditioner can accept.
- **Seek shelter elsewhere** if you do not have an air conditioner and it is too warm to stay inside with the windows closed.
- **Do not add to indoor air pollution.** Do not burn candles or use gas, propane, wood-burning stoves, fireplaces, or aerosol sprays. Do not fry or broil meat, smoke tobacco products, or vacuum. All of these can increase air pollution indoors.
- **Use a portable air cleaner** to reduce indoor air pollution. Make sure it is sized for the room and that it does not make ozone, which is a harmful air pollutant. Portable air cleaners can be used along with efficient central air systems with efficient filters to
- **Create a "clean room"** in your home. Choose a room with no fireplace and as few windows and doors as possible, such as a bedroom. Use a portable air cleaner in the room.
- **Have a supply of N95 respirators** and learn how to use them. They are sold at many home improvement stores and online.
- Long-term smoke events usually have periods when the air is better. When air quality improves, even temporarily, **air out your home** to reduce indoor air pollution.

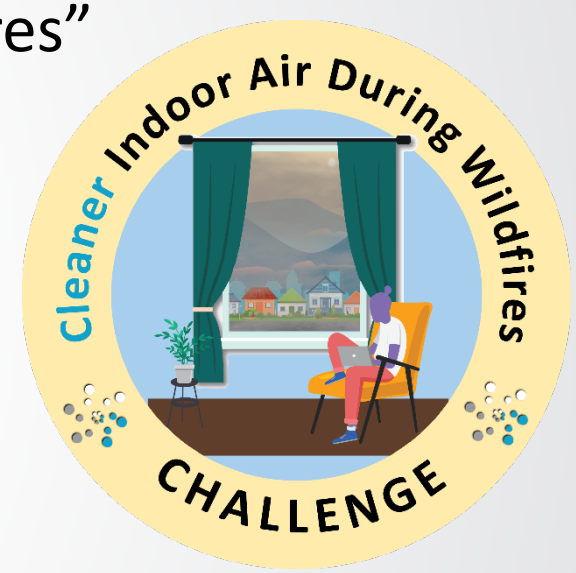
Use a portable air cleaner to reduce

Wildfire ASPIRE study

Advancing Science Partnerships for Indoor Reductions of Smoke Exposures

Interventions:
Research Grants & Challenge Competition

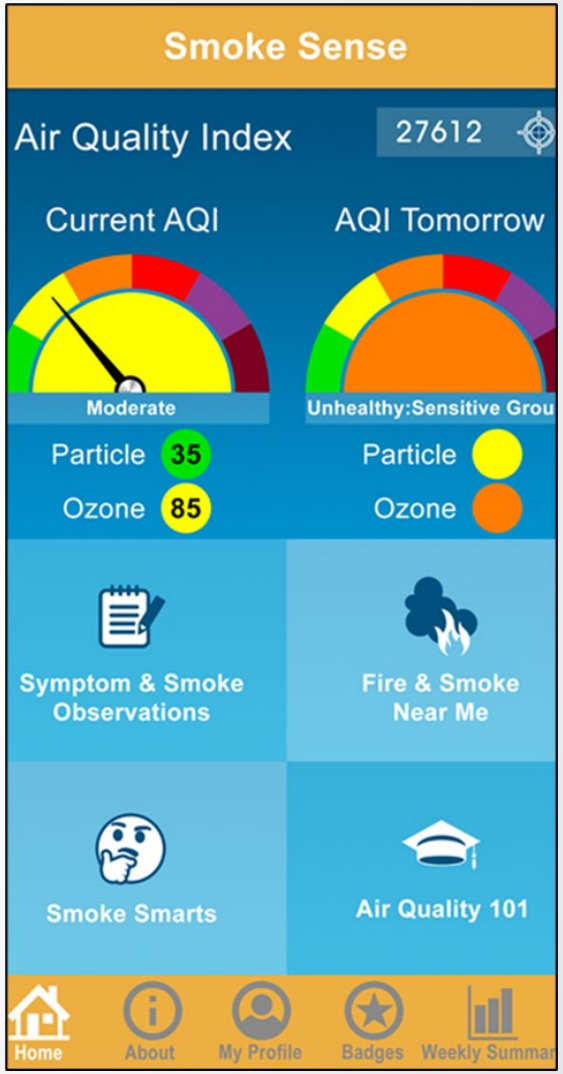
- Research grants: RFA announced in fall 2020, “Interventions and Communication Strategies to Reduce Health Risks of Wildland Fire Smoke Exposures”
  - Expect to make awards in summer 2021



- Challenge competition: Cleaner Indoor Air During Wildfires (Product 9.2.1)
  - Current air cleaning technologies have limitations including cost, maintenance, noise, and lack of cooling – and are not affordable for many at-risk populations
    - EJ communities would greatly benefit from lower cost technologies
  - Prizes to be awarded for ideas that overcome these limitations
    - Worked with Federal, Tribal, State and local partners to develop the criteria the solvers must address

Health Risk Communication

- Smoke Sense app developed to provide air quality and health information
  - Learn more: Mary Clare Hano's **Meet the Scientist** Presentation on Smoke Sense (Product 9.2.2)
  - Work underway to incorporate TracMyAir exposure estimation into Smoke Sense
- Develop strategies for improving health risk communication (Product 9.2.3)
  - At the organizational level, studying communication around large fire events
  - At the individual level, analyzing data on experiences and behaviors related to wildfire smoke information
  - Use findings to offer evidence-based recommendations on health risk communication about wildfire smoke



Questions?

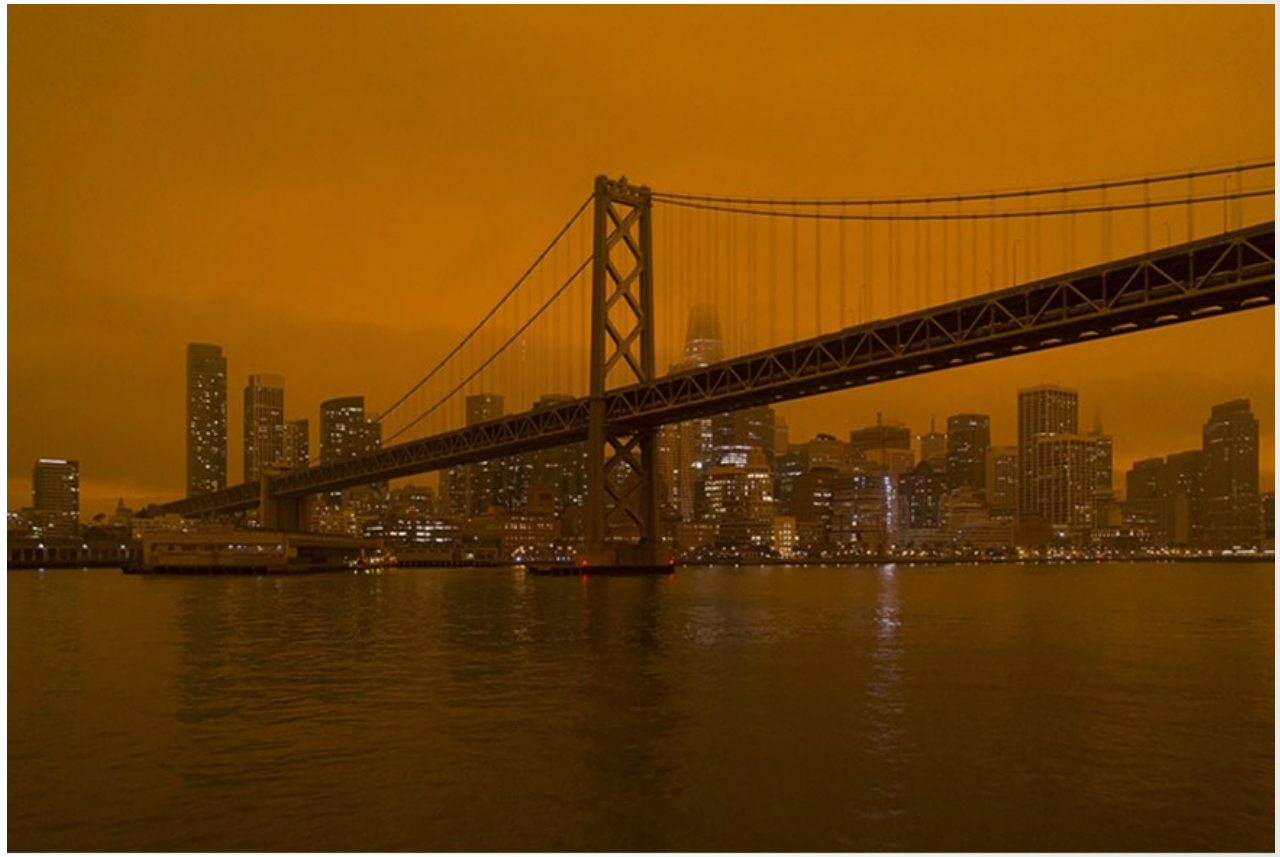
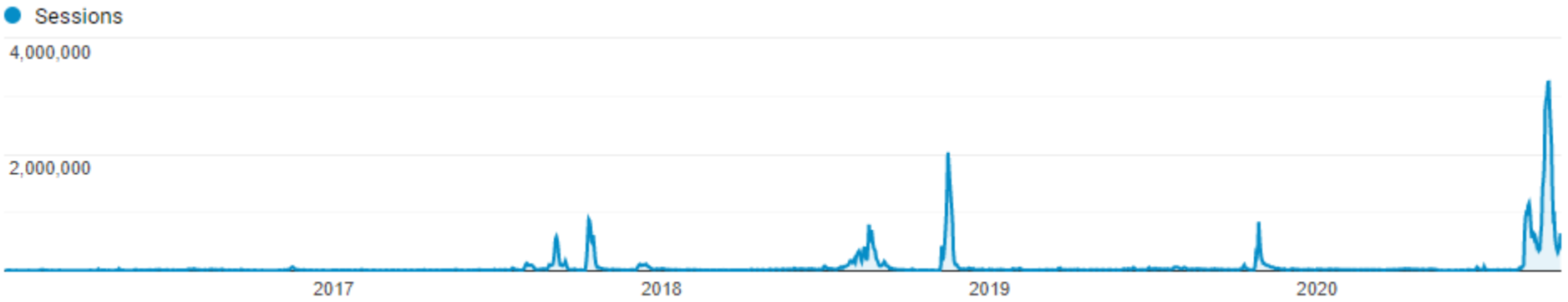


Photo Credit: Christopher Michel

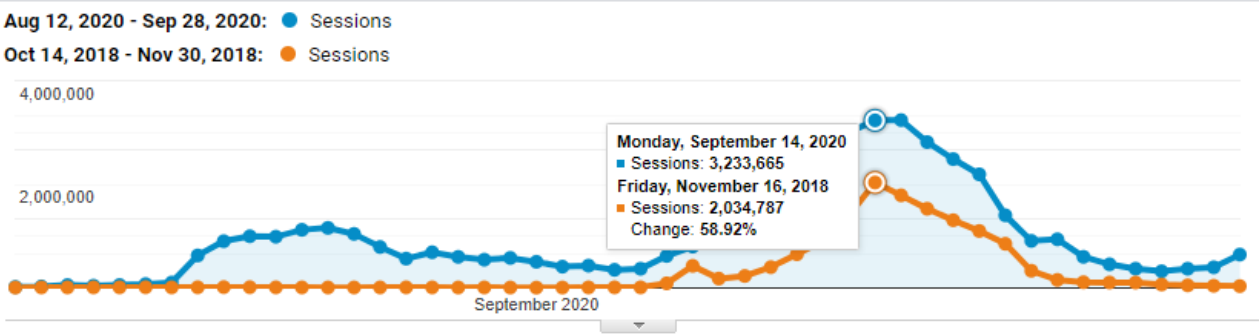
Key AirNow Take-Aways for 2020 Fire Season

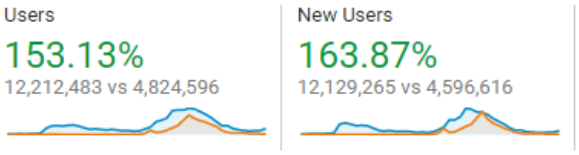
- The current fire event in west is larger and of longer duration than the Camp Fire event of November 2018
- The cloud.gov infrastructure is incredibly resilient; it did not crash and did not slow down
- The Sensor Pilot provides useful and much appreciated information for the public
- We learned more and have more to do

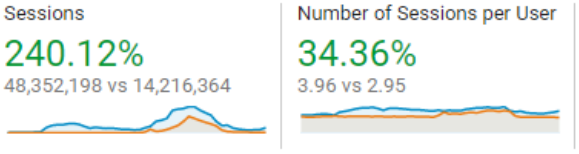
Fires Are Increasingly Driving Traffic

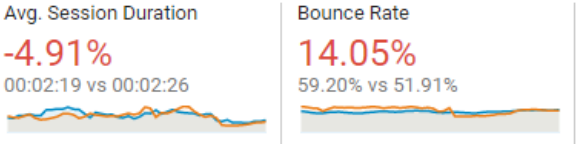


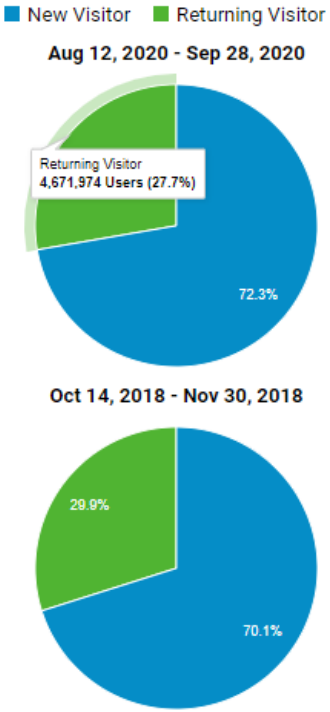
Our hard work paid off



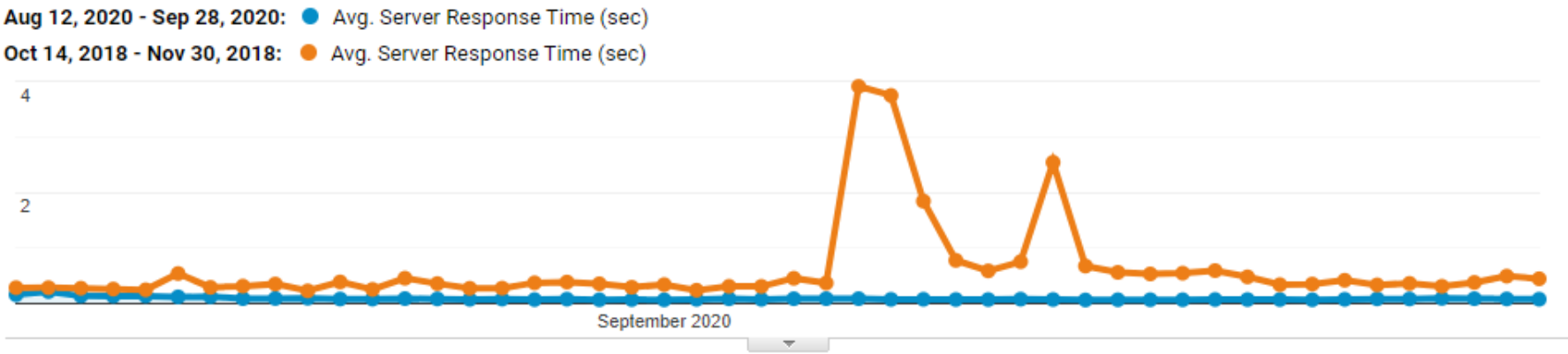








Cloud.gov impressed us!



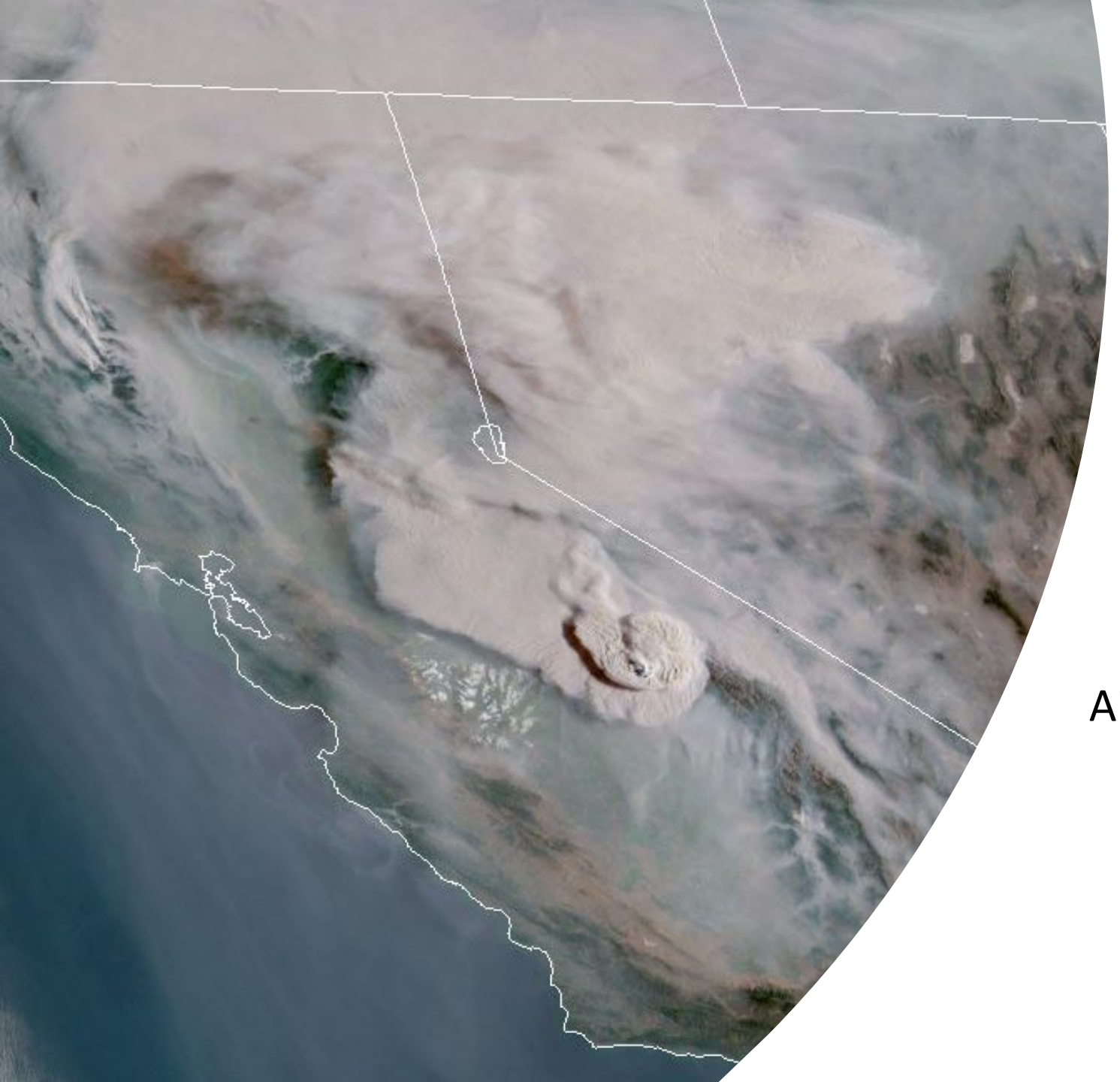
722,010 of pageviews sent page load sample

Avg. Page Load Time (sec)	Avg. Redirection Time (sec)	Avg. Domain Lookup Time (sec)	Avg. Server Connection Time (sec)	Avg. Server Response Time (sec)
-39.30%	-26.18%	-20.07%	-74.92%	-91.52%
2.71 vs 4.47	0.06 vs 0.09	0.03 vs 0.04	0.08 vs 0.30	0.08 vs 0.89

Avg. Page Download Time (sec)
-73.26%
0.11 vs 0.39

AirNow Sensor Data Pilot rollout

- Soft launch on August 14th, 2020 with no significant media outreach
- Release coincided with large number of fires in the West
- Since release, over seven million pageviews of the sensor fire map, a peak of nearly 400 thousand one day, currently between 30 and 40 thousand per day



Wildfire Research Insights from EPA's Pacific Southwest Region 9

Meredith Kurpius, Assistant Director

Air and Radiation Division, EPA Region 9

February 18, 2021

A-E BOSC Subcommittee meeting

Panel Discussion # 4: Wildfire Focus

Public Protection Needs for Wildfire Smoke

- Decision support tools for communities and individuals
- Information that is **available** and **actionable** that leads to **effective** interventions.
- Two distinct phases
  1. Preparedness (e.g., Smoke Ready Communities)
  2. Managing smoke exposure during wildland fire events (e.g., AirNow)
- Most pressing needs for managing smoke exposure:
  - Local smoke conditions: near real-time, and reliable forecasts out multiple days
  - Short-term (sub-daily) and long-term (days to weeks) health impacts/risks and guidance
  - Effectiveness of interventions
  - Mechanisms to inform the public when/which interventions to use

Low-cost sensors for monitoring air quality impacts from smoke

A Region 9/10 and ORD RARE Project Collaboration (2018-2020)*

*Holder et al. Sensors 2020, 20, 4796; http://dx.doi.org/10.3390/s20174796

Evaluation of Low-Cost Sensors During Fires…

Natchez Wildfire
$PM_{2.5}$ max = **284 µg/m³**
Aug 2018
Sensors: AQY, PA
Reference: E-BAM

Pole Creek – Mt. Baldy Wildfires
$PM_{2.5}$ max = **9 µg/m³**
Sept - Oct 2018
Sensors: AQY, PA
Reference: E-Sampler

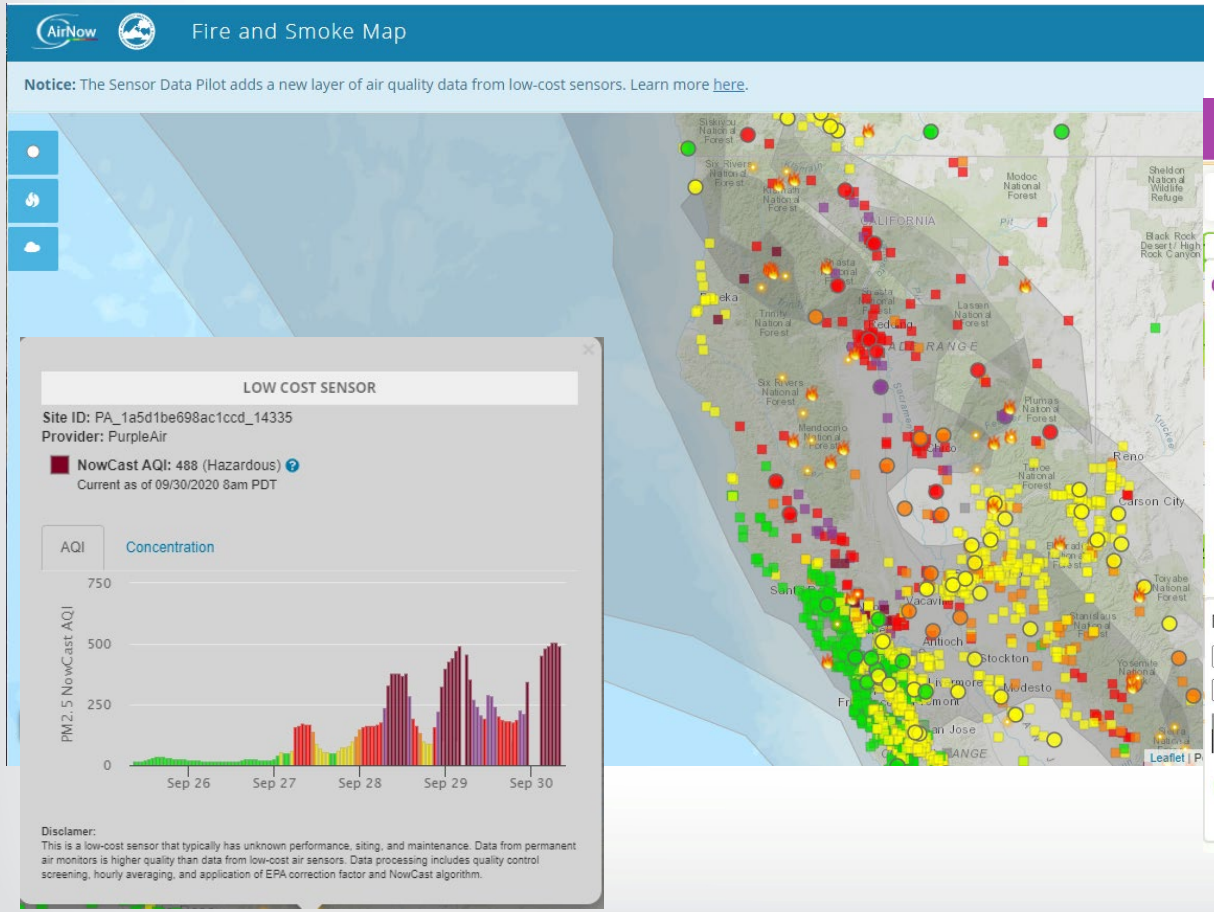
Alder Wildfire
$PM_{2.5}$ max = **291 µg/m³**
Oct 2018
Sensors: AQY, PA, RAMP
Reference: BAM 1020

AIRS Rx Fire
$PM_{2.5}$ max = **40 µg/m³**
March 2019
Sensors: PA, RAMP
Reference: T640x

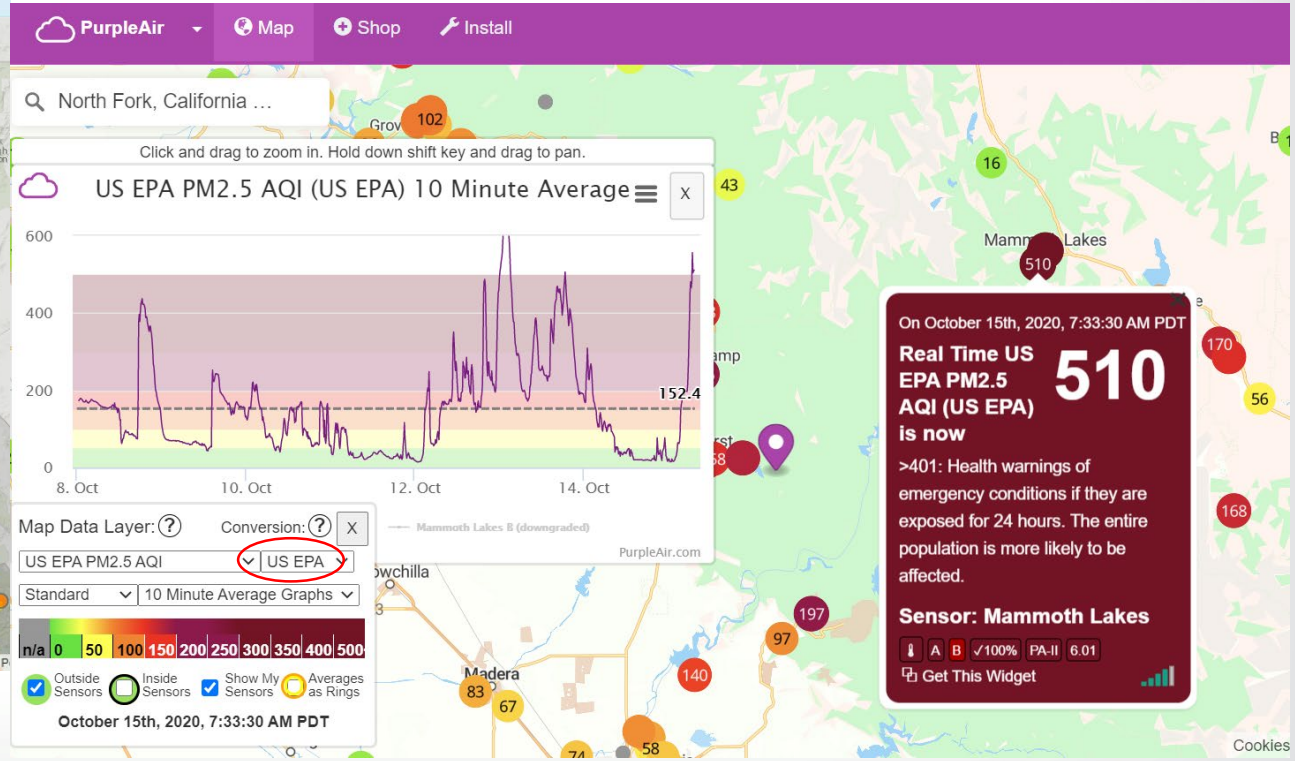
Credit: Andrea Clements, Karoline Barkjohn, and Amara Holder, EPA ORD

Validates US EPA Correction Factor for Purple Air Sensors

AirNow Fire and Smoke Map Sensor Pilot



US EPA Correction Factor for Purple Air



Regional Applied Research Effort Program

Helps Answer Questions About Smoke Mitigation

Are Do-It-Yourself Air Cleaners Safe and Effective?

DIY Air Cleaner, Deluxe Model.
Photo Credit: Dave Conway, Mariposa County APCD

Can a Solar-Charged Air Cleaner Protect Fire Personnel, Evacuees, and Homeless Sleeping in Tents?

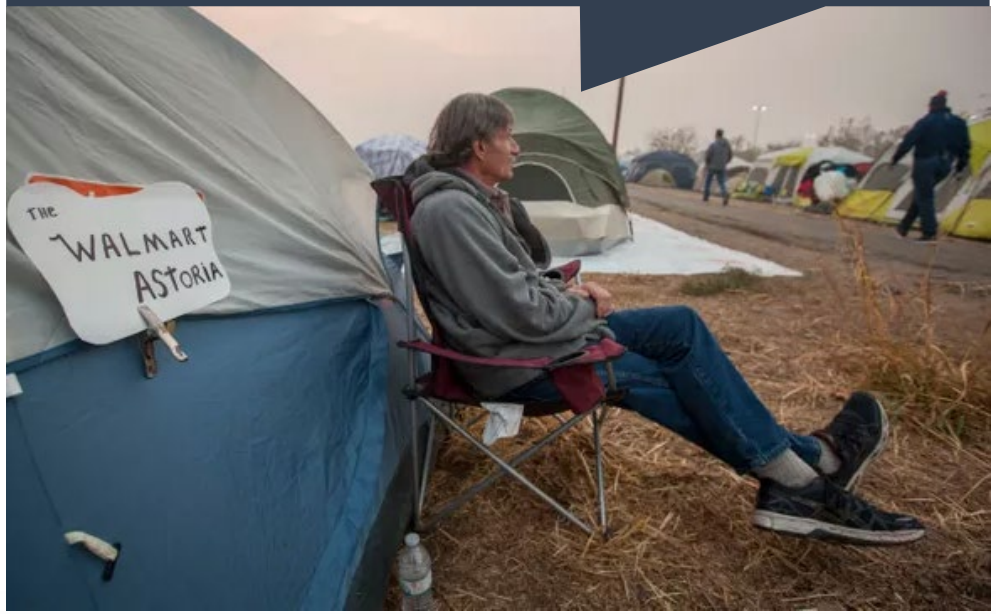


Photo Credit: Kelly Jordan, USA Today

What Level of Instruction is Needed for Effective Use of N95 Masks by the Public?

Photo Credit: Kelly Jordan, USA Today

A-E Research that Has Been Impactful

During wildfire smoke events the public needs information that is available and **actionable** that leads to effective interventions for smoke exposure.

Research that Promotes Available Information

Mobile Ambient Smoke Investigation Capability (MASIC)

Low-cost sensor evaluation

Multi-pollutant sensor pods

Purple Air correction factor (actionable?)

Research that Promotes Effective Interventions

Advancing **S**cience **P**artnerships for **I**ndoor **R**eductions of **S**moke **E**xposure:

- Assessing how effective are air filtration systems, portable air cleaners, and DIY box fan filters (Hoopa Valley Tribe and Missoula, MT)

Appropriate respirator use

Innovative approaches to cleaner indoor air (e.g., challenge)

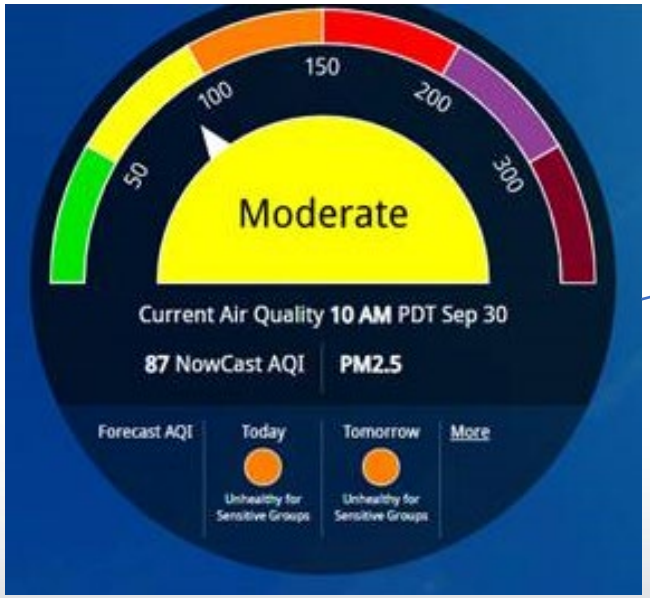
STAR Grant: Interventions & Communication Strategies to Reduce Wildland Fire Health Risks

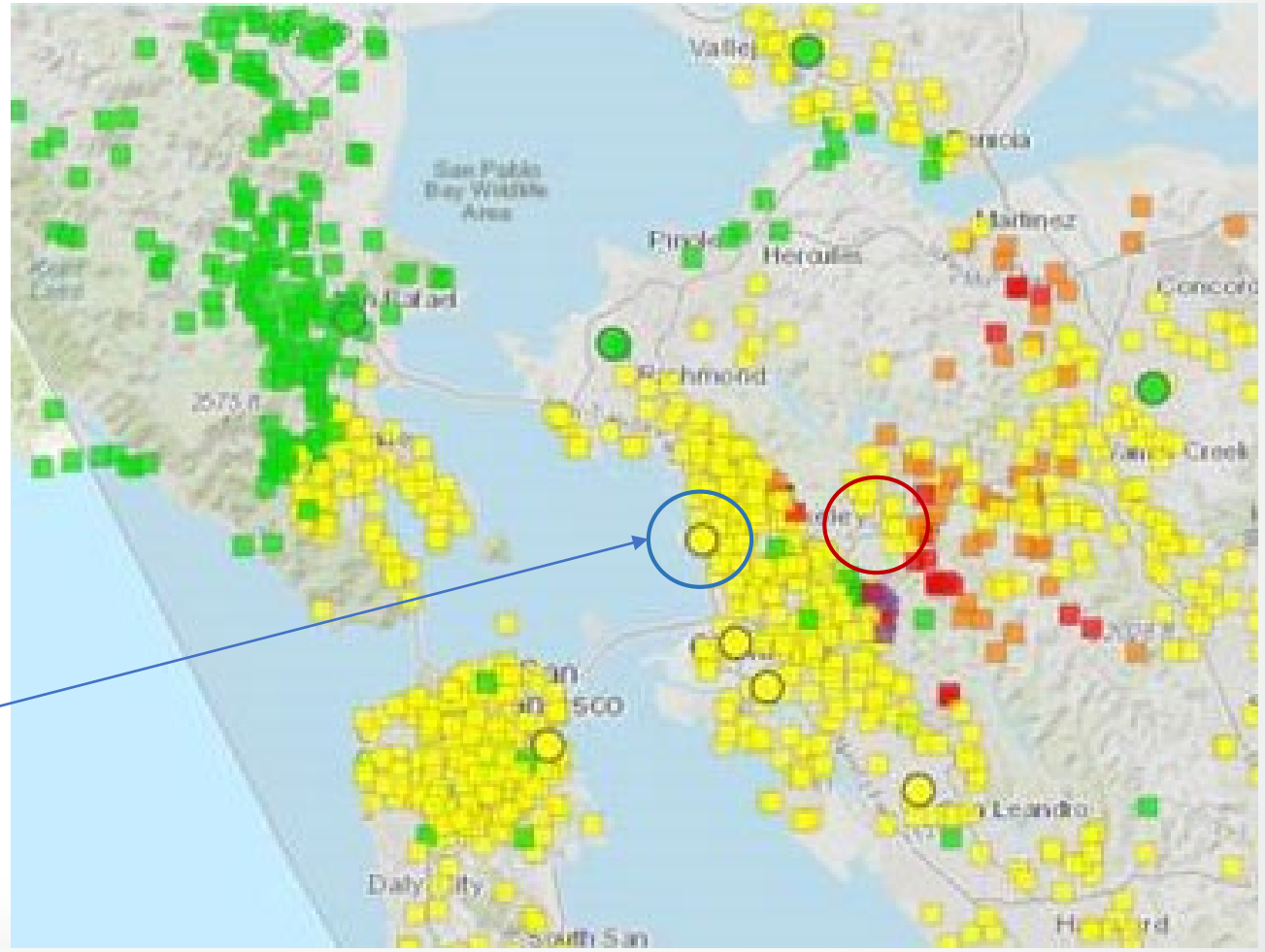
2020 Western Wildfires: Research in Action

September 30, 2020

AirNow message:

- Nowcast AQI ≥ 3-hour average
- Moderate/yellow
- "it's a good day to be active outside"
- Unusually sensitive people: "consider reducing prolonged/ heavy exertion"
- Public behavior: go outdoors, go for a run, open doors and windows





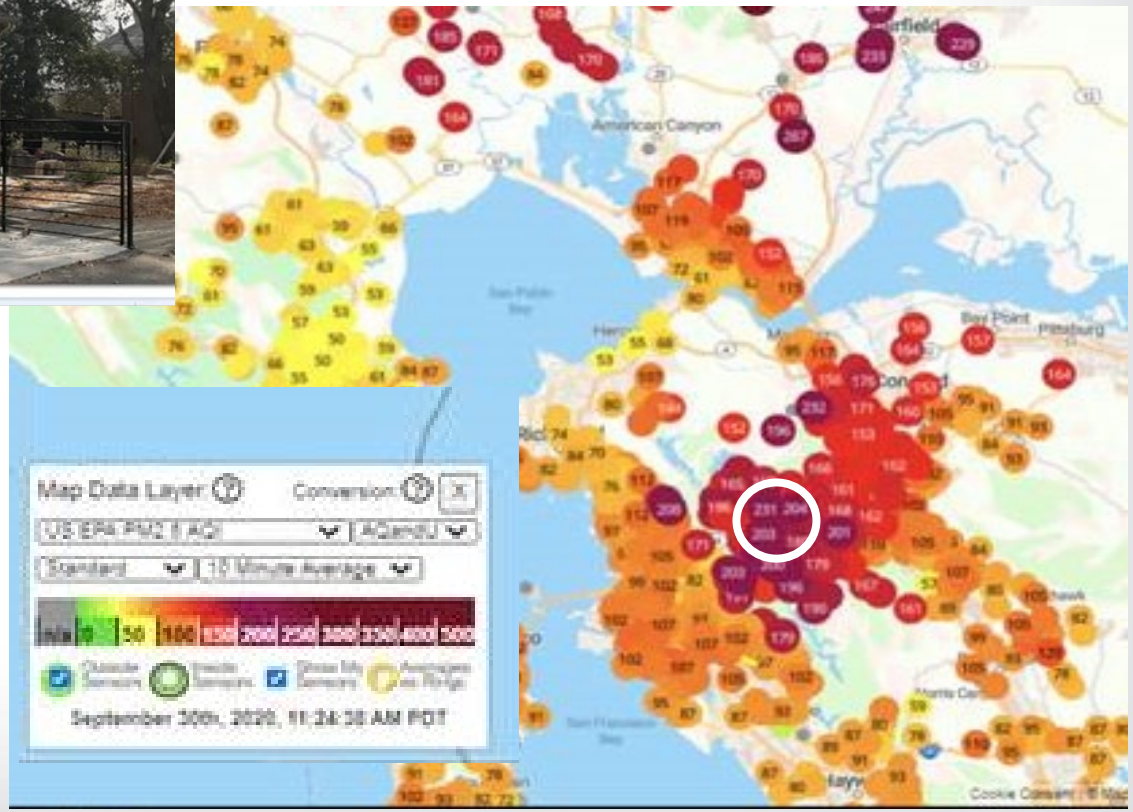
2020 Western Wildfires: Research in Action

September 30, 2020

Actual Experience:

- Visible smoke
- Chest and lungs burning
- Headache, shaking
- Went indoors, shut windows

What does a 10-minute average mean for smoke impacts/risk?

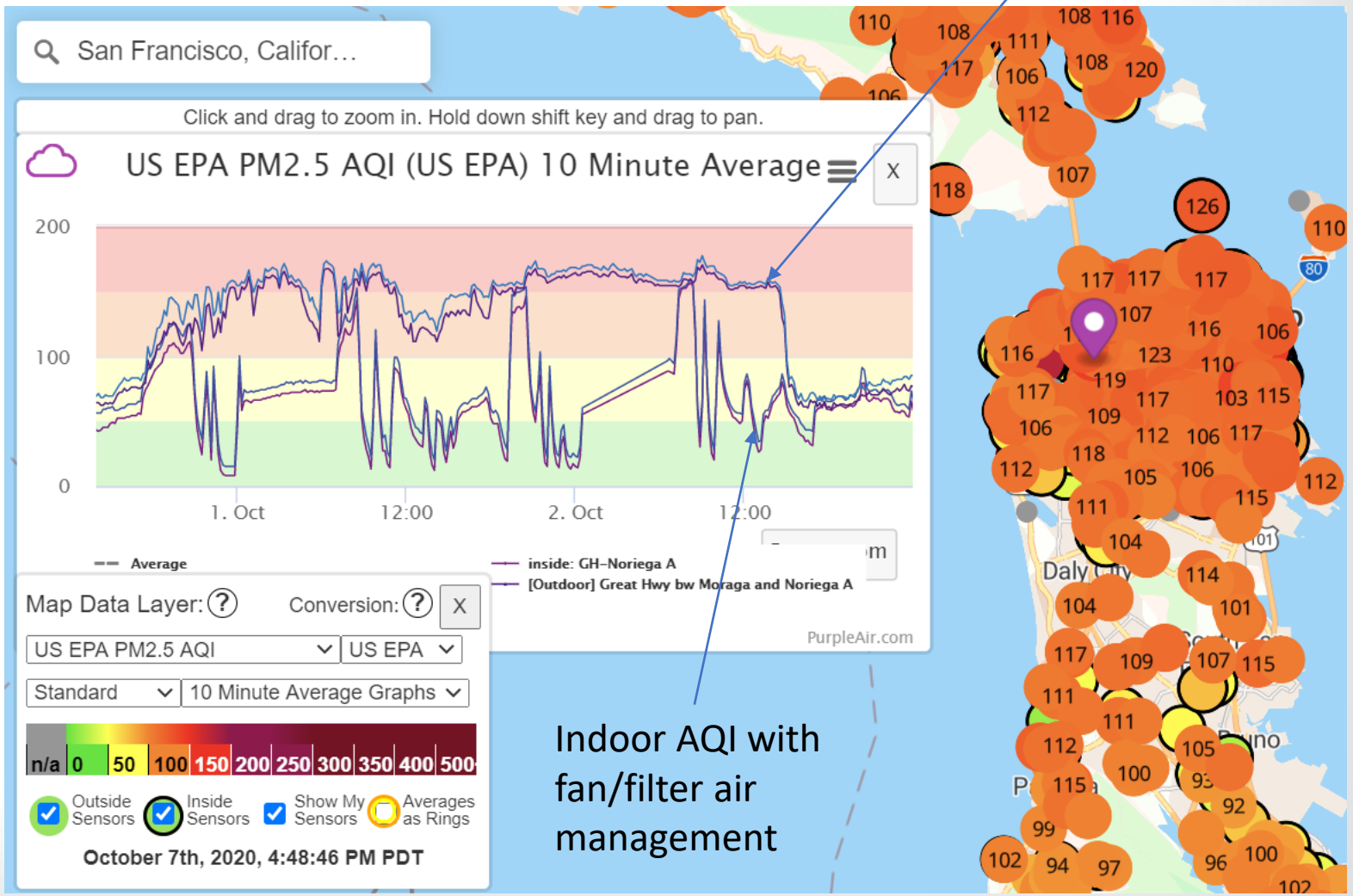


Purple Air message:

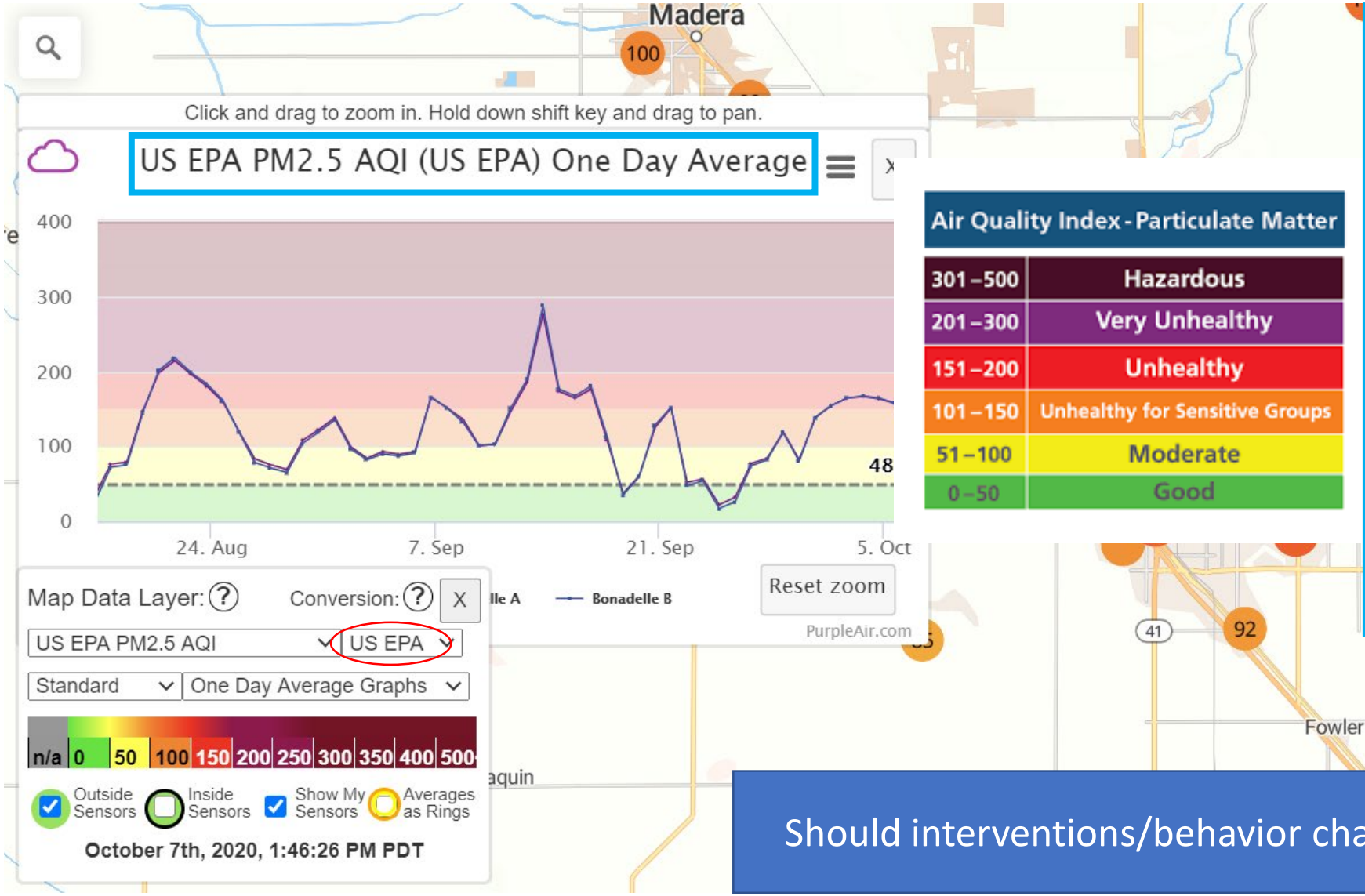
- Very Unhealthy/purple
- 10-min average
- “Move all activities indoors- sensitive groups” (EPA Air Quality Guide for Particulate Matter)
- Public behavior: go indoors, close windows, turn on air cleaner

2020 Western Wildfires: Research in Action

October 1, 2020



Weeks of Smoke with Short Windows of Relief



Air Quality Index - Particulate Matter	
301 – 500	Hazardous
201 – 300	Very Unhealthy
151 – 200	Unhealthy
101 – 150	Unhealthy for Sensitive Groups
51 – 100	Moderate
0 – 50	Good

Fresno, CA

Air Quality Index (AQI)

Daily Average AQI (not 10-min)
34/50 days with daily AQI >100
18/50 days with daily AQI >200

100 AQI = 35 µg/m^3 = 24-hour NAAQS

- 98th percentile (8 days), 3-year average

Should interventions/behavior change with cumulative exposure?

Public Protection Needs for Wildfire Smoke

Moving Forward

Most pressing needs for managing smoke exposure:

- Local smoke conditions: near real-time, and reliable forecasts out multiple days
  - More sensors; longer forecasts; better models for complex terrain; tools that integrate and display information clearly
- Short-term (sub-daily) and long-term (days to weeks) health impacts/risks and guidance
  - Epidemiological studies/review; AQI-like metric to guide behavior; tools to track cumulative exposure
- Effectiveness of interventions
  - Mask use; air cleaner protocols; public perception of shelters; closing buildings (e.g., house or schools) during prolonged events; solutions for low-resource communities and households
- Decision support tools to help the public know when/which interventions to use

Public Protection Needs for Wildfire Smoke

Moving Forward

Groups of special concern: children (schools), environmental justice communities, elderly, rural communities, compromised health, homebound low-income households, outdoor workers, homeless and evacuees.

Photo Credit: Jenna Schoenfeld, NYT

Photo Credit: Ali Kamal

Example of NWS

Actionable/Available Information with Effective Interventions

NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HOME | FORECAST | PAST WEATHER | SAFETY | INFORMATION | EDUCATION | NEWS | SEARCH | ABOUT

Go

View Location Examples

Your local forecast office is
Reno, NV

Nor'easter Gradually Ending; Unsettled West

The powerful Nor'easter, that has impacted the Northeast U.S. with plenty of snow, will gradually be coming to an end gusty winds are expected to persist through Wednesday. Meanwhile, the West will be unsettled, as a cold front slices Intermountain West with mountain snow on Wednesday, while a system drops down the Northwest coast with showe

Hazardous Weather Conditions

- Winter Weather Advisory until February 3, 12:00 AM PST
- Lake Wind Advisory in effect from February 3, 12:00 AM PST until February 3, 04:00 PM PST

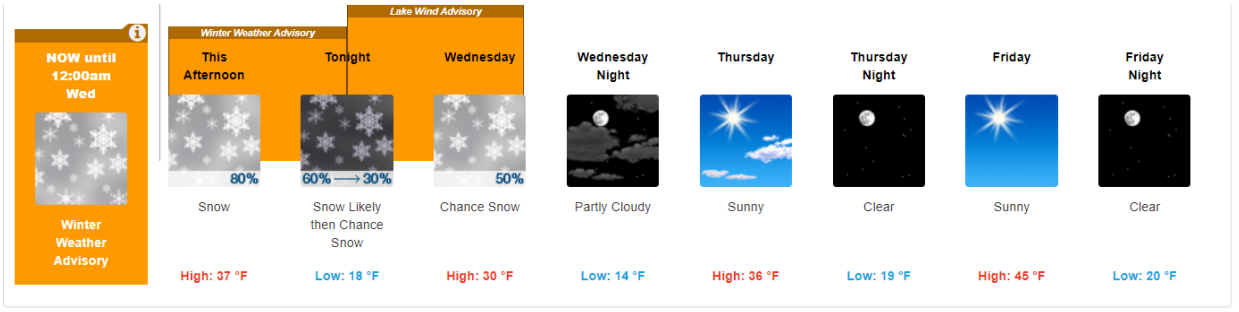
En Español | Share

Current conditions at
TAHOE DONNER (TADC1)
Lat: 39.338194°N **Lon:** 120.273389°W **Elev:** 7399ft.

NA
30°F
-1°C

Humidity	99%
Wind Speed	SW 14 MPH
Barometer	NA
Dewpoint	30°F (-1°C)
Visibility	NA
Wind Chill	19°F (-7°C)

More Information:
Local Forecast Office
More Local Wx
3 Day History
Mobile Weather
Hourly Weather Fore



...WINTER WEATHER ADVISORY NOW IN EFFECT UNTIL MIDNIGHT PST TONIGHT...

* CHANGES...Shortened duration of advisory and reduced snow amounts.

* WHAT...Snow. Additional snow accumulations of 2 to 6 inches near the Sierra crest mainly above 7000 feet, with up to 2 inches down to lake level. Sierra wind gusts up to 75 mph.

* WHERE...Greater Lake Tahoe Area.

* WHEN...Until midnight PST tonight.

* ADDITIONAL DETAILS...Hazardous conditions will continue on Lake Tahoe with wind gusts up to 40 mph and wave heights 2 to 4 feet.

* IMPACTS...Plan on slippery road conditions. The hazardous conditions could impact the evening commute mainly over the higher Sierra passes.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

Even light snowfall causes major travel delays, especially during periods of high traffic volume. Be sure to allow extra time to reach your destination. Leave extra space between vehicles since it takes longer to stop on slick roadways.

The latest road conditions can be obtained by calling 5 1 1.

Other Important A-E Wildfire Smoke Research Areas

- Measurements to support exceptional events demonstrations
  - Ozone in smoke plumes
  - Multi-pollutant measurements
- Effect of fuel characteristics on emissions for prescribed fires
- Smoke Ready Communities Research

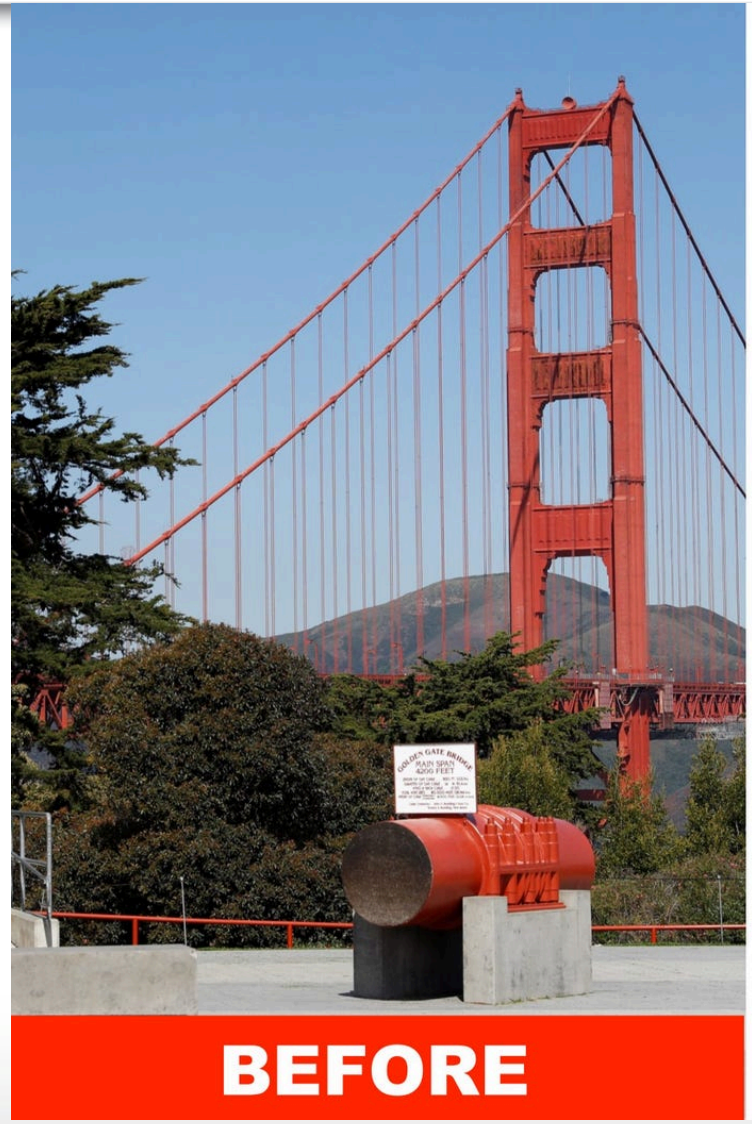


Photo Credit: Stephen Lam, Reuters

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