# Health Impacts of Wildfire Smoke Exposure

Rocky Mountain Section of the Air & Waste Management
July 20, 2021

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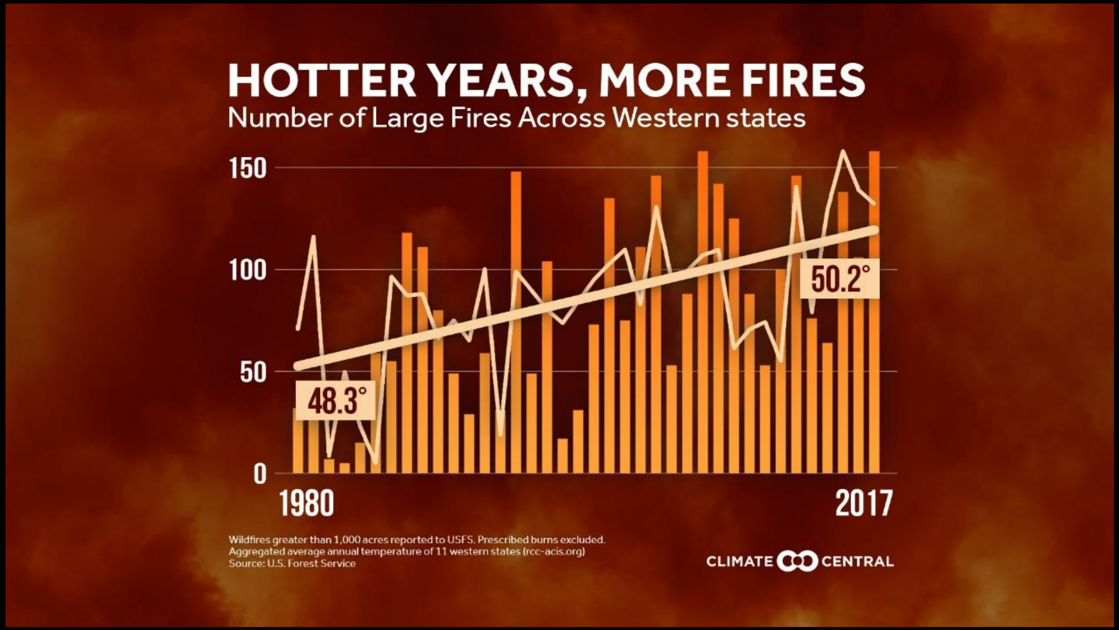
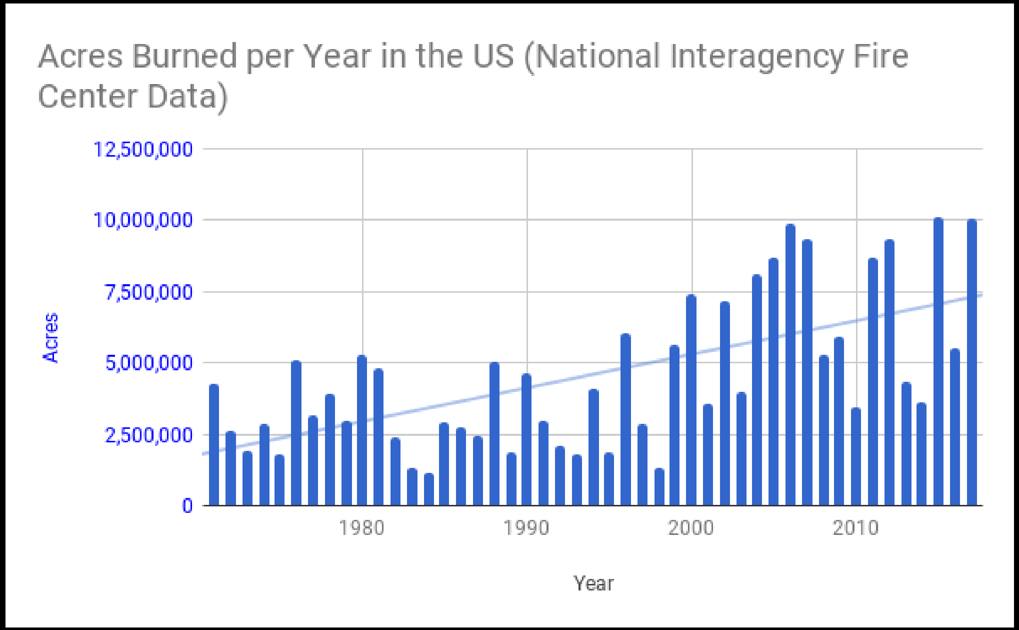
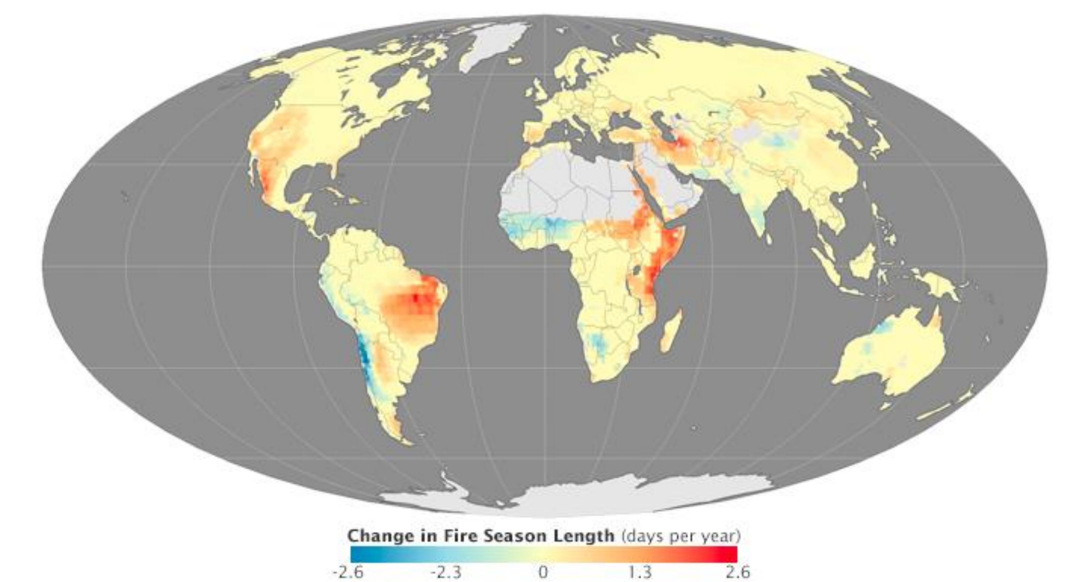



https://www.nifc.gov/fireInfo/fireInfo_stats_totalFires.html




https://earthobservatory.nasa.gov/images/86268/longer-more-frequent-fire-seasons

SCIENCE

# California Wildfires Killed 106 People Two Years Ago. Researchers Say the Smoke Killed 3,652

By Danielle Venton Dec 11, 2020 Save Article

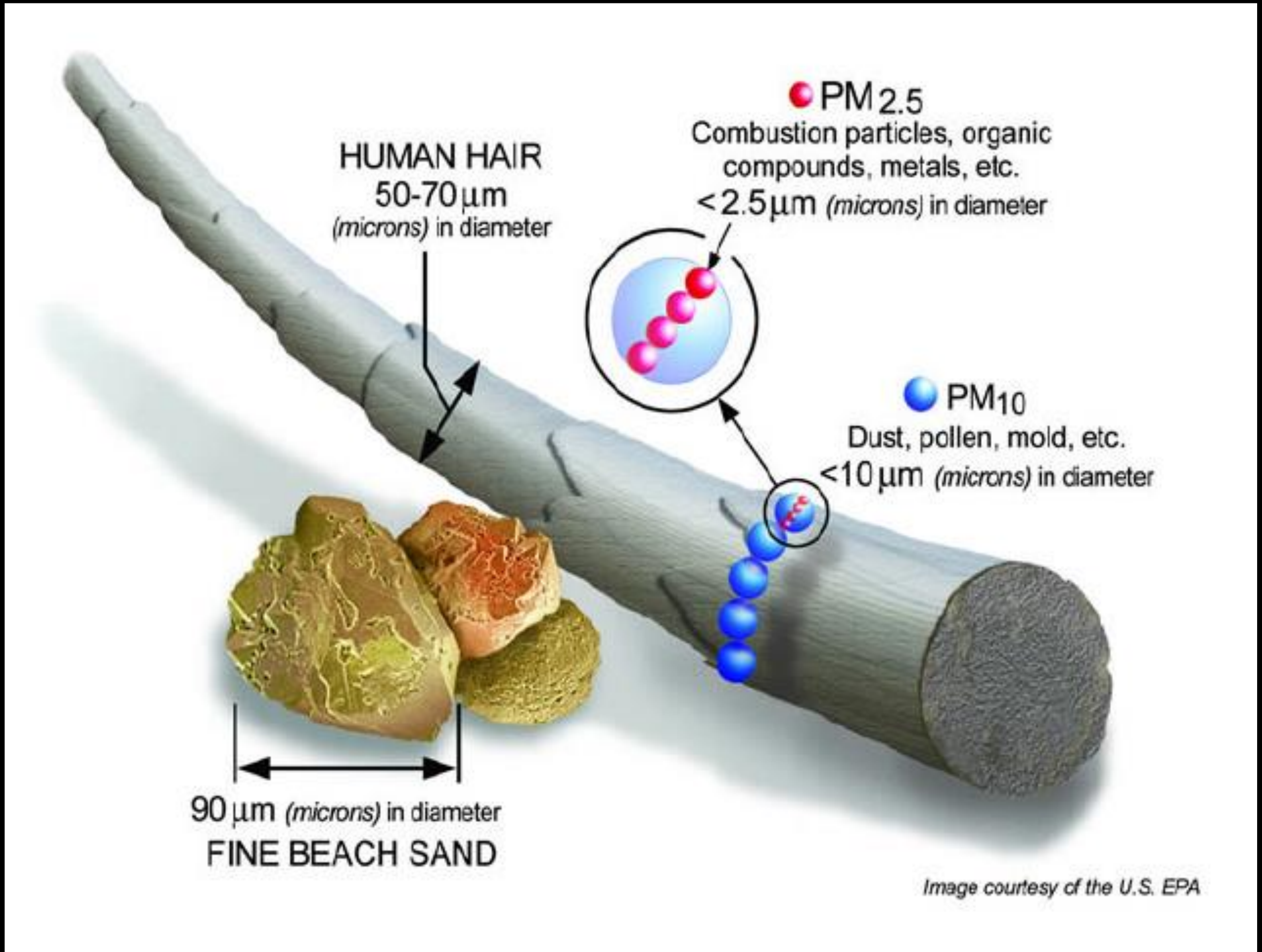
# Emissions from Wildfires with Health Concerns

<u>Primary air pollutants</u>

- CO
- $NO_2$
- PAHs – polycyclic aromatic hydrocarbons
- VOCs – volatile organic compounds
- Particulate Matter (PM)

<u>Secondary air pollutants</u>

- Particulate Matter (PM)
- Ozone



# Why wildfires?

- Globally and regionally, wildfire risk is projected to increase under various potential future climate scenarios.
- The percent of our air pollution due to wildfires will likely increase, not just from climatic changes, but also because of declines in other sources of air pollution

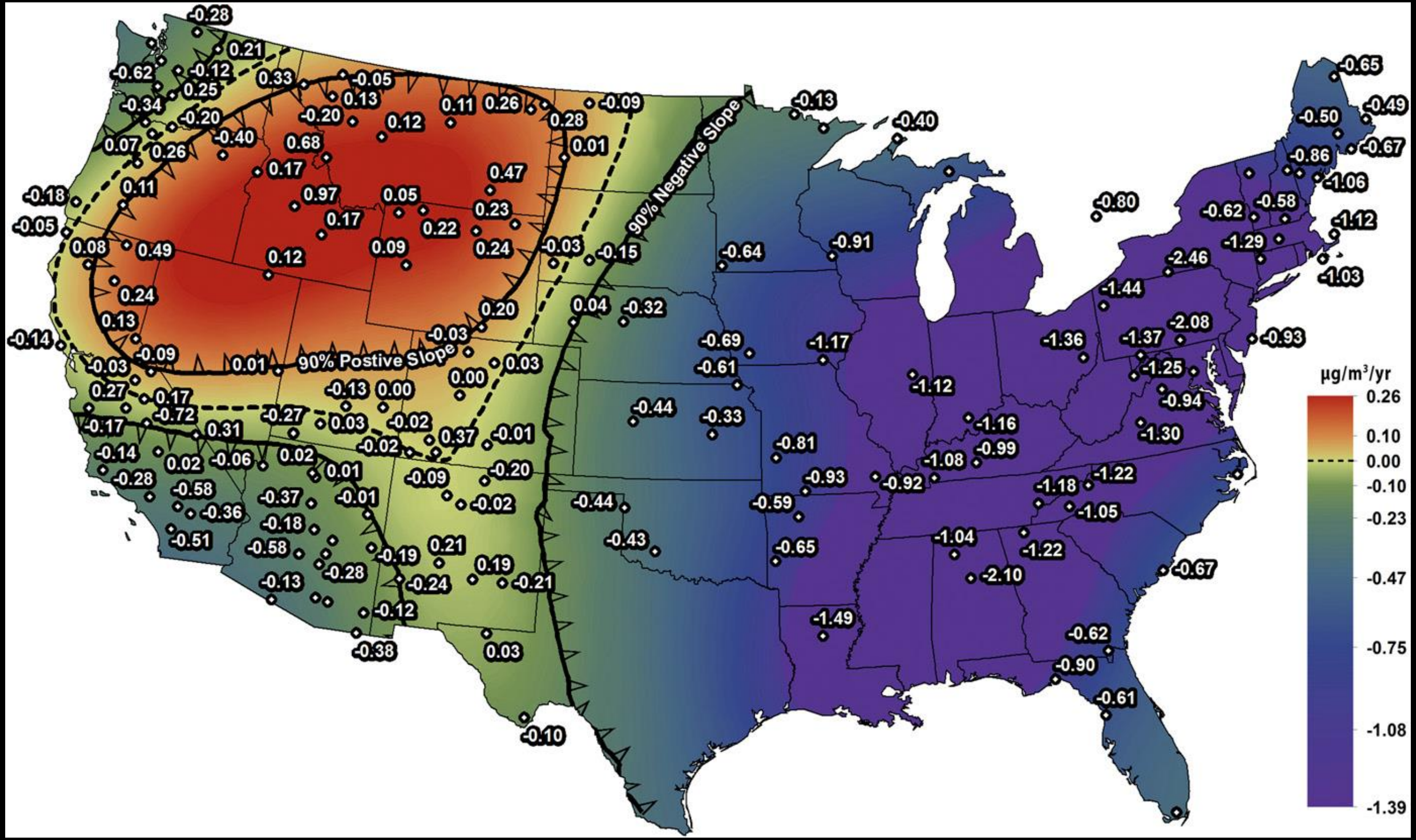
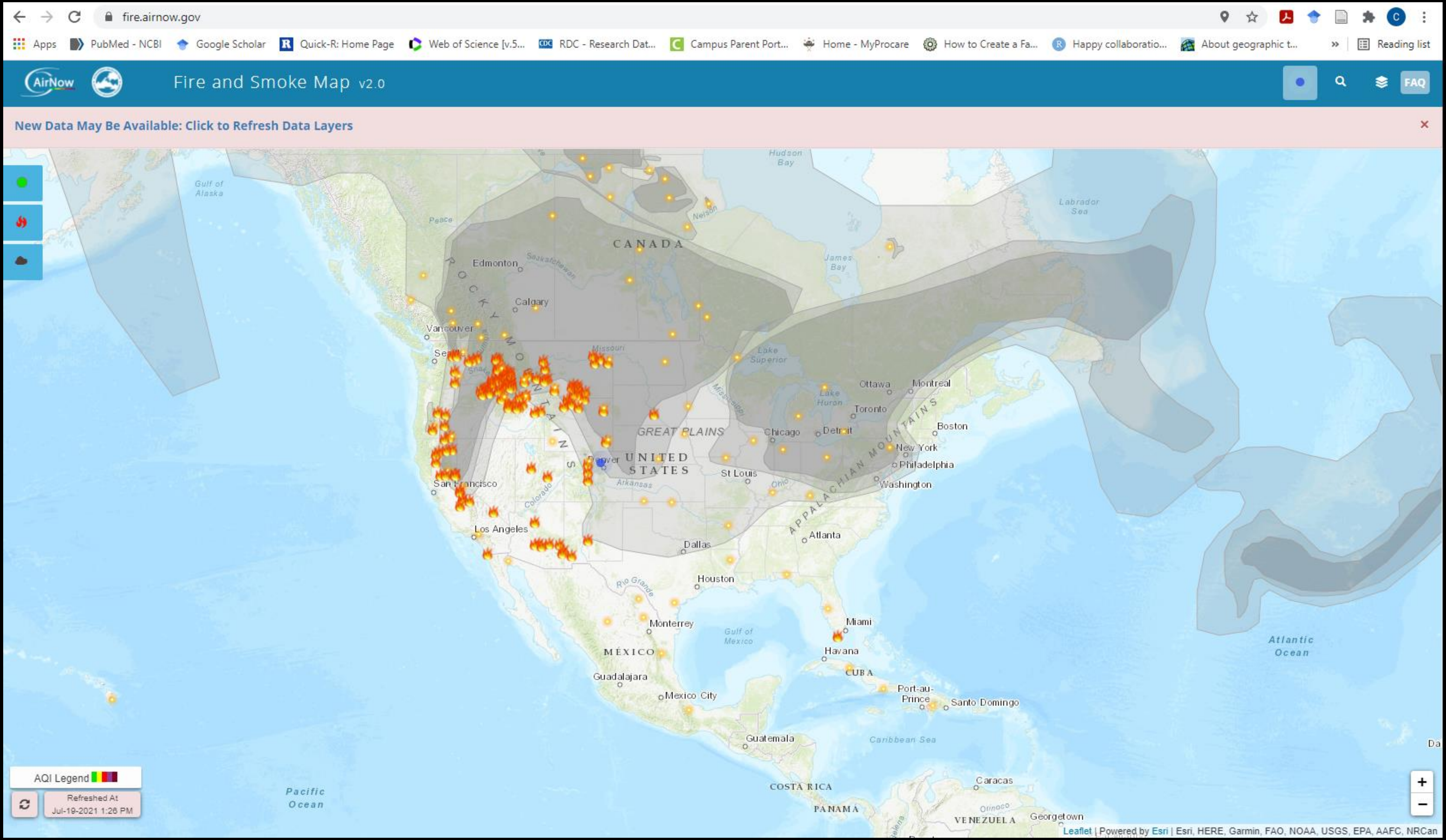



Image: McClure and Jaffe, 2018. www.pnas.org/cgi/doi/10.1073/pnas.1804353115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Fire and Smoke Map v2.0
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Labrador Sea
CANADA
James Bay
Edmonton
Calgary
Vancouver
ROCKY MOUNTAINS
Lake Superior
Ottawa
Montreal
Lake Huron
Toronto
Boston
GREAT PLAINS
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Santo Domingo
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Atlantic Ocean
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COSTA RICA
Caracas
PANAMA
VENEZUELA
Georgetown
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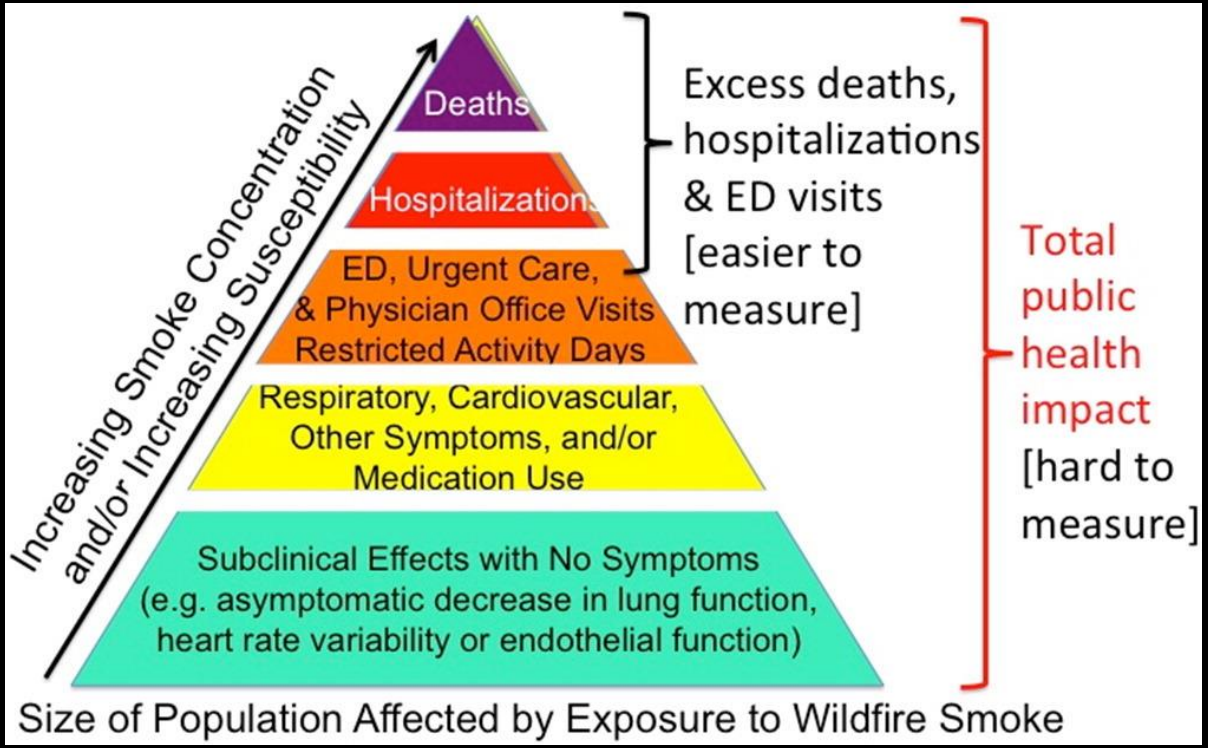
Jul-19-2021 1:26 PM
Leaflet | Powered by Esri | Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, AAFC, NRCan

# Epidemiological Difficulties in Studying Wildfires

- Studies are retrospective
  - → must use administrative health data
- “Tip of the Iceberg”



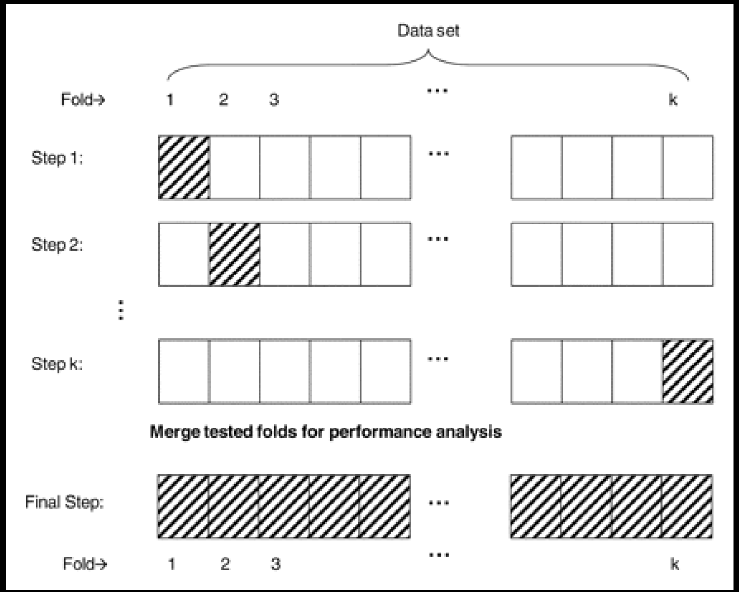

Cascio. (2017). Wildland fire smoke and human health. Science of the Total Environment.

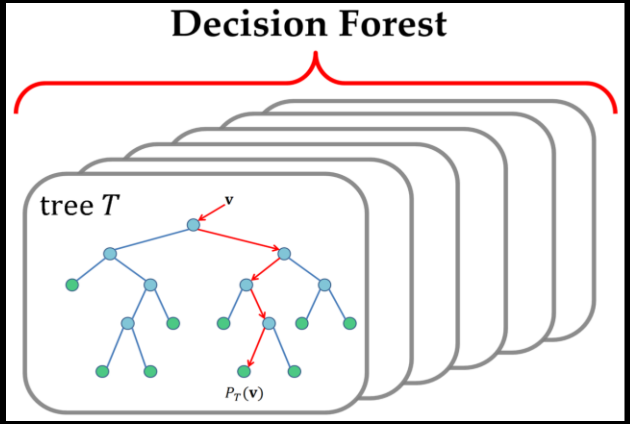
# Exposure Assessment Difficulties with Wildfires

- Monitoring Data
  - Some monitors only measure every third to sixth day
  - Monitors miss a lot of spatial heterogeneity, particularly with fires
- Satellite Data
  - Temporal resolution issues
  - Vertical resolution issues
- Chemical Transport Models
  - Can be inaccurate

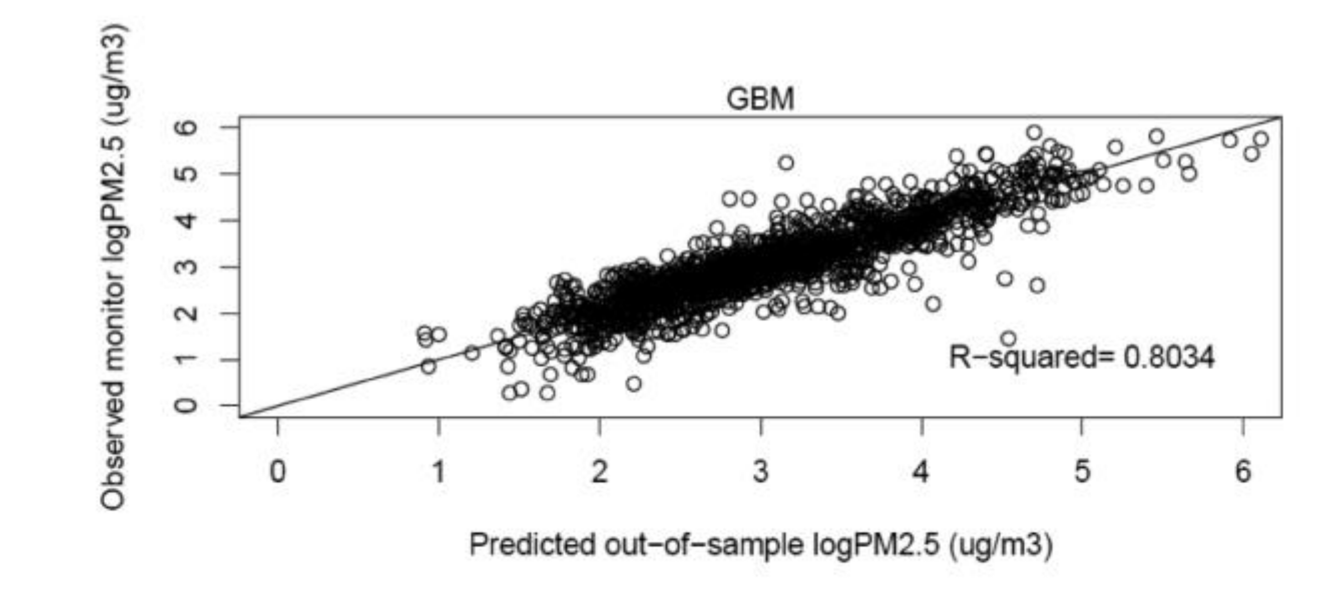
# Exposure Assessment Methods Used in Wildfire Epidemiological Studies

- Blended Models
  - Statistically combine CTMs, satellite data, and monitoring data
  - Sometimes also auxiliary data
- My group uses machine learning to combine many auxiliary data set to create spatiotemporal estimates of air pollution concentrations

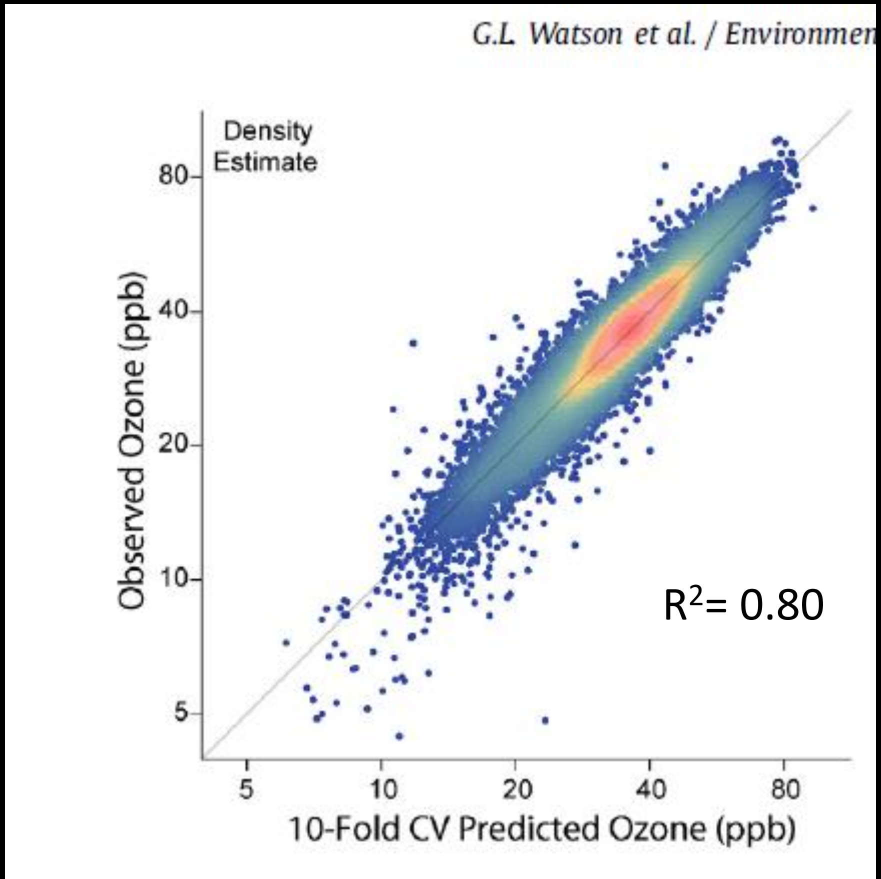


## $PM_{2.5}$ model




## Ozone model




Reid et al. 2015. *Environmental Science & Technology*
Watson et al. 2019 *Environmental Pollution*

# Relative risks of ED visits associated $PM_{2.5}$ and ozone before, during, and after the 2008 northern California wildfires

**Table 5**
Relative risks (and 95% CIs) of ED visits associated with a 10 μg/m$^3$ increase in $PM_{2.5}$ before, during, and after the 2008 northern California wildfires.

| Health outcome | Before fires | During fires | After fires |
|---|---|---|---|
| Combined respiratory | 0.990 (0.953, 1.029) | 1.035 (1.024, 1.045) | 0.985 (0.943, 1.029) |
| Asthma | 1.072 (0.980, 1.172) | 1.115 (1.090, 1.140) | 0.921 (0.845, 1.005) |
| COPD | 0.953 (0.833, 1.091) | 1.054 (1.023, 1.085) | 1.110 (0.999, 1.235) |
| Pneumonia | 0.907 (0.834, 0.988) | 1.010 (0.985, 1.035) | 1.013 (0.925, 1.110) |
| Acute bronchitis | 1.132 (0.980, 1.307) | 1.035 (0.997, 1.074) | 1.066 (0.937, 1.213) |
| Acute respiratory infections | 0.928 (0.870, 0.990) | 0.997 (0.980, 1.015) | 0.952 (0.889, 1.020) |

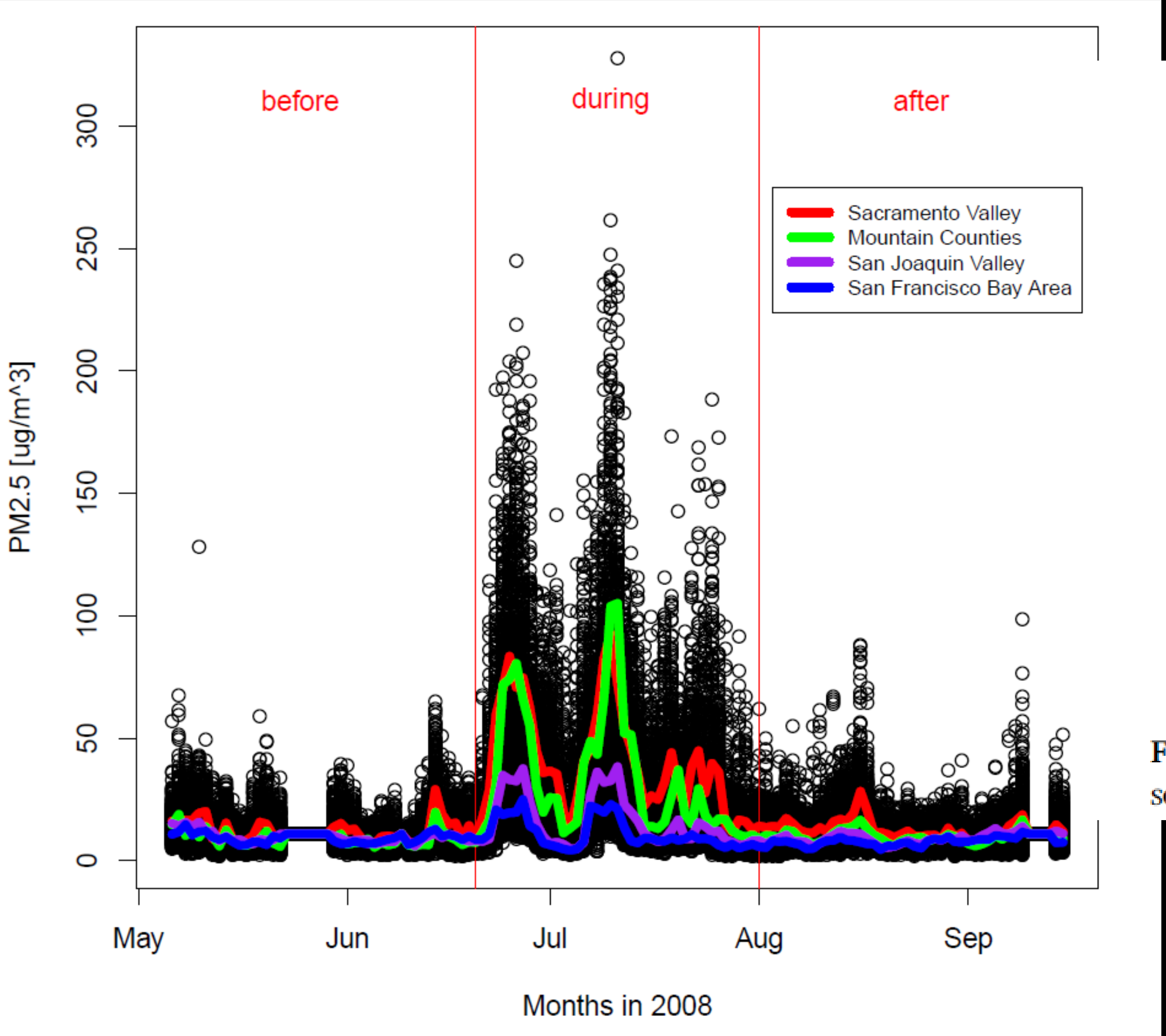
**Table 3**
Relative risks (and 95% CIs) of ED visits associated with a 10 ppb increase in ozone before, during, and after the 2008 northern California wildfires.

| Health outcome | Before fires | During fires | After fires |
|---|---|---|---|
| Combined respiratory | 0.986 (0.968, 1.005) | 1.013 (1.000, 1.027) | 1.046 (1.029, 1.063) |
| Asthma | 0.971 (0.934, 1.008) | 1.050 (1.022, 1.078) | 1.030 (0.997, 1.064) |
| COPD | 0.985 (0.930, 1.043) | 1.031 (0.998, 1.065) | 1.010 (0.964, 1.058) |
| Pneumonia | 0.984 (0.946, 1.023) | 0.992 (0.965, 1.019) | 1.011 (0.975, 1.048) |
| Acute bronchitis | 0.945 (0.878, 1.017) | 1.008 (0.966, 1.052) | 1.006 (0.950, 1.065) |
| Acute respiratory infections | 0.994 (0.962, 1.026) | 0.998 (0.976, 1.020) | 1.083 (1.057, 1.109) |

All models are for the two-day moving average controlling for time trend, day of week, heat index, median income, percent of the population over 65, smoking prevalence, and ozone
Take from paper under revisions at Environment International.

Reid et al. 2019 *Env Int*

# $PM_{2.5}$ and ozone exposure estimates by ZIP code by day for the 2008 northern California wildfires



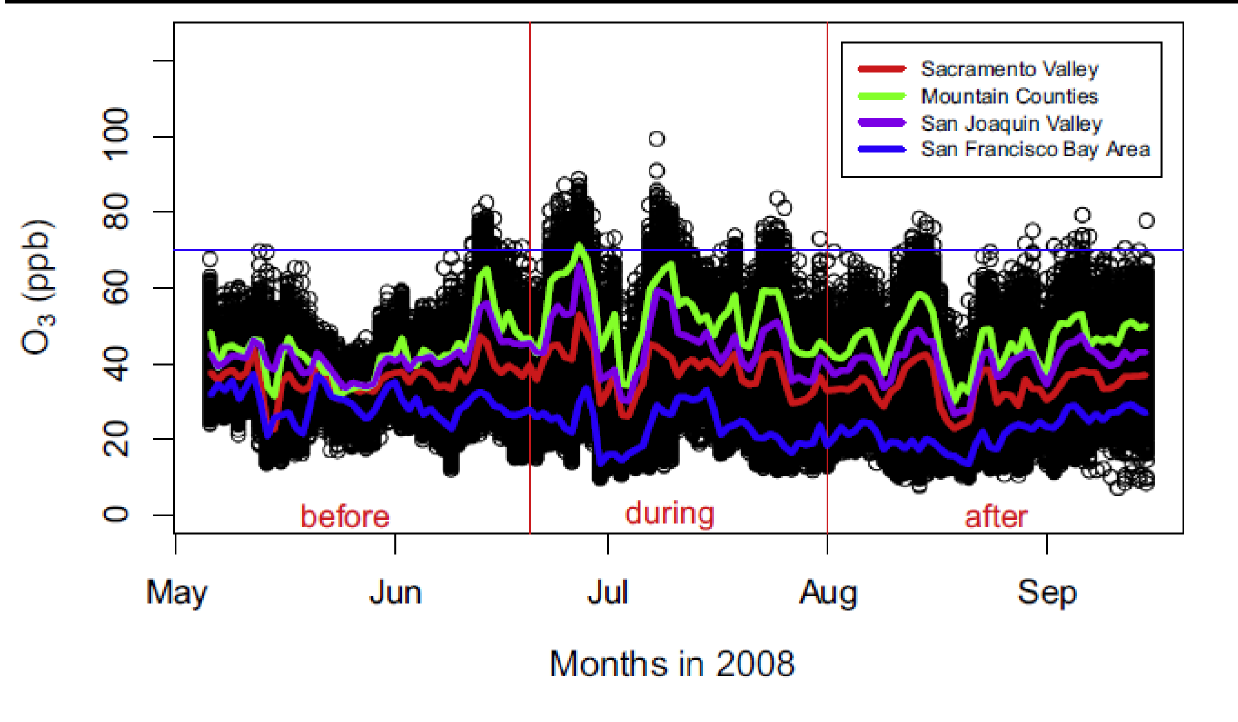




**Fig. 3.** Ozone levels by ZIP-code day during the study period with averages for some air basins.

Reid et al. 2019 *Env Int*

# Effect estimates for association between $PM_{2.5}$ and respiratory **ED visits** modified by SES


All models are for the two-day moving average controlling for time trend, day of week, heat index, median income, percent of the population over 65, smoking prevalence, and ozone
Not yet published.

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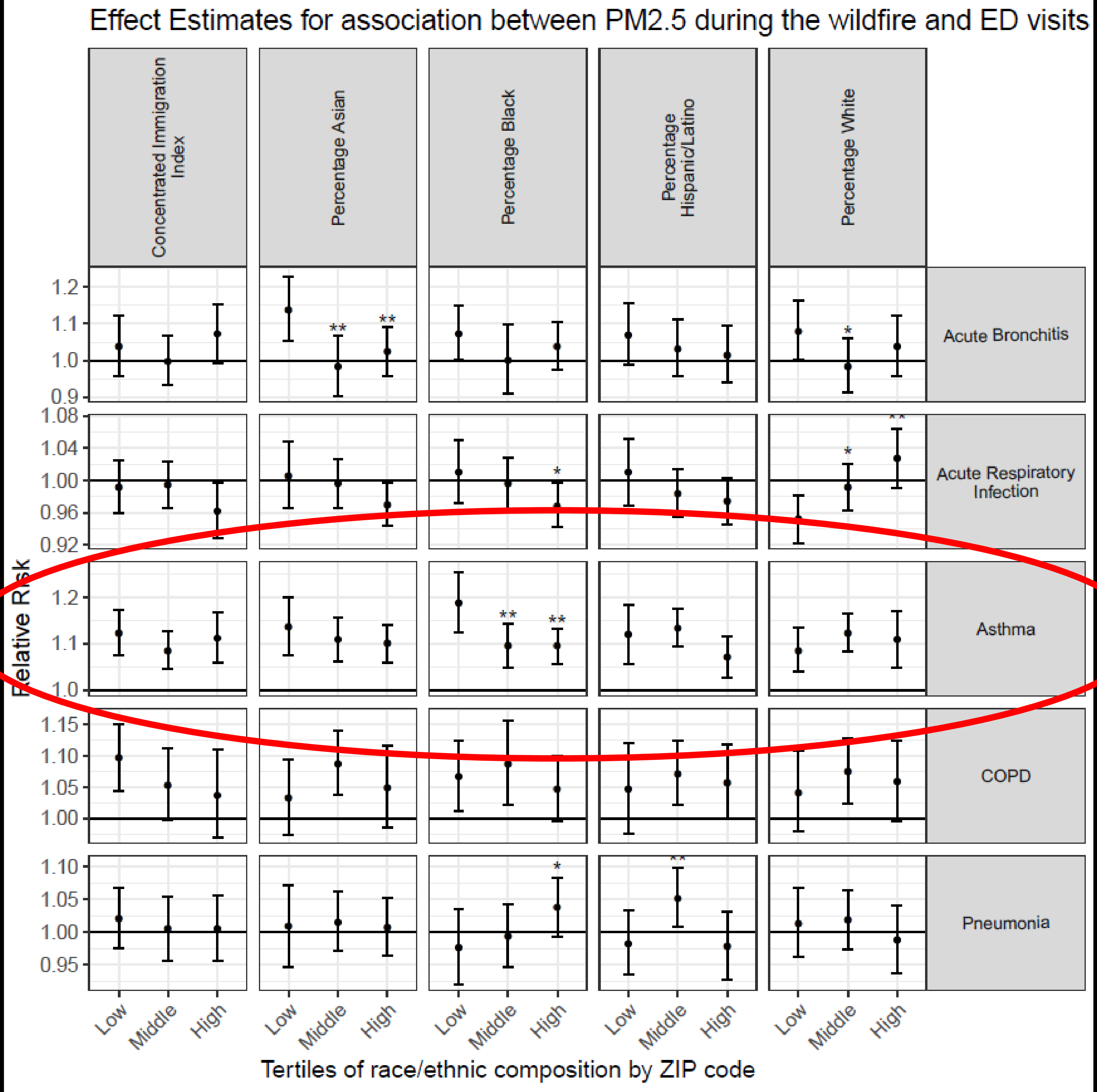
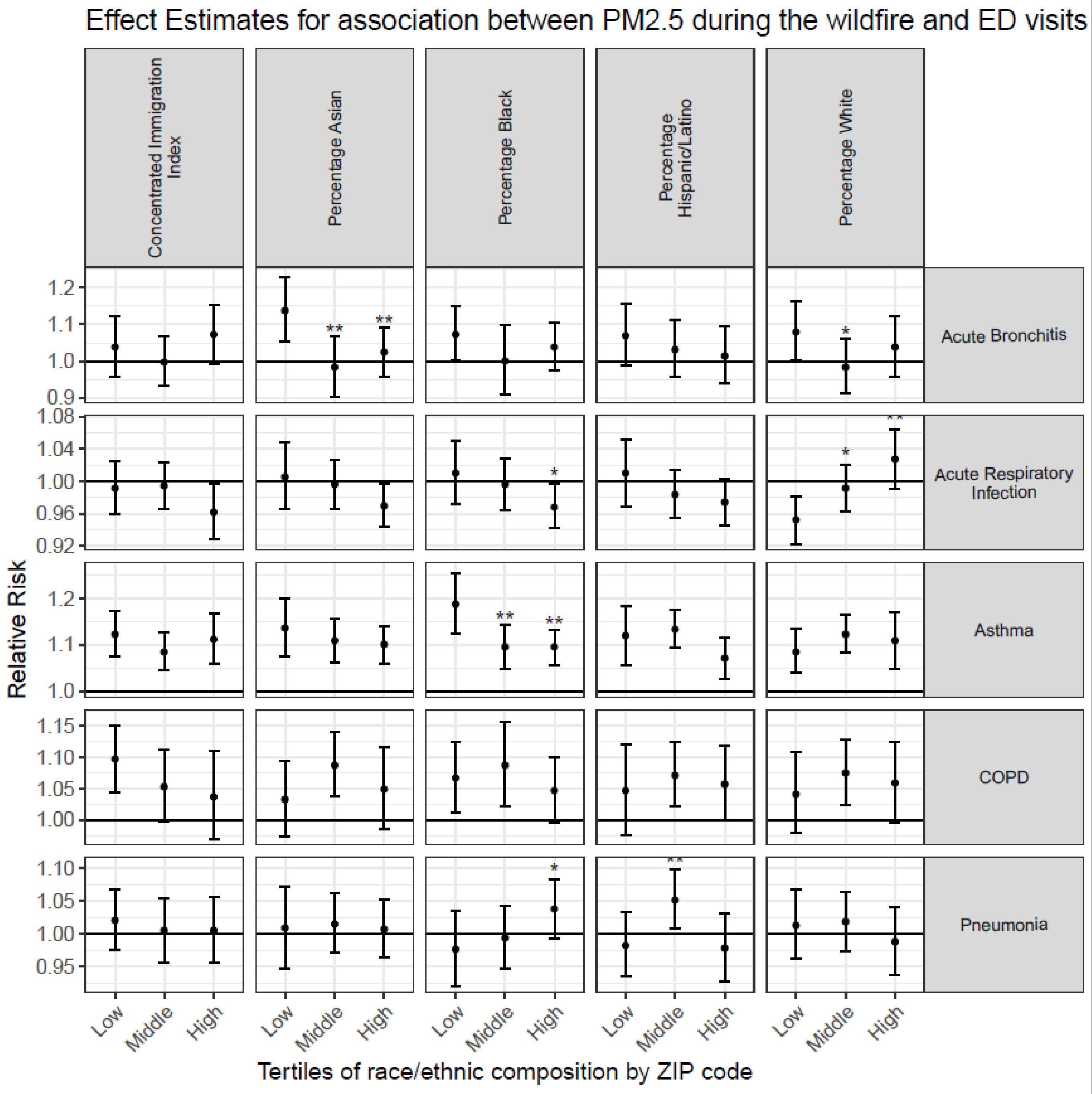



# Effect estimates for association between $PM_{2.5}$ and respiratory **ED visits** modified by racial/ethnic composition

All models are for the two-day moving average controlling for time trend, day of week, heat index, median income, percent of the population over 65, smoking prevalence, and ozone
Not yet published.

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All models are for the two-day moving average controlling for time trend, day of week, heat index, median income, percent of the population over 65, smoking prevalence, and ozone
Not yet published.

# Why are lower SES communities more affected by wildfire smoke?

- In air pollution research from other sources, this is also found
- The differential findings could be due to:
  - Higher exposure to air pollution in lower SES communities
  - The role of the social determinants of health interacting with the environmental determinants of health
  - Or a combination of the two

- With wildfires, though, we wouldn't expect that the patterning of exposure to match the patterning of SES…

# Fires effect on birth weight

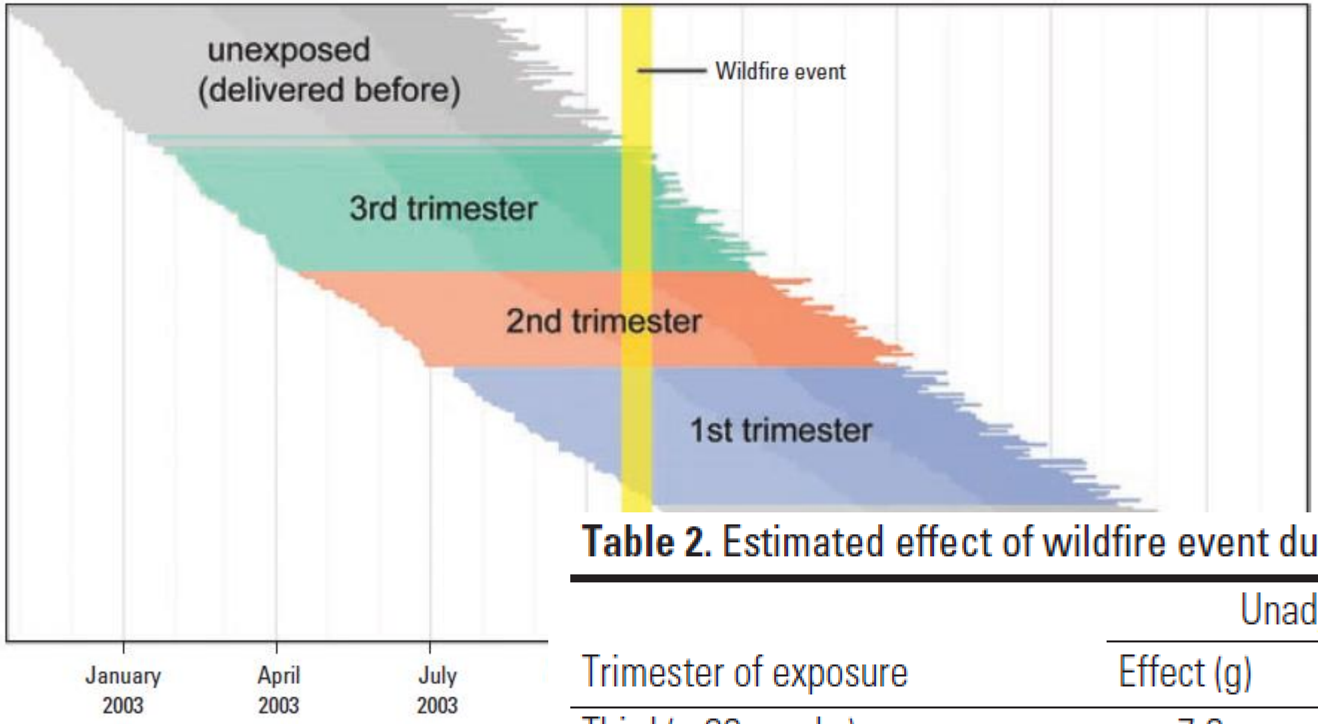


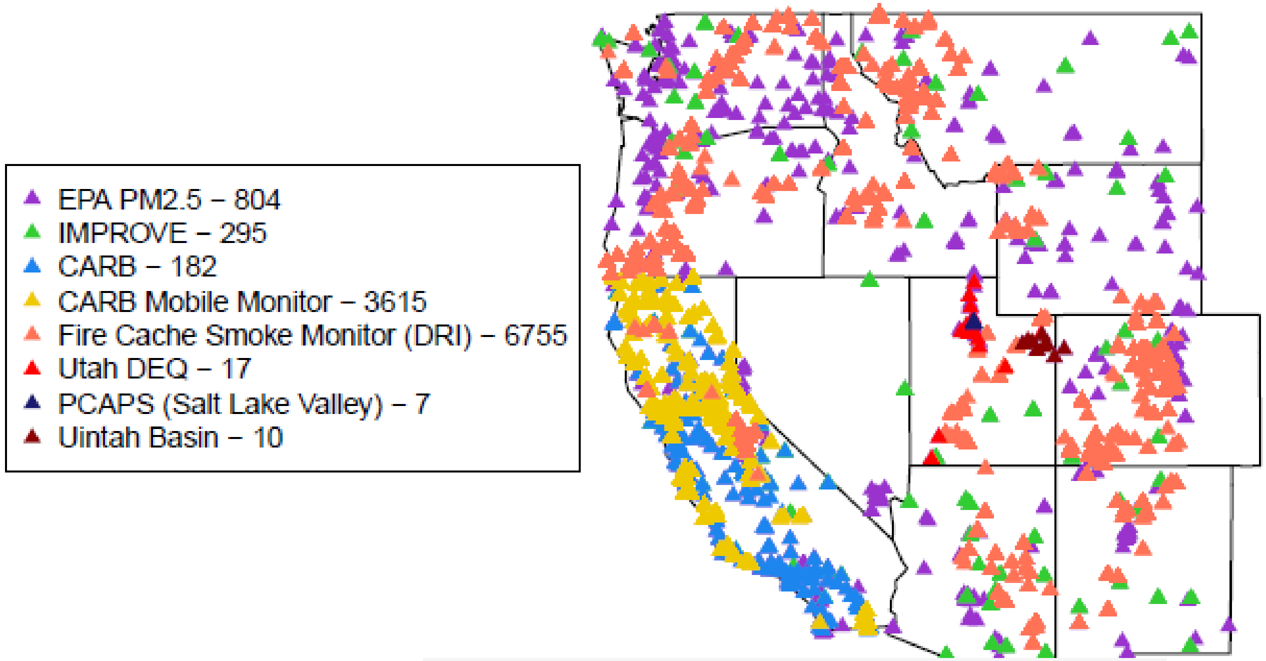

**Figure 2.** Schematic illustrating exposure as
lap between the wildfire event (yellow) an
clarity, gestational intervals are shown orde
from 2002–2004 is shown. Dates on the *x*-ax
seasonality.

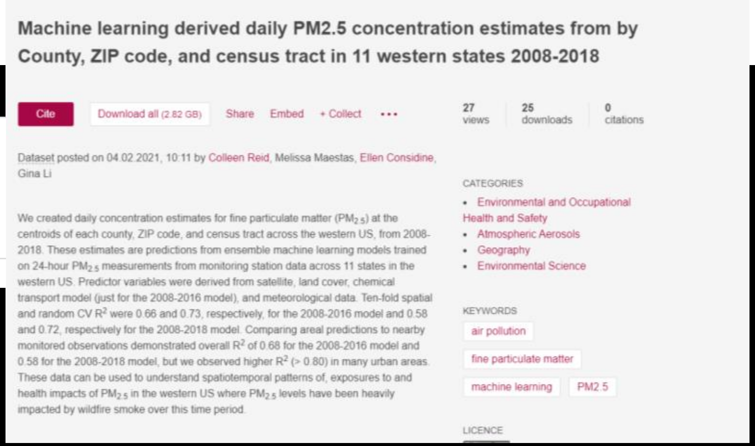
**Table 2.** Estimated effect of wildfire event during gestation on birth weight (g), by trimester.

| | Unadjusted model | | Adjusted model | |
|---|---|---|---|---|
| Trimester of exposure | Effect (g) | 95% CI | Effect (g) | 95% CI |
| Third (≥ 29 weeks) | –7.9 | (–12.8, –3.1) | –7.0 | (–11.8, –2.2) |
| Second (17–28 weeks) | –17.1 | (–21.9, –12.3) | –9.7 | (–14.5, –4.8) |
| First (1–16 weeks) | –3.9 | (–7.8, 0.0) | –3.3 | (–7.2, 0.6) |
| Any trimester | –8.8 | (–11.5, –6.1) | –6.1 | (–8.7, –3.5) |

Adjusted model includes terms for fetal sex, gestational age, parity, maternal age, maternal education, maternal race/ethnicity, secular trend, and season.

Holstius et al. 2012 *EHP*



**Machine learning derived daily PM2.5 concentration estimates from by County, ZIP code, and census tract in 11 western states 2008-2018**

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27 views | 25 downloads | 0 citations

Dataset posted on 04.02.2021, 10:11 by Colleen Reid, Melissa Maestas, Ellen Considine, Gina Li

We created daily concentration estimates for fine particulate matter ($PM_{2.5}$) at the centroids of each county, ZIP code, and census tract across the western US, from 2008-2018. These estimates are predictions from ensemble machine learning models trained on 24-hour $PM_{2.5}$ measurements from monitoring station data across 11 states in the western US. Predictor variables were derived from satellite, land cover, chemical transport model (just for the 2008-2016 model), and meteorological data. Ten-fold spatial and random CV $R^2$ were 0.66 and 0.73, respectively, for the 2008-2016 model and 0.58 and 0.72, respectively for the 2008-2018 model. Comparing areal predictions to nearby monitored observations demonstrated overall $R^2$ of 0.68 for the 2008-2016 model and 0.58 for the 2008-2018 model, but we observed higher $R^2$ (> 0.80) in many urban areas. These data can be used to understand spatiotemporal patterns of, exposures to and health impacts of $PM_{2.5}$ in the western US where $PM_{2.5}$ levels have been heavily impacted by wildfire smoke over this time period.

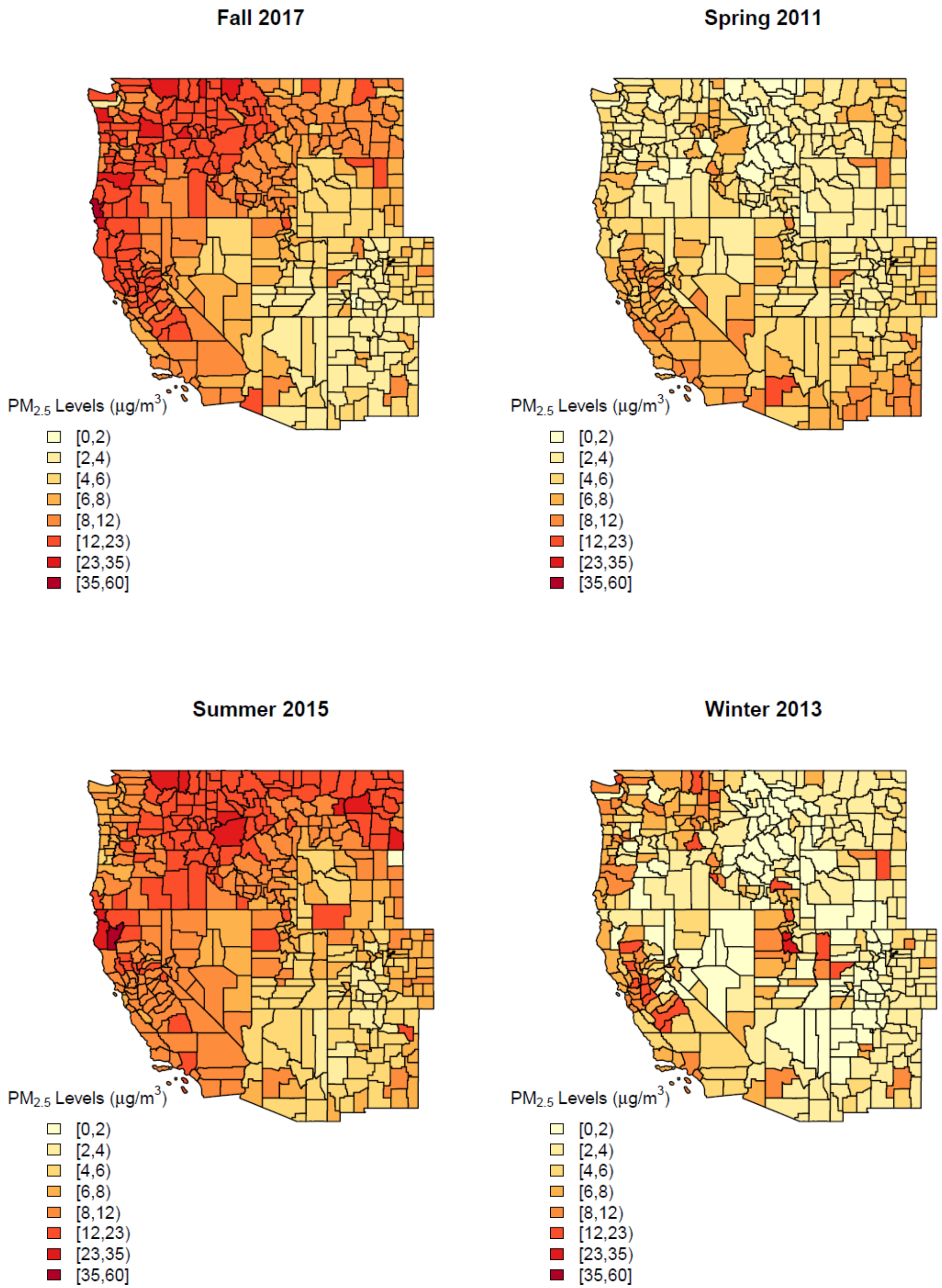
CATEGORIES

- Environmental and Occupational Health and Safety
- Atmospheric Aerosols
- Geography
- Environmental Science

KEYWORDS

air pollution | fine particulate matter | machine learning | PM2.5

LICENCE




figshare

Reid et al. (2021) Scientific Data.

# Thank You!!

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