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Assessing the Impact of Changing Drought Conditions on Wildfire Emissions in Washington and Oregon

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altREU 2021
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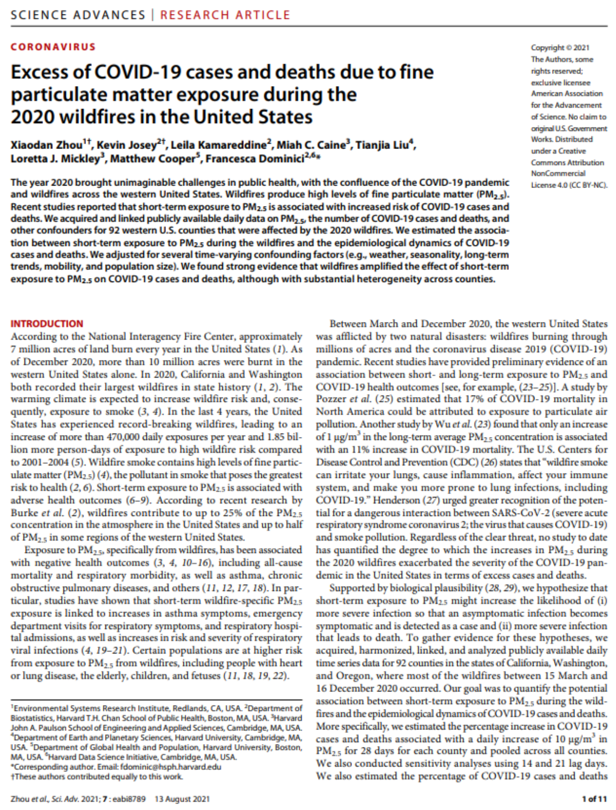
Why study wildfire emissions?

"Studies have shown that short-term wildfire-specific PM2.5 exposure is linked to increases in:

- asthma symptoms
- emergency department visits for respiratory symptoms
- respiratory hospital admissions
- increases in risk and severity of respiratory viral infections. " (Zhou et al, 2021)



SCIENCE ADVANCES | RESEARCH ARTICLE

CORONAVIRUS

Excess of COVID-19 cases and deaths due to fine particulate matter exposure during the 2020 wildfires in the United States

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The year 2020 brought unimaginable challenges in public health, with the confluence of the COVID-19 pandemic and wildfires across the western United States. Wildfires produce high levels of fine particulate matter ($PM_{2.5}$). Recent studies reported that short-term exposure to $PM_{2.5}$ is associated with increased risk of COVID-19 cases and deaths. We acquired and linked publicly available daily data on $PM_{2.5}$, the number of COVID-19 cases and deaths, and other confounders for 92 western U.S. counties that were affected by the 2020 wildfires. We estimated the association between short-term exposure to $PM_{2.5}$ during the wildfires and the epidemiological dynamics of COVID-19 cases and deaths. We adjusted for several time-varying confounding factors (e.g., weather, seasonality, long-term trends, mobility, and population size). We found strong evidence that wildfires amplified the effect of short-term exposure to $PM_{2.5}$ on COVID-19 cases and deaths, although with substantial heterogeneity across counties.

INTRODUCTION

According to the National Interagency Fire Center, approximately 7 million acres of land burn every year in the United States (*1*). As of December 2020, more than 10 million acres were burnt in the western United States alone. In 2020, California and Washington both recorded their largest wildfires in state history (*1*, *2*). The warming climate is expected to increase wildfire risk and, consequently, exposure to smoke (*3*, *4*). In the last 4 years, the United States has experienced record-breaking wildfires, leading to an increase of more than 470,000 daily exposures per year and 1.85 billion more person-days of exposure to high wildfire risk compared to 2001–2004 (*5*). Wildfire smoke contains high levels of fine particulate matter ($PM_{2.5}$) (*4*), the pollutant in smoke that poses the greatest risk to health (*2*, *6*). Short-term exposure to $PM_{2.5}$ is associated with adverse health outcomes (*6*–*9*). According to recent research by Burke *et al.* (*2*), wildfires contribute to up to 25% of the $PM_{2.5}$ concentration in the atmosphere in the United States and up to half of $PM_{2.5}$ in some regions of the western United States.

Exposure to $PM_{2.5}$, specifically from wildfires, has been associated with negative health outcomes (*3*, *4*, *10*–*16*), including all-cause mortality and respiratory morbidity, as well as asthma, chronic obstructive pulmonary diseases, and others (*11*, *12*, *17*, *18*). In particular, studies have shown that short-term wildfire-specific $PM_{2.5}$ exposure is linked to increases in asthma symptoms, emergency department visits for respiratory symptoms, and respiratory hospital admissions, as well as increases in risk and severity of respiratory viral infections (*4*, *19*–*21*). Certain populations are at higher risk from exposure to $PM_{2.5}$ from wildfires, including people with heart or lung disease, the elderly, children, and fetuses (*11*, *18*, *19*, *22*).

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Between March and December 2020, the western United States was afflicted by two natural disasters: wildfires burning through millions of acres and the coronavirus disease 2019 (COVID-19) pandemic. Recent studies have provided preliminary evidence of an association between short- and long-term exposure to $PM_{2.5}$ and COVID-19 health outcomes [see, for example, (*23*–*25*)]. A study by Pozzer *et al.* (*25*) estimated that 17% of COVID-19 mortality in North America could be attributed to exposure to particulate air pollution. Another study by Wu *et al.* (*23*) found that only an increase of 1 $\mu g/m^3$ in the long-term average $PM_{2.5}$ concentration is associated with an 11% increase in COVID-19 mortality. The U.S. Centers for Disease Control and Prevention (CDC) (*26*) states that "wildfire smoke can irritate your lungs, cause inflammation, affect your immune system, and make you more prone to lung infections, including COVID-19." Henderson (*27*) urged greater recognition of the potential for a dangerous interaction between SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2; the virus that causes COVID-19) and smoke pollution. Regardless of the clear threat, no study to date has quantified the degree to which the increases in $PM_{2.5}$ during the 2020 wildfires exacerbated the severity of the COVID-19 pandemic in the United States in terms of excess cases and deaths.

Supported by biological plausibility (*28*, *29*), we hypothesize that short-term exposure to $PM_{2.5}$ might increase the likelihood of (i) more severe infection so that an asymptomatic infection becomes symptomatic and is detected as a case and (ii) more severe infection that leads to death. To gather evidence for these hypotheses, we acquired, harmonized, linked, and analyzed publicly available daily time series data for 92 counties in the states of California, Washington, and Oregon, where most of the wildfires between 15 March and 16 December 2020 occurred. Our goal was to quantify the potential association between short-term exposure to $PM_{2.5}$ during the wildfires and the epidemiological dynamics of COVID-19 cases and deaths. More specifically, we estimated the percentage increase in COVID-19 cases and deaths associated with a daily increase of 10 $\mu g/m^3$ in $PM_{2.5}$ for 28 days for each county and pooled across all counties. We also conducted sensitivity analyses using 14 and 21 lag days. We also estimated the percentage of COVID-19 cases and deaths

Zhou et al., Sci. Adv. 2021; 7 : eabi8789 13 August 2021

Limitations of Current Research

Many aspects of wildfire are currently studied

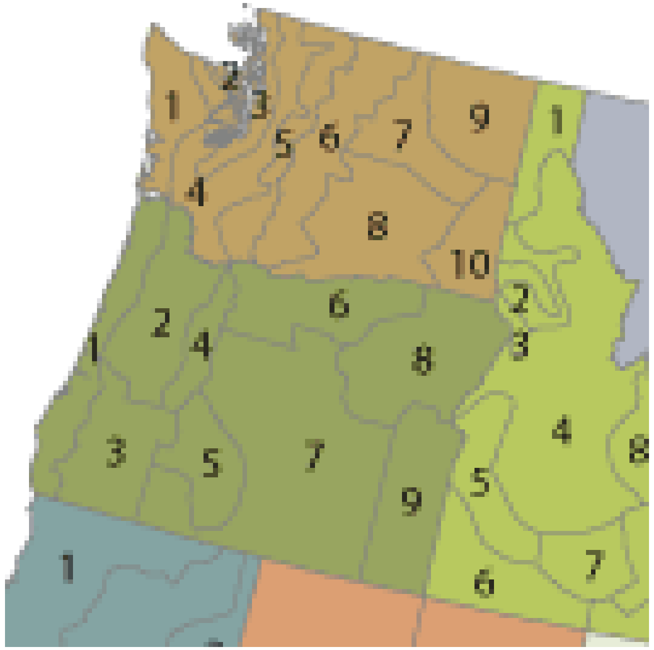
- Ignition source
- Burn area
- Temperature, RH
- Wildfire season duration
- West vs S.E.
- Health impacts
- Historical relationships

Research is needed to better understand the effects of various biophysical characteristics on past and future trends in wildland fire, *including human land use and ignitions, insect outbreaks, invasive species, and* ***climate change*** *(including increasing temperatures, drought, and other factors). The respective roles of these factors will* ***vary regionally****, so data will be needed at a variety of spatial scales.* ***Long-term monitoring and frequent reevaluation will be needed to refine quantitative relationships*** *as the climate continues to warm.*

D.A. Jaffe et al., "Wildfire and prescribed burning impacts on air quality in the United States" (2020)

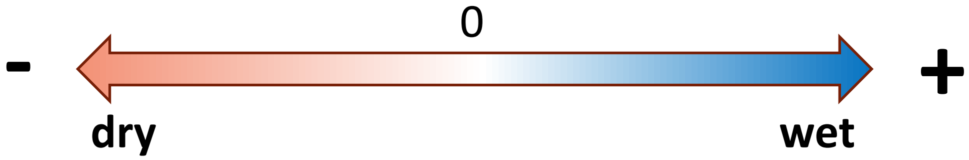
Methods

- Limit area of study to WA and OR
- Emission data from FINN – Fire INventory of NCAR
  - Satellite observations of active fires / vegetation
  - Model estimates emissions from each fire down to 1km resolution



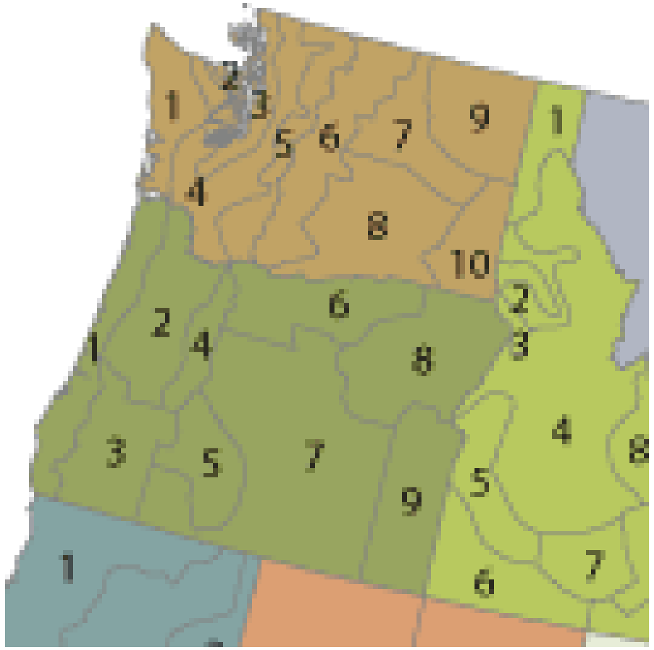
https://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-divisions.php

- PMDI – Modified Palmer Drought Index
  - Modification of the Palmer Drought Severity Index
  - Water balance based on precipitation and temperature



Methods

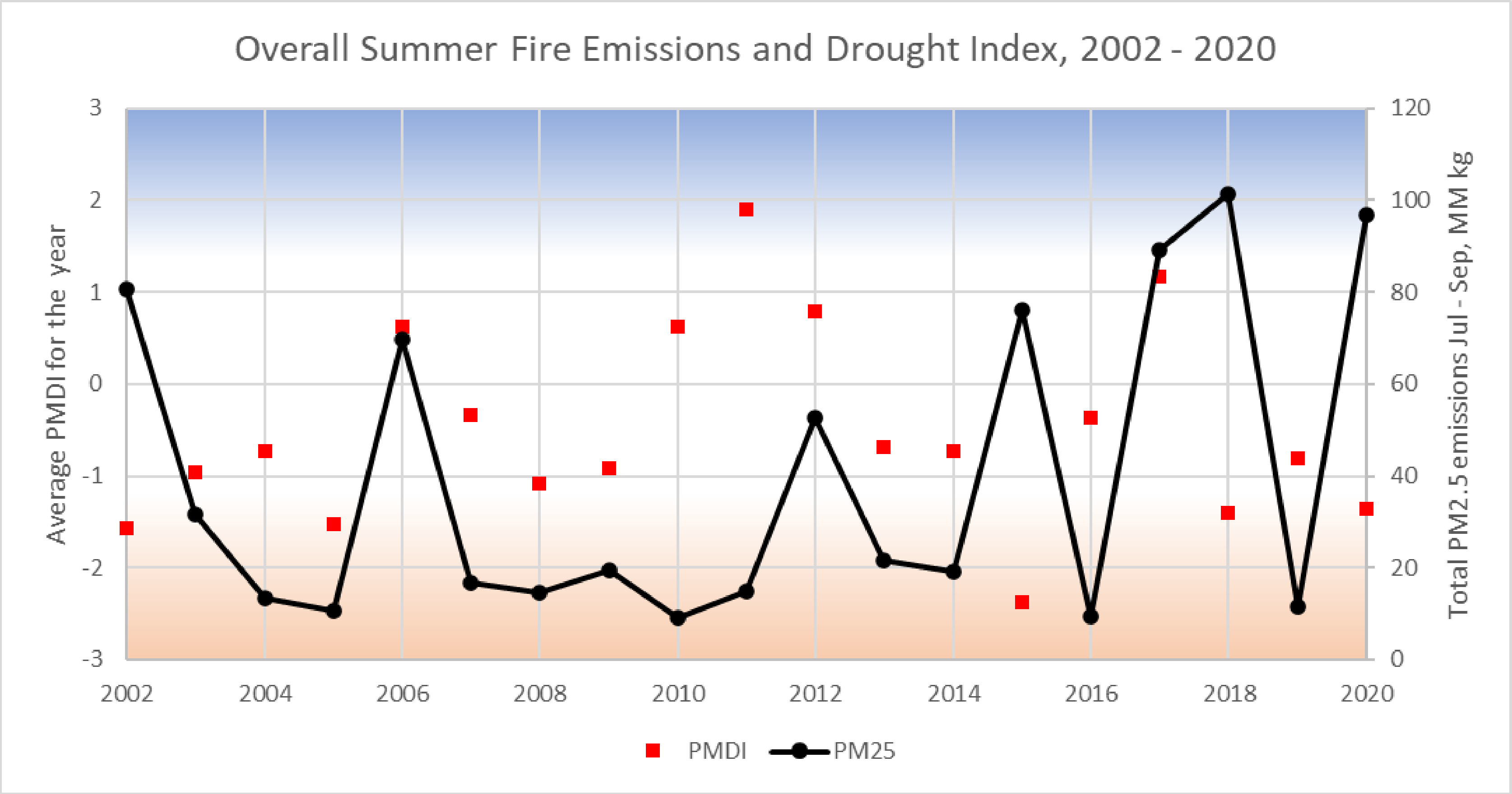
- Aggregated data by:
  - Year
  - Recent vs. long-term drought
  - Vegetation type
    - Forests (4 and 6)
    - Shrublands (2)
    - Grasslands (1)
  - Latitude (proxy to normalize by area)



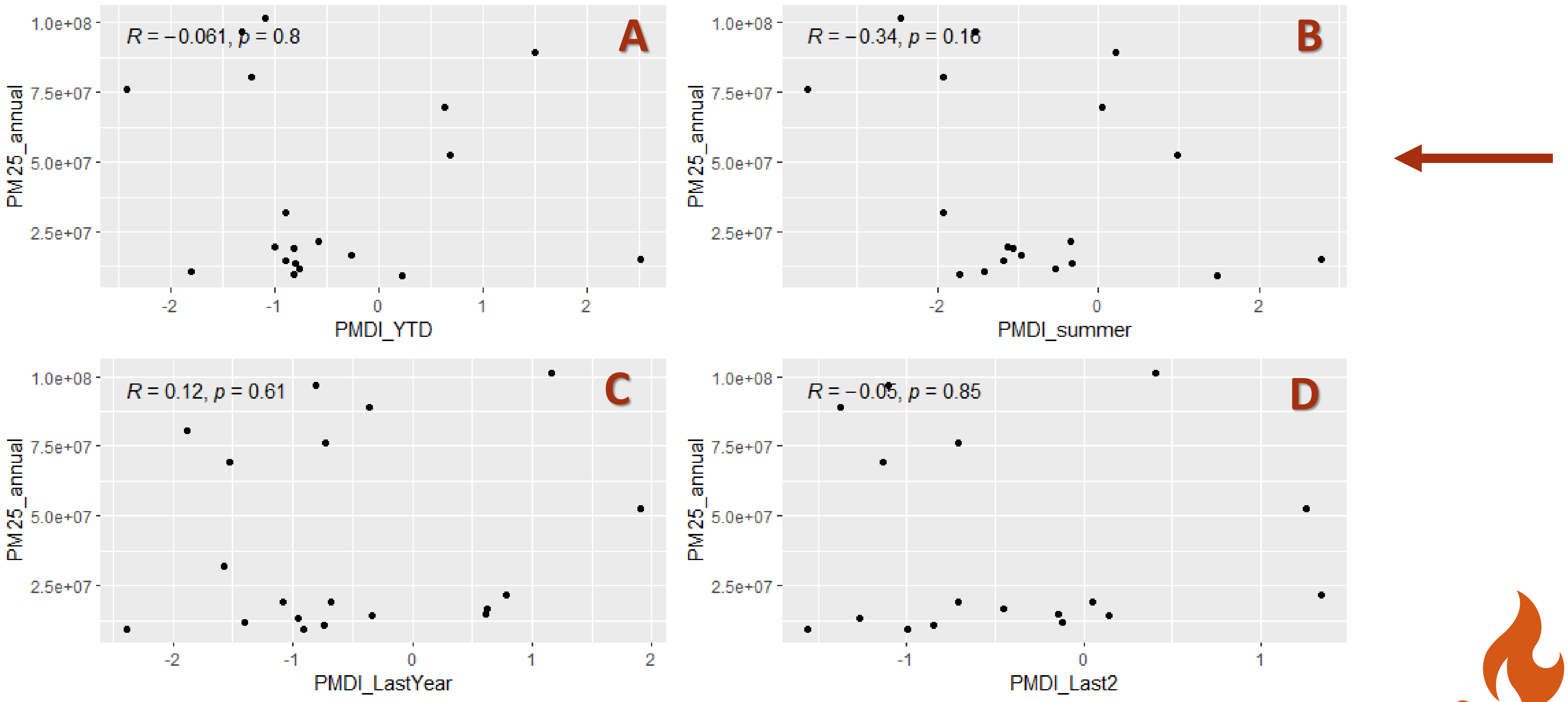
https://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-divisions.php

Results

Most of the past 18 years were mildly dry on average

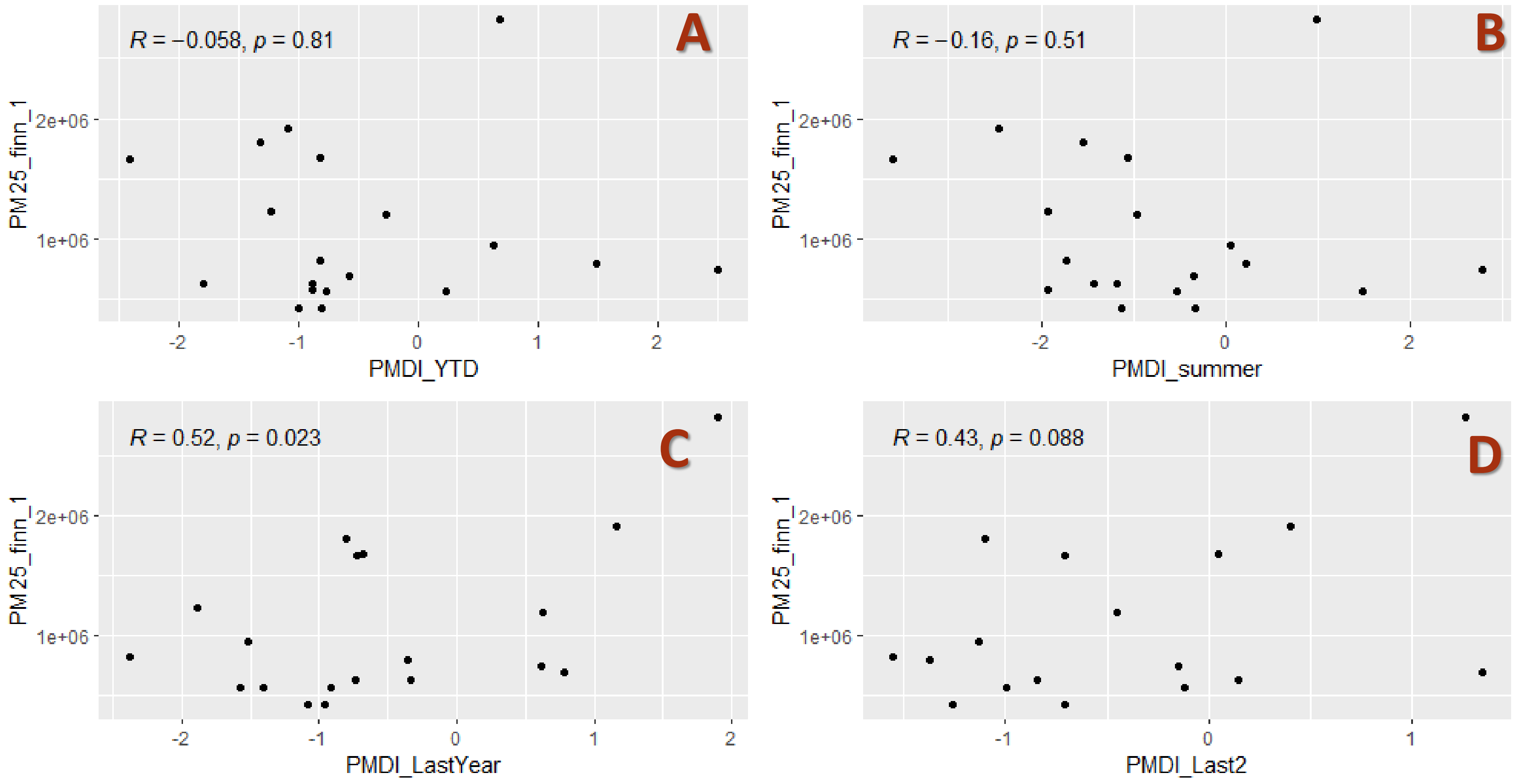


Summer drought conditions correlate more strongly with PM2.5 than longer drought periods*



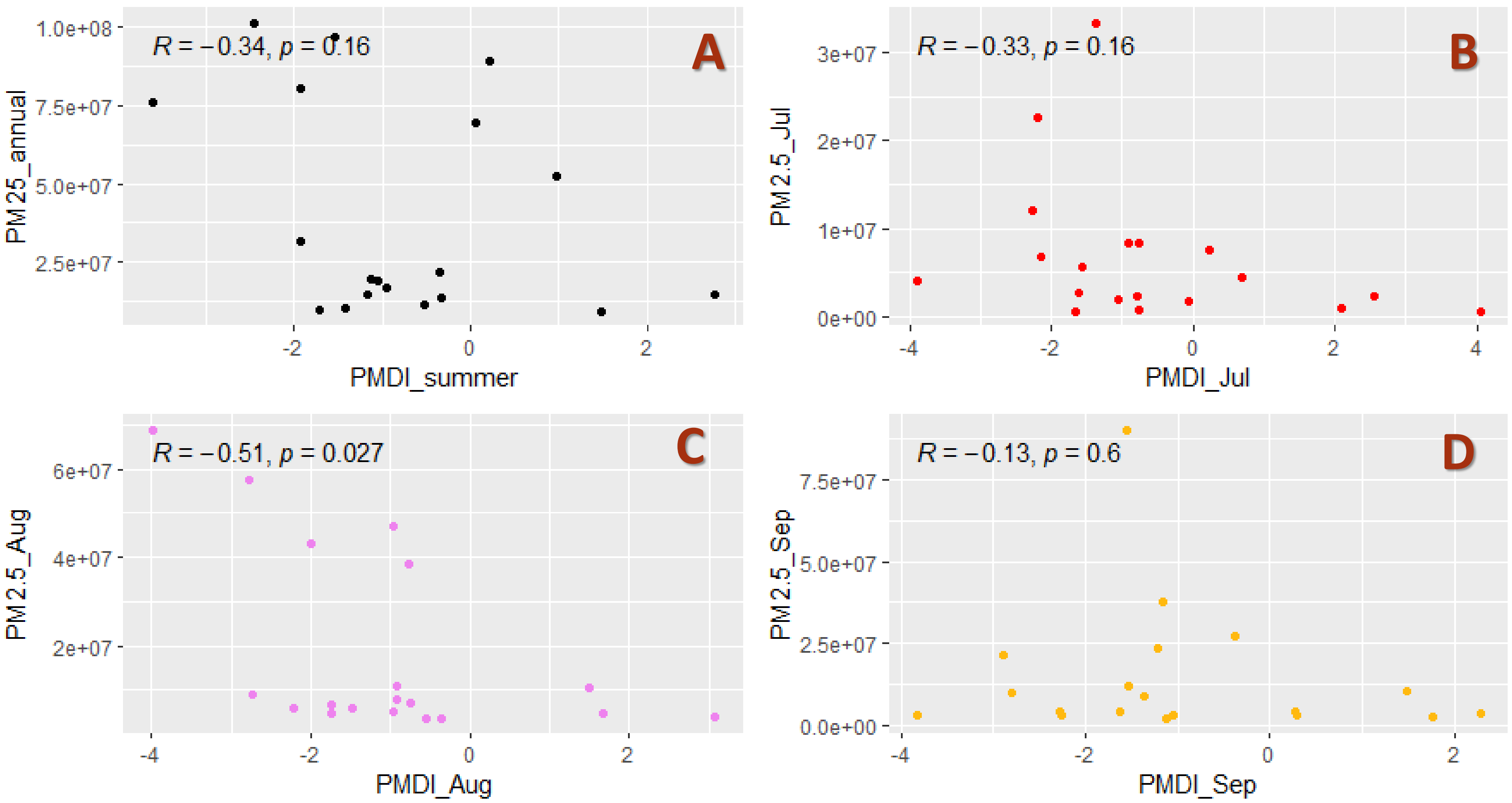
* For the entire area!

Grassland and shrubland emissions increase with wetter previous years

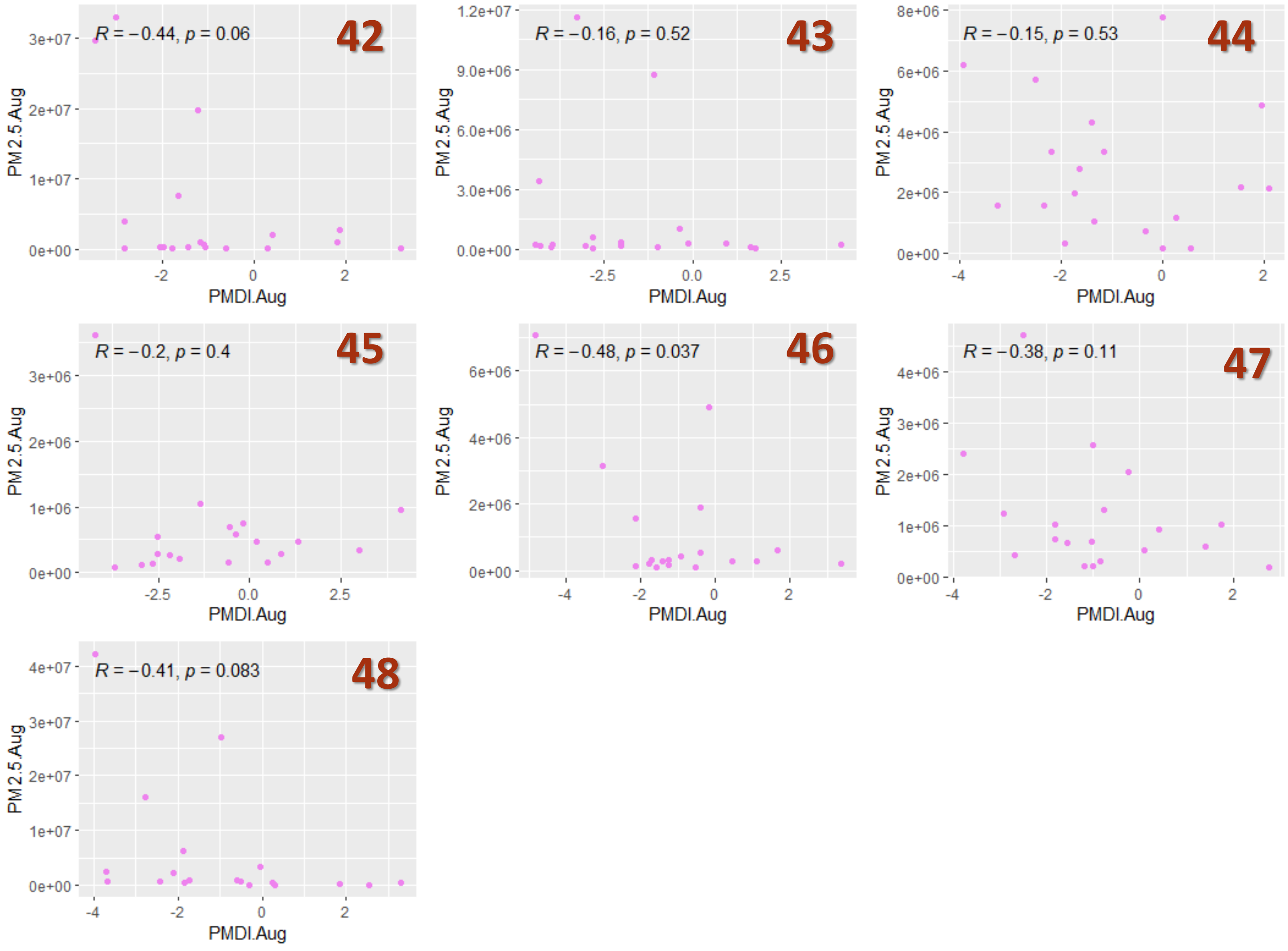


A year following higher vegetative growth has more fuel to burn.

Breaking "summer" down by month shows even more variation



…and even more variation divided by latitude bands



Key Takeaways and Next Steps

Takeaways

- Relationship between fire and climate variables varies a lot even within one season and relatively small area (a state)
- Drought appears to most strongly influence fire during the summer, but some areas have a stronger inverse relationship with previous years

Next Steps

- Normalize emissions by NOAA Climate Division
- Compare emissions to more climate variables!

Questions?