

Public Health Impact of Prescribed Fire (PHIRE) Study – Baseline and Projected Prescribed Fire Smoke Exposures in California

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 - U.S. Forest Service: Leland Tarnay



Background

- Wildfire (WF) intensity and the frequency of severe WFs are increasing in the U.S. west, including California
- Prescribed (Rx) fires will also increase to combat this threat
 - CAL FIRE is scaling up to a target of 500,000 acres per year for fuels treatment by 2025^a

What are the air quality and health impacts of Rx smoke, in the context of WF smoke?

- WF: high-intensity, unmanaged smoke, broad spatial scale
- Rx: low-intensity, managed smoke, local spatial scale

Research Components

- Exposure Modeling – Sonoma Technology
- Health Analysis – CA Dept of Public Health and U.S. EPA
- Community Engagement – CA Dept of Public Health

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Baseline Scenario – Fire Inventory Data Sources

WF Data

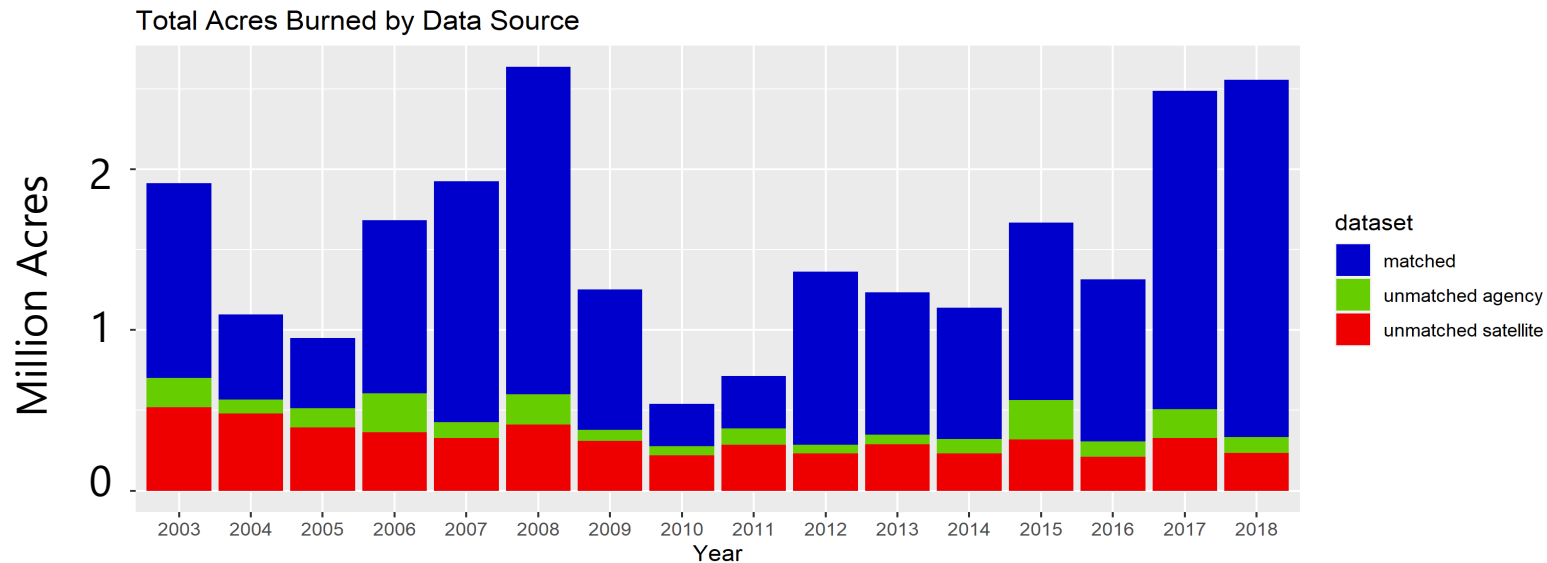
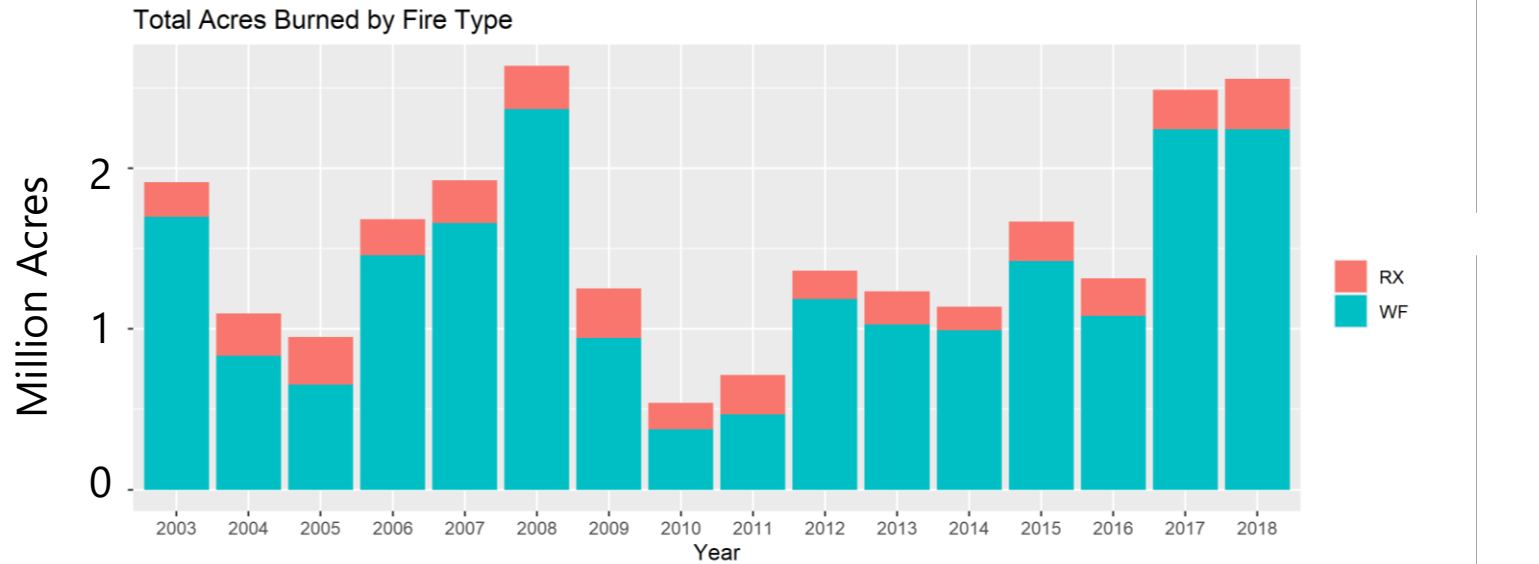
- Satellite
 - MODIS 2003-2018
- Agency
 - 2003-2017 (USFS FPA FOD)^a
 - 2018 (GeoMAC, ICS-209, FIRESTAT, CAL FIRE)

Rx Fire Data

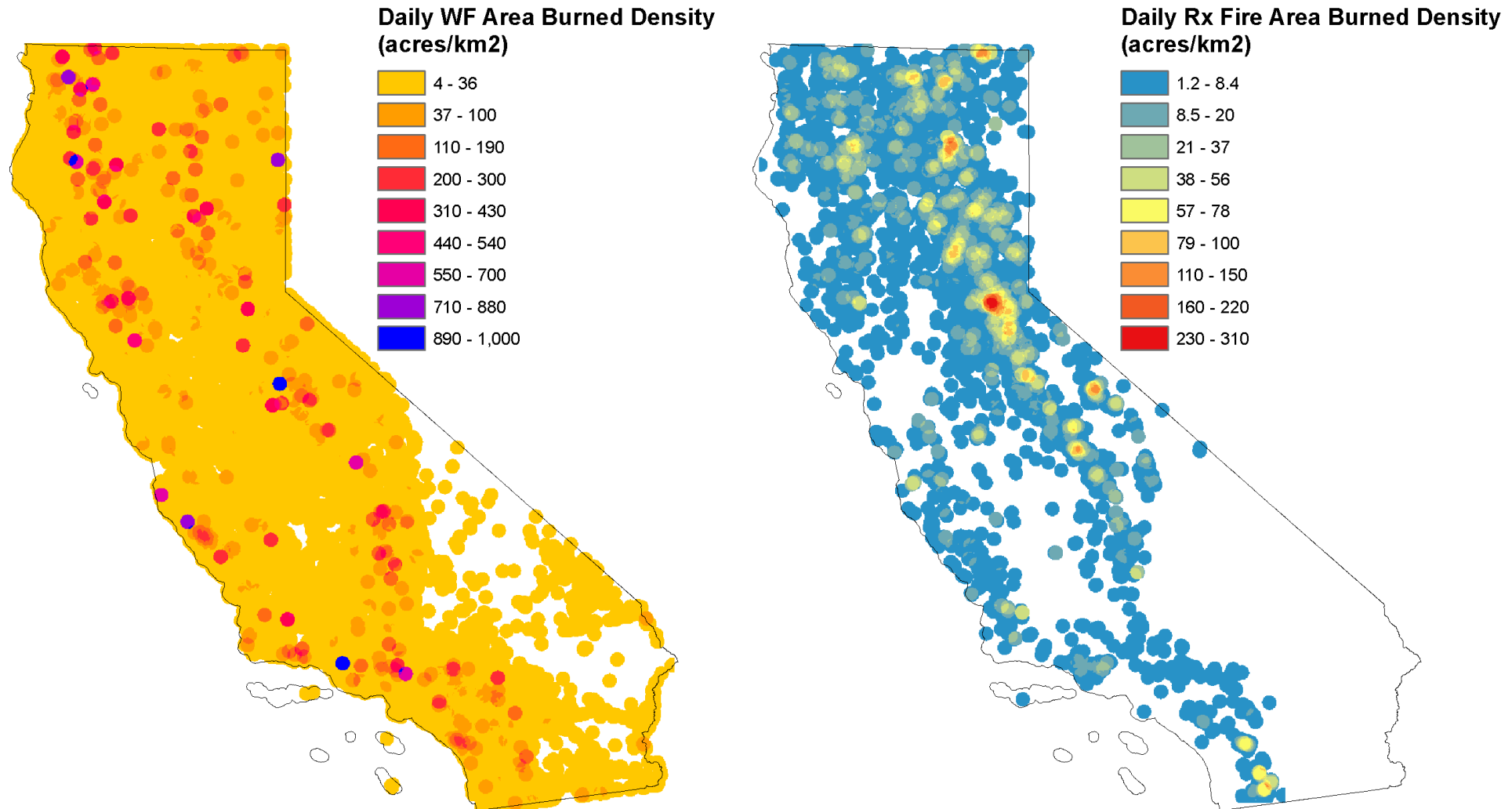
- Satellite
 - MODIS 2003-2018
- Agency
 - 2003-2018 (CAL FIRE, USFS FACTS, CARB PFIRS)

All records were spatiotemporally joined and matched to remove duplicates and reconcile differences in data records from difference sources

Fire Inventory 2003-2018



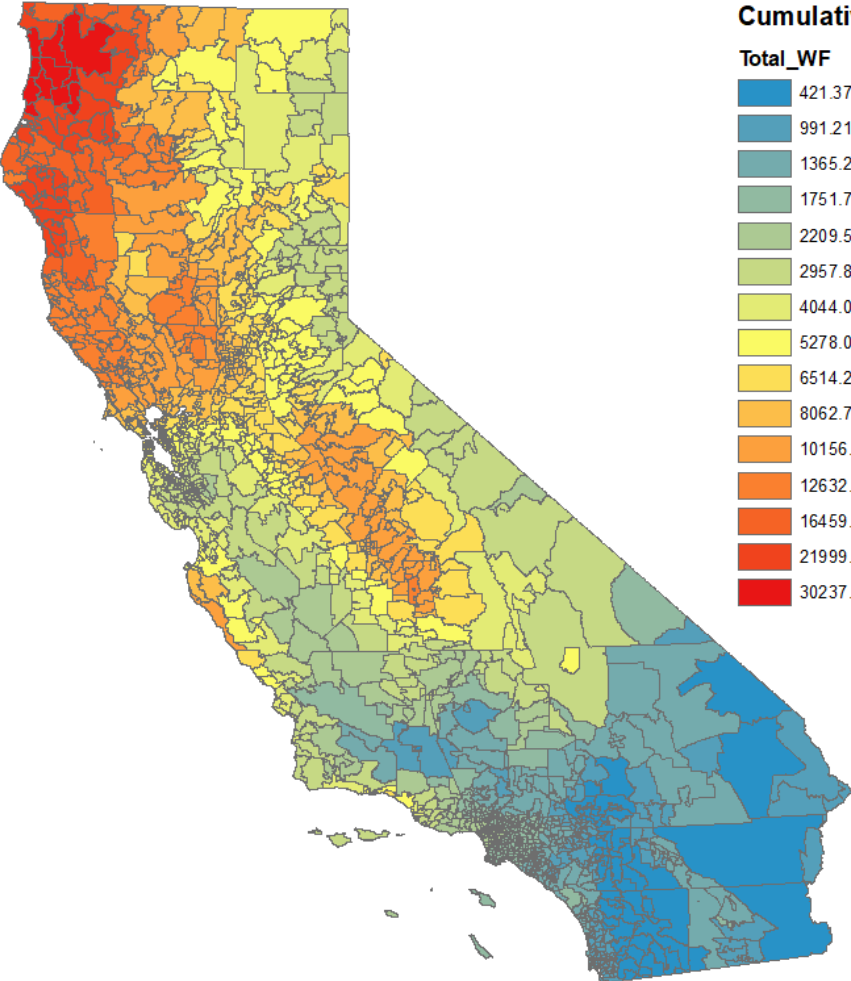
Distribution of Daily Fire Activities (2008-2017)



Baseline Scenario – Smoke Modeling for 2008-2017

- BlueSky Smoke Modeling Framework^a
 - FCCS (fuel loading) > Consume (fuel consumption) > Prichard-O’Neill Emissions^b (smoke emissions) > FEPS Plumerise (plumerise)
- HYSPLIT Smoke Dispersion
 - 0-500 m height average
 - North American Mesoscale 12-km (NAM12) meteorology
- Dispersion results downscaled to 1-km grid space using bilinear interpolation
- Daily intersection with HMS smoke plume data

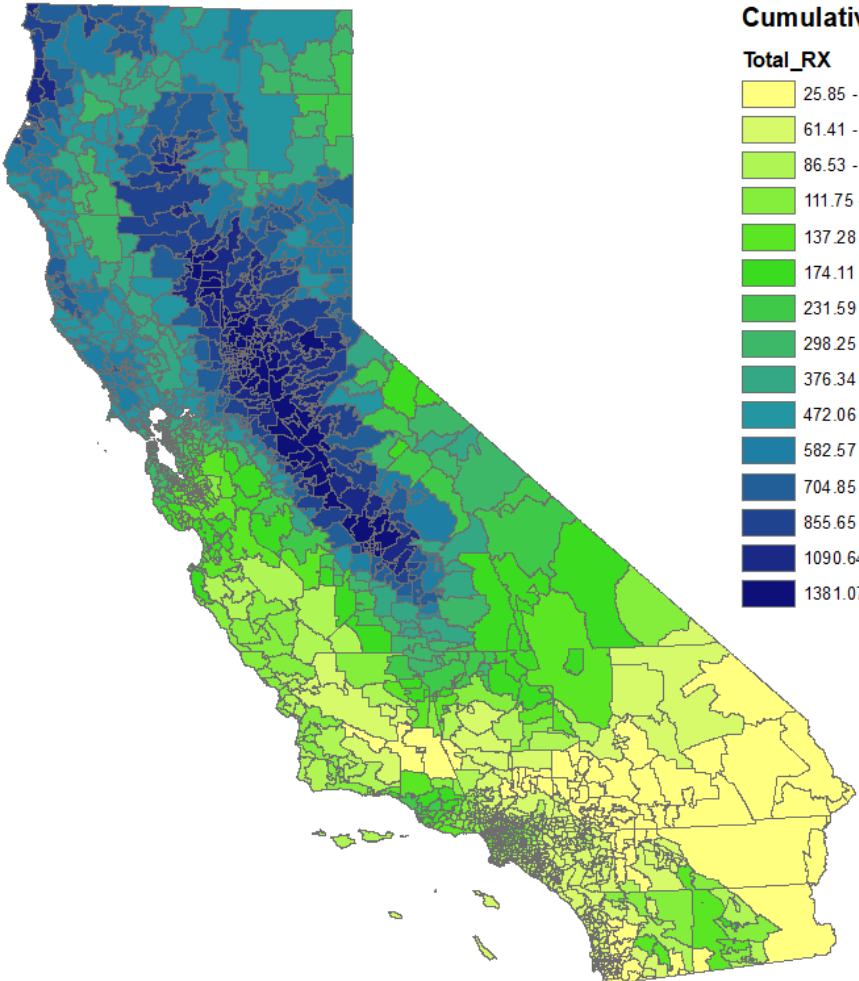
Cumulative Modeled PM_{2.5} Exposure from WF and Rx Smoke (2008-2017)



Cumulative WF PM2.5 2008-2017

Total_WF

421.37 - 991.20
991.21 - 1365.27
1365.28 - 1751.78
1751.79 - 2209.58
2209.59 - 2957.81
2957.82 - 4044.02
4044.03 - 5278.02
5278.03 - 6514.21
6514.22 - 8062.70
8062.71 - 10156.28
10156.29 - 12632.55
12632.56 - 16459.37
16459.38 - 21999.59
21999.60 - 30237.62
30237.63 - 42595.43

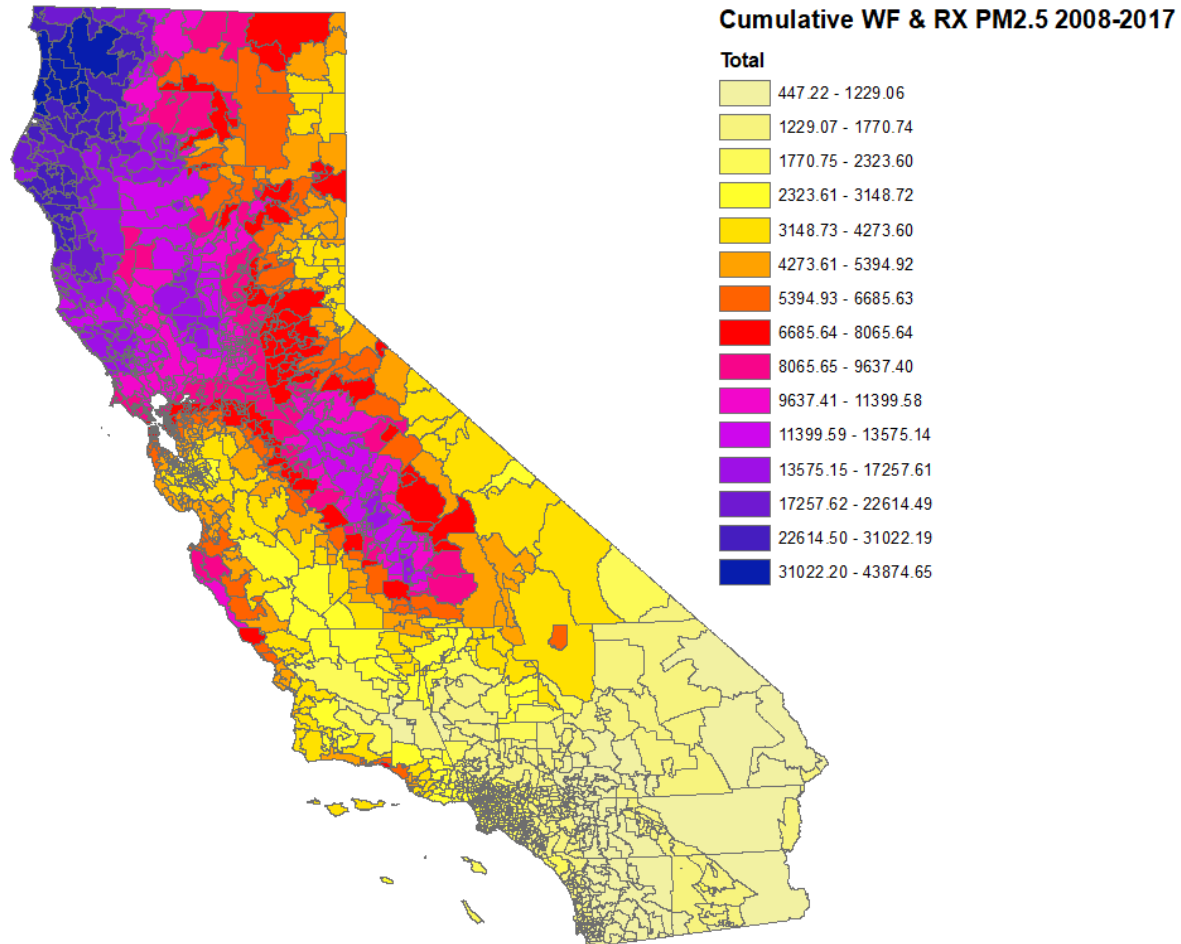


Cumulative RX PM2.5 2008-2017

Total_RX

25.85 - 61.40
61.41 - 86.52
86.53 - 111.74
111.75 - 137.27
137.28 - 174.10
174.11 - 231.58
231.59 - 298.24
298.25 - 376.33
376.34 - 472.05
472.06 - 582.56
582.57 - 704.84
704.85 - 855.64
855.65 - 1090.63
1090.64 - 1381.06
1381.07 - 1747.55

Cumulative PM_{2.5} from Smoke Exposure



- WF PM_{2.5} exceeds Rx PM_{2.5} at all ZIP codes
- Cumulative Rx PM_{2.5} is at most 32% of cumulative WF smoke at the ZIP code level

Modeled PM_{2.5} Validation

Bluesky PM _{2.5}		Correlation			
Fire Type	Filter	IMPROVE PM _{2.5}	IMPROVE Measured TC ^a	IMPROVE Derived TC ^b	AQS PM _{2.5}
WF + RX	Modeled PM2.5 > 0	0.24	0.38	0.29	0.14
WF + RX	Modeled PM2.5 > 0, HMS= T	0.23	0.36	0.28	0.30
WF	Modeled PM2.5 > 0	0.24	0.40	0.30	0.15
WF	Modeled PM2.5 > 1	0.23	0.37	0.28	0.23
WF	Modeled PM2.5 > 5	0.18	0.32	0.24	0.25
WF	Modeled PM2.5 > 0, HMS= T	0.23	0.36	0.28	0.30
WF	Modeled PM2.5 > 1, HMS= T	0.19	0.33	0.24	0.28
WF	Modeled PM2.5 > 5, HMS= T	0.12	0.28	0.19	0.24
RX	Modeled PM2.5 > 0	0.11	0.13	0.08	0.08
RX	Modeled PM2.5 > 1	0.12	0.24	0.05	0.07
RX	Modeled PM2.5 > 5	0.21	0.42	0.11	0.07
RX	Modeled PM2.5 > 0, HMS= T	-0.09	-0.12	-0.06	-0.03
RX	Modeled PM2.5 > 1, HMS= T	-0.18	-0.57	-0.07	-0.11
RX	Modeled PM2.5 > 5, HMS= T	-0.35	-1.00	-0.32	-0.17

^a2015-2017 Only

^bTC = EC + 1.8 X OC

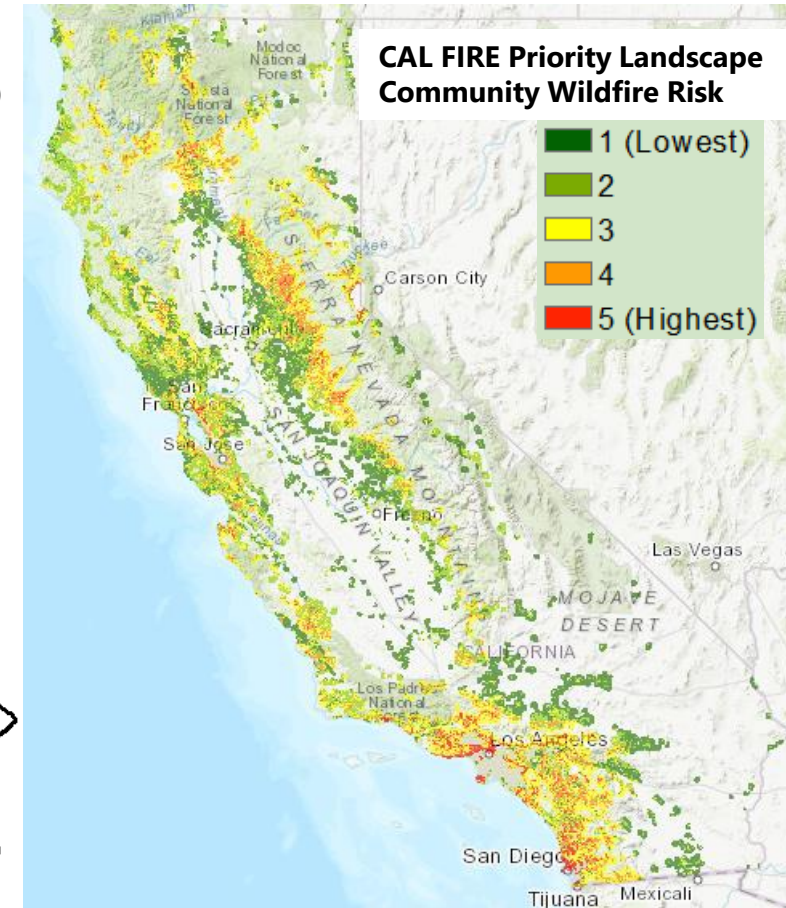
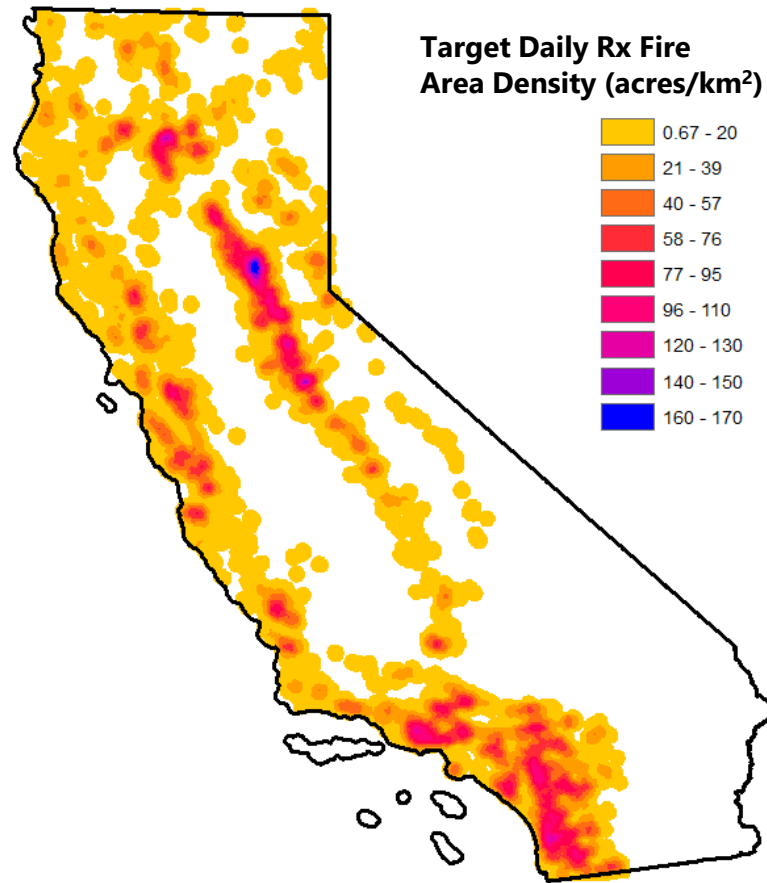
- Best correlations with IMPROVE measured total carbon (TC), although these were only moderate correlations
- Low-to-moderate correlations with AQS PM_{2.5} and IMPROVE calculated TC
- In general, there were stronger correlations for modeled WF smoke than for modeled Rx smoke

Target Prescribed Fire Scenario

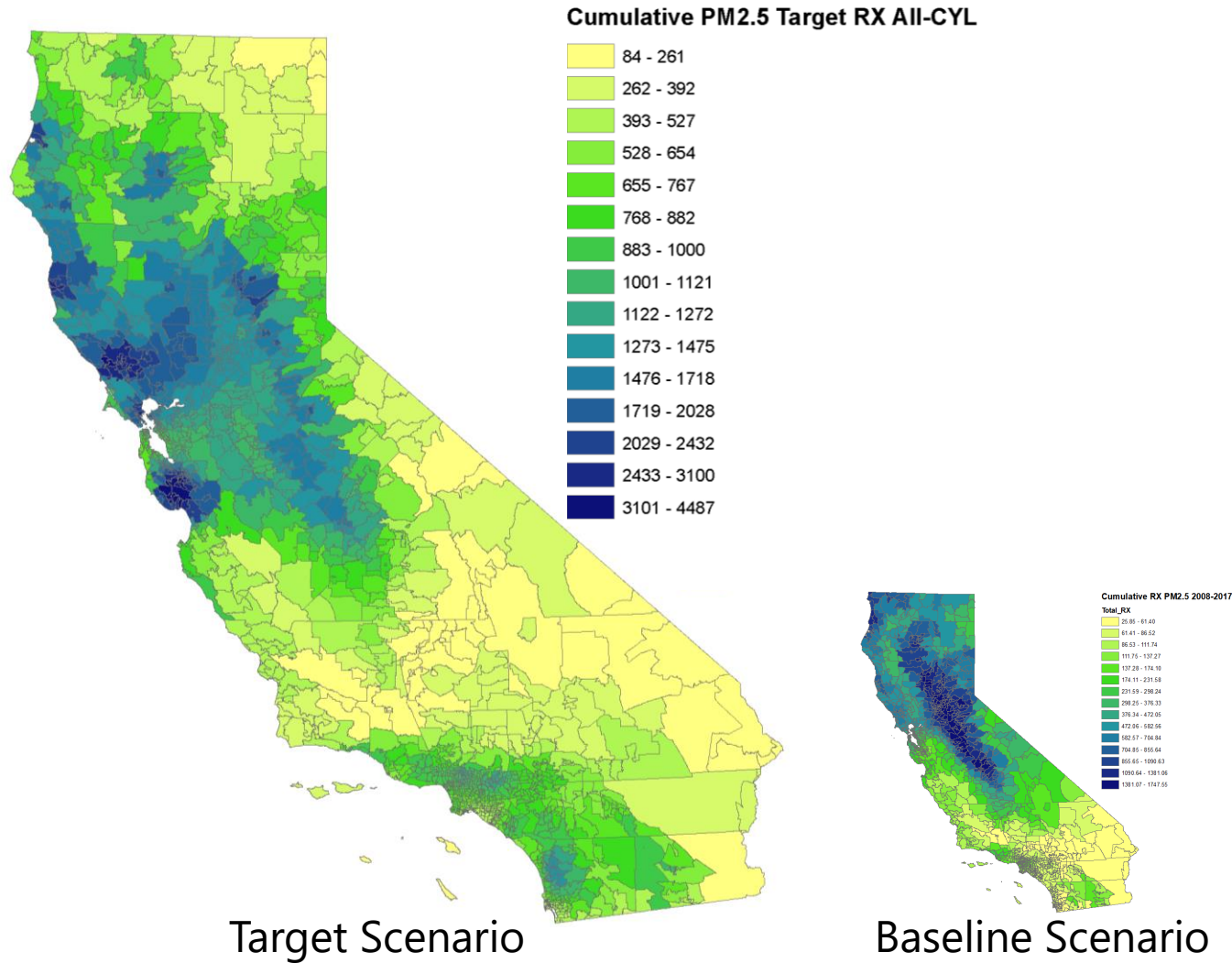
- Rx fire inventory used for classifications (size by vegetation type)
- Randomly distributed within CAL FIRE Priority Landscape (risk to communities^a) Class 4 and 5 (~4 million acres)
- Randomly assigned to eight annual cycles, 500,000 acres per cycle
- Randomly allocated to burn days in each annual cycle
 - CARB Burn Day (go, no-go) for each California Air Basin
- 2014 meteorology data used for smoke modeling of each cycle to keep meteorology constant
 - Median number of burn days for 2008-2017 records
 - Wind, soil moisture, and precipitation within 2 standard deviations compared to baseline period (2008-2017) averages

Target Scenario – Projected Prescribed Fire Area

- Fire locations were randomly selected in piecewise manner to avoid overlap
- Each annual cycle has ~500,000 acres burned



Target Scenario - PM_{2.5} Exposure from Projected Rx Activities



- Projected smoke impacts seen in the Northern Coast Range, SF Bay Area, Sacramento Valley, San Joaquin Valley, and Sierra Nevada
- Smoke impact level is three times of the baseline Rx smoke impact on average

Summary and Continued Work

- A 2003-2018 wildfire and prescribed fire inventory was developed based on satellite observations and multiple agency records
- Target prescribed fire inventories for eight annual cycles were generated
- Daily emissions and dispersion modeling was done for the baseline and target Rx fire inventories
- Smoke PM_{2.5} exposure was extracted for each California ZIP code
 - Moderate agreement was found with IMPROVE and AQS sites
- This work is ongoing:
 - Intercomparison between baseline and target scenarios
 - Health effects, attributable health burden, and mortality analysis
 - Community engagements, including surveys and listening sessions



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