Trend and Effects of Wildfire Smoke in Washington

Washington Department of Labor and Industries
Wildfire Smoke Rule-Making Stakeholders Meeting

January 27, 2022

What is smoke?

- Gases
- Liquids
- Solids

Particles

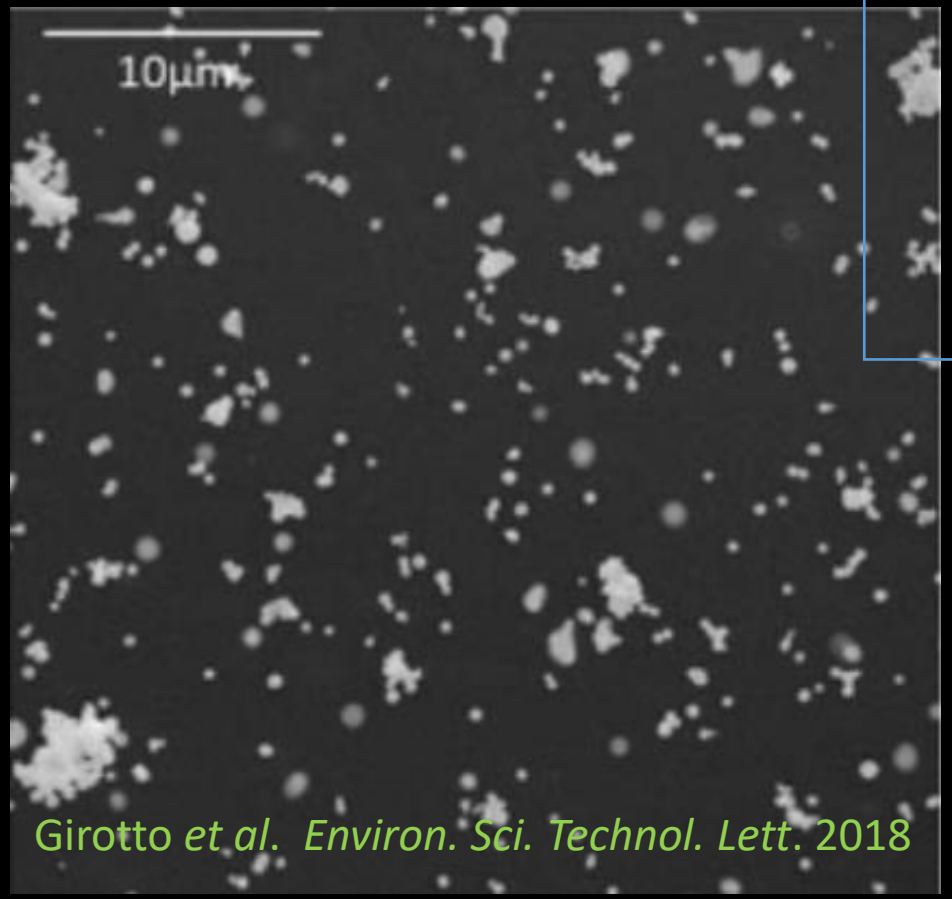
Carbon dioxide
Carbon monoxide
Methane
Water vapor

Elemental carbon
NOx
SOx
Water
Many VOCs including:
- Formaldehyde
- Acrolein
- PAHs

Metals and other elements

70-80% of the metals and PAHs in wildfire smoke have been found in particles less than 0.1 µm

Most wildfire smoke particles are ~ 0.05-micron (µm) in diameter

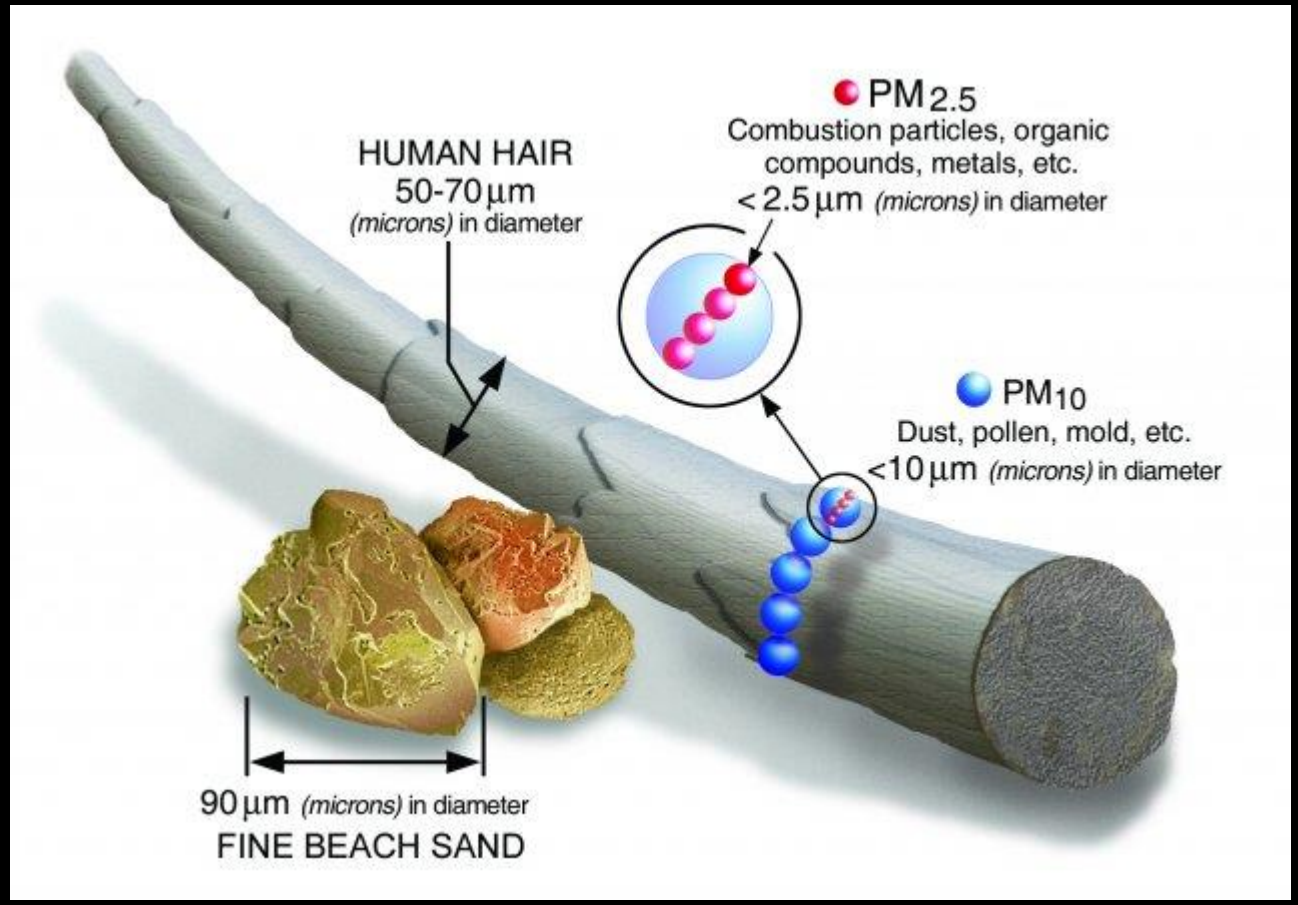


Girotto *et al*. *Environ. Sci. Technol. Lett*. 2018

Particulate Matter 2.5 ($PM_{2.5}$)

Particles that are 2.5 micrometers or less in diameter

US EPA requires states and local air authorities to monitor $PM_{2.5}$ and report the daily average concentrations as micrograms per cubic meter of air



Three $PM_{2.5}$ Monitoring Methods

Gravimetric

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Beta Attenuation

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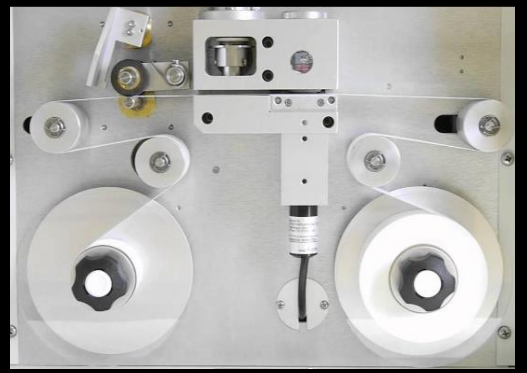

Optical

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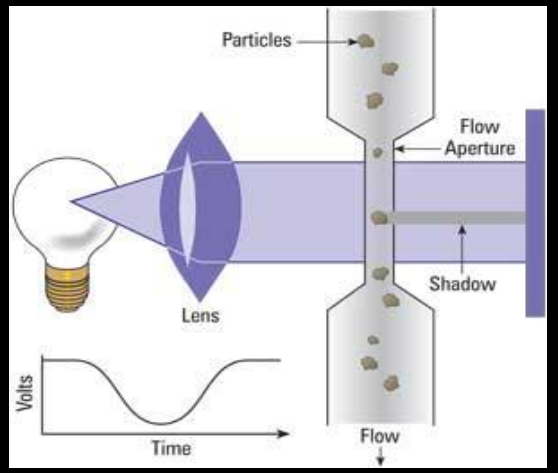

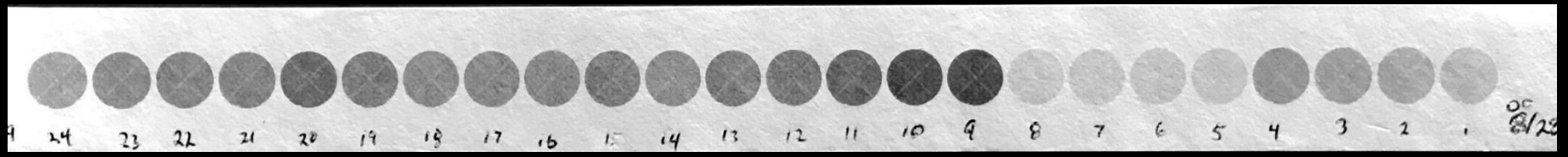

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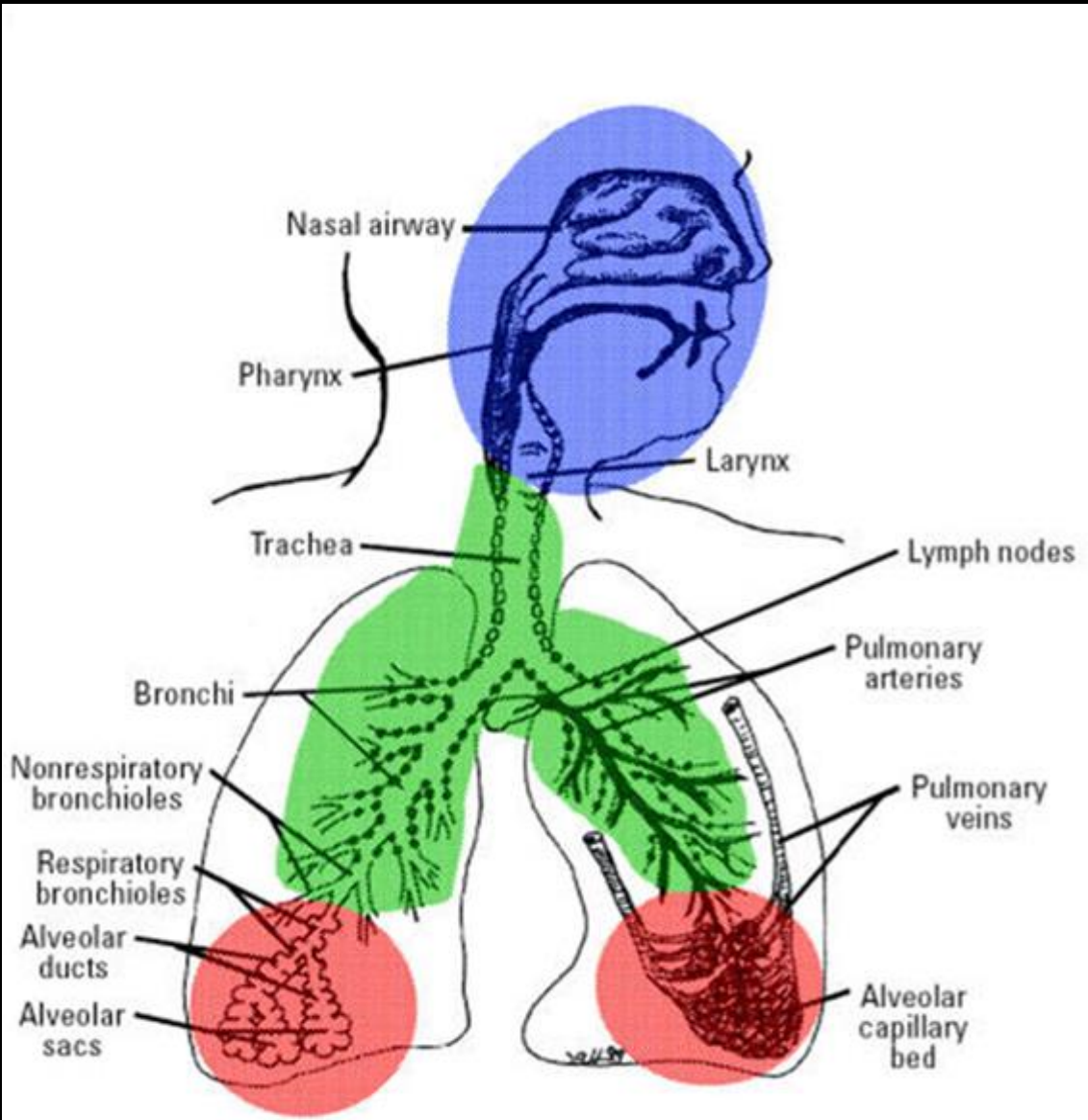
$PM_{2.5}$ in EPA's Air Quality Index

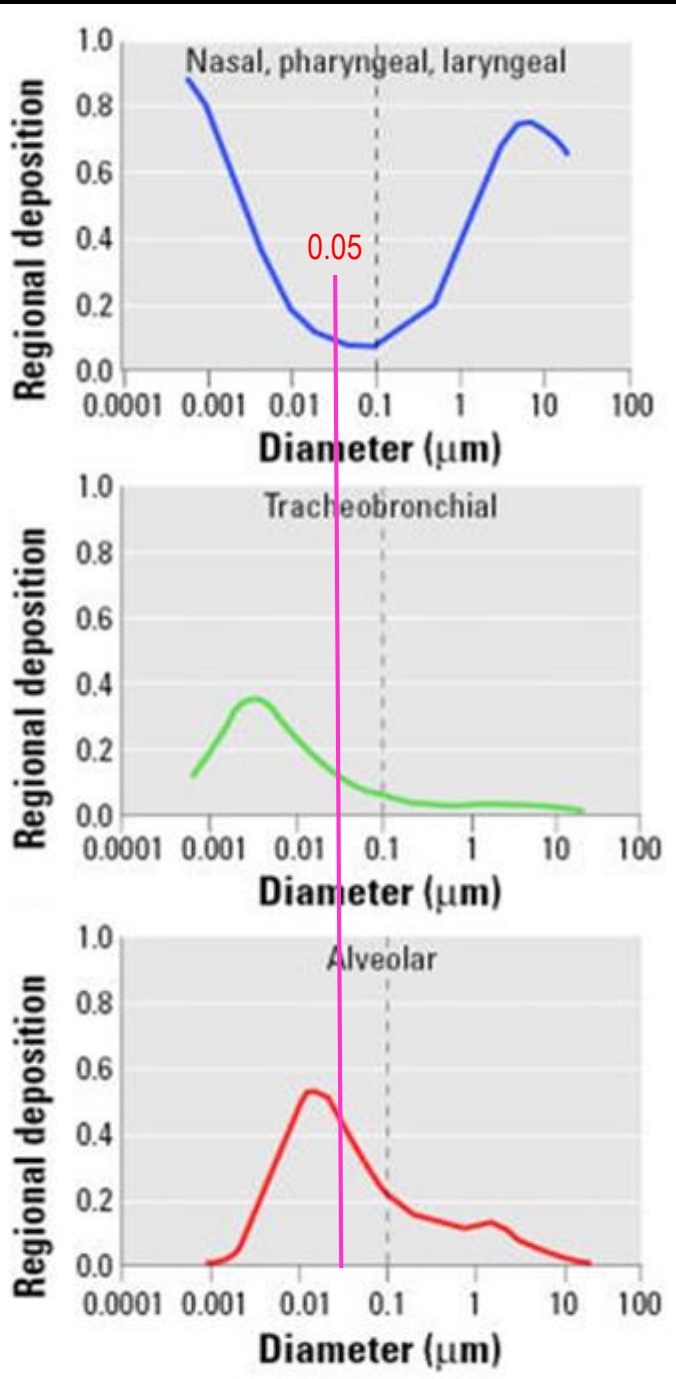
States and local air authorities calculate and announce which AQI health category each monitor is in

Air Quality Index values and category divisions:

Daily average Concentration ($\mu g/m^3$)	AQI Index Value	AQI Category
0 to 12.0	0-50	Good
12.1 to 35.4	51-100	Moderate
35.5 to 55.4	101-150	Unhealthy for Sensitive Groups
55.5 to 150.4	151-200	Unhealthy
150.5 to 250.4	201-300	Very Unhealthy
250.5 to 350.4	301-400	Hazardous
350.5 to 500	401-500	

Deposition in respiratory tract regions depends on particle size





Oberdörster, *et al.* 2005 *Env Health Perspectives*: 113, 7.

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FRED GREAVES/REUTERS

Firefighters in California have faced a historic fire season in 2018, and climate models predict that wildfires will become more common and intense.

EPIDEMIOLOGY

Scientists scramble to study wildfires' health effects

Blazes have created natural experiments in nearby towns and a monkey-breeding colony.

BY SARA REARDON

Record-setting wildfires have burnt through northern California over the past month, blanketing huge swathes of the western United States in a smoky haze and destroying an area larger than London. Now scientists are hoping that the fiery summer will help them determine whether exposure to wildfire smoke damages health over the long term.

Finding answers is becoming more urgent because the behaviour of wildfires — in the United States and elsewhere — is expected to shift in the coming decades. Climate models predict that many more people worldwide will be exposed to toxic smoke as these blazes become more common and intense. US wildfires already produce about one-third of the country's particulate-matter pollution, airborne particles that are small enough to enter and damage human lung tissue[1].

"When we think about climate-change policy and cost–benefits, if we don't include human-health impacts we're not getting an accurate assessment," says Michelle Bell, an environmental-health researcher at Yale University in New Haven, Connecticut. "The line between natural and anthropogenic air pollution has blurred in terms of wildfires."

One of the reasons researchers know so little about wildfires' effects on health is that epidemiological studies of air pollution typically do not distinguish between the sources of pollutants that people breathe in. The sensors used in such research measure only the size of particles in the air, making it hard to link ▶

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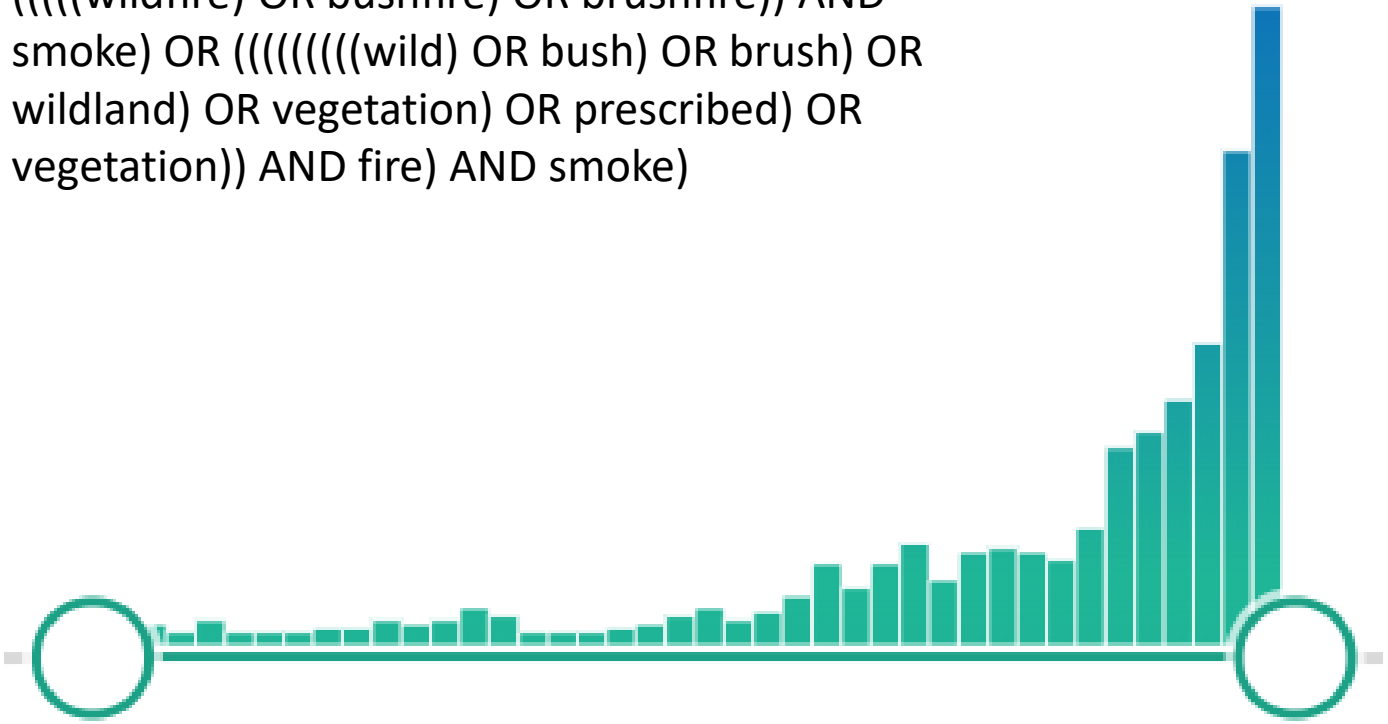
RESULTS BY YEAR

(((((wildfire) OR bushfire) OR brushfire)) AND smoke) OR (((((((((wild) OR bush) OR brush) OR wildland) OR vegetation) OR prescribed) OR vegetation)) AND fire) AND smoke)



1981 2022

Adverse Health Effects of Wildfire Smoke

Emergency Dept. Visits (EDVs)

for any non-trauma cause

increased ~1.3 % per 10-µg/m^3 daily avg. $PM_{2.5}$

on smoke days in people age 15 – 64

in Sydney

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Respiratory Diseases

rate increases per 10-µg/m^3 daily avg. wildfire $PM_{2.5}$

In Sydney, EDVs, by ~1% in the population as a whole on smoke days

In WA, Hospital Admissions (HAs) by 5% in the population as a whole on the third day after smoke exposure

In CA, HAs by 5% in population as a whole on the day and day after smoke exposure

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Washington State Dept. of Health, Chelan-Douglas Health District, Kittitas County Public Health, and Okanogan County Public Health 2012 Wildfire Study

Compared to before the fire, outpatient visits for respiratory diseases in people 19 – 64 increased ~33% during the fire, and stayed ~26% higher for 19-days after the fire

Surveillance Investigation of the Cardiopulmonary Health Effects of the 2012 Wildfires in North Central Washington State

Washington State Department of Health

Chelan-Douglas Health District

Kittitas County Public Health Department

GCHD Grant County Health District

Okanogan County Public Health

Asthma

rate increases per 10-µg/m^3 daily avg. wildfire $PM_{2.5}$

- In Darwin, symptoms onset by ~ 30.5% in people 18-78 the day after smoke exposure
- In OR, physician office visits by ~ 5% in the population as a whole on smoke days
- In OR, EDVs by ~ 8.9% in the population as a whole on smoke days
- In CA, HAs by 4% in people 20-64 on the day and day after smoke exposure
  - In WA, HAs by 5.5 % in people 15-65 on smoke days,

    and

    7.7% in the population as a whole by the 3rd day
  - In OR, HAs by 6.5% in the population as a whole on smoke days

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Doubleday et al. Environmental Health (2020) 19:4
https://doi.org/10.1186/s12940-020-0559-2

Environmental Health

RESEARCH Open Access

Mortality associated with wildfire smoke exposure in Washington state, 2006–2017: a case-crossover study

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Abstract

Background: Wildfire events are increasing in prevalence in the western United States. Research has found mixed results on the degree to which exposure to wildfire smoke is associated with an increased risk of mortality.

Methods: We tested for an association between exposure to wildfire smoke and non-traumatic mortality in Washington State, USA. We characterized wildfire smoke days as binary for grid cells based on daily average $PM_{2.5}$ concentrations, from June 1 through September 30, 2006–2017. Wildfire smoke days were defined as all days with assigned monitor concentration above a $PM_{2.5}$ value of 20.4 μg/m^3, with an additional set of criteria applied to days between 9 and 20.4 μg/m^3. We employed a case-crossover study design using conditional logistic regression and time-stratified referent sampling, controlling for humidex.

Results: The odds of all-ages non-traumatic mortality with same-day exposure was 1.0% (95% CI: − 1.0 - 4.0%) greater on wildfire smoke days compared to non-wildfire smoke days, and the previous day's exposure was associated with a 2.0% (95% CI: 0.0–5.0%) increase. When stratified by cause of mortality, odds of same-day respiratory mortality increased by 9.0% (95% CI: 0.0–18.0%), while the odds of same-day COPD mortality increased by 14.0% (95% CI: 2.0–26.0%). In subgroup analyses, we observed a 35.0% (95% CI: 9.0–67.0%) increase in the odds of same-day respiratory mortality for adults ages 45–64.

Conclusions: This study suggests increased odds of mortality in the first few days following wildfire smoke exposure. It is the first to examine this relationship in Washington State and will help inform local and state risk communication efforts and decision-making during future wildfire smoke events.

Keywords: Wildfire, Wildfire smoke, Environmental epidemiology, Mortality

Background

Wildfires are increasing in the western United States during the summer and fall months, emphasizing the importance of understanding the health impacts of wildfire smoke exposure [1, 2]. It is estimated that the total forest fire area burned in the western U.S. nearly doubled during 1984–2015 compared to the area projected to have burned without climate change [3]. This trend is expected to worsen, with climate projections indicating wildfires in the western U.S. will increase in freque[illegible] [4, 5]. The Intergovernmental Panel on Climate Change (IPCC) estimates that climate change will increase the length of wildfire season in North America by 10–30% [6], which is expected to result in worsening air quality during wildfire season in the coming decades [7].

Wildfire smoke contains a wide range of compounds known to be harmful to human health, including fine particulate matter ($PM_{2.5}$), acrolein, benzene, carbon monoxide, and polycyclic aromatic hydrocarbons [8, 9]. Exposure [illegible]ese toxic compounds is of concern near the source, [illegible]d extending several hundred to thousands of kilometers [illegible]way [10–12]. While it has been shown that the toxic com[illegible]ounds from wildfire smoke travel long distances from the [illegible]source, potentially exposing thousands of individuals, the

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Mortality associated with wildfire smoke exposure in Washington state, 2006-2017: a case-crossover study

Calculated odds of death on and after wildfire smoke days relative to non-smoke days

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Washington 2006-2017, June through September

	Daily average $\mu g/m^3$ $PM_{2.5}$	SE
Wildfire smoke	23.4	2.4
Non-wildfire smoke	5.3	0.1
Increase	18.1	2.5

Results

- Among people age 45 – 64, odds of respiratory disease-caused death in were ~ 35% greater than normal on smoke days
- Among people of any age, odds of COPD-caused death were ~ 14% greater than normal on smoke days

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Out-of-hospital cardiac arrests
increases per 10-µg/m^3 daily average
on the day and day after smoke exposures

In Victoria, AU, by ~7.8% in people 35+

and

in Melbourne, by ~12.7% in people 35-64

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Clinical-level effects of wildfire smoke

- Non-trauma emergency dept. visits
- Respiratory
  - Asthma & COPD exacerbation
  - Pneumonia
- Cardiovascular
  - Arrhythmia
  - Myocardial infarction
  - Heart failure
- Cerebrovascular Diseases and Stroke

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Sub-clinical effects of wildfire smoke

Studies of less severe symptom rates

consistently show many people experience:

- **Headaches**
- **Coughing**
- **Sneezing**
- **Runny nose**
- **Sputum production**
- **Sore throats**
- **Itchy or watery eyes**

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Cumulative wildfire smoke exposure

- **The longer time people breathe smoke, the higher their total exposure**

- **Illness and death incidences increase as cumulative exposure increases over multi-day WFS episodes**

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toxics

MDPI

Article

Sustained Effects on Lung Function in Community Members Following Exposure to Hazardous $PM_{2.5}$ Levels from Wildfire Smoke

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Abstract: Extreme wildfire events are becoming more common and while the immediate risks of particulate exposures to susceptible populations (i.e., elderly, asthmatics) are appreciated, the long-term health effects are not known. In 2017, the Seeley Lake (SL), MT area experienced unprecedented levels of wildfire smoke from July 31 to September 18, with a daily average of 220.9 $\mu g/m^3$. The aim of this study was to conduct health assessments in the community and evaluate potential adverse health effects. The study resulted in the recruitment of a cohort (n = 95, average age: 63 years), for a rapid response screening activity following the wildland fire event, and two follow-up visits in 2018 and 2019. Analysis of spirometry data found a significant decrease in lung function (FEV_1/FVC ratio: forced expiratory volume in first second/forced vital capacity) and a more than doubling of participants that fell below the lower limit of normal (10.2% in 2017 to 45.9% in 2018) one year following the wildfire event, and remained decreased two years (33.9%) post exposure. In addition, observed FEV_1 was significantly lower than predicted values. These findings suggest that wildfire smoke can have long-lasting effects on human health. As wildfires continue to increase both here and globally, understanding the health implications is vital to understanding the respiratory impacts of these events as well as developing public health strategies to mitigate the effects.

Keywords: wildfire smoke; community; spirometry; health effects

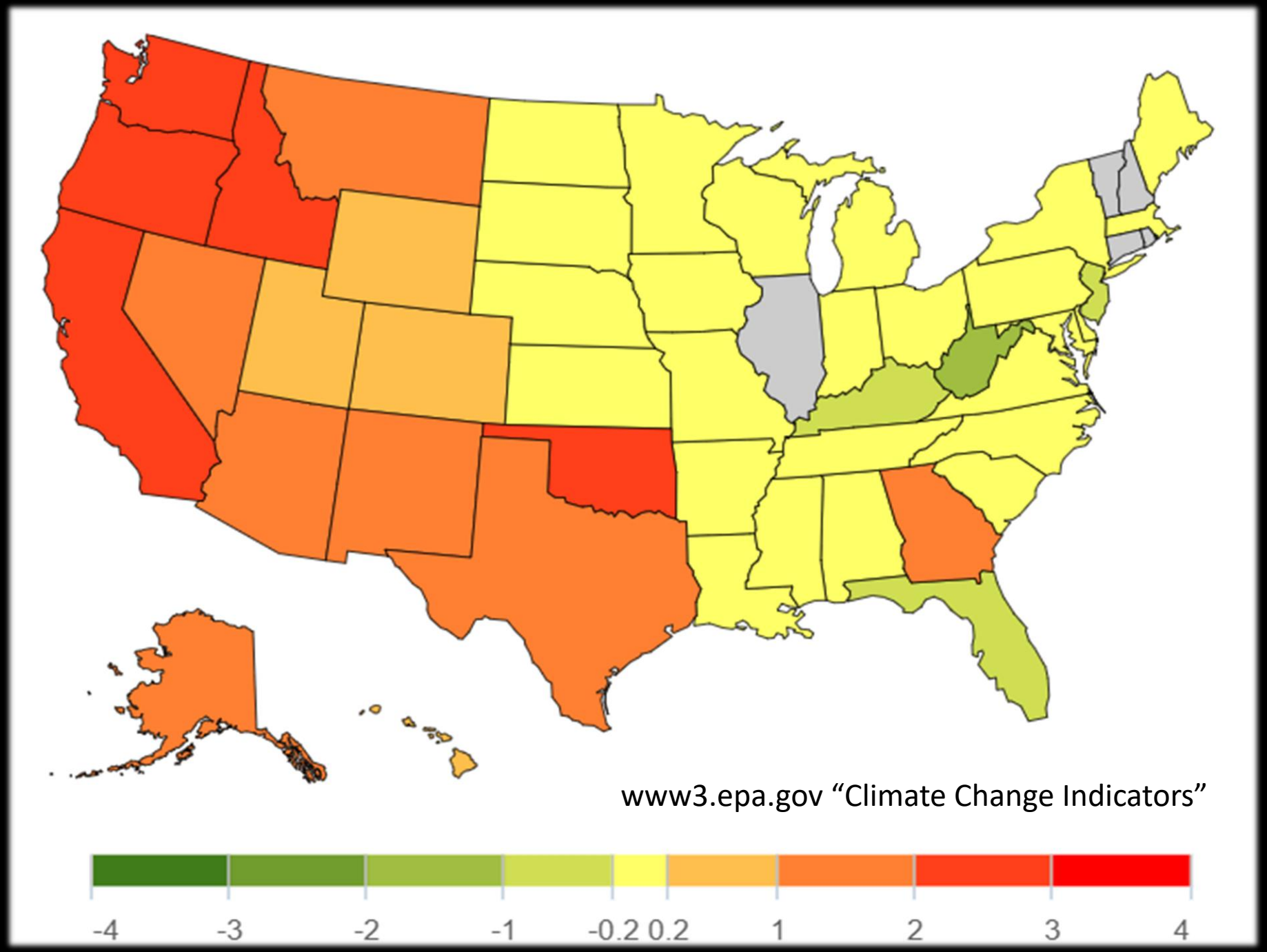
1. Introduction

Wildfires have become a major global concern, and in the United States (US) there are hundreds of thousands to millions of acres burned [1,2]. Consequently, wildland smoke emissions are progressively being recognized as a public health concern, due to large scale wildfire fire events [3]. The increased number of these events are attributed to anthropogenic climate change, including warmer temperatures, early spring melt, and decreased winter precipitation [4]. Lightning and human ignition of excess forest fuels from years of previous fire suppression activity, as well as forest management practices, have contributed to large scale wildland fire events [5]. It has been projected that there will be an ~50% increase in burned areas across the western US between 2009 and 2050 and future predictive models show that this area will continue to see rapidly growing fire activity with increases of 80% burned areas in the Pacific Northwest alone [6,7]. While the western states (Washington, Oregon, Montana, Idaho, California, Wyoming, Nevada, Arizona) shoulder a majority of fires/acres burned (7 million+ in 2017), the Midwest and South had hundreds of thousands of acres of wildfires in 2017. Because of fire location and prevailing wind patterns, western Montana communities in the Northern Rockies are

University of Montana and Missoula County Health Dept. studied prolonged effects of smoke on lung function after community exposure to hazardous levels

- They tracked 95 Seeley Lake residents, age 23 to 85 (average 63), following a July 31 to September 18, 2017 smoke episode with average PM2.5 of 220.9-µg/m3
- Measured lung function starting right after the fire then with follow-ups in 2018 and 2019
- The number of participants that fell below the lower limit of normal function increased from 10.2% in 2017 to 45.9% in 2018, and remained 33.9% decreased two years post-exposure

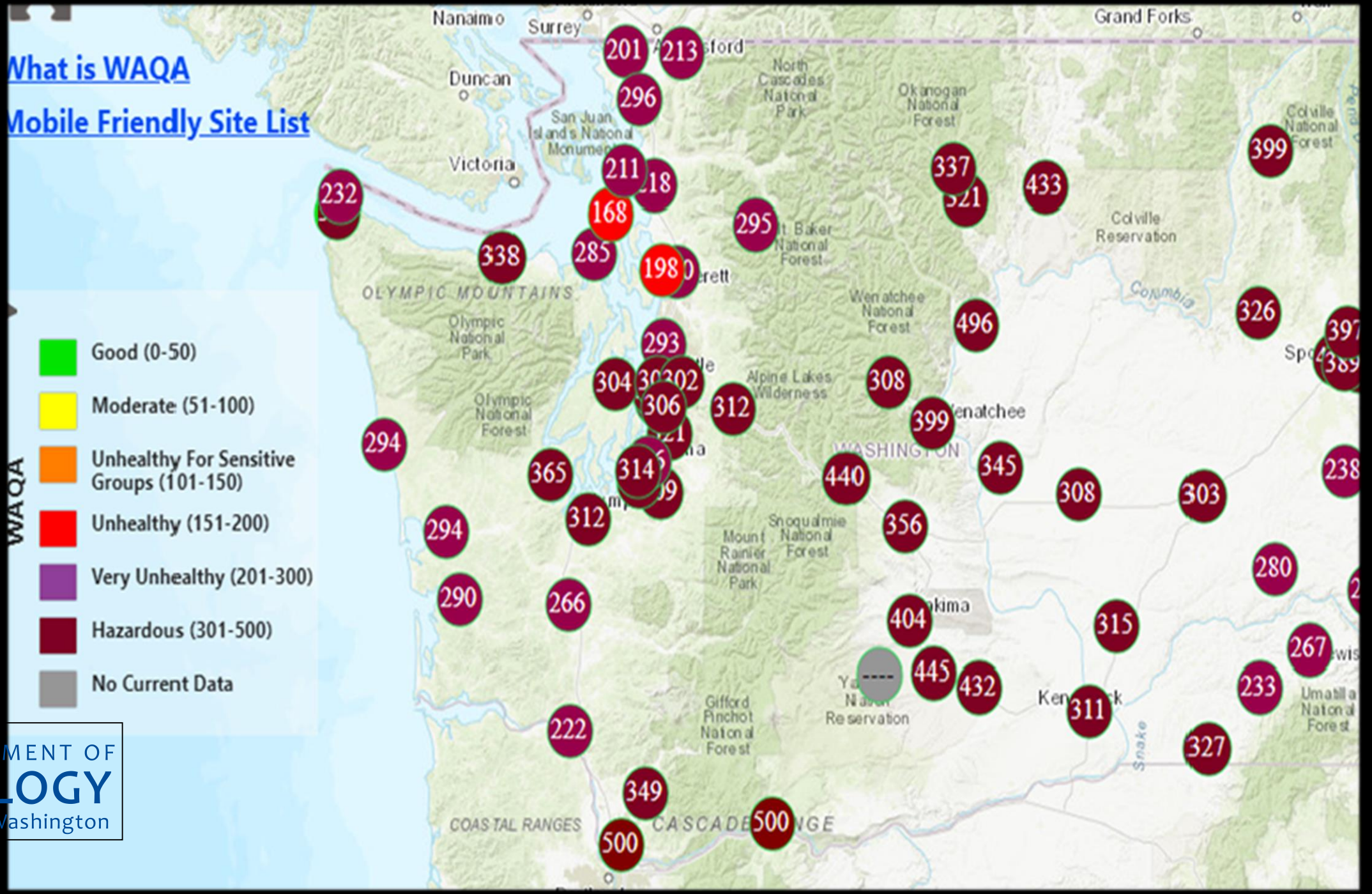
Acres per square mile burned in 2002-2018 relative to 1984-2001



www3.epa.gov “Climate Change Indicators”

2020 wildfire smoke episode

Air quality monitor-ing network



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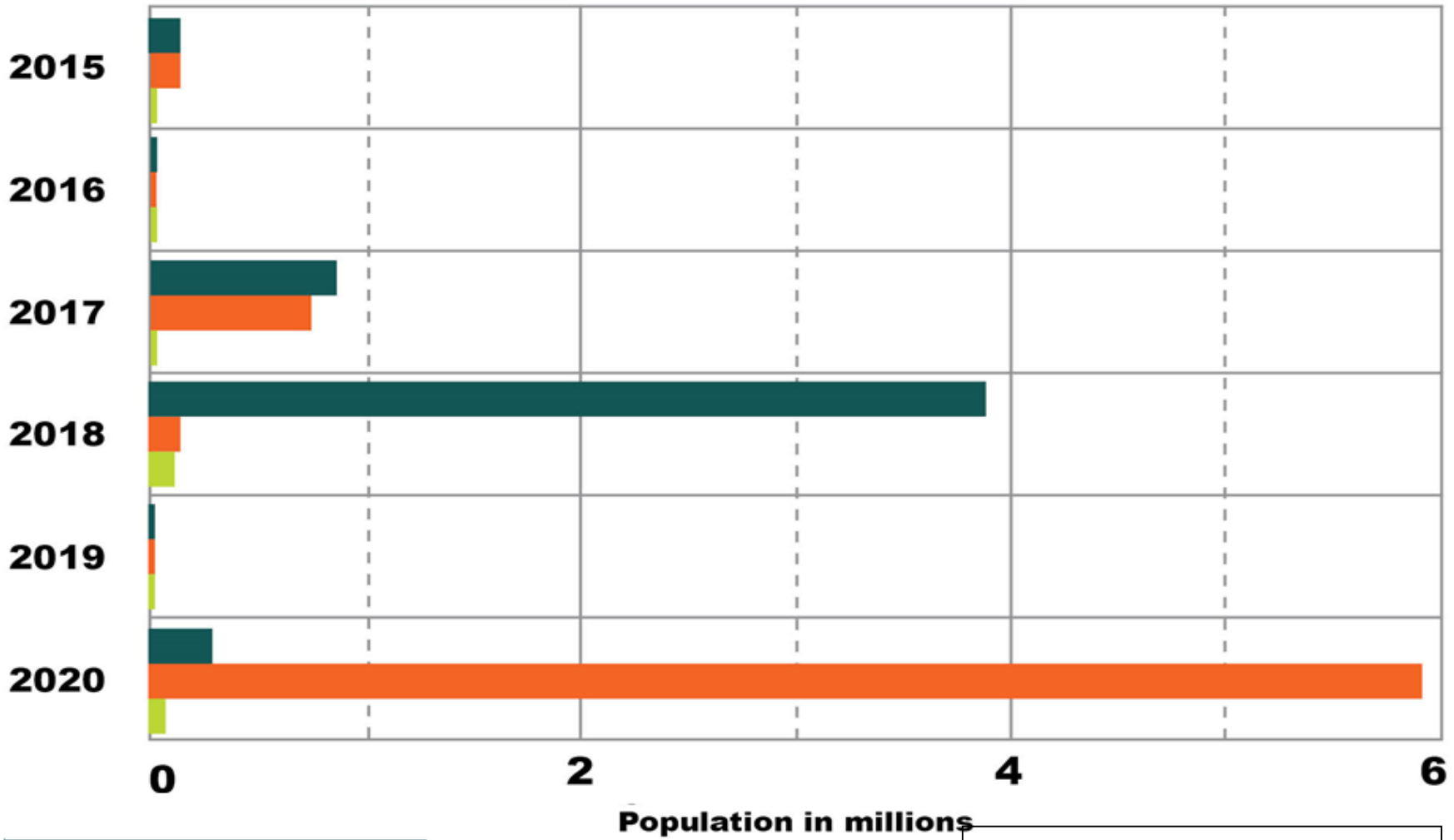
Washingtonians exposed to very unhealthy & worse air quality; June — September



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Conclusions

- Exposure to wildfire $PM_{2.5}$ increases acute respiratory, cardiovascular, and cerebrovascular illnesses and deaths incidences
- Incidences tend to increase on the day of smoke exposure and for some effects one or more days thereafter
- Prolonged adverse effects are evident in some cases
- Current evidence is insufficient to determine if there is a safe level of exposure

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Questions?

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