



Wildland Fire Research to Protect Health and the Environment

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US EPA Office of Research and Development (ORD)*

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Emissions from wildland fires



Air quality measurements during smoke events



Health and ecosystem impacts of smoke



Risk communication and interventions to reduce smoke exposures



Instruments to measure wildfire emissions

EPA ORD and partners are developing, testing, and applying emerging air measurement technologies to measure and understand smoke emissions and air quality impacts

- Developing sensor payload to support unmanned aerial system (UAS) measurements directly in smoke plumes
- Advancing low-cost sensor measurements with prize challenges
- Testing to determine how commercially available sensors function under a range of smoky conditions



The Kolibri air sampling system is attached to a small unmanned aerial system.



The Thingy AQ was originally designed in response to a 2018 Wildland Fire Sensors Challenge.



The Teledyne T640 is a new optical based PM FEM and was tested in the laboratory under non-smoke and extremely smoky conditions.

EPA ORD and partners conducted 33 controlled burns under different combustion conditions with Ponderosa pine fuels at the Rocky Mountain Research combustion facility in Missoula, MT



Ponderosa Pine Needles (PPN)/
Ponderosa pine fine dead wood (PPW)

- Detailed measurement of emissions leads to:
 - More accurate exposure assessments from wildfire smoke
 - Improvements in treatment of ambient PM_{2.5} associated with wildfire



Fire activity and emissions inventory

EPA ORD developed a multi-year fire activity and emissions inventory for the [EQUATES](#) project

- A consistent emissions inventory that avoids artificial step-changes in the model estimates due to changes in modeling methodology rather than real-world phenomena
- This will provide improved information to inform development of air quality management strategies.

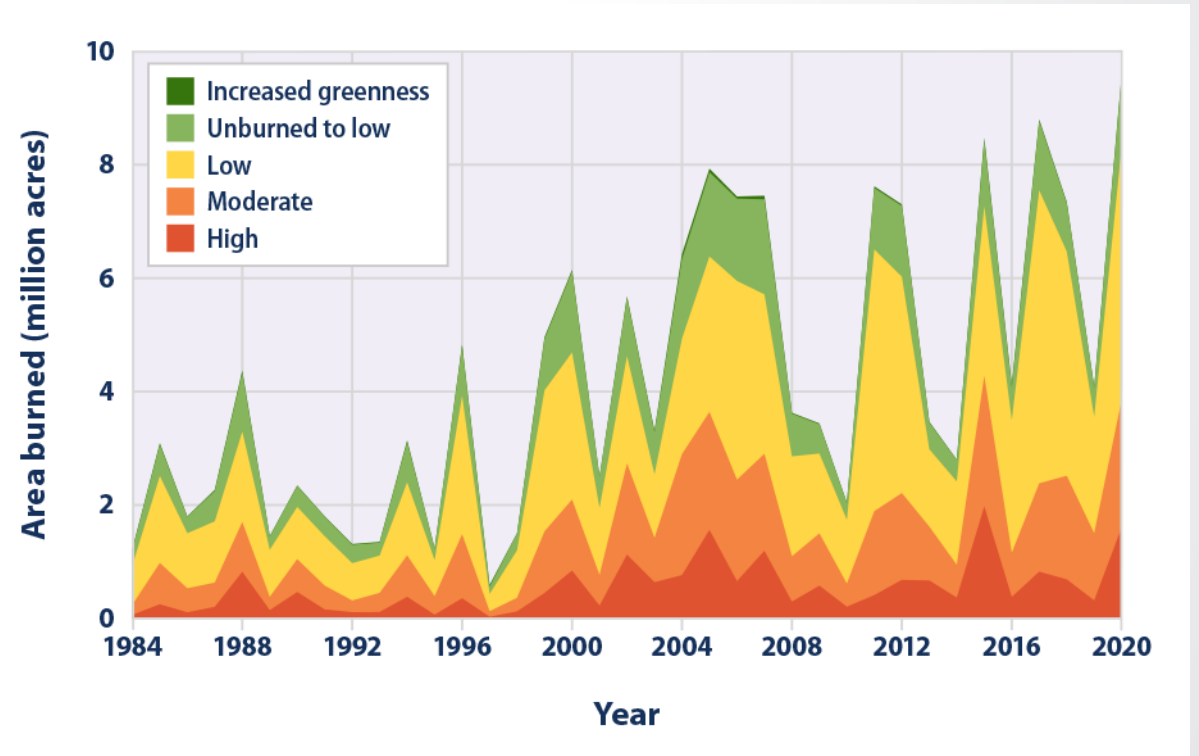


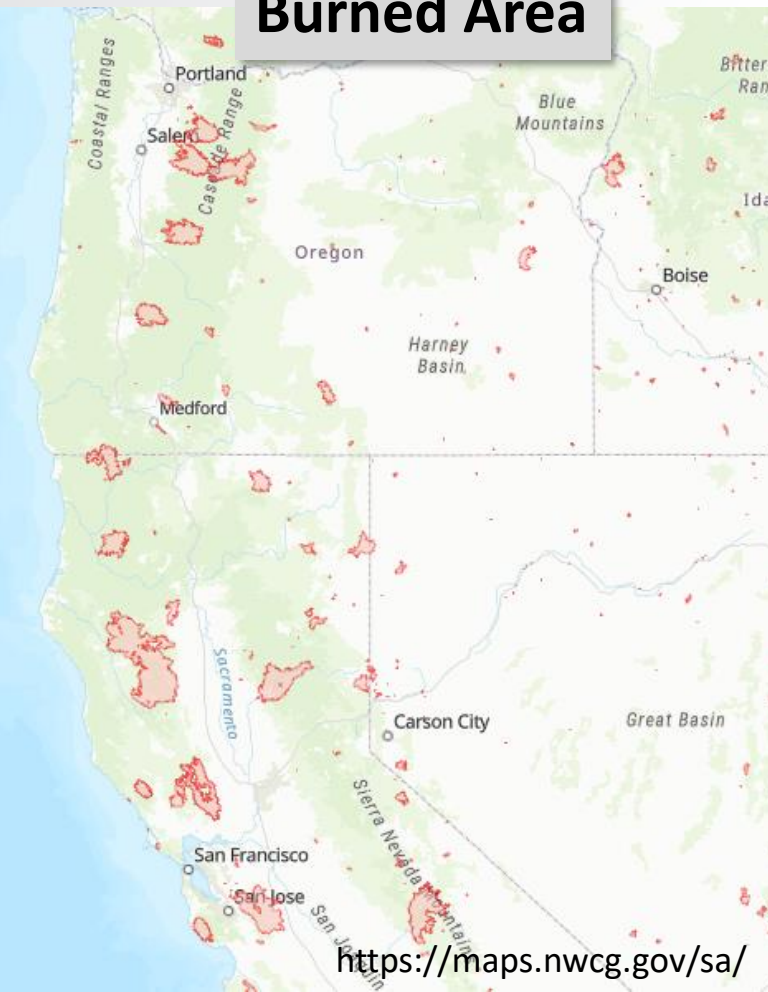
Image: <https://www.epa.gov/climate-indicators/climate-change-indicators-wildfires>



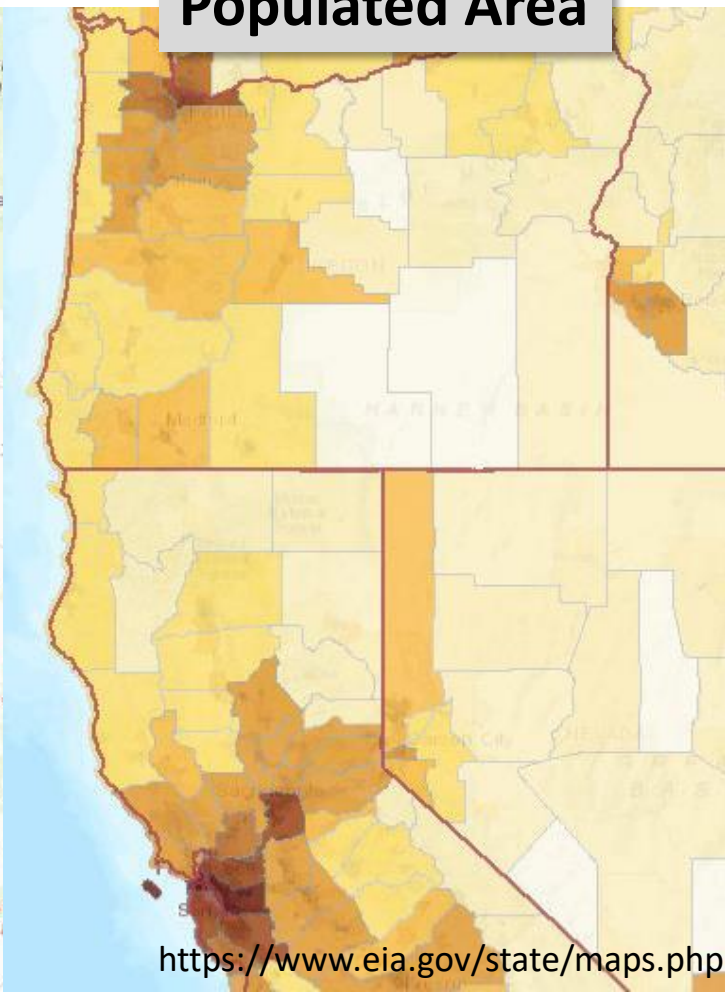
Characterizing Wildfire Smoke Impacts on Air Quality

Many areas impacted by wildfires have few or no air quality monitors

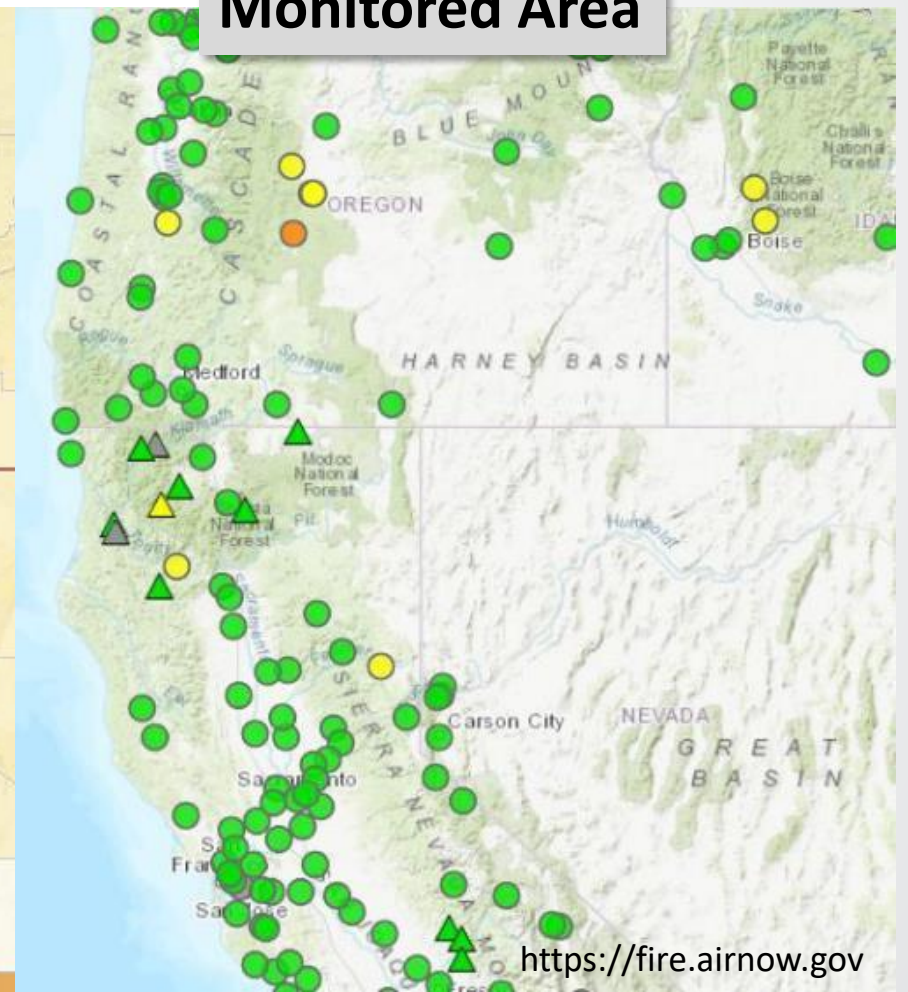
Burned Area



Populated Area



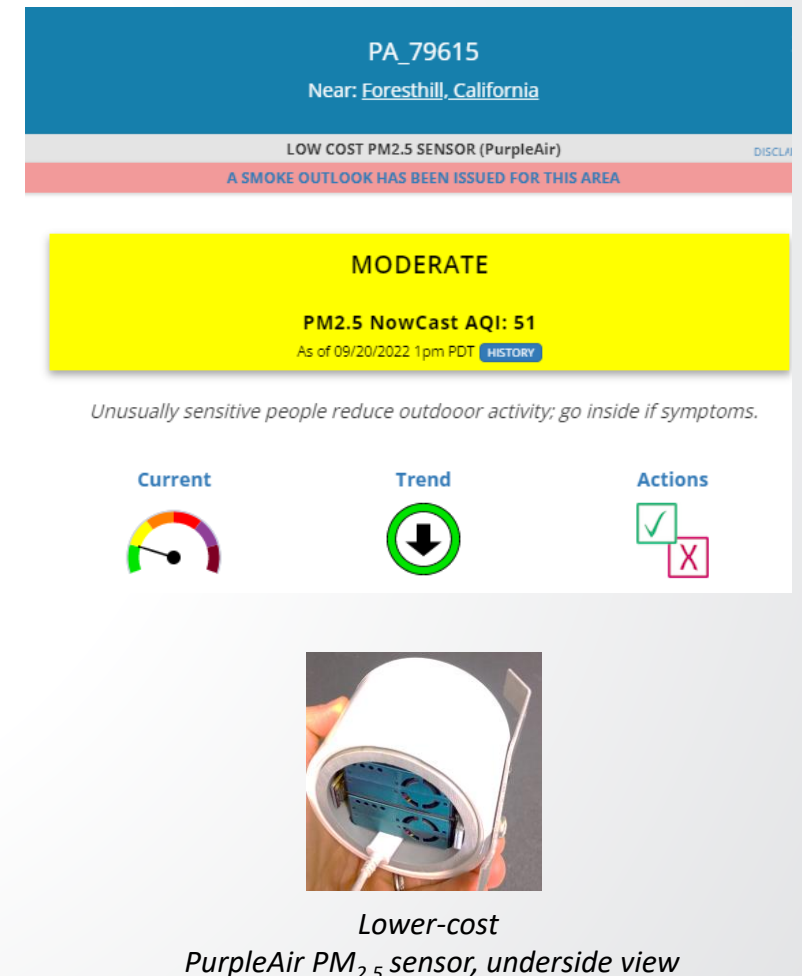
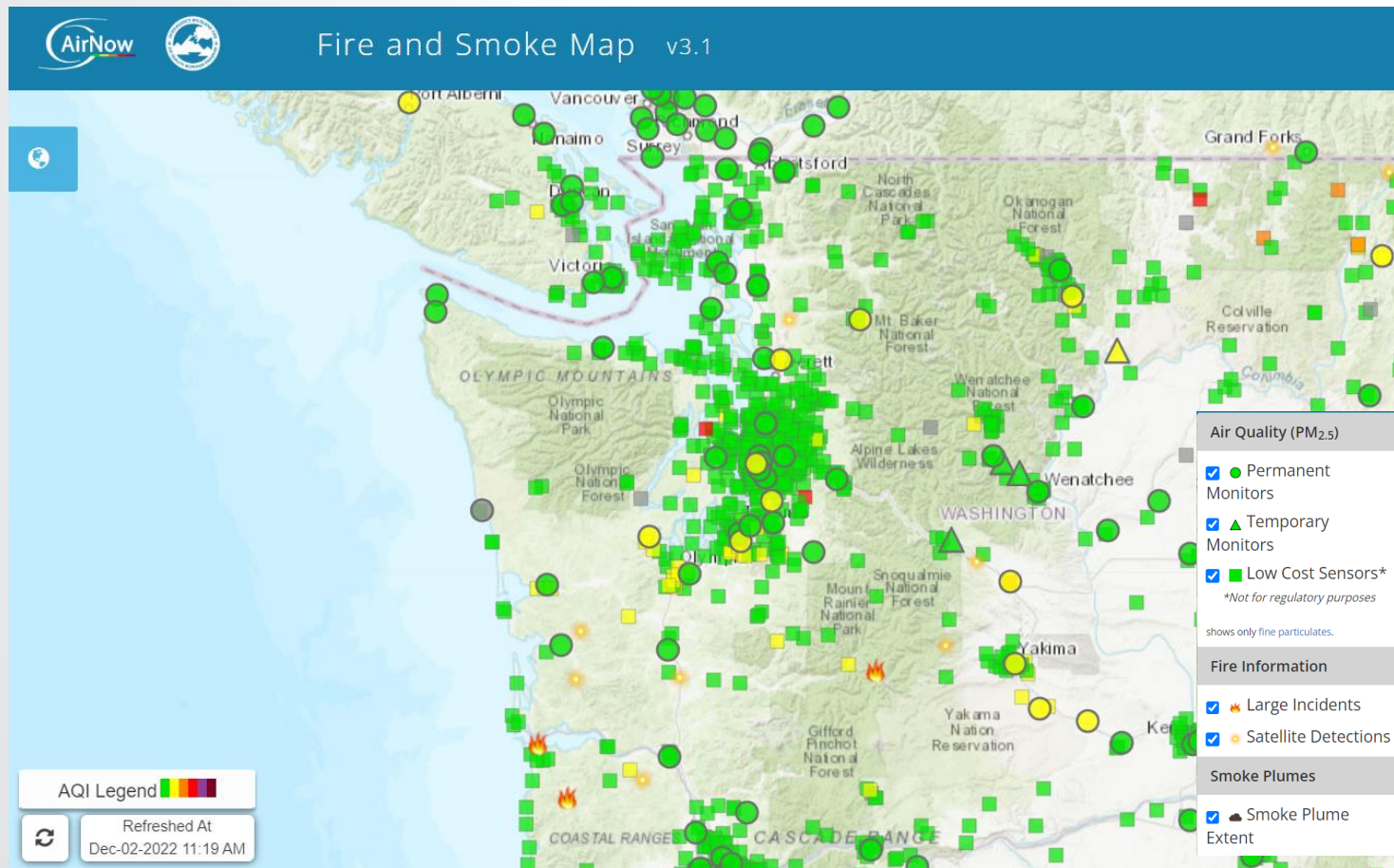
Monitored Area





AirNow: Fire and Smoke Map

EPA ORD research provided quality assurance and correction strategy to enable PM_{2.5} sensor data (PurpleAir) to be included as a layer on the [AirNow Fire and Smoke map](#) which improves coverage of AQI information in areas without regulatory-grade monitors

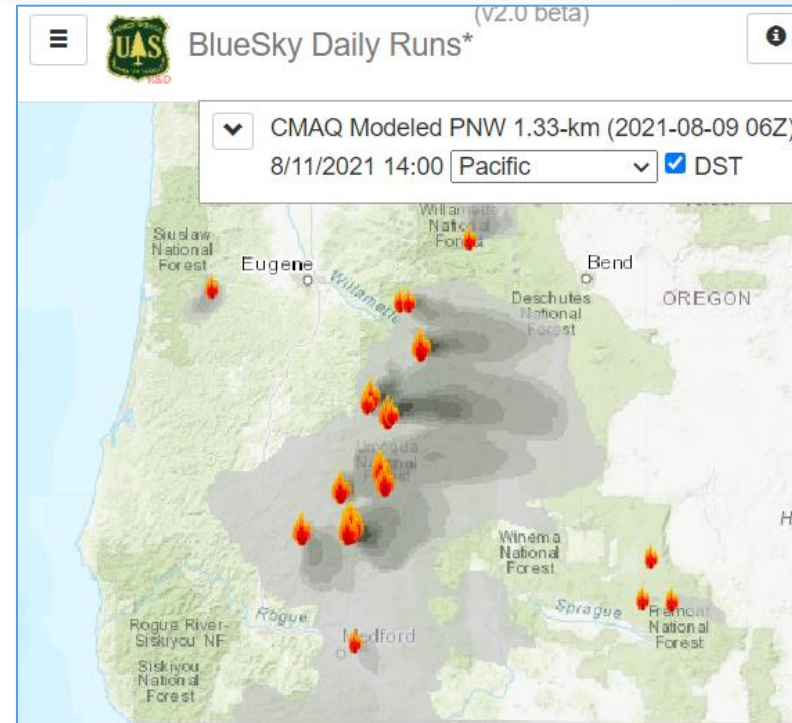




Wildfire Smoke Air Monitoring Response Technology (WSMART)



- Supplemental monitoring (mobile monitoring, sensors) adds value to:
 - Ground-truth air quality models
 - Assess front line worker smoke exposure
 - Add observations in areas without air quality data
- WSMART initiated in 2021 to support White House and EPA Administrator goals; continuing as an Air, Climate and Energy Product (FY23-26)



Air monitors for supplemental smoke monitoring

- Stationary sensors: PM_{2.5}; Multipollutant model (PM_{2.5}, CO, CO₂, TVOCs)
- Vehicle Add-on Mobile Monitoring Systems (VAMMS): ORD developed mobile PM_{2.5} sensor package



- **Partnering with EPA Regions and the Office of Air and Radiation (OAR)**

- Loan on request to **state, local, and tribal (SLT) air organizations** to meet their supplemental monitoring needs

Initiate SLT loans via a webform request:

<https://www.epa.gov/air-sensor-toolbox/wildfire-smoke-air-monitoring-response-technology-wsmart-pilot>

- **Partnering with the Interagency Wildland Fire Air Quality Response program**

- Provided supplemental PM_{2.5} sensors directly to the USFS Rocky Mountain Cache
 - Multipollutant & VAMMS technologies sent to incident through direct request by Air Resource Advisors (ARAs) deployed to incident management teams





Air Sensor Toolbox

EPA's Air Sensor Toolbox web page provides multiple resources on air sensors, which can be used by citizen scientists and others

- Updated in 2022, the Air Sensor Guidebook is one of the most popular resources in the toolbox



<https://www.epa.gov/air-sensor-toolbox>

How to Use Air Sensors



What Do My Sensor Readings Mean?



What is EPA Doing?



Resources and Funding

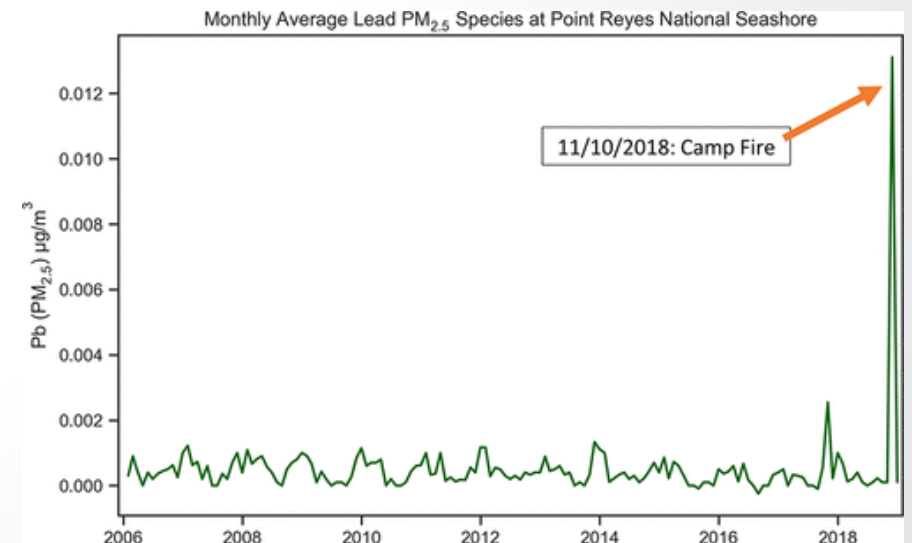
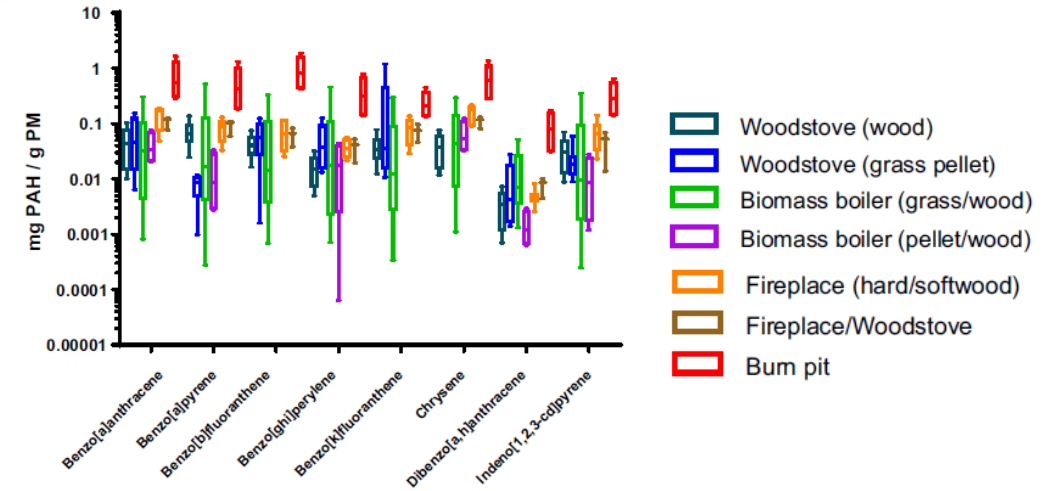




Fires at the Wildland-Urban Interface (WUI)

EPA ORD is investigating the impact of wildland fires that cross into urban areas

- Burning of different synthetic materials showed:
 - Smoke from flaming conditions was more toxic on a mass basis than smoldering samples
 - Burning plastic was more toxic and mutagenic than other fuels [Article](#)
- Analysis of existing AQS data showed that lead (Pb) and other metals can be mobilized from structure fires in the WUI in much higher concentrations than when natural fuels are burned, affecting air and water quality [Article](#)





Exposure to Wildfire Smoke

EPA ORD created a smart phone app to measure/estimate personal exposure

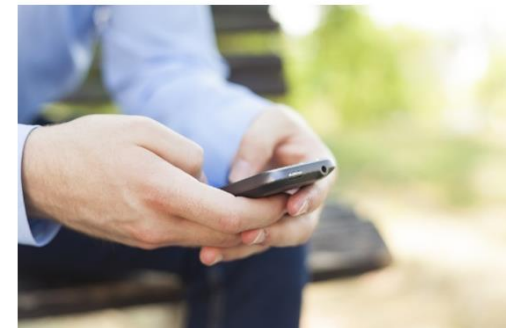
- TracMyAir was developed and evaluated for prediction of individual exposures to PM and O₃. Evaluation showed that the measured indoor attenuation factor was substantial and using TracMyAir instead of outdoor pollutant concentrations can improve health effect estimates



EPA's TracMyAir App: Using smart phones to predict near real-time air pollution exposures

Background

To better understand people's contact with air pollutants and their potential for adverse health effects, it's important to estimate how much time they spend in different locations and what the air pollutant concentrations are in those locations. Using currently available personal air monitors to collect this information has several limitations, including burden on participants, cost, and need for substantial technical expertise.





Wildland Fire Impacts on Human Health

EPA ORD is improving understanding of wildland fire smoke impacts on human health, especially in at-risk populations

- Completed research
 - In animal studies, filtering smoke to remove particles showed that gaseous components still caused respiratory responses. [Article](#)
 - In hemodialysis patients, higher wildfire smoke PM_{2.5} exposure was associated with increases in death rates across all causes on the same day and cumulatively over 30 days following exposure. [Article](#)
 - A literature review showed wildfire smoke contributes to many air pollutants, and is a risk factor for CV effects, especially in susceptible populations. [Article](#)



Wildland Fire Impacts on Human Health (2)

EPA ORD is improving understanding of wildland fire smoke impacts on human health, especially in at-risk populations

- New projects underway
 - Comparative chemistry and toxicity of emissions from wildland, prescribed, and structural fires
 - Gestational and postnatal exposure to wildfire smoke and use of respiratory medications in early life
 - Health based assessment of HEPA filters and activated charcoal in the cumulative risk of wildfire smoke exposure in at-risk sub-populations





Wildfire ASPIRE Study

*Advancing Science Partnerships for Indoor
Reductions of Smoke Exposures*

Problem

- Frequency and magnitude of wildland fires is increasing
- Many US communities are exposed to wildland fire smoke for days, weeks, or even months
- Smoke can infiltrate from ambient air to the indoor environment

Community Partners

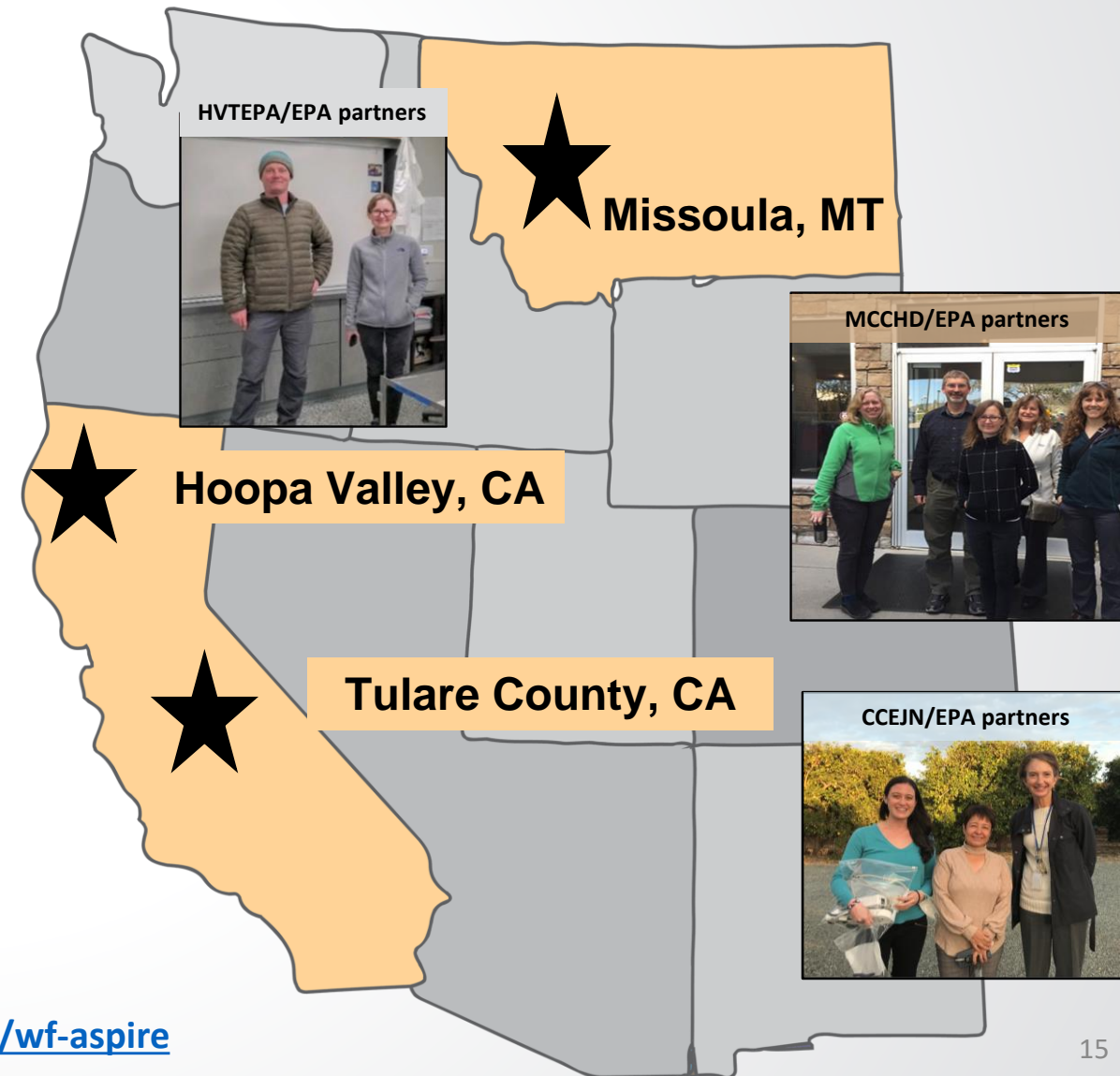
- Missoula City-County Health Department (MCCHD)
- Hoopa Valley Tribal EPA (HVTEPA)
- Central California Environmental Justice Network (CCEJN)

Research Focus

- What science is available to support recommendations for communities to develop cleaner air spaces in larger buildings (e.g., schools, community centers)?
- What interventions are effective for reducing indoor smoke exposures and related risks?

Learn more at:

<https://www.epa.gov/air-research/wf-aspire>





Field Studies of Wildfire Smoke

Multi-component Approach/Initial Accomplishments

- Monitor indoor/outdoor $\text{PM}_{2.5}$ concentrations in commercial and public buildings under typical conditions and opportunistically when smoke events occurred (Missoula, Hoopa)
 - Completed air quality measurements and detailed building inspections; journal article under development
 - Working with ASHRAE to develop guideline to recommend building measures to minimize occupant health impacts of smoke; [interim planning framework](#) issued Feb. 2021



PurpleAir sensor





ASPIRE-Health

Multi-component Approach/Initial Accomplishments

- Assess use of low-cost air cleaners in homes to improve indoor air quality and protect health (Hoopa, Tulare County)
 - Completed Hoopa pilot studies - Fall 2021 (wildfire smoke focus) and Winter 2022 (residential wood smoke focus); journal articles under development
 - Conducted Tulare County pilot study - Summer/Fall 2022, will inform full study in 2023



*EPA and Hoopa Valley Tribe EPA
Partner*

PurpleAir sensor





Do-It-Yourself (DIY) Air Cleaners

Multi-component Approach/Initial Accomplishments (*cont.*)

- **Laboratory studies:** Assess various air cleaner technologies in an environmentally-controlled room
 - Completed DIY air cleaner safety evaluations; UL report issued – [*Wildfire Safety Research: An Evaluation of DIY Air Filtration*](#)
 - Completed DIY air cleaner evaluations; journal article published – [*Impact of do-it-yourself air cleaner design on the reduction of simulated wildfire smoke in a controlled chamber environment*](#)
 - Nearing completion of effectiveness of commercial air cleaners for removal of smoke volatile organic compounds (VOCs)

DIY air cleaner designs





Science-based Challenges

Multi-component Approach/Initial Accomplishments (*cont.*)



The Thingy AQ was originally designed in response to a 2018 Wildland Fire Sensors Challenge.



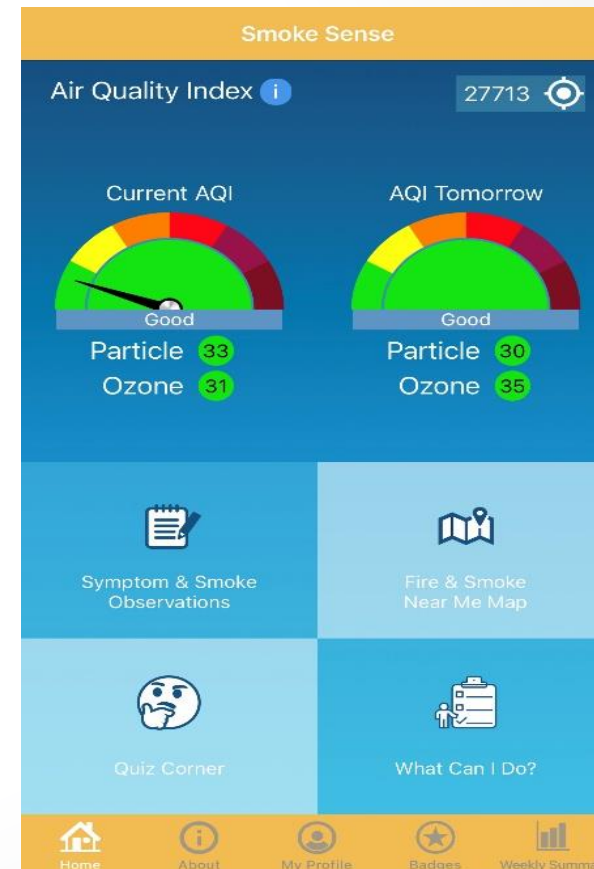
- Stimulate development of innovative, low-cost, and sustainable ways to reduce outdoor air pollutants in homes during wildland fire smoke or other high pollution events - [Cleaner Indoor Air During Wildfires Challenge](#)
 - Completed Phase 1 (written concepts)
 - 5 winners and 3 honorable mentions were invited to submit to the phase 2 competition
 - Phase 2 (prototype evaluation) underway



Communicating Information

EPA ORD is conducting research on the most effective ways to communicate wildland fire-related information about air quality, health risks, and exposure-reducing actions

- EPA supports the [Smoke Sense](#) mobile app to communicate information on smoke and air quality conditions
 - The app allows over 50,000 users to share their experiences with smoke, health effects, and exposure reducing behaviors
 - For iPhone and Android
 - Spanish version available





Communicating Information

EPA ORD is conducting research on the most effective ways to communicate wildland fire-related information about air quality, health risks, and exposure-reducing actions

- EPA provides resources via [Smoke Ready Communities](#) to help the public understand the risks of smoke exposure and how to take actions *before* a wildfire
 - Resources can help public health officials incorporate communication into their smoke response plans
 - Created by EPA ORD and the US Forest Service
 - Development with critical input from partners - the city and county of Butte and Silver Bow (MT) and Garfield County (CO)



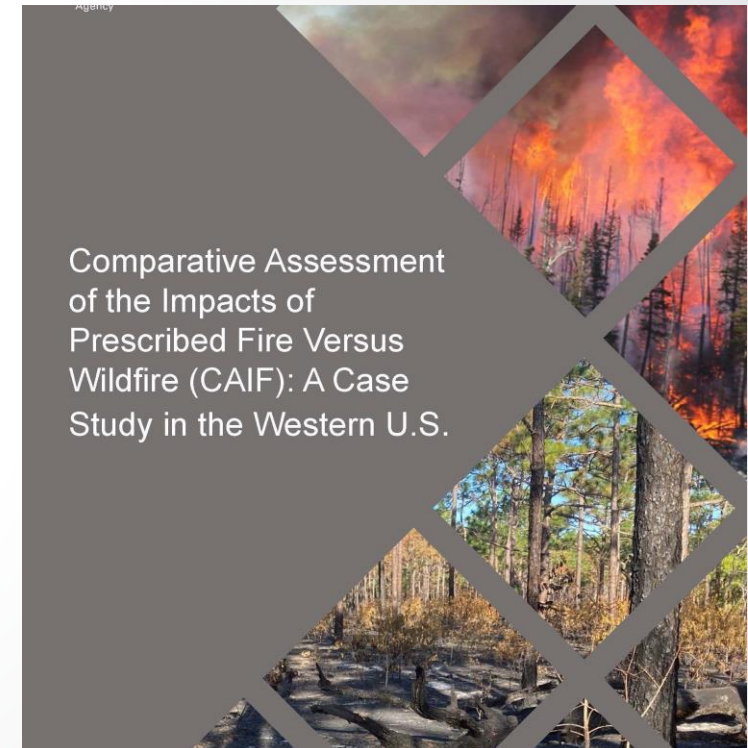


Comparative Assessment of the Impacts of Prescribed Fire Versus Wildfire (CAIF): A Case Study in the Western US

EPA ORD developed a report in collaboration with over 50 scientific staff from EPA, US Forest Service (USFS), Department of the Interior (DOI), and National Institutes of Standards and Technology (NIST)

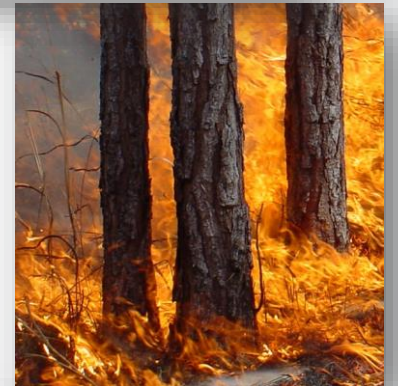
EPA released the [CAIF report](#) comparing the air quality and health impacts of smoke from wildfires and prescribed fires used for land management purposes

- Prescribed fire may be able to reduce the overall size of a future wildfire and associated smoke-related health impacts
- Prescribed fire may result in smoke-related air quality and public health impacts, but at a much smaller scale compared to a wildfire



EPA ORD is improving understanding of wildland fire smoke impacts on water quality, ecosystems and sensitive plants and animals

- Recently completed
 - A literature review found that post-fire nutrients, metals, disinfection byproducts and VOCs have exceeded primary drinking water standards under some conditions. [Article](#)
 - A literature review and synthesis found that there are complex relationships between biotic disturbance agents, e.g., insects, pathogens, and likelihood and severity of wildfires. Interactions between these agents and forest characteristics and fuel management can impact wildfire risks. [Article](#)
 - ORD has developed the HexFire simulator to integrate fire simulators with ecosystem models. HexFire can be readily linked to a wide range of ecological response models and used by non-wildfire experts. [Article](#)

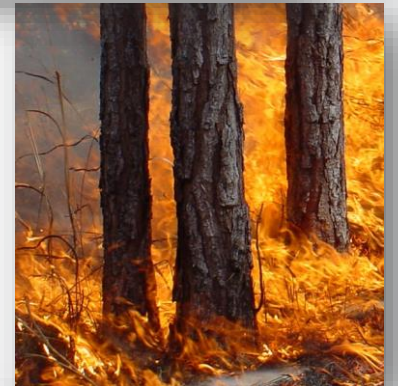




Wildland Fire Impacts on Ecosystems (2)

EPA ORD is improving understanding of wildland fire smoke impacts on water quality, ecosystems and sensitive plants and animals

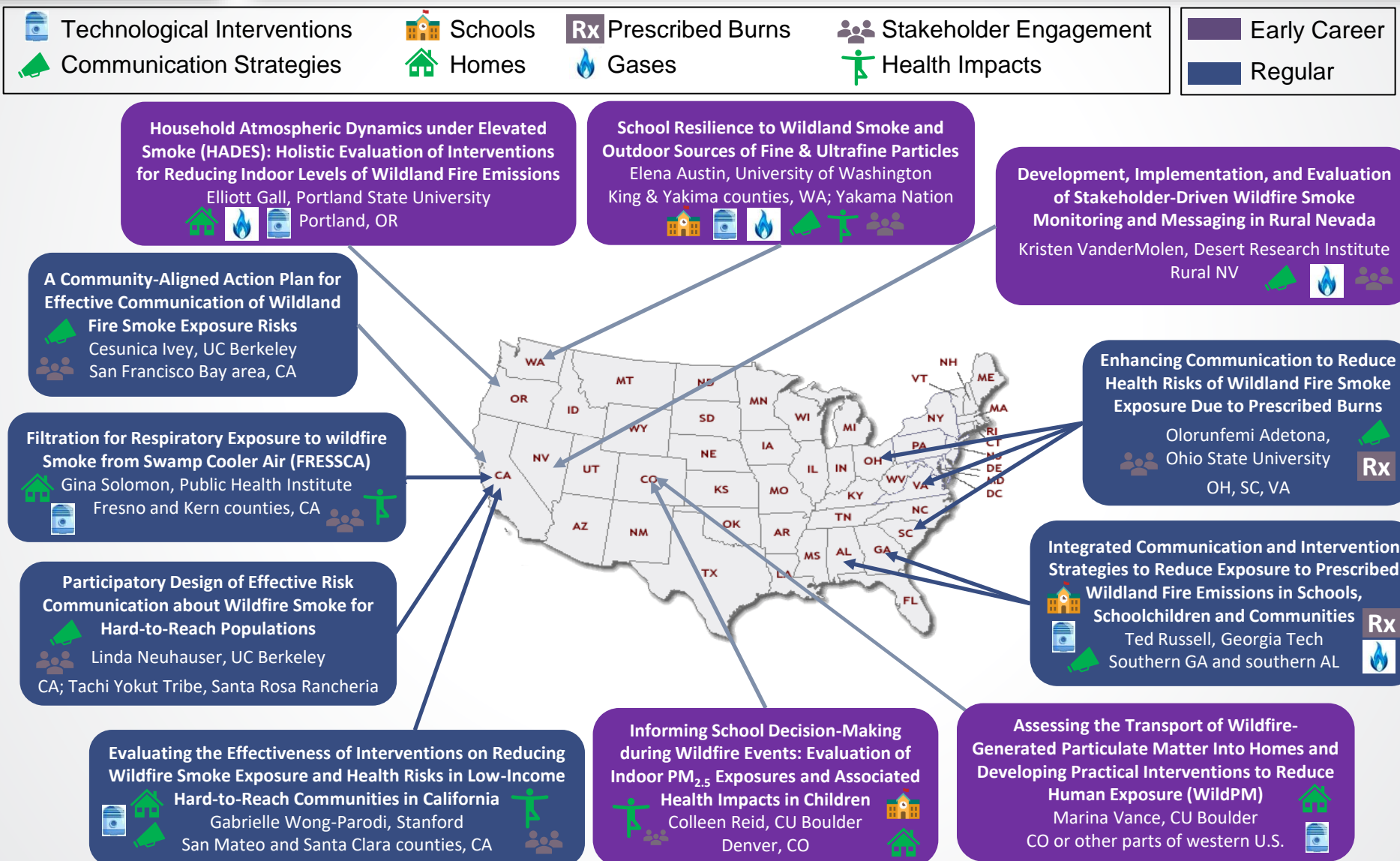
- New projects underway
 - Mapping and modeling watershed resilience to climate-related floods, droughts, and wildfire
 - Evaluating strategies to reduce adverse hydrologic and water quality effects from wildfires under a changing climate
 - Developing and applying models for evaluating wildland fire impacts on salmon habitat and populations





Science to Achieve Results (STAR) “Interventions” Grants

Interventions and Communication Strategies to Reduce Health Risks of Wildland Fire Smoke Exposures





STAR Project on Evaporative Coolers



Filtration for Respiratory Exposure to Wildfire Smoke from Swamp Cooler Air

PI Gina Solomon, Public Health Institute

Goal: Reduce wildfire smoke exposures and health risks among agricultural workers and other low-income families by **designing, testing, and deploying an affordable and effective** filtration system for residential evaporative coolers.

Study Locations: Coalinga & Arvin-Lamont, CA

Partners and Stakeholders:

Tracking California

Illinois Institute of Technology

Central California Environmental Justice Network

University of California San Francisco

University of Colorado Boulder

California Department of Public Health

Lawrence Berkeley National Labs



<https://trackingcalifornia.org/fressca/fressca>



STAR Project on Conditions for School Closings

Informing school decision-making during wildfire events: Evaluation of indoor $\text{PM}_{2.5}$ exposures and associated health impacts in children

PI Colleen Reid, University of Colorado Boulder

Goal: To inform the intervention of whether schools should stay open or closed during wildfire air pollution events

Study Sites: Denver Metro Area

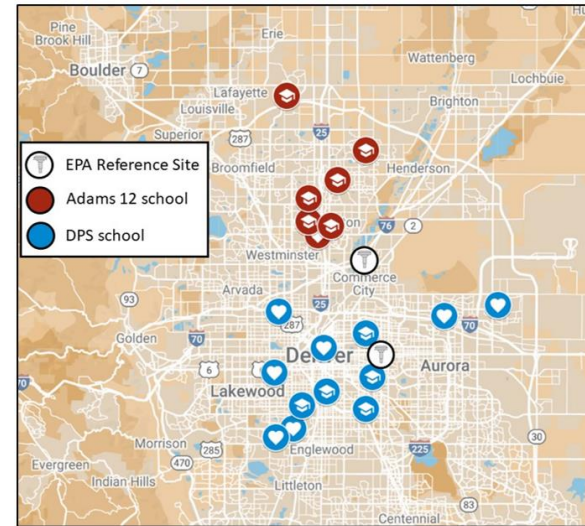
Partners and Stakeholders:

Denver Public Schools

Adams-12 School District

Denver Department of Public Health and Environment

Regional Air Quality Council





Contact

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Wildfire Resources

Smoke-Ready Toolbox for Wildfires

One-stop resource for wildfire smoke information

<https://www.epa.gov/smoke-ready-toolbox-wildfires>

Wildfire ASPIRE (Advance Science Partnerships for Indoor Reductions of Smoke Exposures) Study

Improve understanding of indoor exposures during wildland fires; complementary field and laboratory studies and new health component

Website: <https://www.epa.gov/air-research/wildfire-study-advance-science-partnerships-indoor-reductions-smoke-exposures>

Schools as Community Cleaner Air and Cooling Centers

<https://www.epa.gov/arp/schools-community-cleaner-air-and-cooling-centers>

One of the communities involved in this project is Pima County, Arizona

ASHRAE Interim Guidance

<https://www.ashrae.org/file%20library/technical%20resources/covid-19/guidance-for-commercial-building-occupants-from-smoke-during-wildfire-events.pdf>

Do-It-Yourself Air Cleaner Evaluation

Holder et al. (2022): *Impact of do-it-yourself air cleaner design on the reduction of simulated wildfire smoke in a controlled chamber environment.* <https://doi.org/10.1111/ina.13163>

Wildfire Smoke: A Guide for Public Health Officials and Accompanying Factsheets

<https://www.airnow.gov/wildfire-guide-information/>

Wildfire Smoke and Your Patients' Health: Online Course

<https://www.epa.gov/wildfire-smoke-course/about-wildfire-smoke-course>

SmokeSense

A crowdsourced study of health impacts from smoke exposures; Mobile app <https://www.epa.gov/air-research/smoke-sense-study-citizen-science-project-using-mobile-app>

AirNow – Fire and Smoke Map

Project to merge regulatory-grade air measurements with data from low-cost sensors (PurpleAir) to expand information available to inform non-regulatory decisions - <https://fire.airnow.gov/>