

Air Pollution from Wildfires and Human Health Implications in Alaskan Communities



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YALE SCHOOL OF FORESTRY & ENVIRONMENTAL STUDIES

IARPC WILDFIRES TEAM MEETING, 12 MAY 2016



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YALE SCHOOL OF FORESTRY & ENVIRONMENTAL STUDIES

Overview

- ❖ Wildfire Smoke & Human Health
- ❖ Present-Day Wildfire-Specific Pollution
- ❖ Future Mid-Century Wildfire-Specific Pollution
- ❖ Concluding Remarks & Discussion



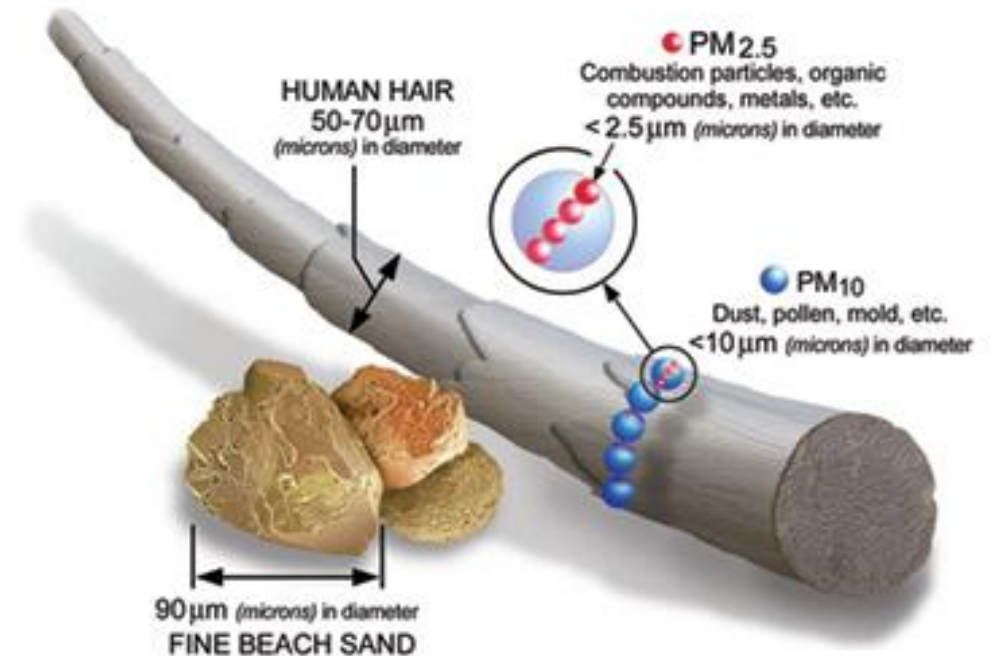
Wildfire Smoke & Human Health

PC: J Albert Diaz/AP

Wildfire smoke impairs human health



PC: John Newman



PC: U.S. EPA

Wildfire PM_{2.5} may be more harmful than PM_{2.5} from other sources

Western U.S. (561 Counties)

Wildfire-specific PM_{2.5} (Liu et al., 2016):

7.2% (0.25%, 14.63%) increase in respiratory admission rate (RAR) comparing Smoke Wave (SW)_{99.5} days (wildfire-PM_{2.5} >37μg/m³) to non-SW days (wildfire smoke ≤20μg/m³)

Average difference in daily PM_{2.5} levels between intense SW and non-SW day: 29.6μg/m³

Corresponds to **7.2% (95% CI: 0.25%, 14.63%)** increase in RAR per 29.6μg/m³ increase of PM_{2.5}

Southwestern U.S. (25 counties)

Total PM_{2.5} (Bell et al., 2008):

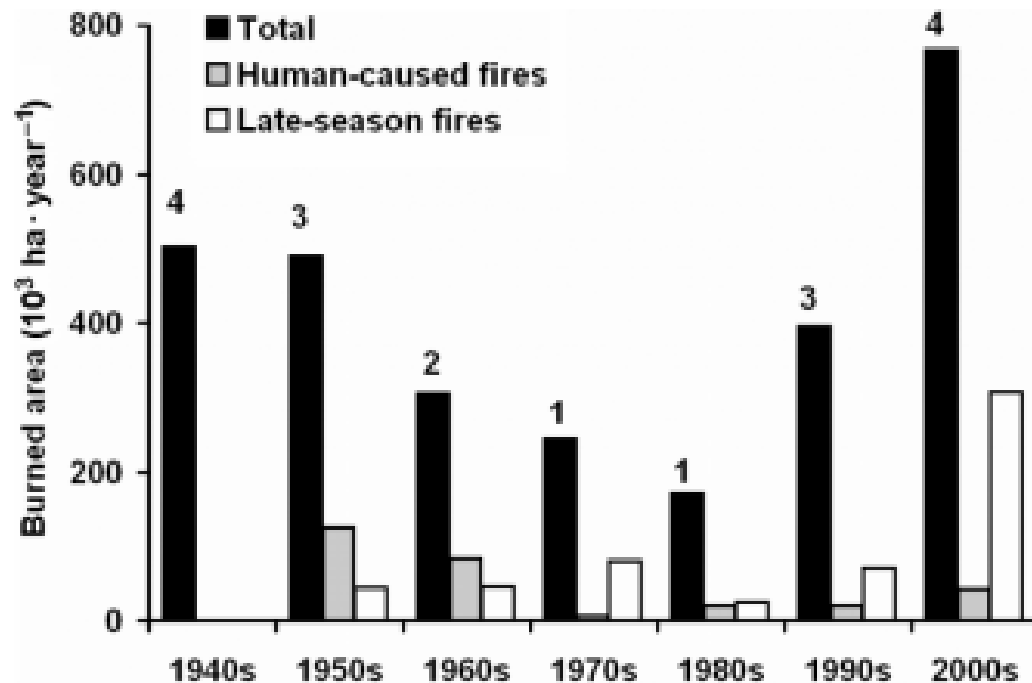
0.94% (0.22-1.67%) increase in RAR per 10μg/m³

Corresponds to **2.81% (95% CI: 0.64, 5.02%)** increase in RAR per 29.6μg/m³ increase of PM_{2.5}

Slide courtesy of Jia Coco Liu

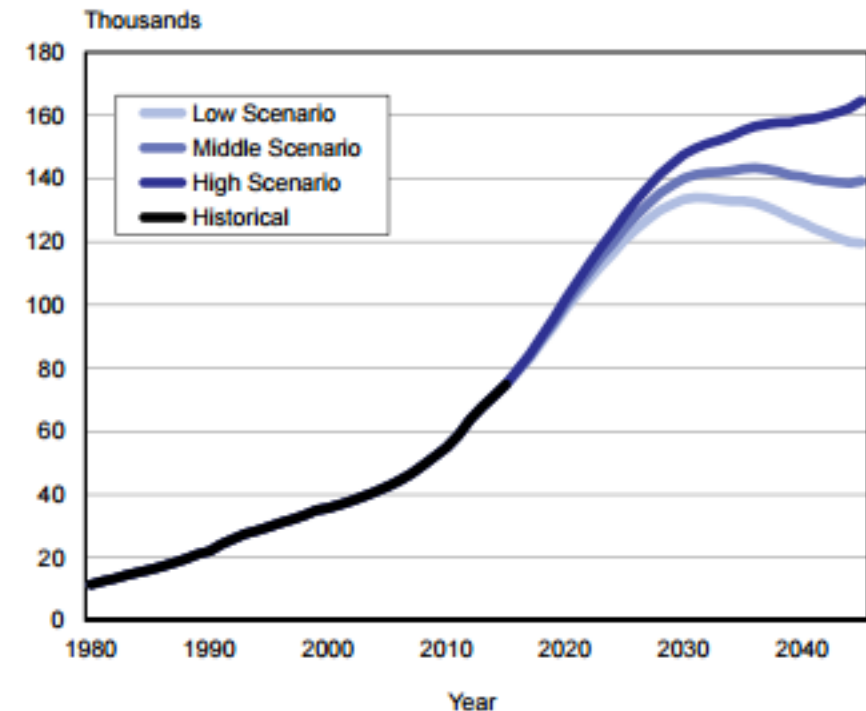
Why Alaska? More exposure, More susceptible?

Forest fire burned area trends by decades



Source: Kasischke et al. 2010

Alaska 65+ yr population projections to 2045



Source: Alaska Department of Labor and Workforce Development, Research and Analysis Section


How do wildfire patterns affect the human health of Alaskan communities?

Research Objectives:

1. Conduct a non-occupational exposure assessment of **only wildfire-induced** particulate matter sized $2.5\mu\text{m}$ or smaller (PM_{2.5}) for **Alaska** during the **present-day** (1997 – 2010).
2. Identify **vulnerable subpopulations** of Alaskan communities to wildfire-induced PM_{2.5} exposure in the **present** (1997-2010) and **future** (2047-2051).
3. Estimate **future** wildfire-induced PM_{2.5} levels and associated **health impacts** in Alaska around the mid-21st century (2047-2051).



EPA PM_{2.5} Monitors 1999-2014

An aerial photograph of a city at night, showing illuminated streets and buildings. A thick layer of smoke or haze is visible in the upper portion of the image, partially obscuring the sky. The text is overlaid on this background.

Present-Day (1997-2010) Wildfire-Specific Pollution

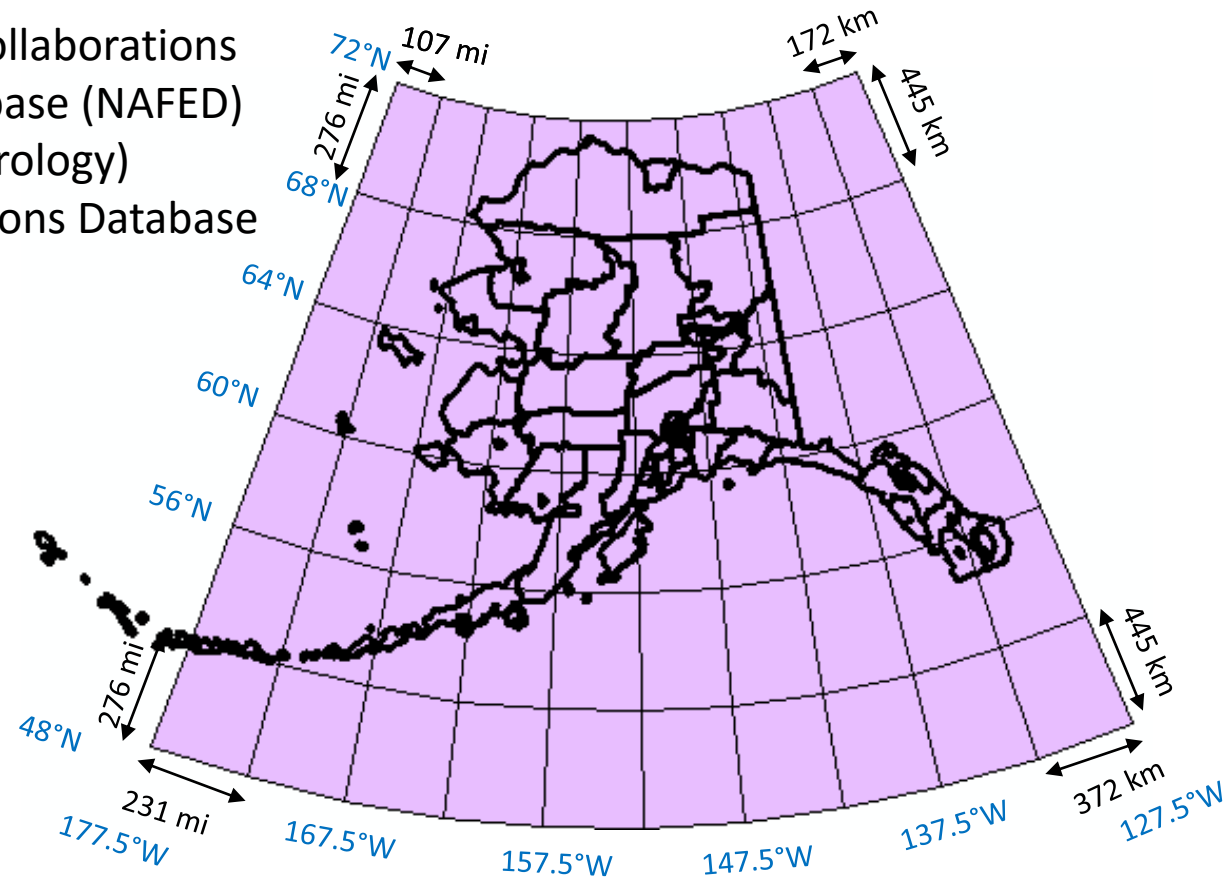
PC: Lucia Woo

Data & Methodology

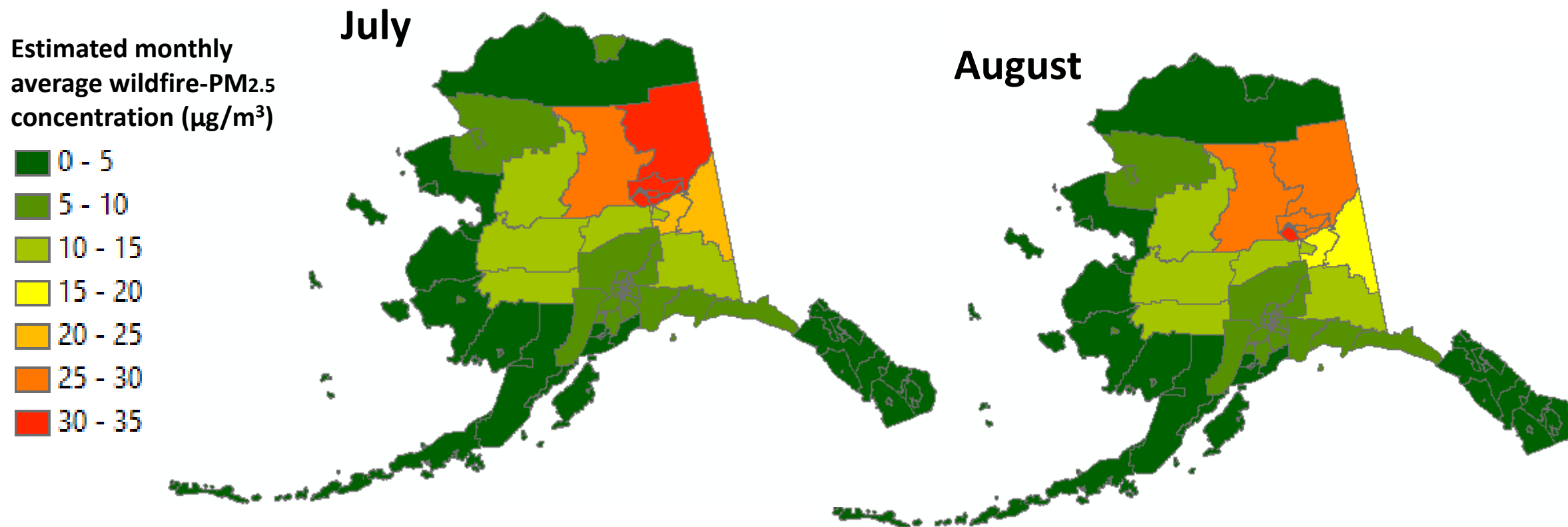
PRESENT-DAY Wildfire-PM_{2.5} Exposure Level Data:

Courtesy of Drs. Xu Yue & Loretta Mickley, Yale & Harvard collaborations

- Fire Data Input: North America Fire Emissions Database (NAFED)
- Transport & Deposition Model: GEOS-Chem (meteorology)
 - Extensively validated against Global Fire Emissions Database (GFED)
- Spatial Coverage & Resolution:
 - Almost the entire state of Alaska (48°N-72°N, 177.5°W-127.5°W)
 - Grid size: 4° x 5°: Derived to census tract level using area-weighted average
- Time Period & Temporal Resolution:
 - 1997 – 2010, focusing on fire season (Apr-Oct)
 - Monthly, averaged across the years
- Population Data: 2000 Decennial Census

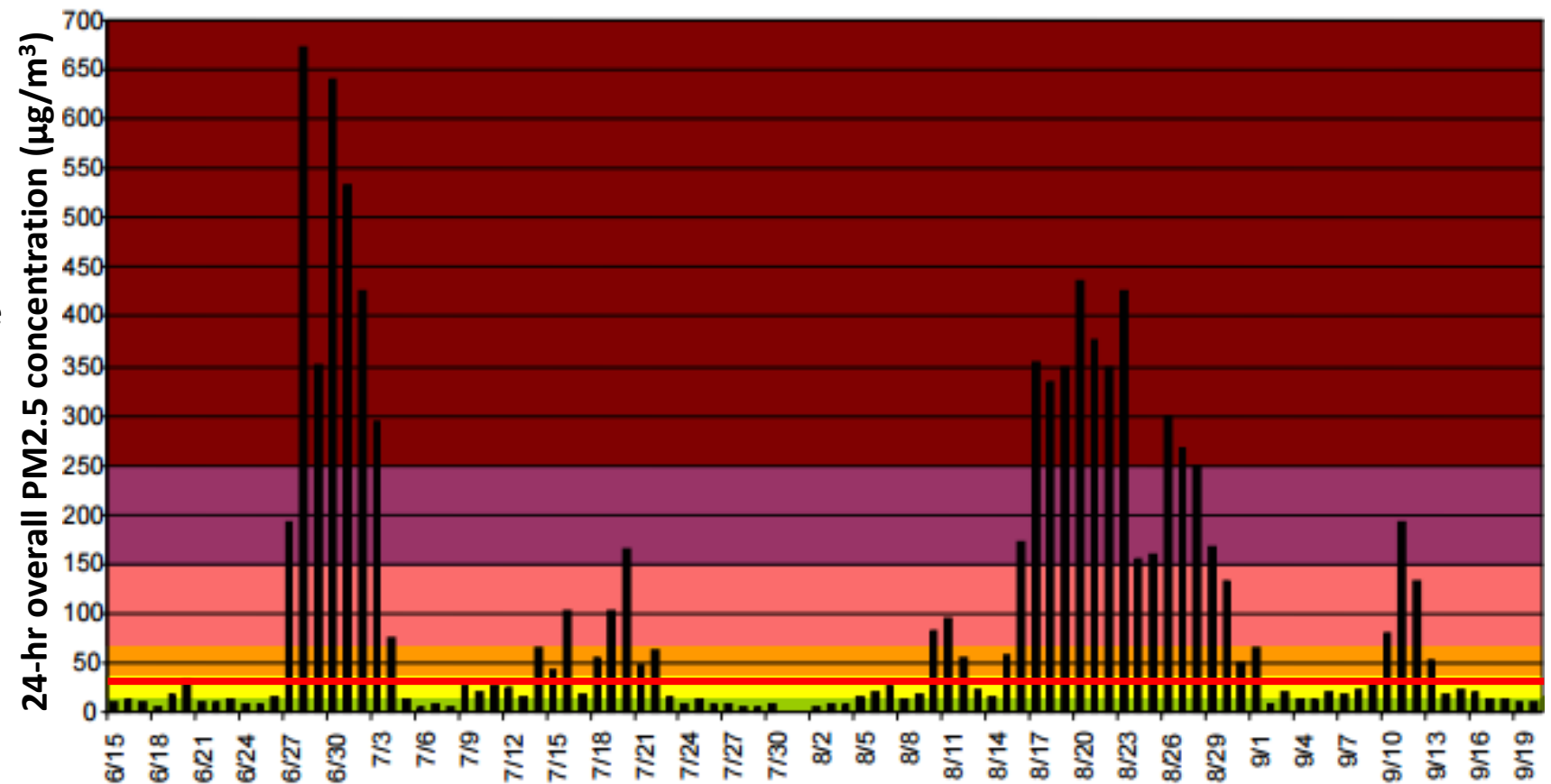
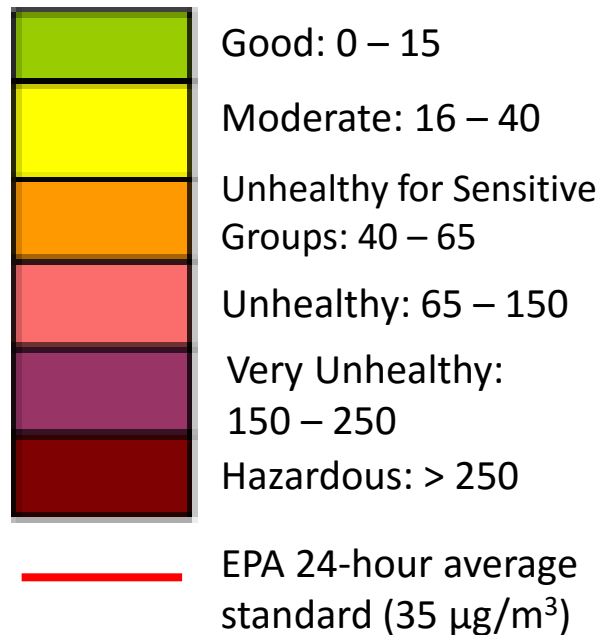


Wildfire-PM_{2.5} exposure levels during 1997-2010 are the highest in the interior Alaska and during July and August



Monthly average of $\sim 30\text{--}35\text{ }\mu\text{g}/\text{m}^3$ PM_{2.5} is unsafe

EPA Air Quality Index:
24-hr PM_{2.5} average ($\mu\text{g}/\text{m}^3$)



Source: Alaska Department of Environmental Conservation

Which subpopulations have the highest and lowest wildfire-PM_{2.5} exposure levels?

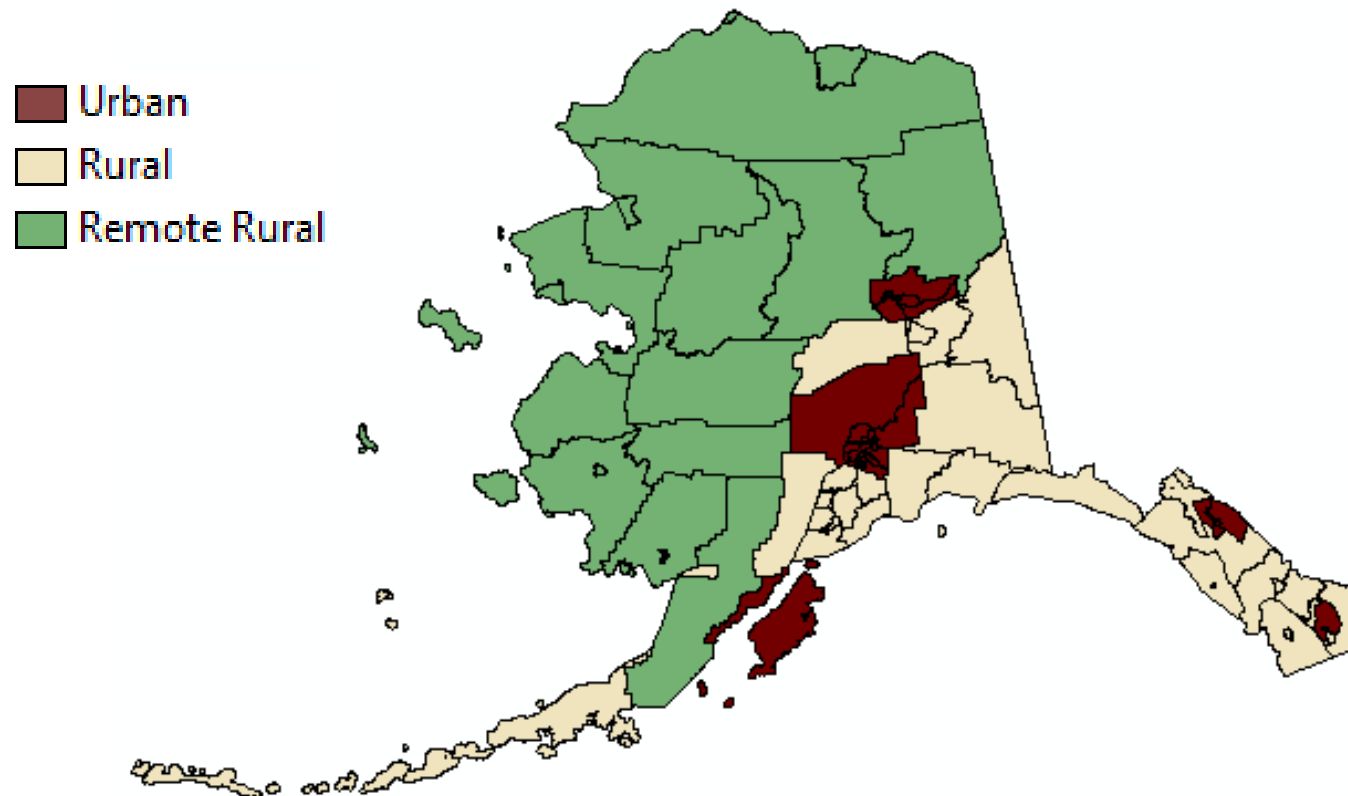
- Developed Settlement Type
- Sex
- Age
- Race/Ethnicity
- Native Tribe
- Occupation Industry
- Poverty
- Unemployment
- Household Income
- Education Level

Most of Alaska is “remote rural” aka very limited access to road or ferry

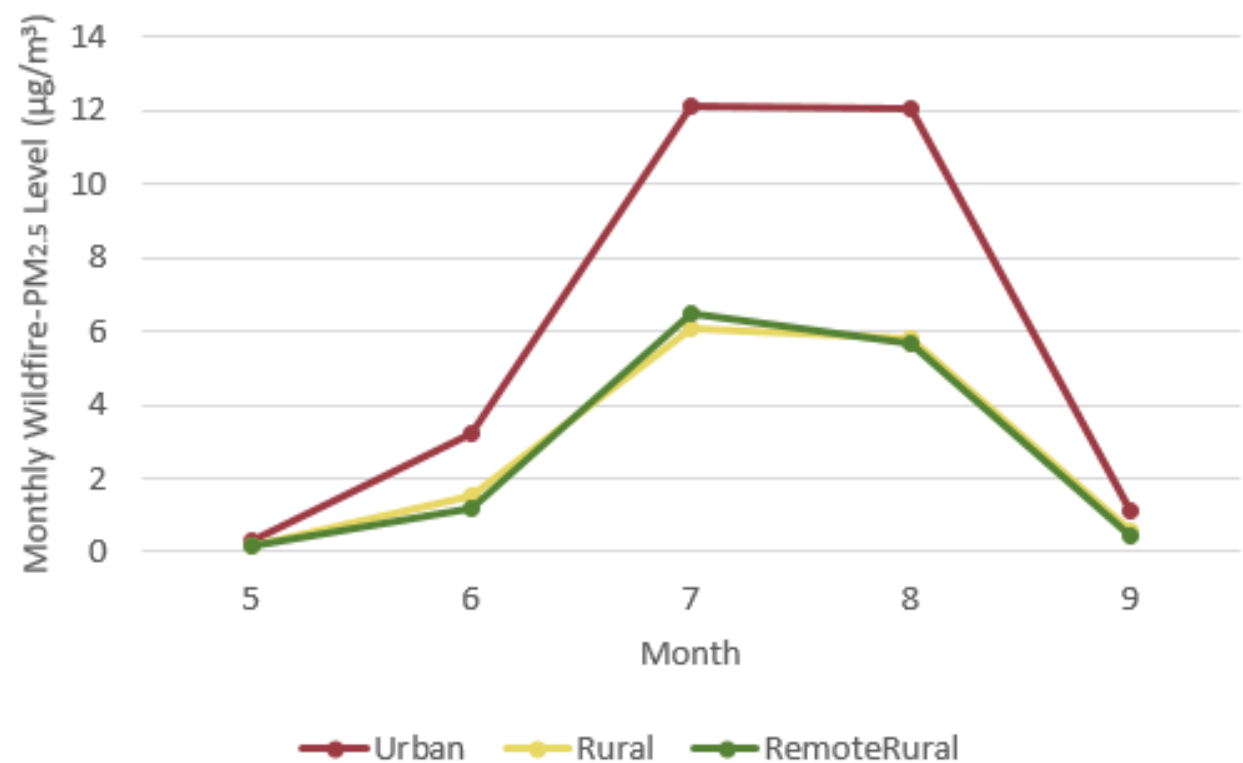
Urban = Medium Metro, Small Metro, Micropolitan (n=102 census tracts; 461,139 people) - 2006 National Center for Health Statistics

Rural = Not urban or remote rural (n=38 tracts, 105,674)

Remote Rural = Boroughs and census areas with very limited road and ferry access (n=18 tracts; 60,119) - Scott Goldsmith, University of Alaska Anchorage)

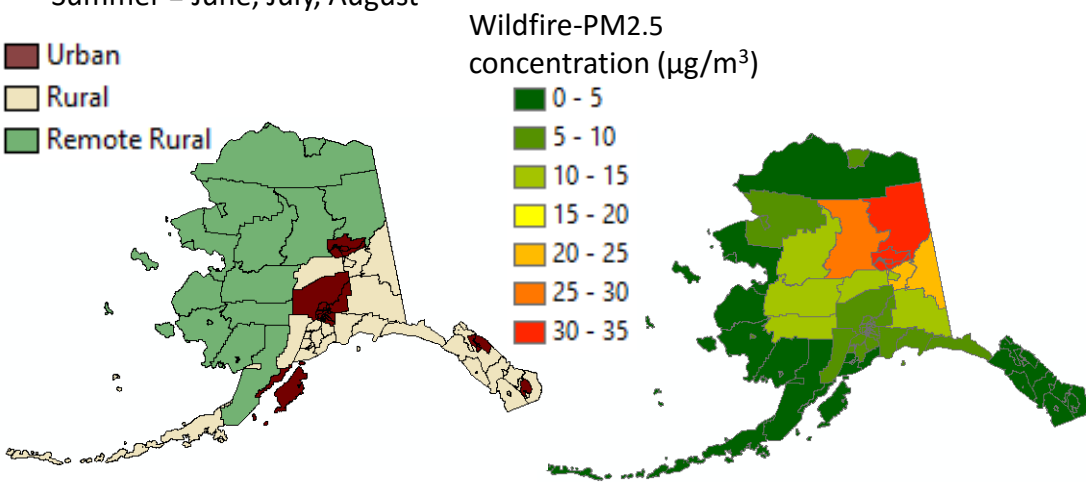


Urban areas experience higher wildfire-PM_{2.5} exposure than rural and remote rural areas

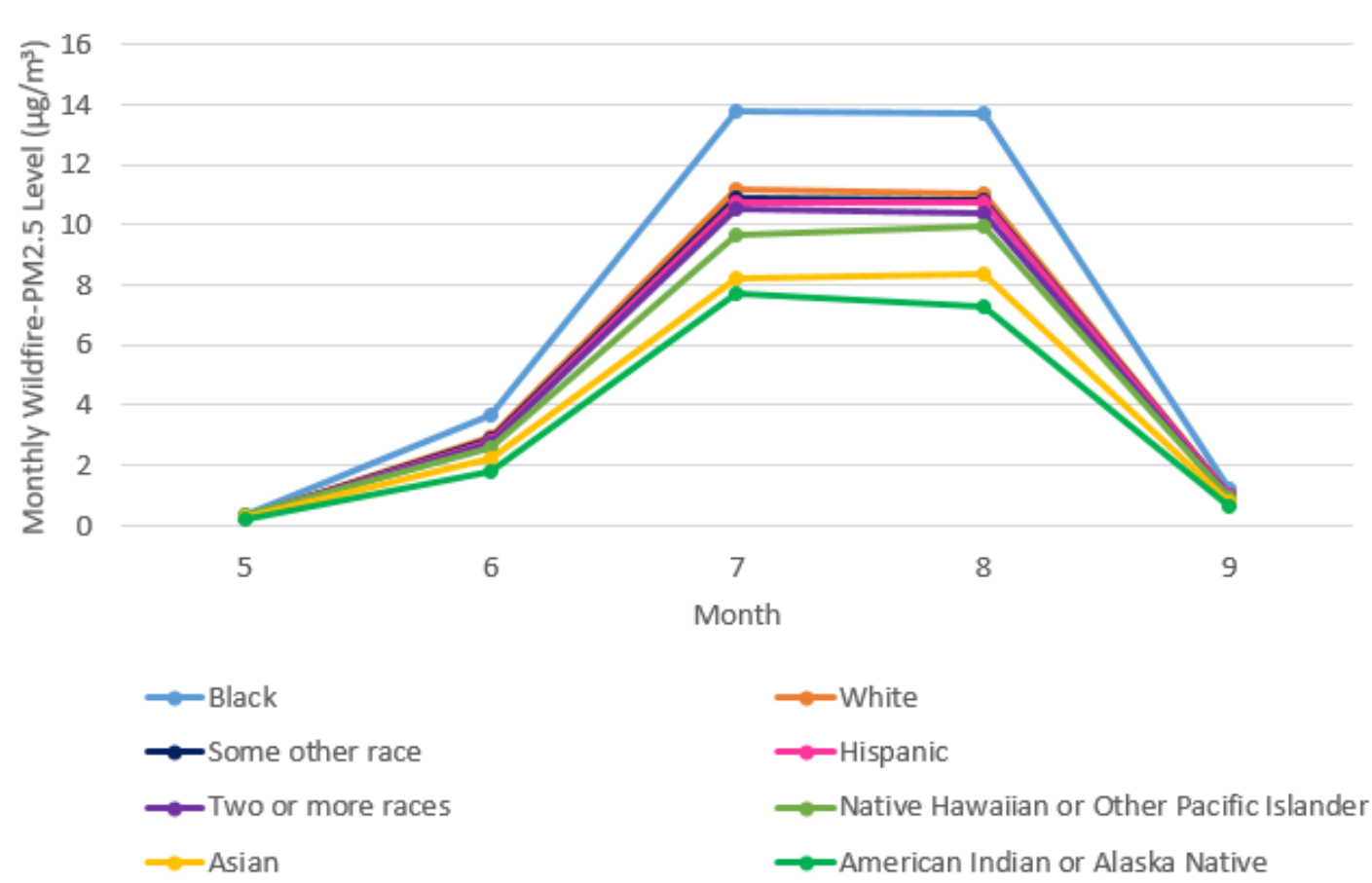


Developed Settlement Type	Summer Average Exposure Level [µg/m³]	Population Size (% of Total)
Urban	9.13	461,139 (74%)
Rural	4.46	105,674 (17%)
Remote Rural	4.45	60,119 (10%)

* Summer = June, July, August

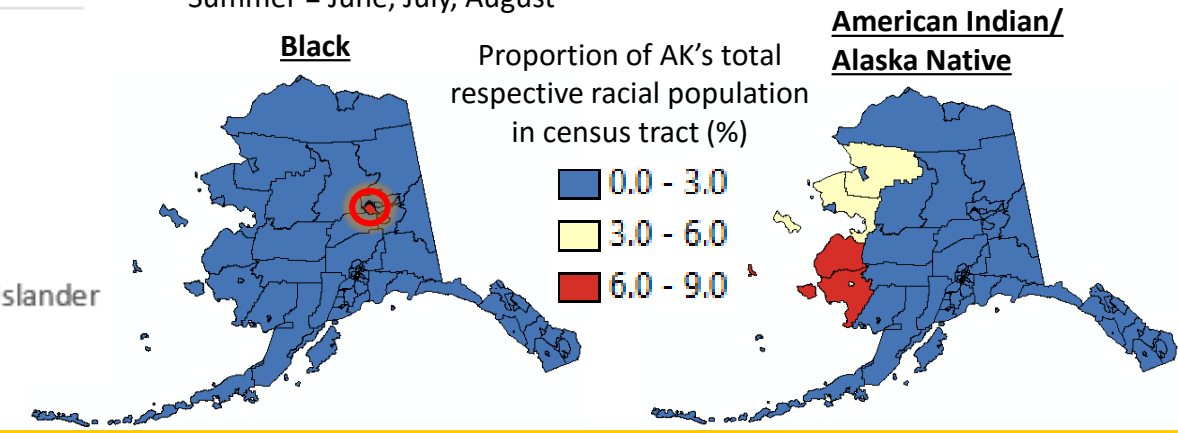


Blacks experience the highest exposure level, and American Indians or Alaska Natives the lowest level

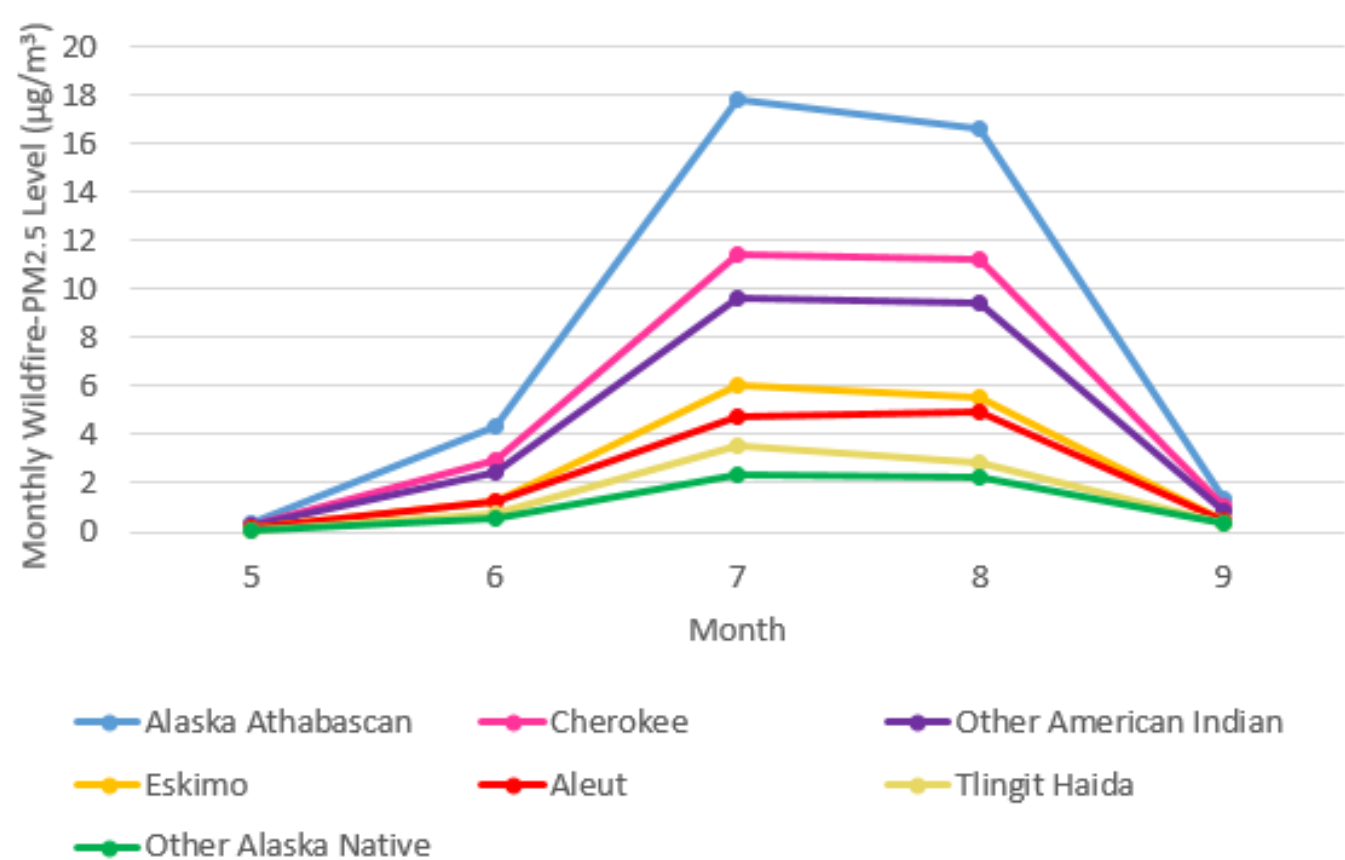


Race/Ethnicity	Summer Average Exposure Level [µg/m³]	Population Size (% of Total)
Black	10.36	21,787 (3%)
White	8.39	434,534 (69%)
Some other race	8.19	9,997 (2%)
Hispanic	8.11	25,852 (4%)
Two or more races	7.85	34,146 (5%)
Native Hawaiian and Other Pacific Islander	7.39	3,309 (1%)
Asian	6.25	25,116 (4%)
American Indian or Alaska Native	5.58	98,043 (16%)

* Summer = June, July, August

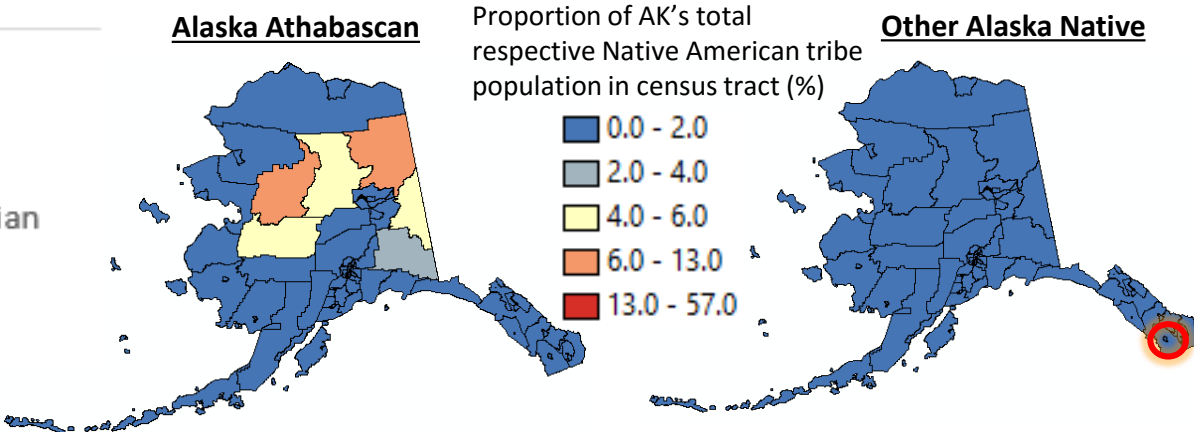


Among the Native tribes, Alaska Athabascans experience by far the highest exposure level, and the Other Alaska Natives experience the lowest

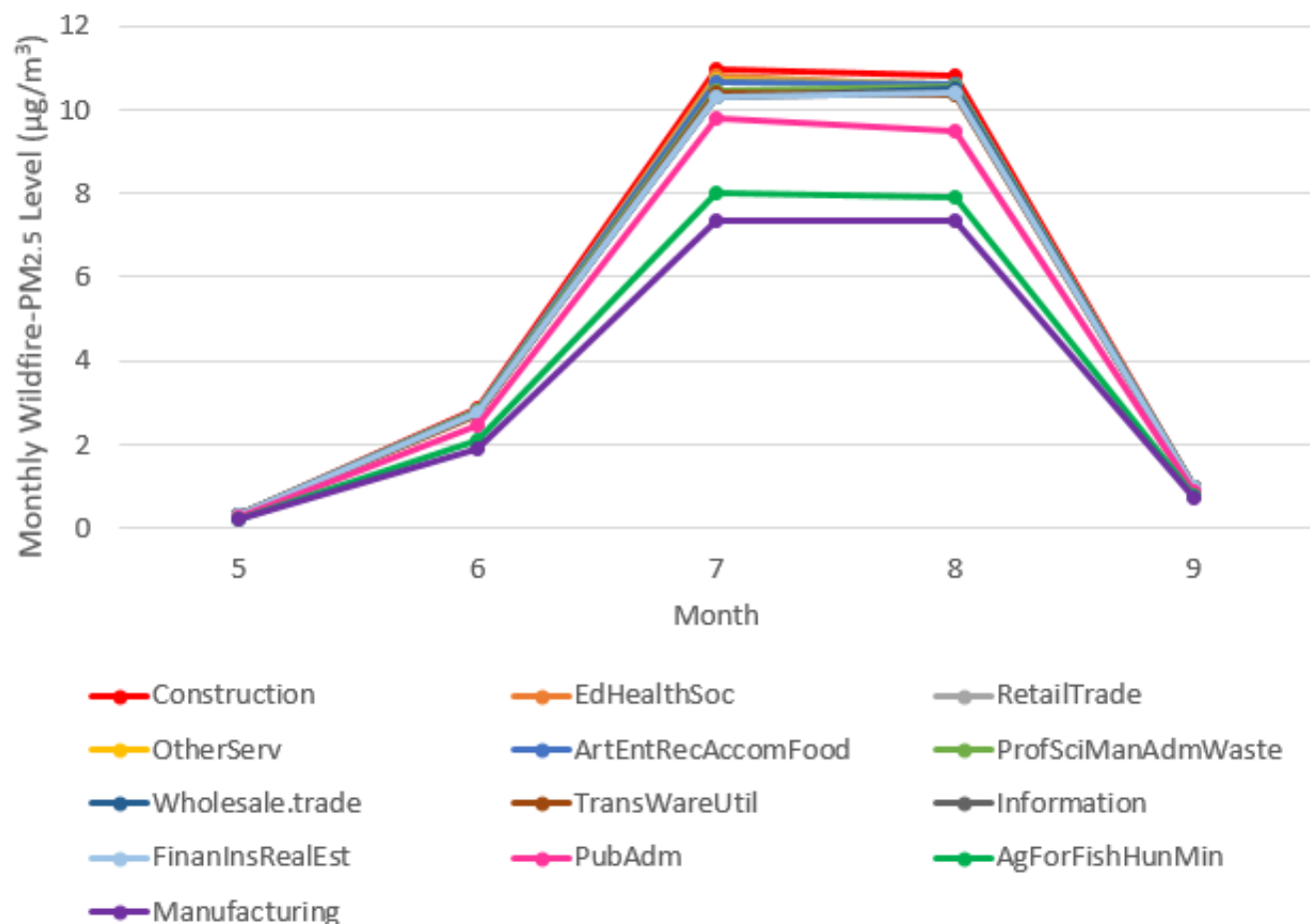


Native Tribe	Summer Average Exposure Level [µg/m³]	Population Size (% of Total)
Alaska Athabaskan	12.89	11,910 (15%)
Cherokee	8.53	962 (1%)
Other American Indian	7.17	4,151 (5%)
Eskimo	4.26	41,481 (53%)
Aleut	3.63	8,282 (11%)
Tlingit-Haida	2.38	9,153 (12%)
Other Alaska Native	1.72	1,699 (2%)

* Summer = June, July, August



Occupation industry subpopulations also experience differential wildfire-PM_{2.5} exposure



Occupation Industry	Summer Average Exposure Level [µg/m ³]	Employed Civilian 16+ yr Population Size (% of Total)
Construction	8.20	20,534 (7%)
Educational, health and social services	8.05	61,165 (22%)
Retail trade	8.04	32,638 (12%)
Other services (except public administration)	8.03	15,866 (6%)
Arts, entertainment, recreation, accommodation and food services	8.03	24,099 (9%)
Professional, scientific, management, administrative, and waste management services	7.94	21,322 (8%)
Wholesale trade	7.85	7,215 (3%)
Transportation and warehousing, and utilities	7.82	25,043 (9%)
Information	7.82	7,652 (3%)
Finance, insurance, real estate, and rental and leasing	7.82	12,934 (5%)
Public Administration	7.26	30,070 (11%)
Agriculture, forestry, fishing and hunting, and mining	6.00	13,774 (5%)
Manufacturing	5.52	9,220 (3%)

* Summer = June, July, August



Future (2047-2051) Wildfire-Specific Pollution under Climate Change

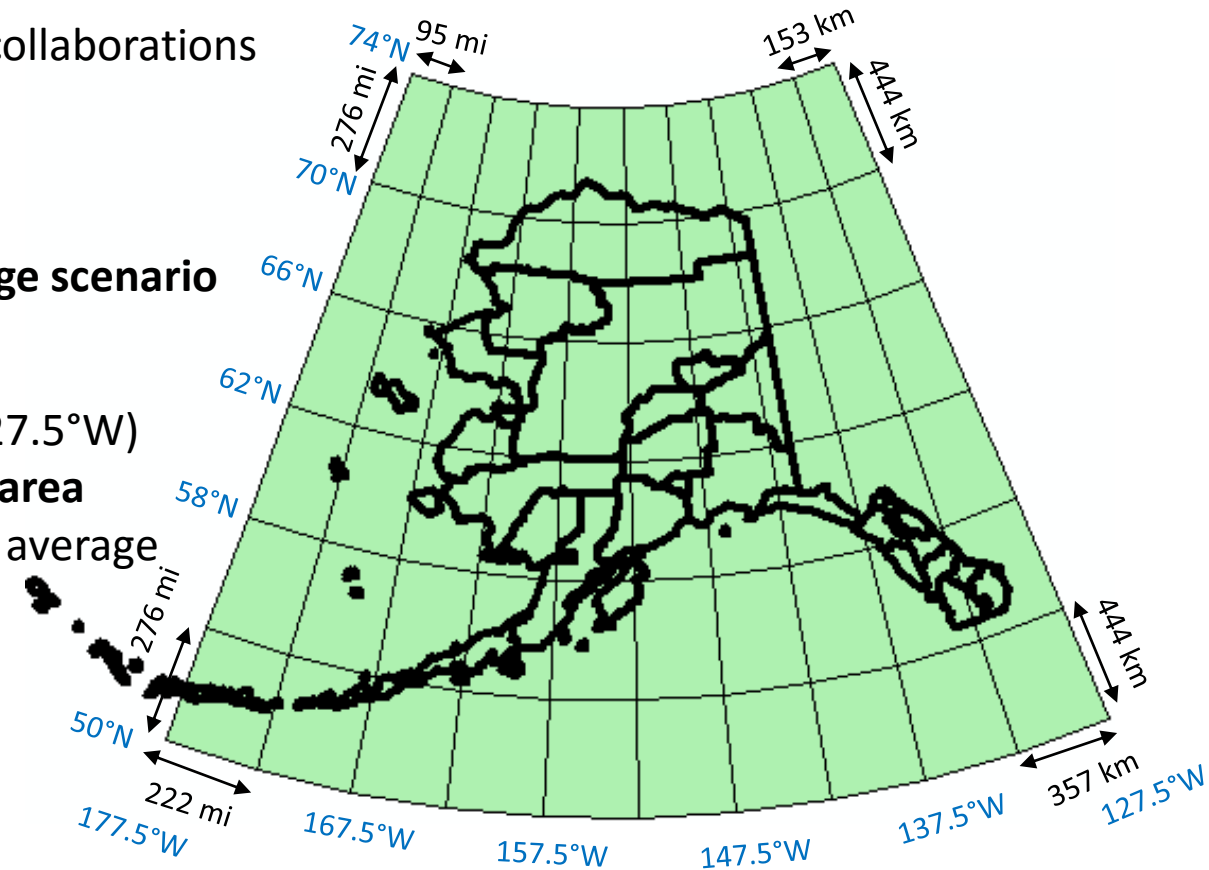
PC: Bureau of Land Management Alaska Fire Service

Data & Methodology

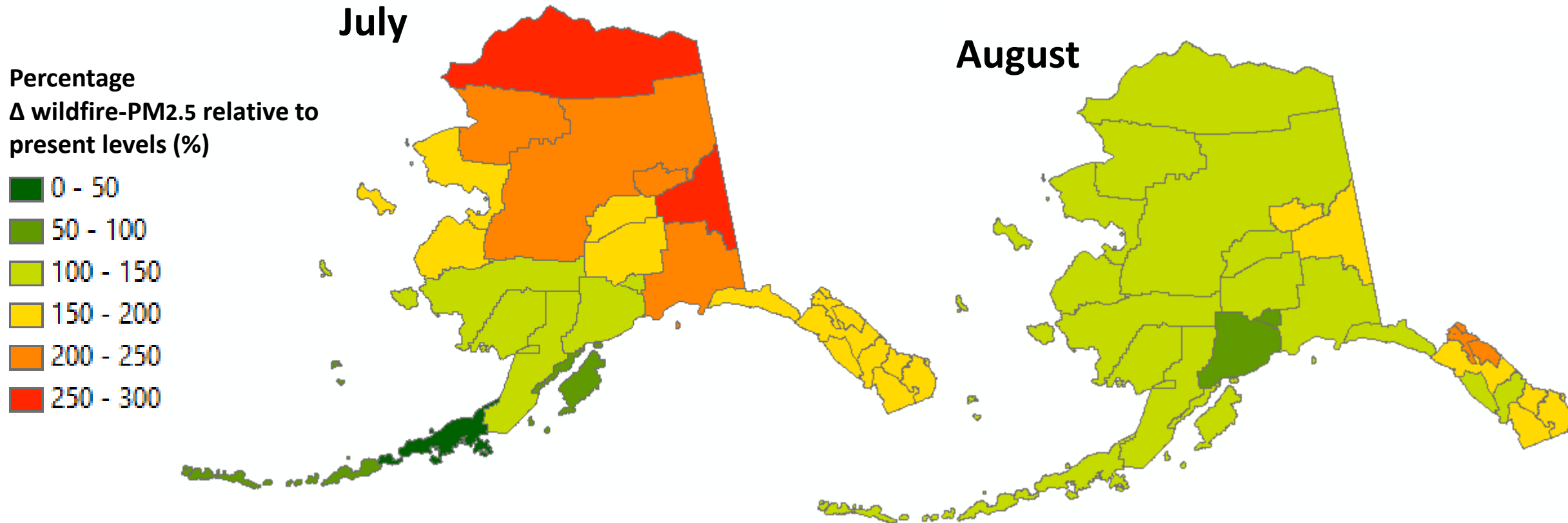
FUTURE Wildfire-PM2.5 Exposure Level Data:

Courtesy of Drs. Xu Yue & Loretta Mickley, Yale & Harvard collaborations

- **Ensemble of 13 climate models**
(expected higher temperature & humidity) &
GEOS-Chem based transport model
- **Future Simulation: under IPCC's A1B climate change scenario**
- Spatial Coverage & Resolution:
 - Entire state of Alaska (**50°N-74°N**, 177.5°W-127.5°W)
 - Grid size: 4° x 5°: Derived to **borough/census-area** (county-equivalent) level using area-weighted average
- Time Period & Temporal Resolution:
 - **1997 – 2001 & 2047-2051**, focusing on fire season (Apr-Oct)
 - Monthly, averaged across the years



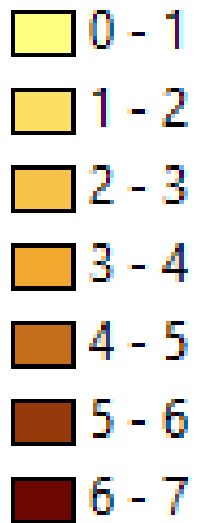
Almost the entire Alaska will be exposed to at least 100% increased wildfire-PM_{2.5} levels under climate change by 2047-2051 relative to 1997-2001



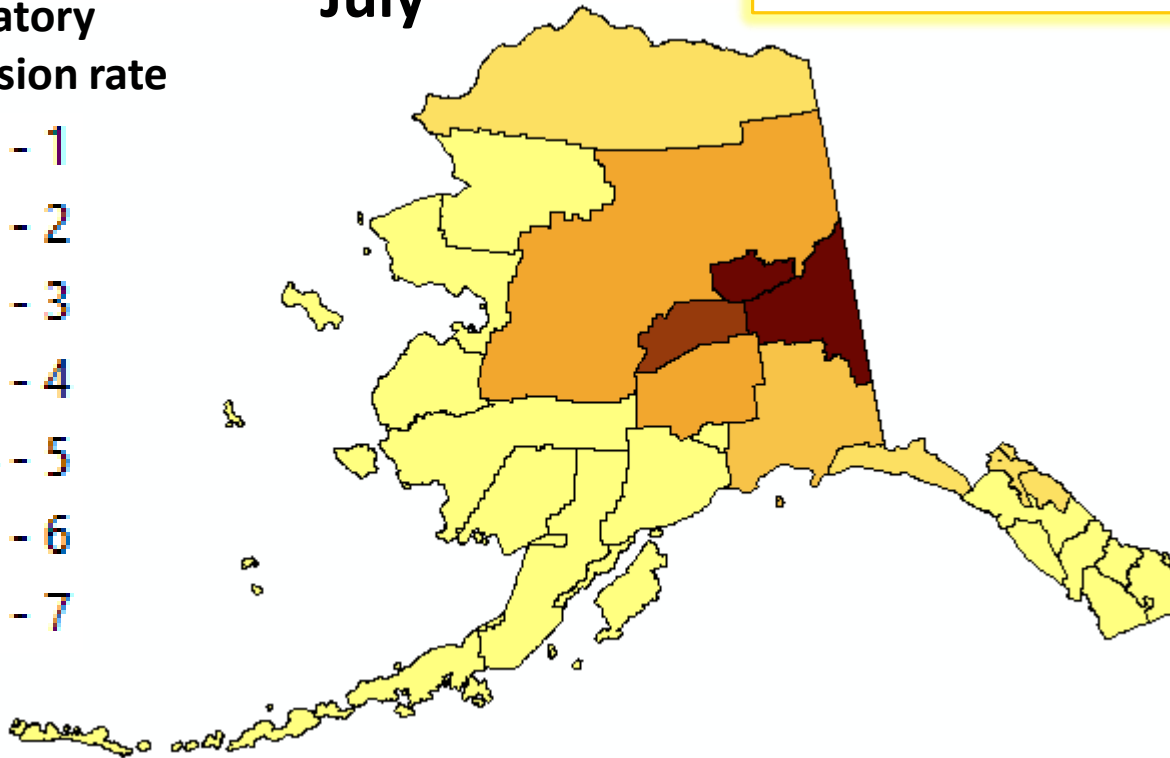
The respiratory hospitalization rate from wildfire smoke in the interior Alaska for the elderly population will increase by 2-7% under climate change from 1997-2001 to 2047-2051

7.2% (95% CI: 0.25%, 14.63%) increase in respiratory admission rate
per $29.6\mu\text{g}/\text{m}^3$ increase of wildfire- $\text{PM}_{2.5}$ (Liu et al 2016)

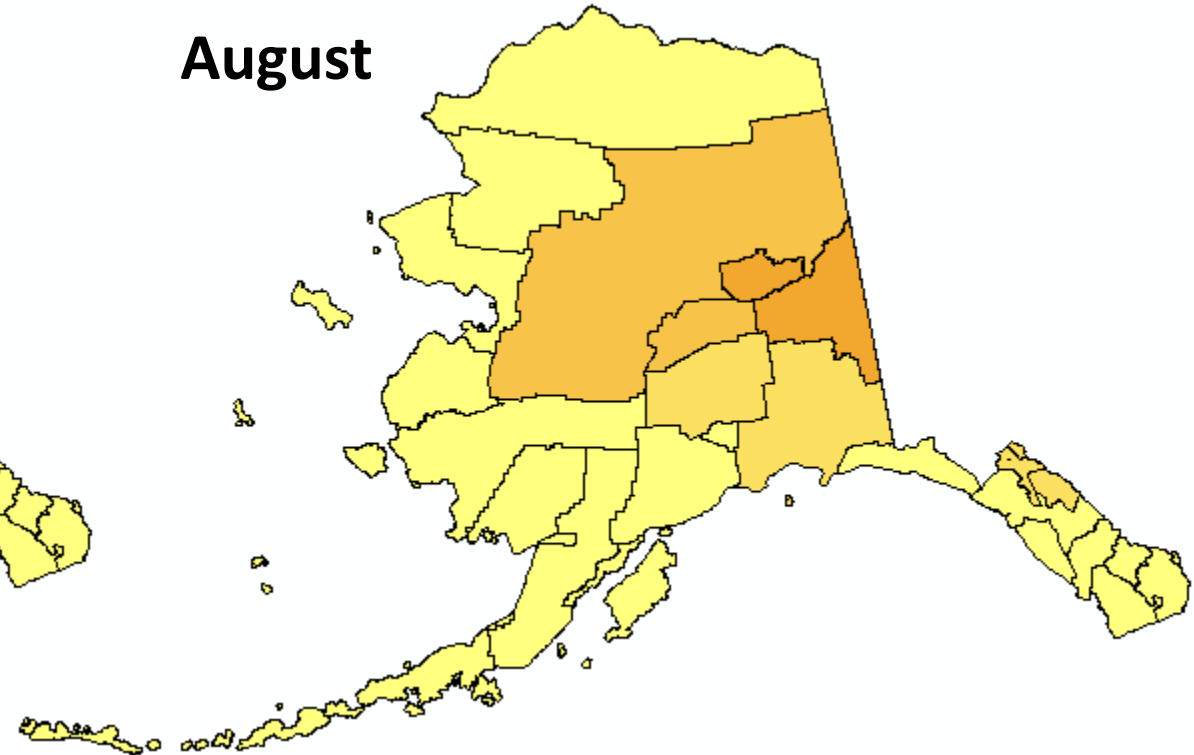
% increase in
respiratory
admission rate



July



August





Concluding Remarks & Discussion

PC: Western Arctic National Parklands

Concluding Remarks

- Alaska currently is experiencing high levels of wildfire-specific PM_{2.5} during July and August, especially in the interior.
- Alaska will experience increased levels of wildfire smoke exposure and associated health burden across the state by the mid-century under climate change.
- Air quality in Alaska poses an environmental justice issue since my findings suggest different subpopulations experience different levels of wildfire smoke exposure.
- More research is needed as this study only seeks to start the discussion on a topic previously untouched: potential human health impacts of wildfire smoke in Alaskan communities

References

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Questions? Feedback?

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Downtown Anchorage on May 22, 2014



on May 27, 2014 (PC: Lucia Woo)