CASAP IX
CONGRESO COLOMBIANO Y CONFERENCIA INTERNACIONAL
DE CALIDAD DE AIRE, CAMBIO CLIMÁTICO Y SALUD PÚBLICA

Wildland fire, air quality, and climate change

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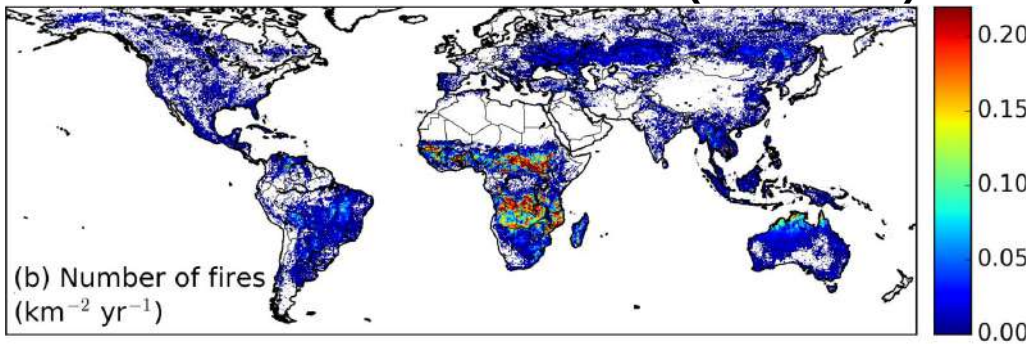
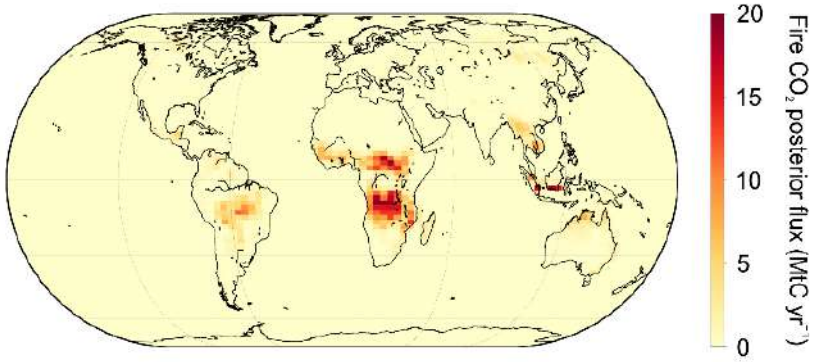
Global burned area and emissions

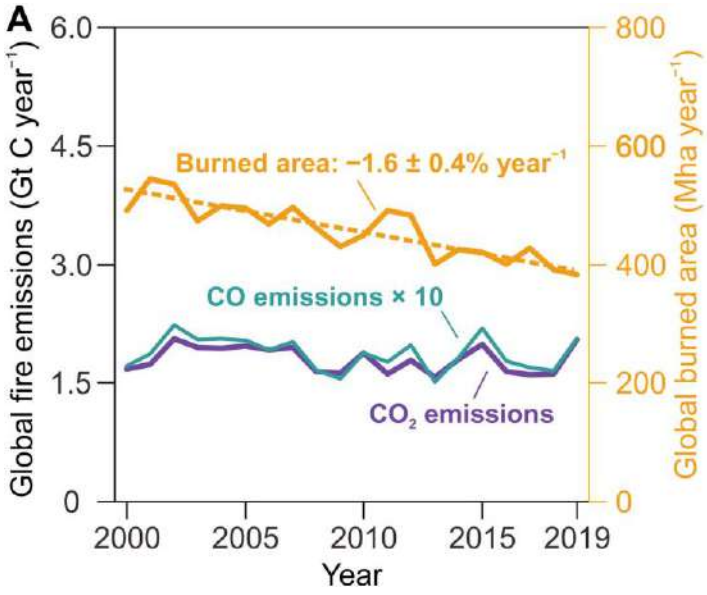
- Global burned area declined by ~25% over the past 2 decades, despite the influence of climate.[1]
- Global fire emissions have remained stable, despite decrease in burned area.[2]
- Declining emissions from reduced burn area, compensated by increased forest burning, including Amazonia ecosystems.[2]

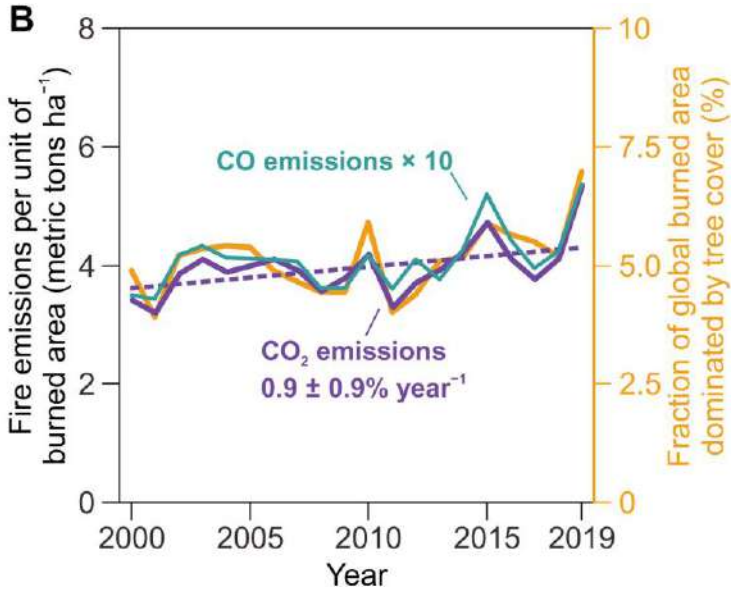
Mean annual number of fires (2003-2015)[1]



Mean fire CO_2 emission (2000-2019)[2]







1. Andela et al. (2017) *Science*
2. Zheng et al. (2021) *Science Advances*

Fire impacts on air pollution and health

Cascio (2018) *Science of the Total Environment:*

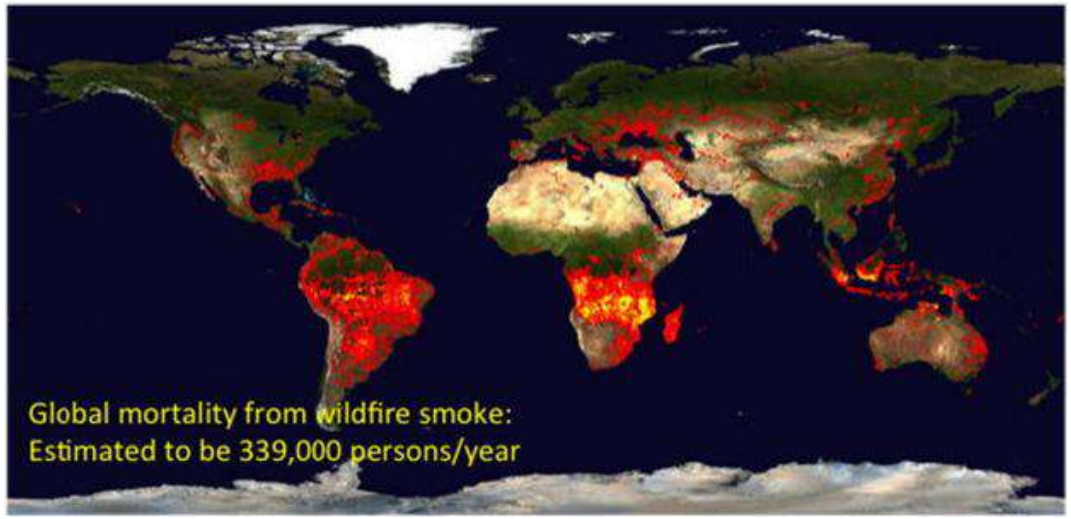
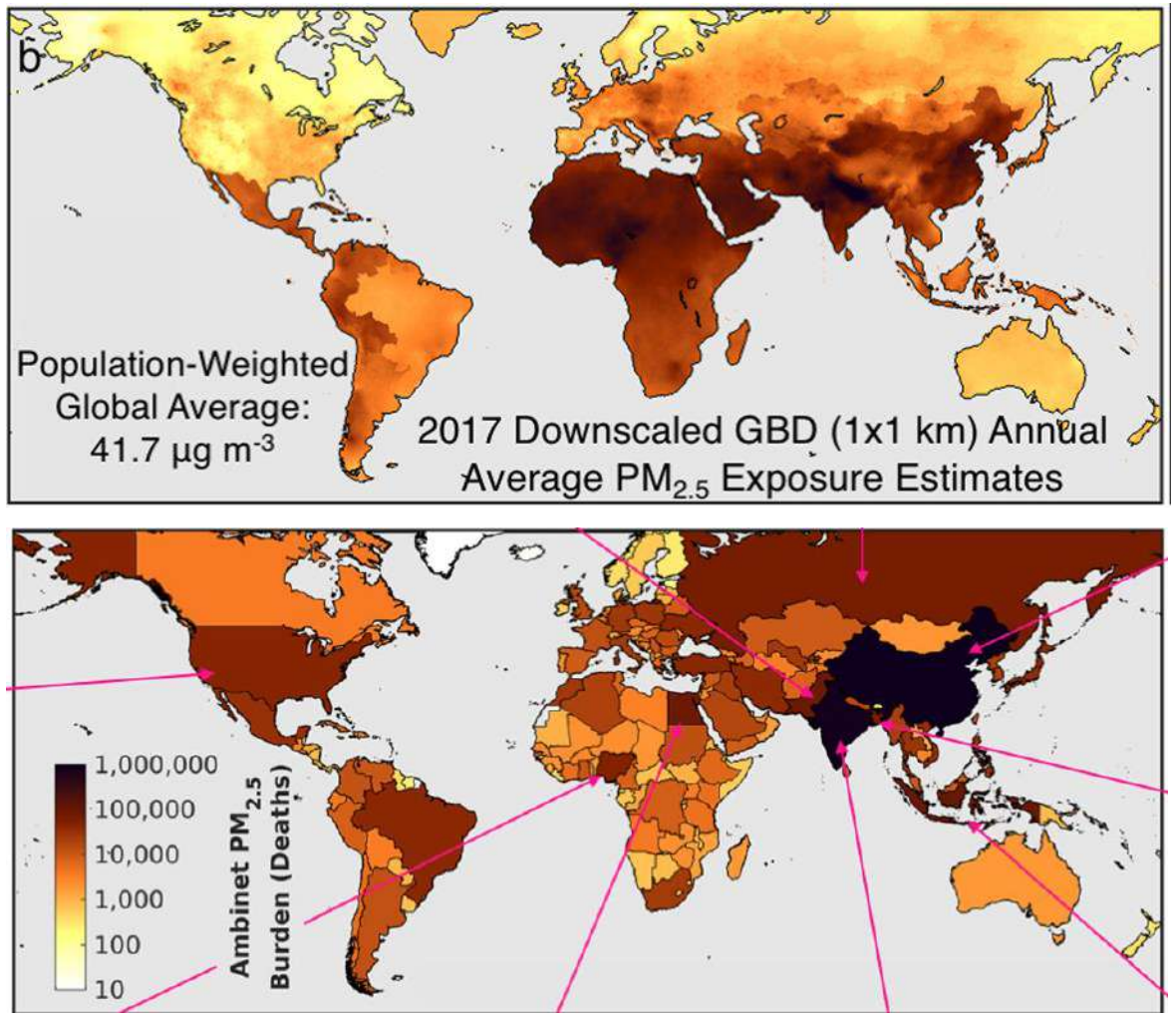


Table 1. Estimates of the global and regional annual mortality attributable to LFS and estimates from 2 years that corresponded with strong El Niño and La Niña conditions.

Scenario	Global	Sub-Saharan Africa[a]	Southeast Asia[b]	South America[c]
Annual average (1997–2006)	339,000	157,000	110,000	10,000
EL Niño year (September 1997–August 1998)	532,000	137,000	296,000	19,000
La Niña year (September 1999–August 2000)	262,000	157,000	43,000	11,000

1. Johnston et al. (2012) *Environmental Health Perspectives*

Fire impacts on air pollution and health

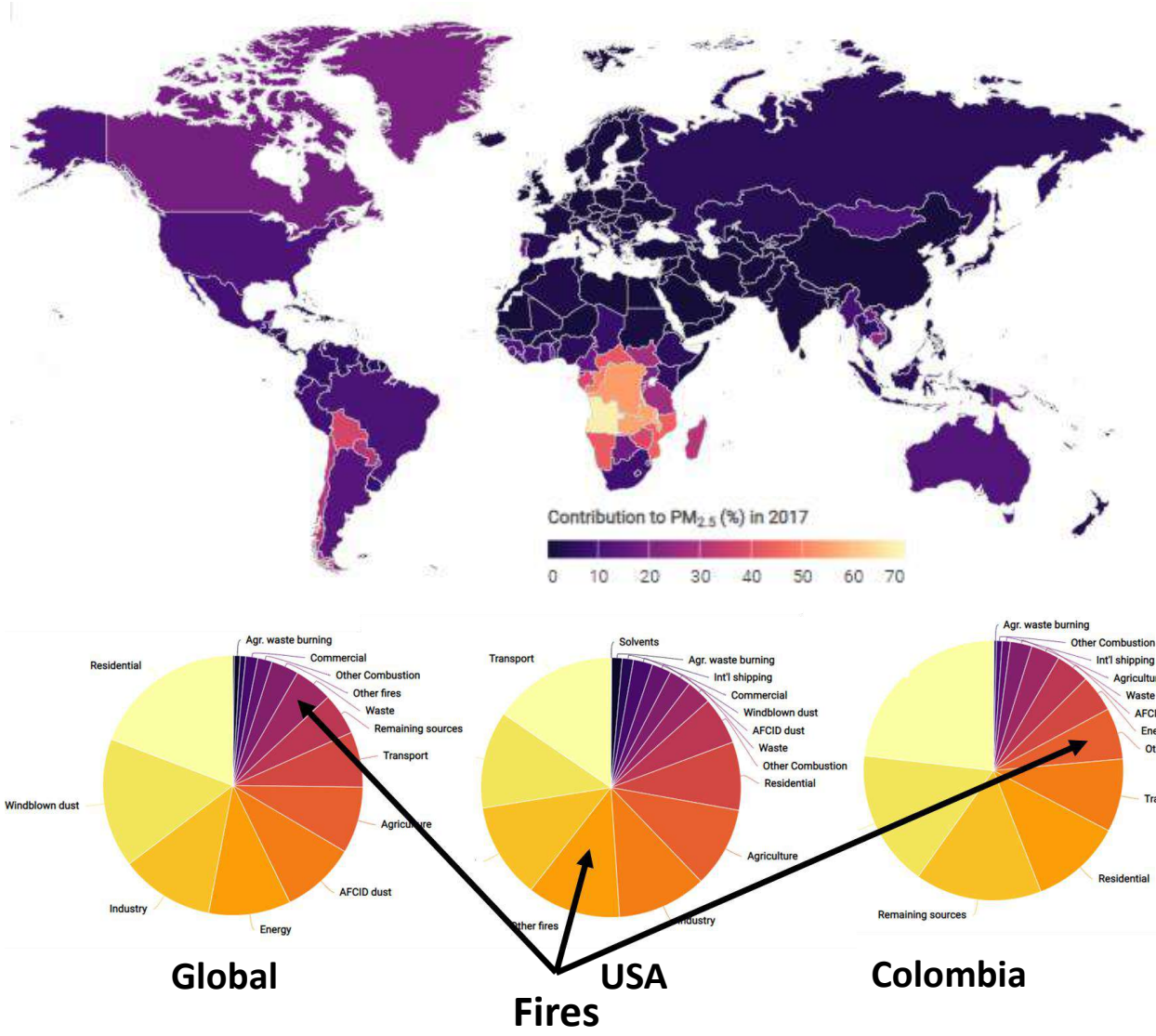


$PM_{2.5}$ exposure and disease burden[1]:

	$PM_{2.5}$ (µg/m^3)	Deaths	Death rate (/10^5)
Global	41.6	3833×10^3	51
USA	7.8	47000	14
LatAM Central	20.8	66000	27
LatAM Andean	25.9	15000	25
Colombia	21.25	11818	25

1. McDuffie et al. (2021) *Nature Communications*

Fire impacts on air pollution and health



Contribution of fires:
(*deforestation, boreal forest, peat, savannah, and temperate forest fires*)

	% $PM_{2.5}$	$PM_{2.5}$ ($\mu g/m^3$)	Deaths
Global	3.4%	1.4	130300
USA	11.6%	0.9	5440
LatAM Central	7.4%	1.5	4860
LatAM Andean	14.2%	3.7	2165
Colombia	6.4%	1.4	760

1. McDuffie et al. (2021) *Nature Communications*

Fire impacts on air pollution and health

Findings From Recent Research on Physical Health Effects of Wildfire Smoke

1

Respiratory Effects
- Several studies have found associations between wildfire smoke and increases in emergency department visits for respiratory diseases, such as asthma (Malig, et al., 2021; Wettstein, et al., 2018; Alman, et al., 2016; and Rappold, et al., 2011).
- Recent research has also linked smoke to increased asthma diagnoses at emergency departments, office visits, and outpatient visits, as well as an increase in inhaler medication refills (Gan, et al., 2020).

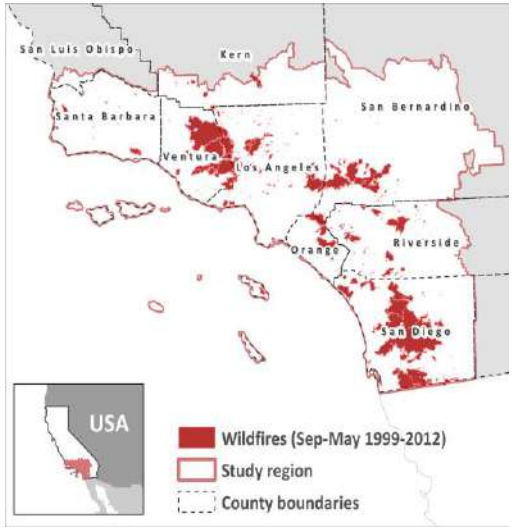
Cardiovascular Effects
- Several studies have found links between wildfire smoke and increases in emergency department visits for cardiovascular reasons, such as heart attacks (Malig, et al., 2021; Wettstein, et al., 2018; and Rappold, et al., 2011).
- A recent study has linked wildfire smoke to an increase in out-of-hospital cardiac arrests (Jones, et al., 2020)
- Other studies have failed to find associations between smoke and cardiovascular-related emergency department visits (Alman, et al., 2016), physician visits, and hospital admissions (Henderson, et al., 2011).

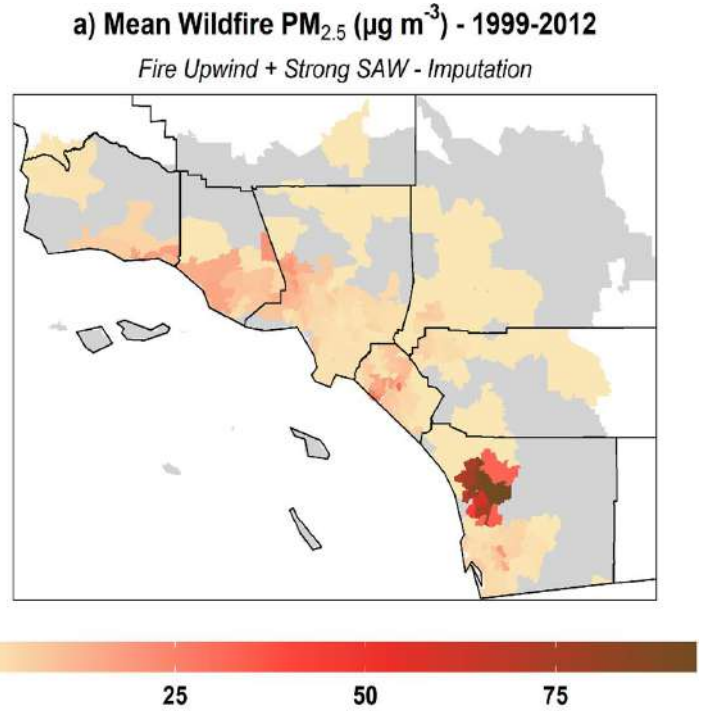
Poor Pregnancy and Birth Outcomes
- A couple of recent papers have found associations between smoke and pre-term births (Heft-Neal, et al., 2022 and Abdo, et al., 2019).
- Recent studies have also found links between smoke and a greater risk of gestational diabetes in pregnant people (Abdo, et al., 2019), as well as slightly reduced birth weight among infants exposed to smoke in utero (Holstius, et al., 2012).

Increased Mortality
- Various studies have found a positive relationship between smoke and-all-cause and respiratory-related mortality (Chen, et al., 2021 and Doubleday et al., 2020).
- Research is more mixed regarding the relationship between smoke and cardiovascular-related mortality, with some research finding positive associations (Chen, et al., 2021) and others not (Doubleday et al., 2020).

LAO

2





Increases in respiratory hospitalizations:
- +1.3% to 10% with +10 µg m^{-3} in wildfire-specific $PM_{2.5}$
- +0.7% to 1.3% with +10 µg m^{-3} in non- wildfire-specific $PM_{2.5}$

1. Petek (2022) California LAO
2. Aguilera et al. (2021) *Nature Communications*

Wildland fire smoke in the U.S.

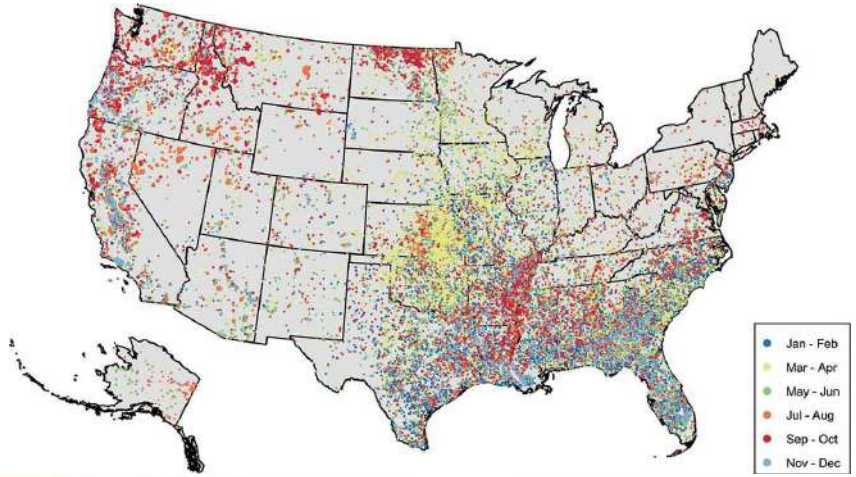
Wildland fires are the largest source of primary $PM_{2.5}$ emissions in U.S.

- 40% of US residents estimated to live in areas with a moderate to high contribution of wildland fires to ambient $PM_{2.5}$
- > 10 million experience unhealthy air quality caused by wildland fires multiple times per year
- Thousands of premature deaths and illnesses attributed to wildland fire smoke emissions each year

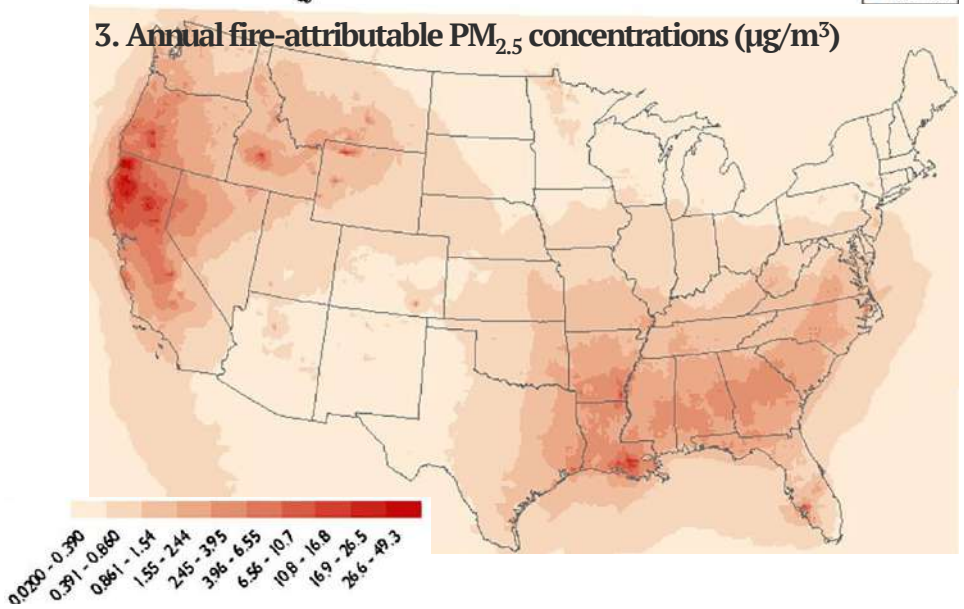
1. US EPA (2017) National Emissions Inventory
2. Rappold, et al. (2017) *Environ. Sci. Technol.*
3. Fann et al. (2018) *Sci. of the Tot. Env.*

Wildland fire smoke in the U.S.

1. 2017 MODIS hotspot fire detections

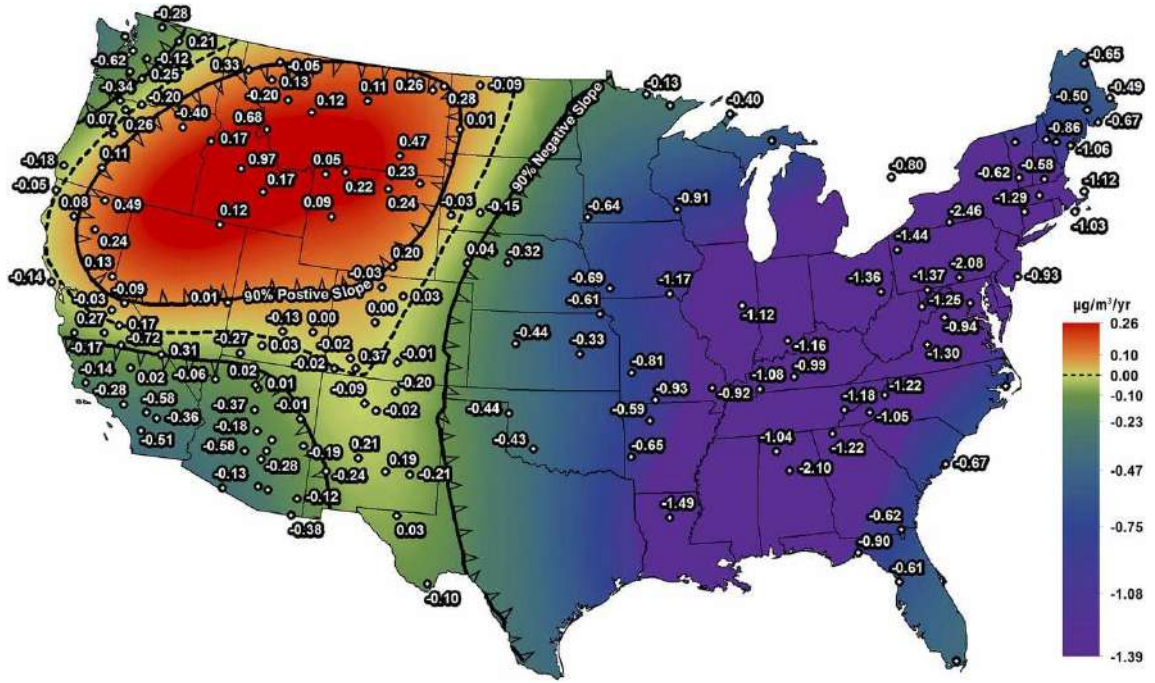


3. Annual fire-attributable $PM_{2.5}$ concentrations ($\mu g/m^3$)



US particulate matter air quality improves except in wildfire-prone areas[2]

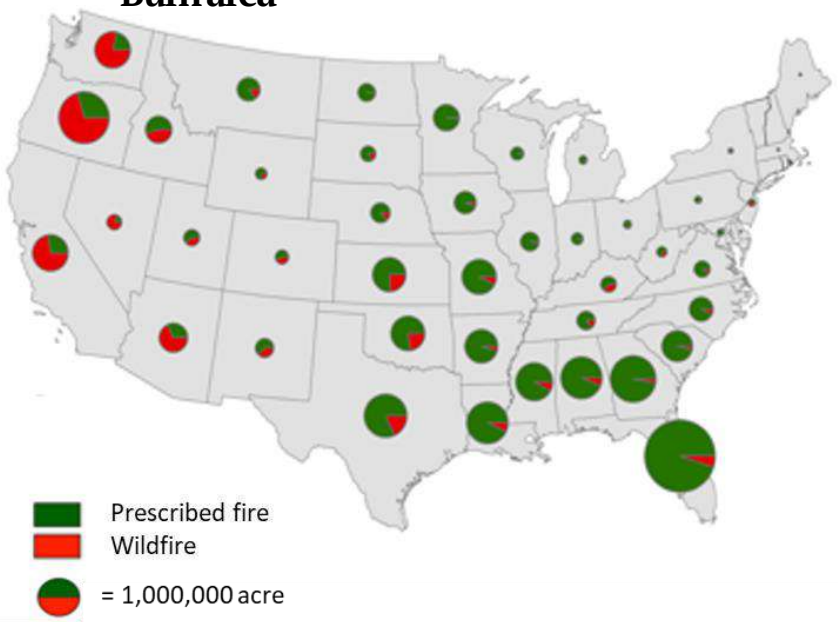
2. Observed PM trends for 1988–2016



1. Jaffe et al. (2020) *J. Air Waste Manage. Assoc.*
2. McClure et al. (2018) *PNAS*
3. Fann et al. (2018) *Sci. of the Tot. Env.*

Wildland fire smoke in the U.S.

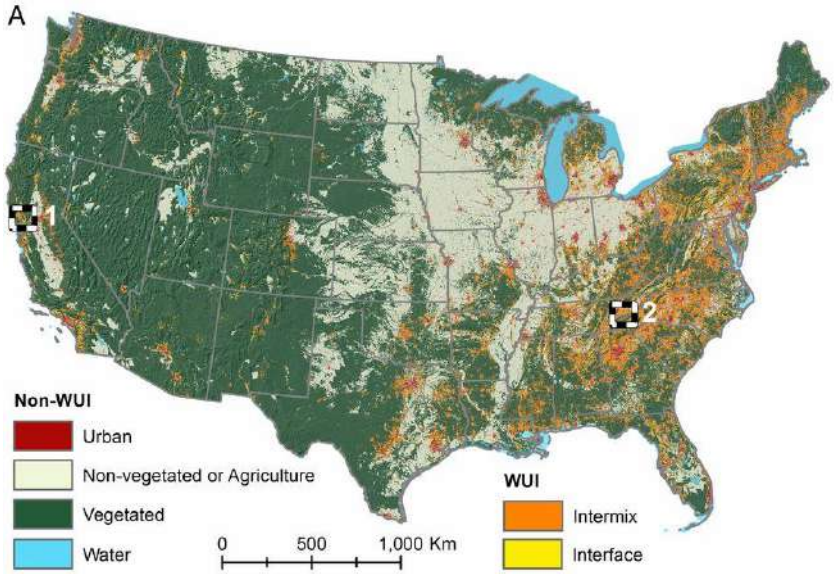
Burn area[1]



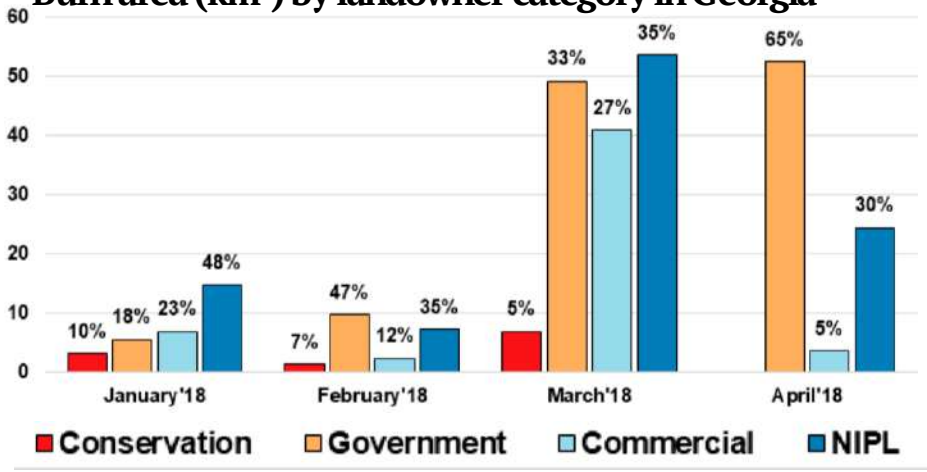
Wildfire

Prescribed fire

Wildland-urban interface[2]



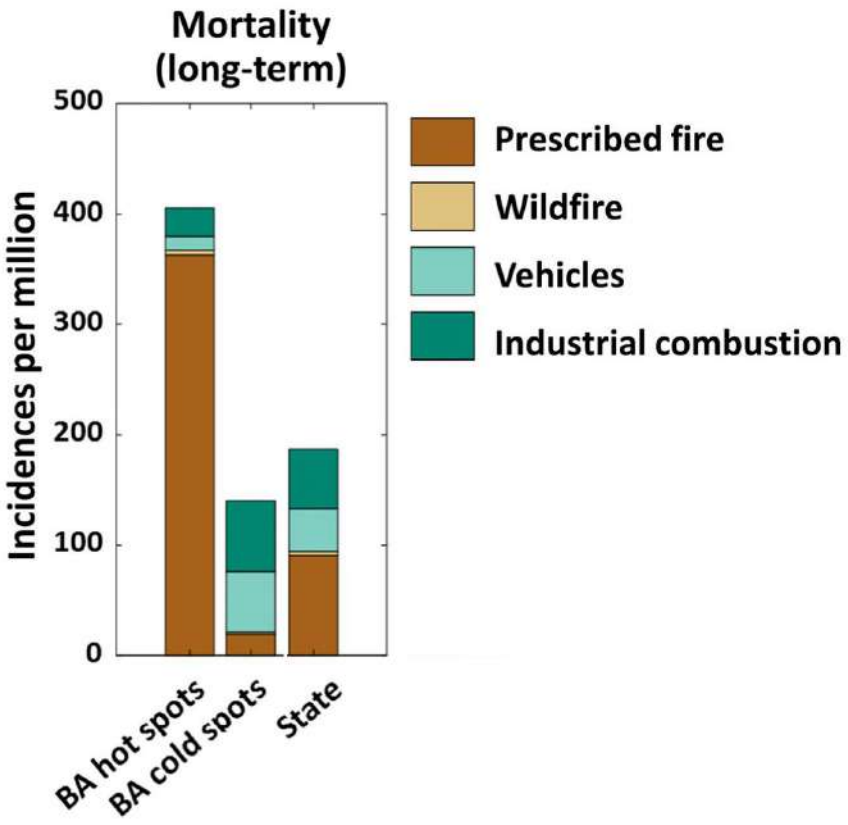
Burn area (km^2) by landowner category in Georgia[3]



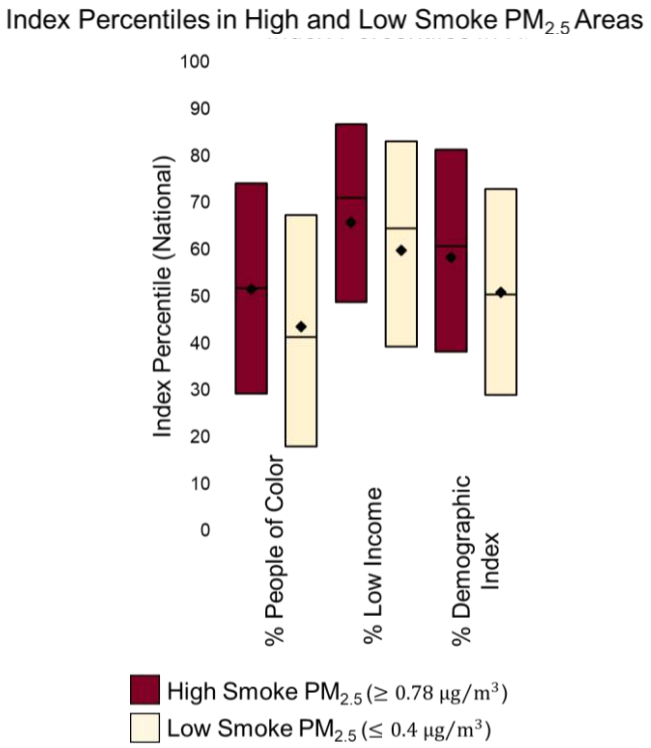
1. US EPA (2017) National Emissions Inventory
2. Radeloff et al. (2018) *PNAS*
3. Johnson Gaither et al. (2019) *IJERPH*

Wildland fire in the Southeastern US

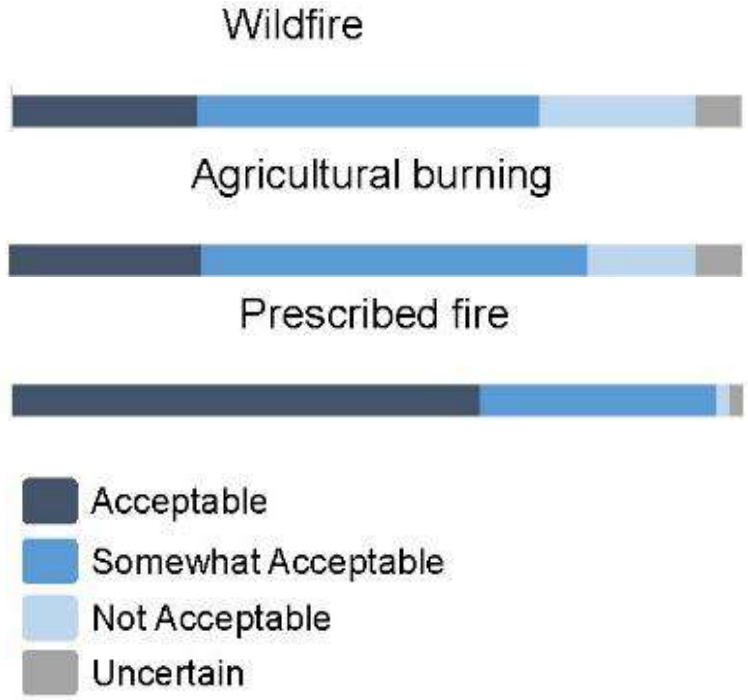
Impact of major emission sectors in Georgia[1]



Southeastern populations impacted by smoke[2]

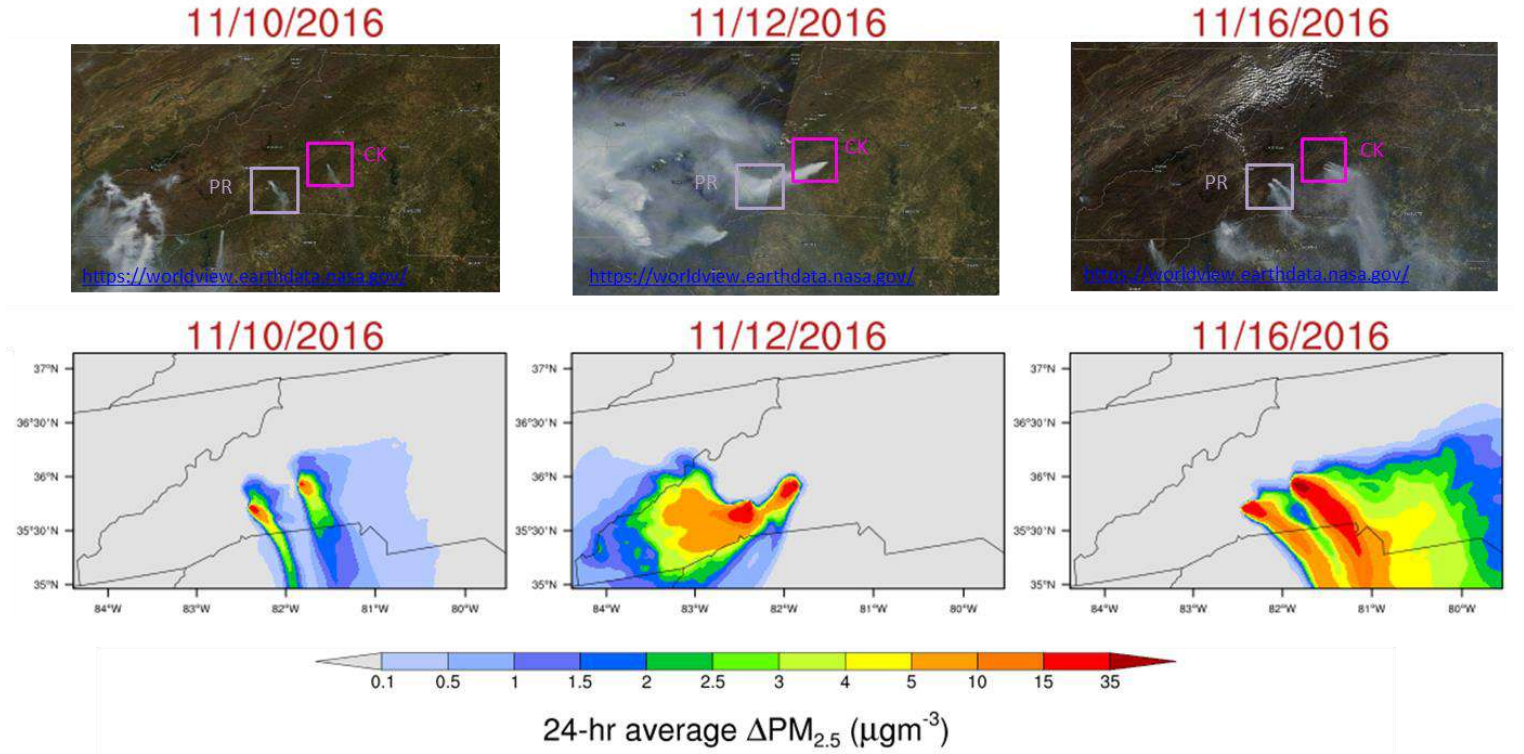


Perceptions of smoke in North Carolina[3]



1. Afrin et al. (2021) *Sci. of the Tot. Env.*
2. Johnson et al. (under review)
3. Johnson et al. (under review)

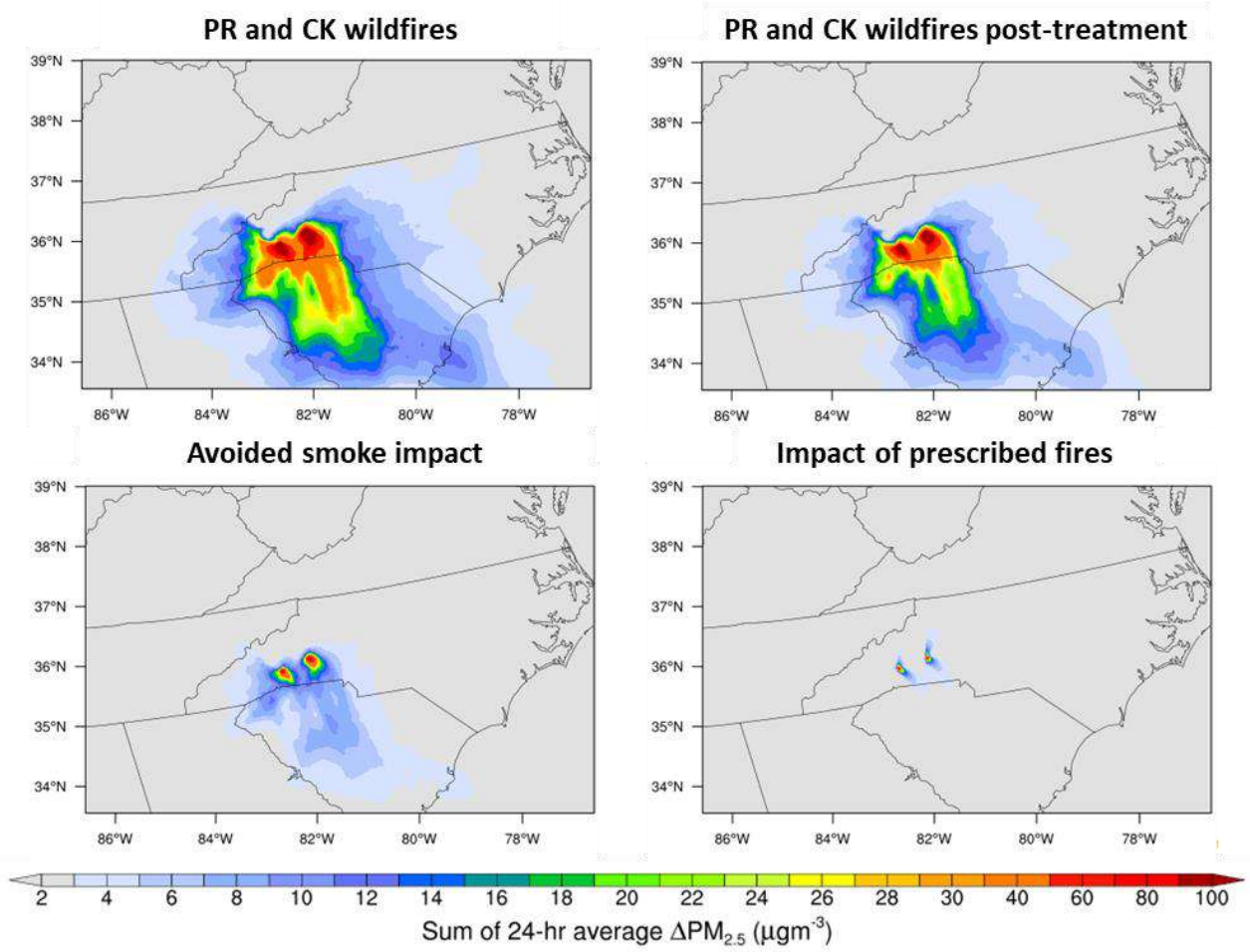
Air quality impacts and trade-offs of wild and prescribed fire



1. Afrin et al. (under review)

Air quality impacts and trade-offs of wild and prescribed fire

Wildfires – no prescribed fire
vs
Wildfires – with prescribed fire
vs
Prescribed fires

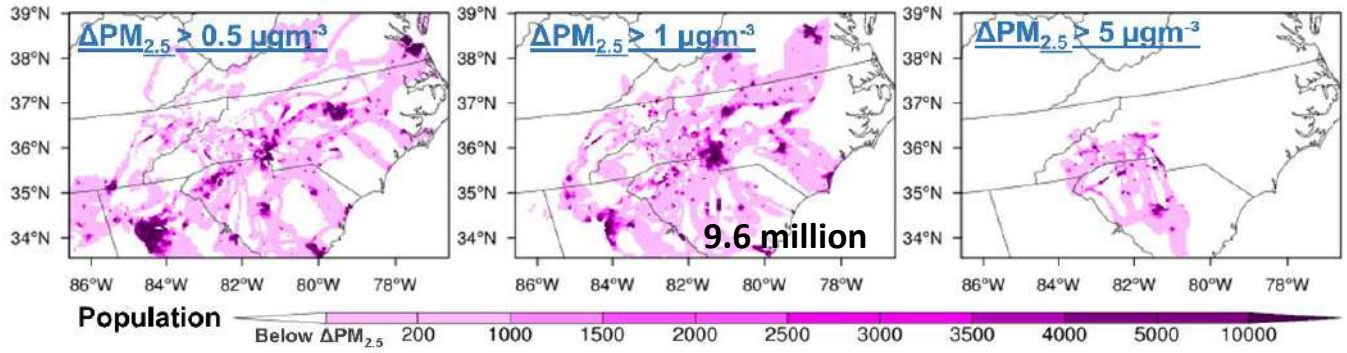


Wildland fire in the Southeastern US

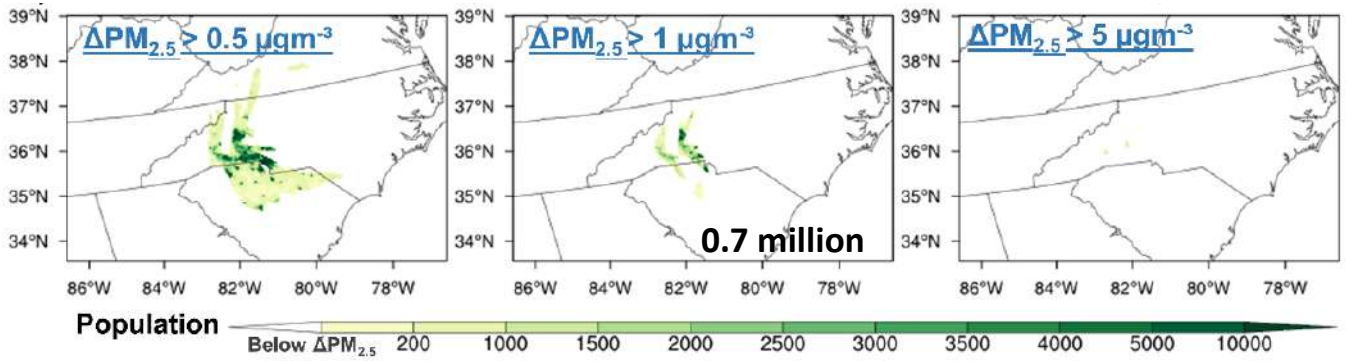
Favored Population : Population exposed to smoke on fewer days

Affected Population : Population exposed to fire smoke on more days

Favored Population



Affected Population



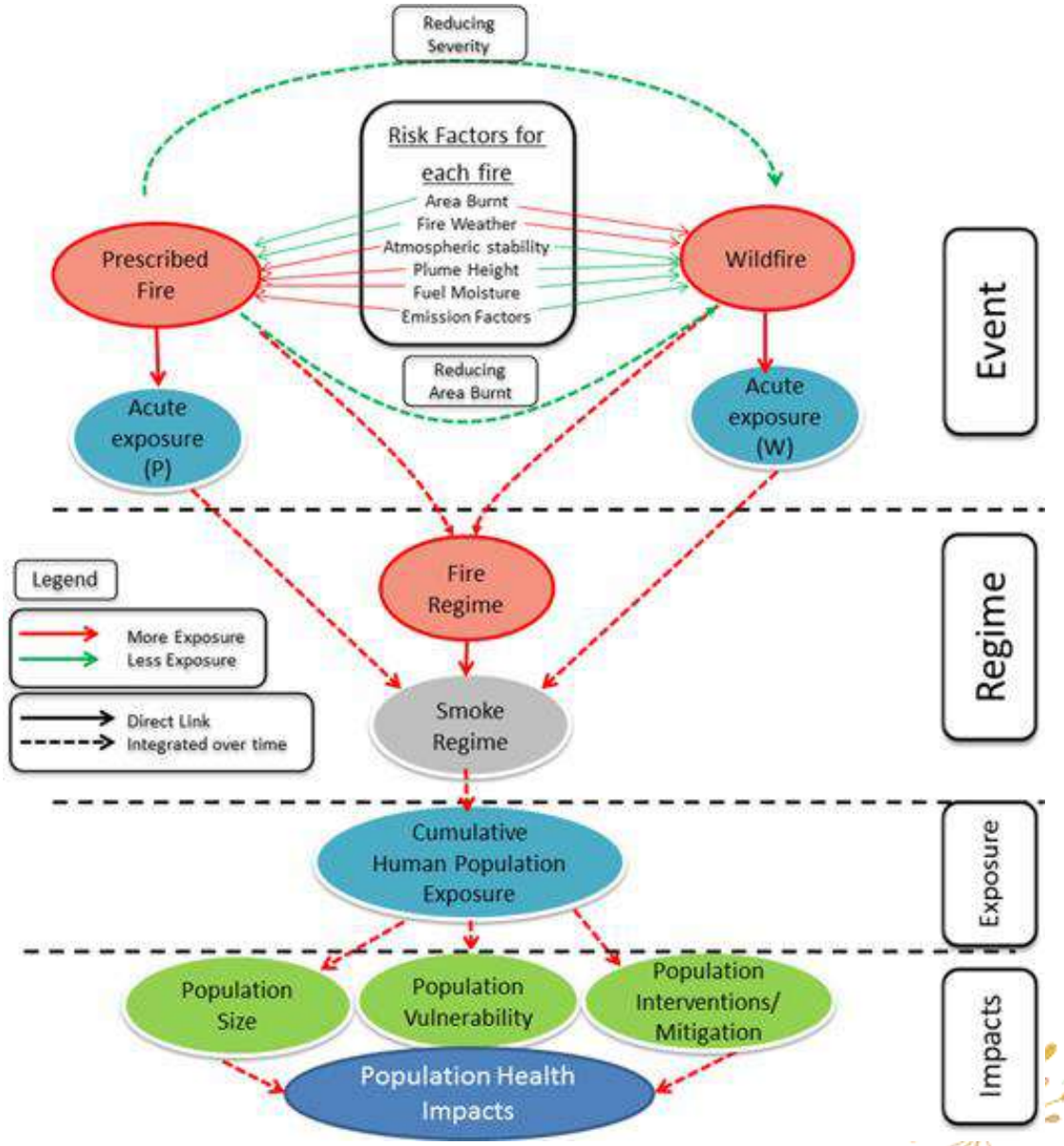
1. Afrin et al. (under review)

Interrelations in smoke impacts

- Fire and air quality should be approached as coupled socio-environmental systems

- Better characterizing wildland fire-air quality systems across different regions is an important research need spanning different research fields.

Transdisciplinary approach to understand health effects of fire smoke[1]



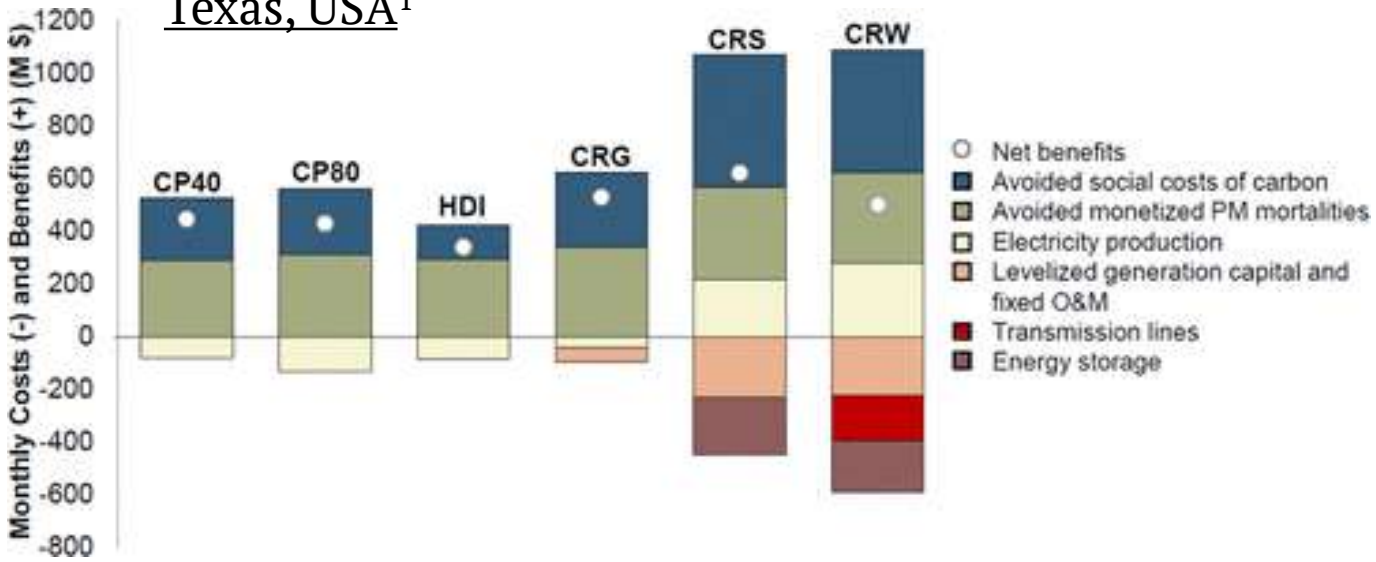
1. Williamson et al. (2016), Environ. Res. Lett.

Informed smoke management decision-making

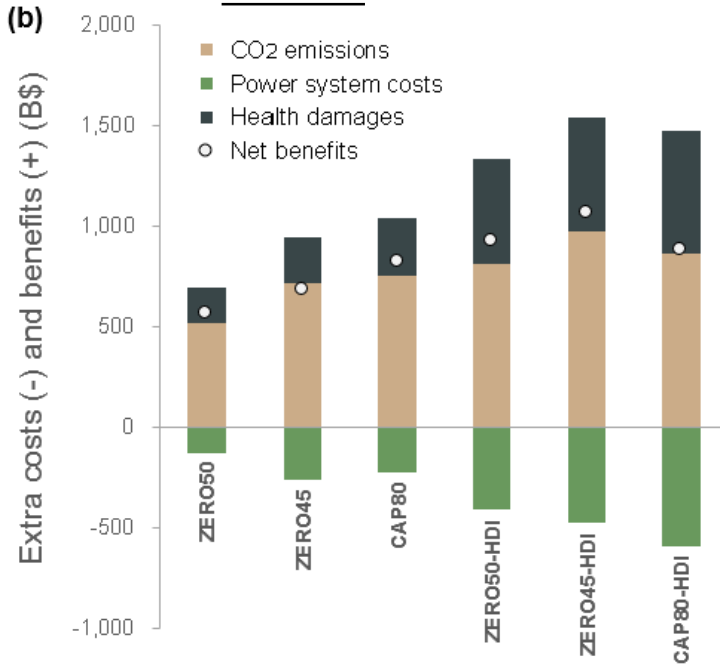
Comprehensive cost and benefit assessments of wildland fire are needed, inclusive of air pollution and climate externalities.

Net benefits of each decarbonization in power sector:

Texas, USA[1]



China[2]



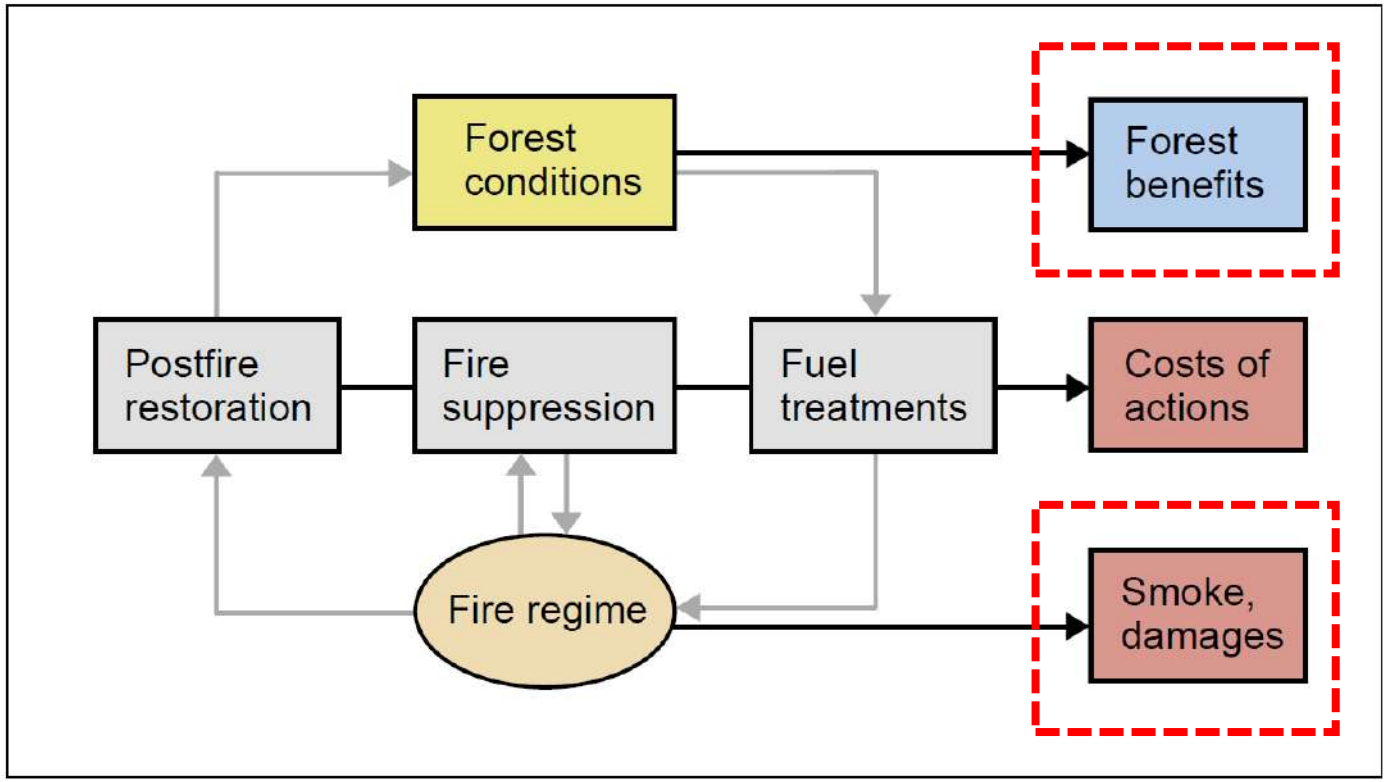
1. Luo et al. (2022) *Environ. Sci. Technol.*
2. Luo (under review)

Informed smoke management decision-making

Cost–benefit analysis, inclusive of air pollution and climate externalities:

- → Fire inventories and emission factors
- → Improved air quality simulations
  - → Resolution
  - → Smoke plume treatments
  - → Chemical mechanisms
- → Uncertainty quantification
- → Climate change interactions
- → Monetized actions, smoke impacts, ecological services, climate benefits, social implications, and others.

[1] Fire management decision cycle with benefits and costs



1. Kline (2004) *US Forest Service. Res. Note PNW-RN-542*

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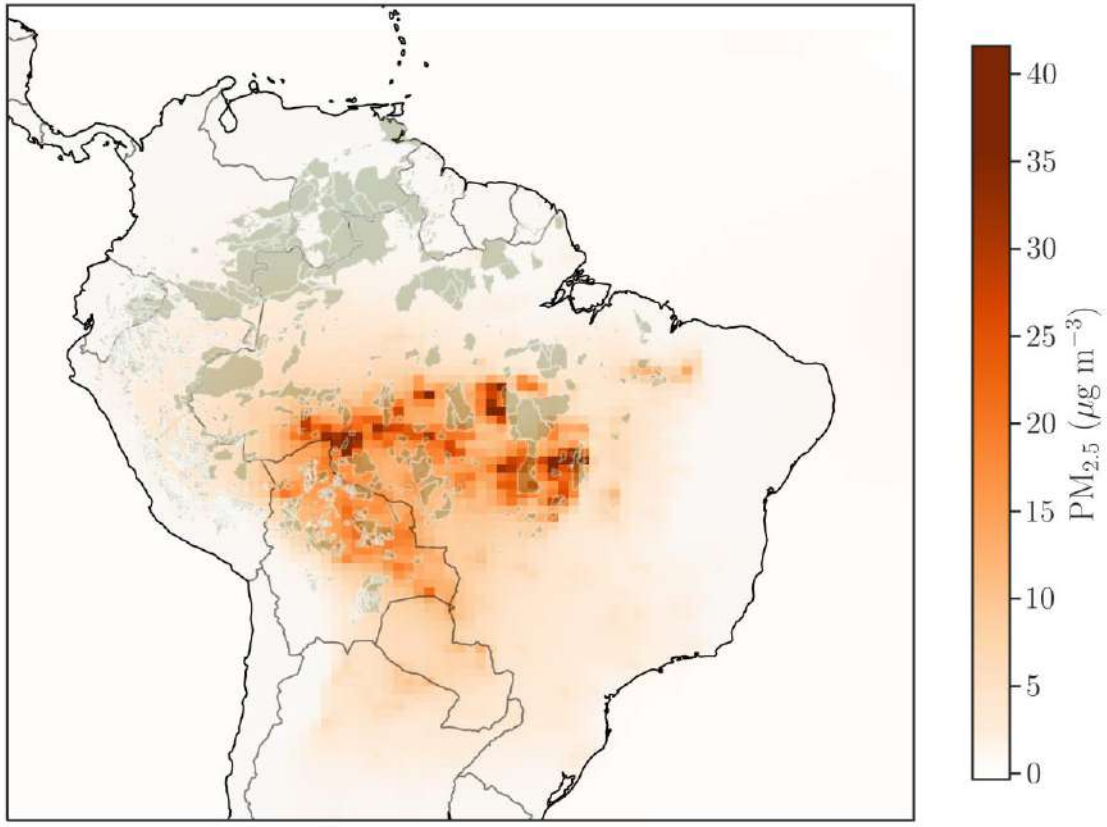
Indigenous territories and smoke enhancement of $PM_{2.5}$



"Fires has a detrimental effect on health across South America, and a disproportionate impact on Indigenous territories"

- 2 deaths per 100,000 people per year across South America.
- 4 premature deaths per 100,000 people in the Indigenous territories.

1. Eimy Xiomary Bonilla (2022)