

Wildfires, Smoke, and Outdoor Recreation in the Western United States

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AERE Session: Air Quality and Behaviors

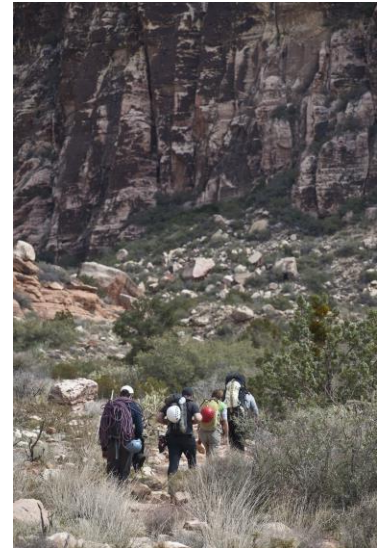
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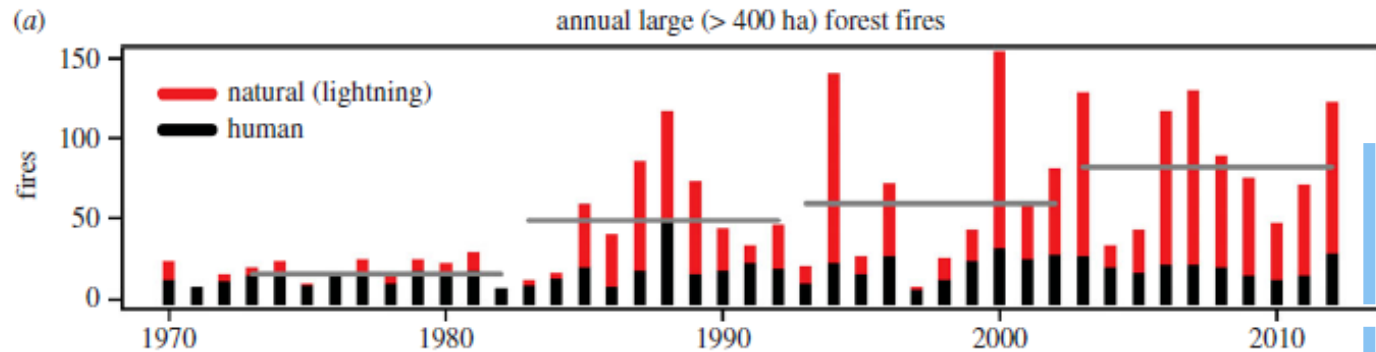
Outdoor recreation & public lands

- Outdoor recreation and visits to public lands are on the rise
 - 327.5 million visitors to national parks in 2019
 - 6 highest-visitation years on record: 2014-2019
 - BLM lands: 20% increase over last 10 years
- Outdoor recreation is significant economic driver – 2.2% of US GDP (BEA 2019)
 - Higher in the West...3.3% in Utah & Colorado; 5% in Montana



Wildfire trends

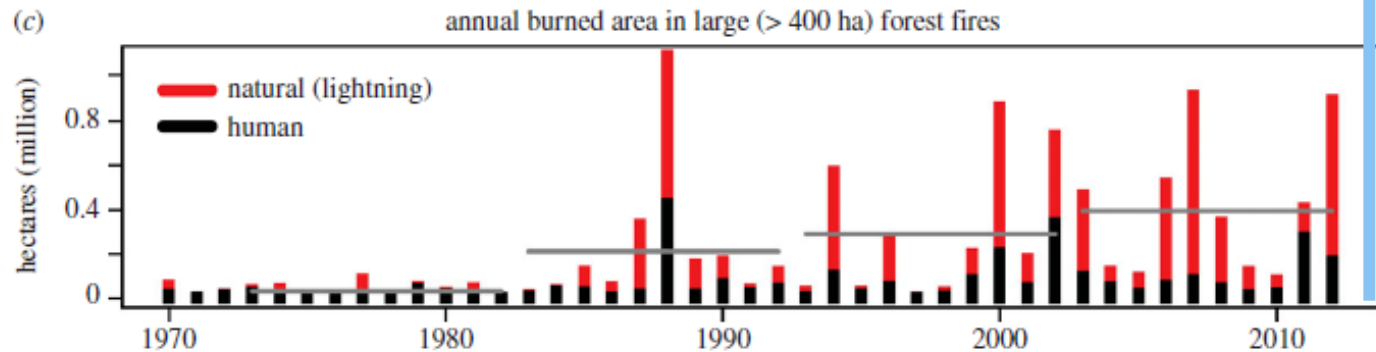
Wildfires are increasing in frequency and severity



2020 season:

104 fires

5.6 million hectares



Source: Westerling (2016)

Wildfire smoke accounts for ~50% of PM_{2.5} exposure in western US, compared to <20% a decade ago (Burke et al., 2020)



Wildfire & outdoor recreation

- Wildfire poses a problem for outdoor recreation for three reasons:
 - Most fires in the US occur where recreation takes place – in 2018, 63% on federal lands (Hoover & Hanson 2019)
 - Most fires occur when recreation takes place – summer months
 - Smoke exposure high for recreationists, who spend many hours outdoors
 - Some studies find health benefits of exercise offset by negative health effects of smoke (Korrick et al. 1998)



Literature

- Effect of fire-damaged landscapes on recreation demand
 - Combined revealed and stated preference (e.g., hypothetical fire scenarios) data; how fire characteristics affect trip frequency & values (Loomis, González-Caban, & Englin 2001; Englin, Loomis, & González-Cabán 2001; Hesselin et al. 2003; Hesselin, Loomis, & González-Cabán 2004; Boxall & Englin 2008; Tanner, Lupi & Garnache 2019)
- Effect of fire on national park visitation (using monthly & annual data over multiple years & fires) (Duffield et al. 2013 (Yellowstone NP); Kim & Jakus 2019 (5 Utah NPs))



Literature (cont.)

- The impact of wildfire smoke on outdoor recreation has received less attention
 - Surveys after wildfire event: how people alter their outside activities, including exercise & recreation (Richardson, Champ, & Loomis 2012; Fowler et al. 2019)
 - Studies of air pollution (not specific to smoke) in national parks
 - PM2.5 levels often as high as urban areas; affect visitation (Keiser, Lade & Rudik 2018)
 - WTP to improve visibility (Rowe, d'Arge, & Brookshire, 1980; Schulze et al. 1983; Boyle et al. 2016; Haider et al. 2019 – application to wildfires in BC)
- Studies find that health effects of exposure to wildfire smoke are significant (Reid et al. 2016 review of 53 epi studies; Miller, Molitor & Zou 2017 large sample of Medicare recipients)

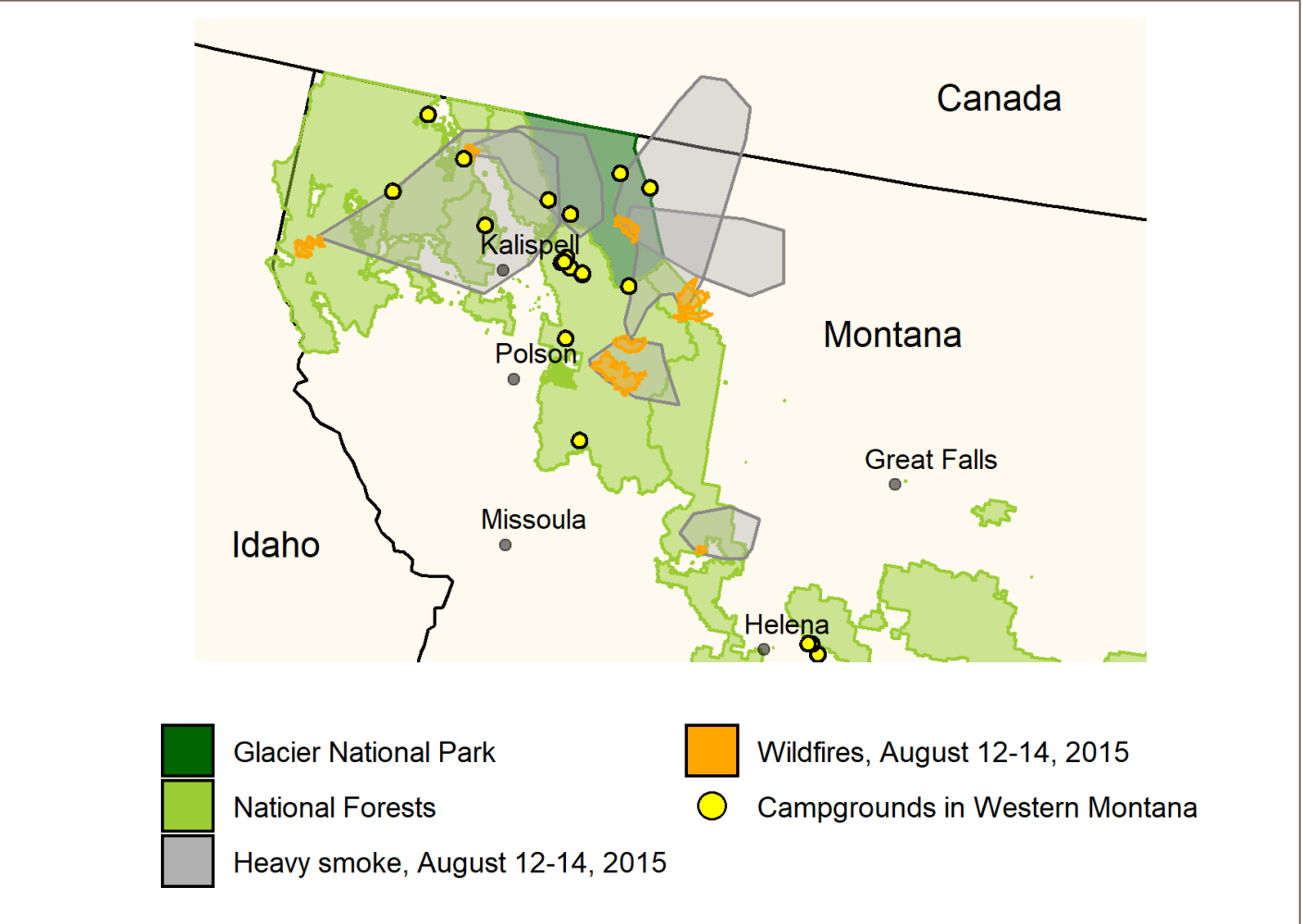


This study

- Calculates the extent to which wildfire and adverse smoke conditions affected campers on public lands across the continental western US over a 10-year period
- Estimates the impact of wildfire and smoke on campground use
 - Unique recreation data:
 - Daily data, 2008-2017, from www.recreation.gov (25 million individual records; 3.3 million unique users)
 - Campsite reservations, cancellations, transaction dates, no. of people in party; individual campground and recreation area (e.g., national park, national forest ranger district, etc)
 - For this study, we aggregate to campground level – 1,069 campgrounds
 - Merged with wildfire & smoke data:
 - MODIS daily fire detection data, filtered by USGS Monitoring Trends in Burn Severity (MTBS) dataset (to exclude fires < 1,000 acres)
 - NOAA Hazard Mapping System smoke plume data, combined with interpolated EPA daily ground-level PM_{2.5} monitoring data from Burkhardt et al. (2019) (to include only smoke plumes that reflect adverse ground-level conditions – i.e., where PM_{2.5} is at least 1.64 std dev above the seasonal mean for days without smoke plumes)



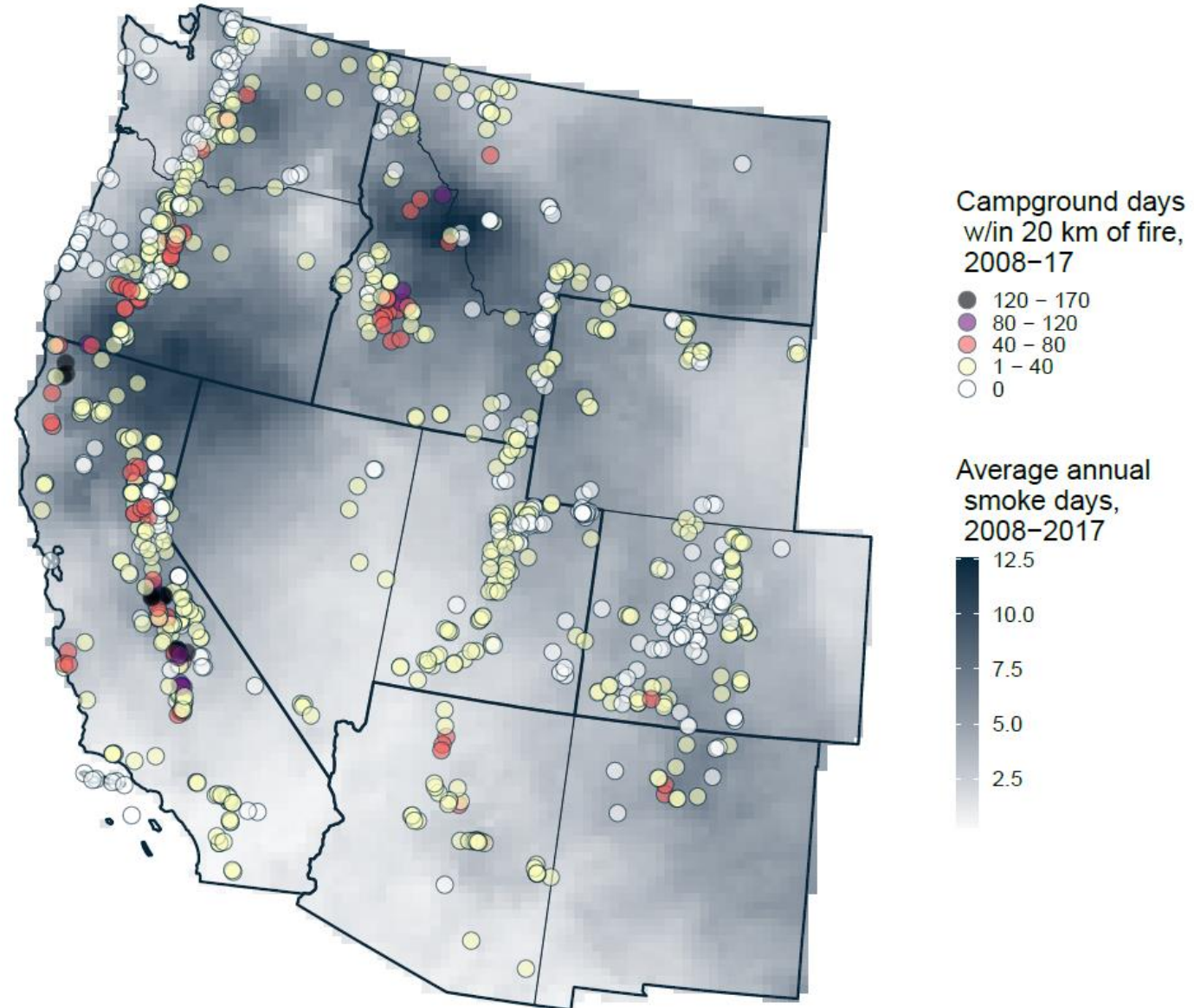
A sample map of fire, smoke, and campground data



Results: fire and smoke impacts on campgrounds

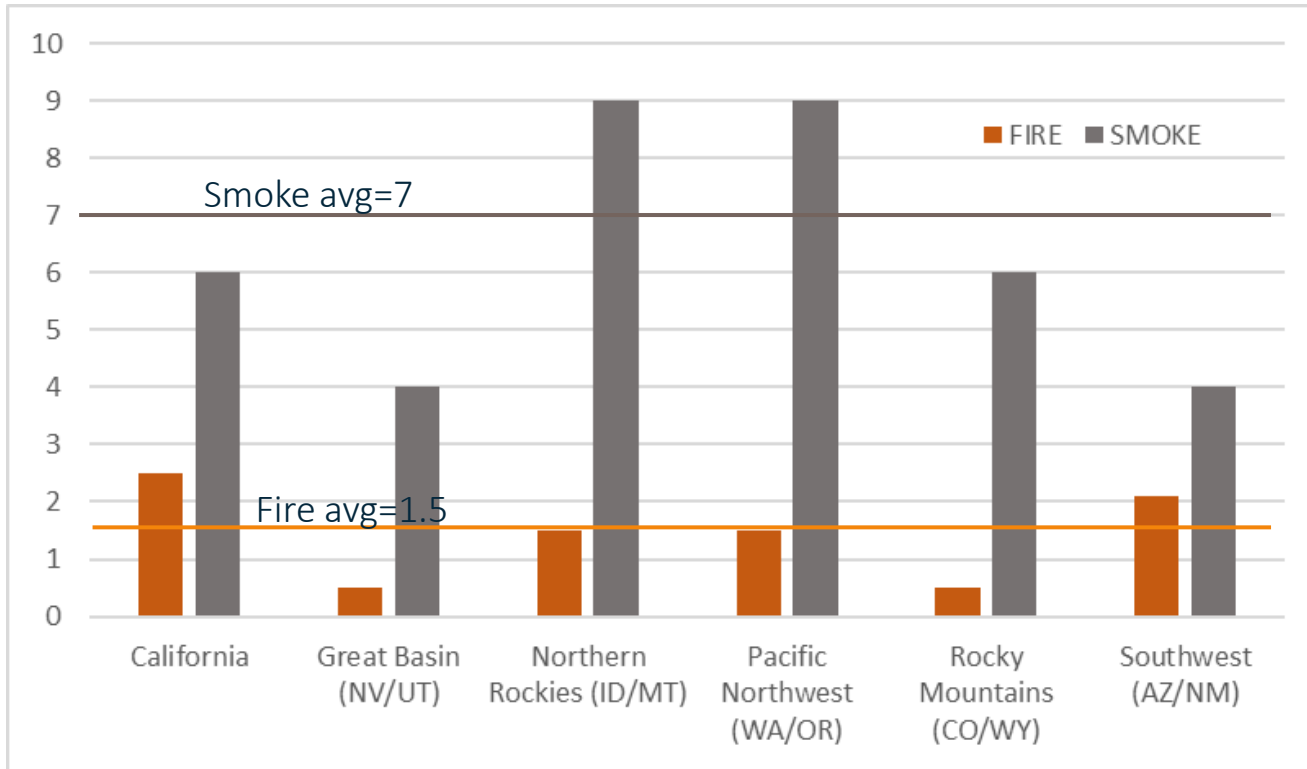
Note:

- Some smoky regions don't have very many campgrounds (e.g. eastern Oregon)
- Some regions have lots of campgrounds and don't get a lot of fire and smoke (e.g., CO & UT)
- Some regions have campgrounds affected by smoke but not often near a fire (e.g., northern Rockies)
- California has it all – lots of campgrounds + fire and smoke



Results: fire and smoke impacts on campgrounds (cont.)

Average number of days per year per campground with a fire nearby (w/in 20 km) or under adverse smoke conditions

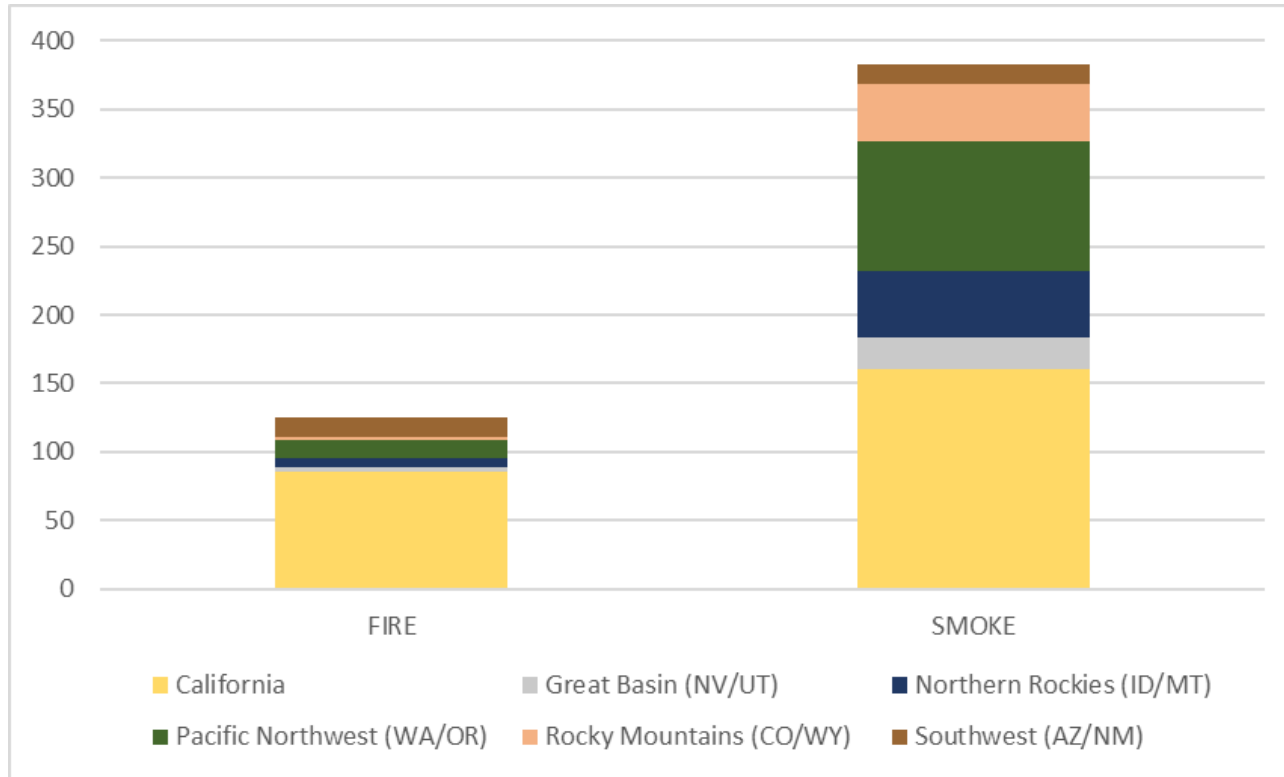


- Campgrounds are affected more often by smoke than fire
 - Average campground has 4.7 times as many smoky days as days with a fire nearby
- Smoke has large effects in regions that don't have many fires... Pacific NW and Northern Rockies
 - 11-12 percent of the days the campgrounds in those regions are open have smoky conditions – *shorter camping season*
- Southwest campgrounds average almost as many days with a fire nearby as California



Results: fire and smoke impacts on campers

Average number of camper-days (in thousands) per year with a fire nearby (w/in 20 km) or under adverse smoke conditions

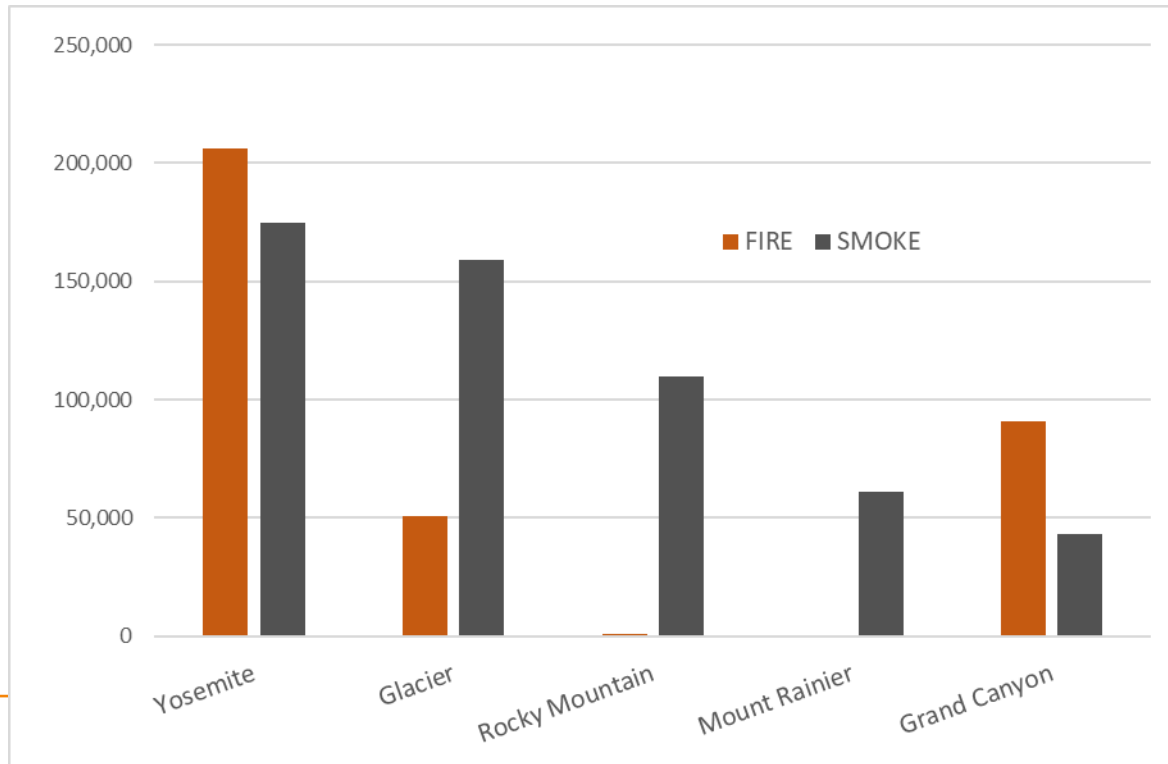


- 3 times as many campers affected by smoke as fire
- A total of 383,000 people per year, on average, are camping under adverse smoke conditions
- Although California has largest *number* of person-days affected by smoke, Northern Rockies and Pacific NW have largest *percent* of person-days affected (7% vs 4%) [bigger denominator in California, i.e., more camper-days in total]
- Few campers affected by fire and smoke in Southwest



Results: National park visitation

- Using monthly visitation data at national parks, we scaled our camping numbers to obtain estimates of average number of national park visitors affected by fire and smoke per year:



Total for all national parks in sample...

- 392,000 people per year visit when a fire is nearby*
- 1 million people per year visit during adverse smoke conditions*



Effects of fire and smoke on campground use

- Panel fixed effects regressions at individual campground level:
 - Daily occupancy rate – share of available campsites occupied on a given day
 - Cancellation rate, pre-arrival – share of upcoming week’s reservations that are cancelled on a given day
 - Cancellation rate, post-arrival (i.e., mid-stay) – number of cancellations during scheduled stays as a share of the number of occupants at the campground on a given day

$$y_{it} = \beta^f fire_{it} + \beta^s smoke_{it} + \alpha \sum_{\tau=t}^{t+7} precip_{i\tau} + \varphi_i + \gamma_{k(i),t} + \varepsilon_{it}$$

$fire_{it}$ is an indicator equal to 1 if actively burning fire is within 20 km of campground i on date t

$smoke_{it}$ is an indicator equal to 1 if campground i has adverse smoke conditions on date t

FEs: week-of-year, day-of-week, indicators for federal holiday & day before federal holiday;
recreation area by month-of-year and recreation area by year

Control for upcoming week’s total precipitation at campground i



Summary statistics

		Fire		Smoke	
	Baseline Mean	Mean	t-stat	Mean	t-stat
Occupancy rate	0.306	0.348	1.38	0.365	8.47
Pre-arrival cancellation rate	0.007	0.03	14.6	0.013	11.2
Post-arrival cancellation rate	0.001	0.011	7.56	0.002	5.0
No. of obs.	1,281,992	12,839		59,264	

Note: The t-stat is for a test of the difference in means relative to the baseline (no smoke or fire), clustering at the recreation area level.

Observations restricted to May through September.



Regression results

	Occupancy rate	Pre-arrival cancellation rate	Post-arrival cancellation rate
Fire	-.064** (0.011)	0.016** (0.0024)	0.01** (0.002)
Smoke	-0.011** (0.0021)	0.0043** (0.00043)	0.00095** (0.00029)
Mean of dep. var.	0.31	0.0096	0.001
No. of obs.	1,349,460	1,042,028	842,225

** p<0.01, * p<0.05

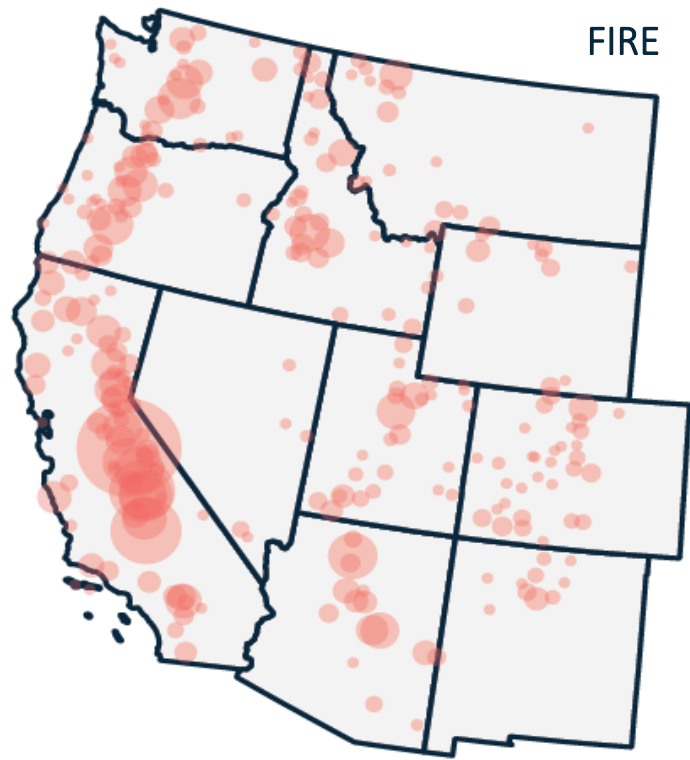
All regressions include campground, recreation area-by-month of year, recreation area-by-year, week-of-year, and day-of-week fixed effects, and indicators for holidays and day before holidays. In addition, regressions control for the upcoming week's total precipitation. Campground observations are weighted by the number of campsites, and standard errors, shown in brackets, are clustered by recreation area. The observations are restricted to May through September.



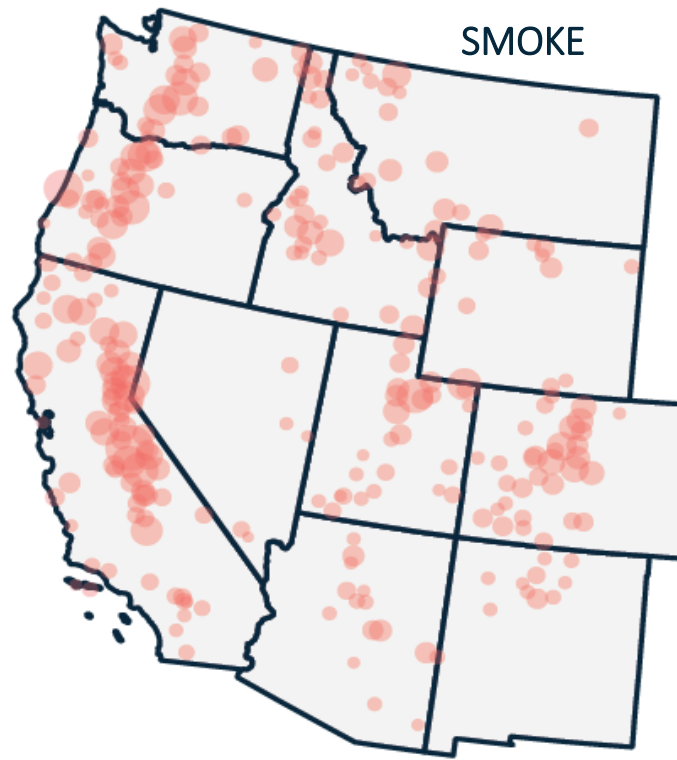
Interpreting regression results

- Fire and smoke have statistically significant impacts on campground use – occupancy rates & cancellation rates
- But magnitudes are relatively small, especially for smoke...
 - smoky conditions cause a 1.1 percentage point decline in occupancy – at mean, drop from 30.6 pct to 29.5 pct

Maps of reductions in camper-days due to fire & smoke, by recreation area



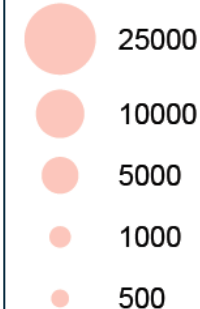
Median=95; min=0, max=33,495



Median=233; min=0, max=5,304

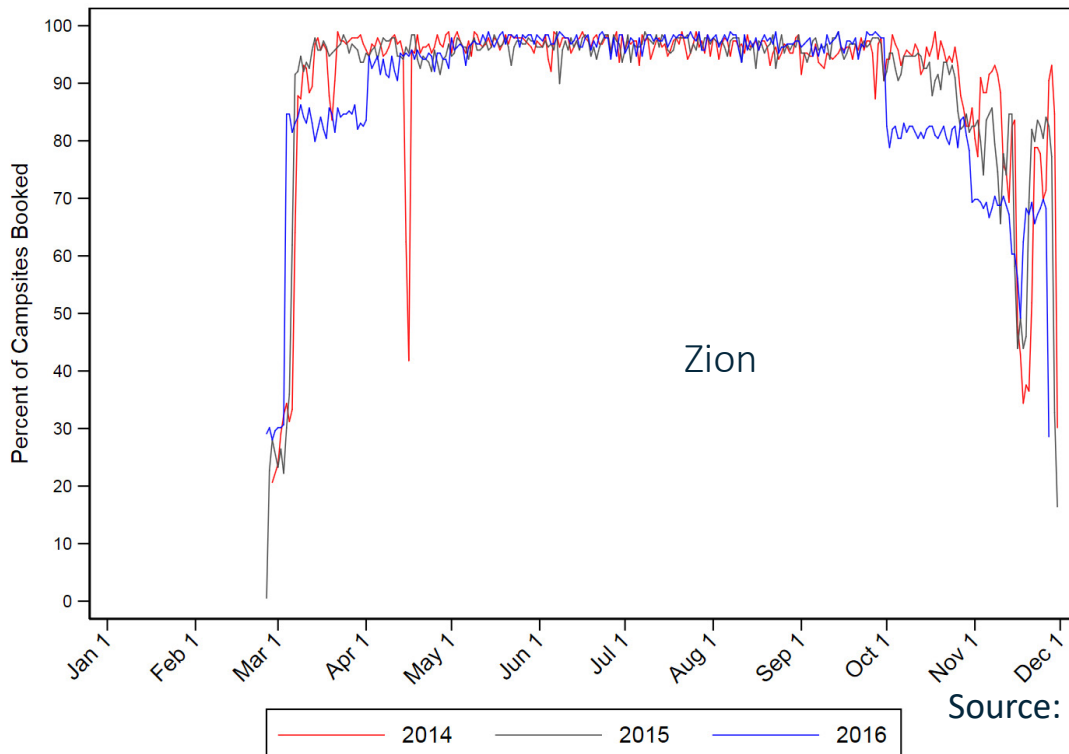
Note: Fire displaces larger numbers of campers where it occurs but the median recreation area experiences greater impacts from smoke

Total reduced camper-days, 2008–2017

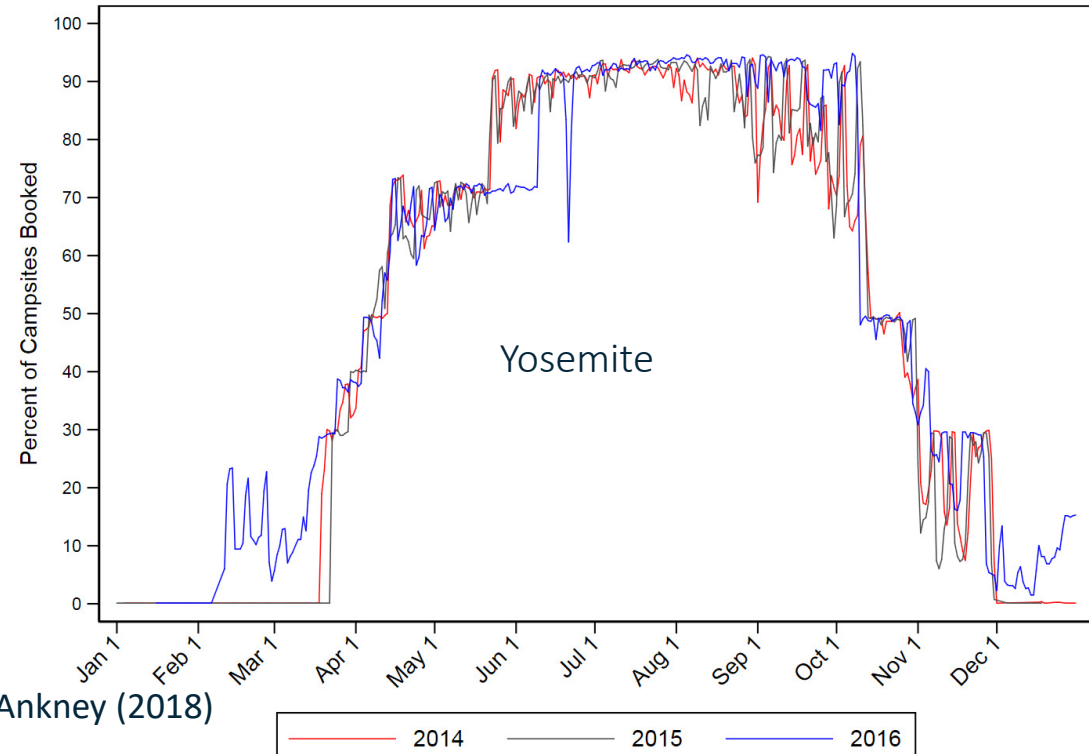


Discussion, implications of findings, next steps

- Avoidance behavior appears to be limited, especially when it comes to smoke. Why?
 - Measurement error—i.e., cancellations are undercounted? Unlikely due to refunds
 - Constraints on visitors' vacation times and/or campground availability
 - If they cancel, they may not be able to go for the rest of the year
 - Popular national park campgrounds fill up during summer months :



Source: Walls, Wichman & Ankney (2018)



Discussion, implications of findings, next steps (cont.)

- A substantial number of people recreating on public lands in the western US are affected by wildfire and especially smoke every year...
 - nearly 400,000 people per year are camping on federal lands under adverse smoke conditions
 - at least 1 million people visit national parks during adverse smoke conditions
 - highly exposed to poor air quality (outdoors most of the day)
 - loss of visibility, diminished views in otherwise scenic locations
- Policy options?
 - Forest management, e.g., mechanical thinning, prescribed burns, and managed wildfires (off-season), to reduce likelihood and severity of fire
 - Encourage behavioral adjustments through flexible pricing, nudges to shift time of use, locations
 - Increase supply of campgrounds in safer locations

Next steps in our research... using micro-data, estimate structural model (e.g., travel cost) of camping demand; estimate welfare effects of wildfire and smoke. Stay tuned.



A scenic view of a campsite in a forest. In the foreground, there are several tents: a green and white tent on the left, a white tent in the middle, and a large orange and white tent on the right. A silver SUV is parked behind the white tent. The ground is dry and sandy. In the background, there are tall pine trees and a large, prominent rock formation with a rounded top. The sky is clear and blue.

Thank you!

Comments, questions, suggestions:
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