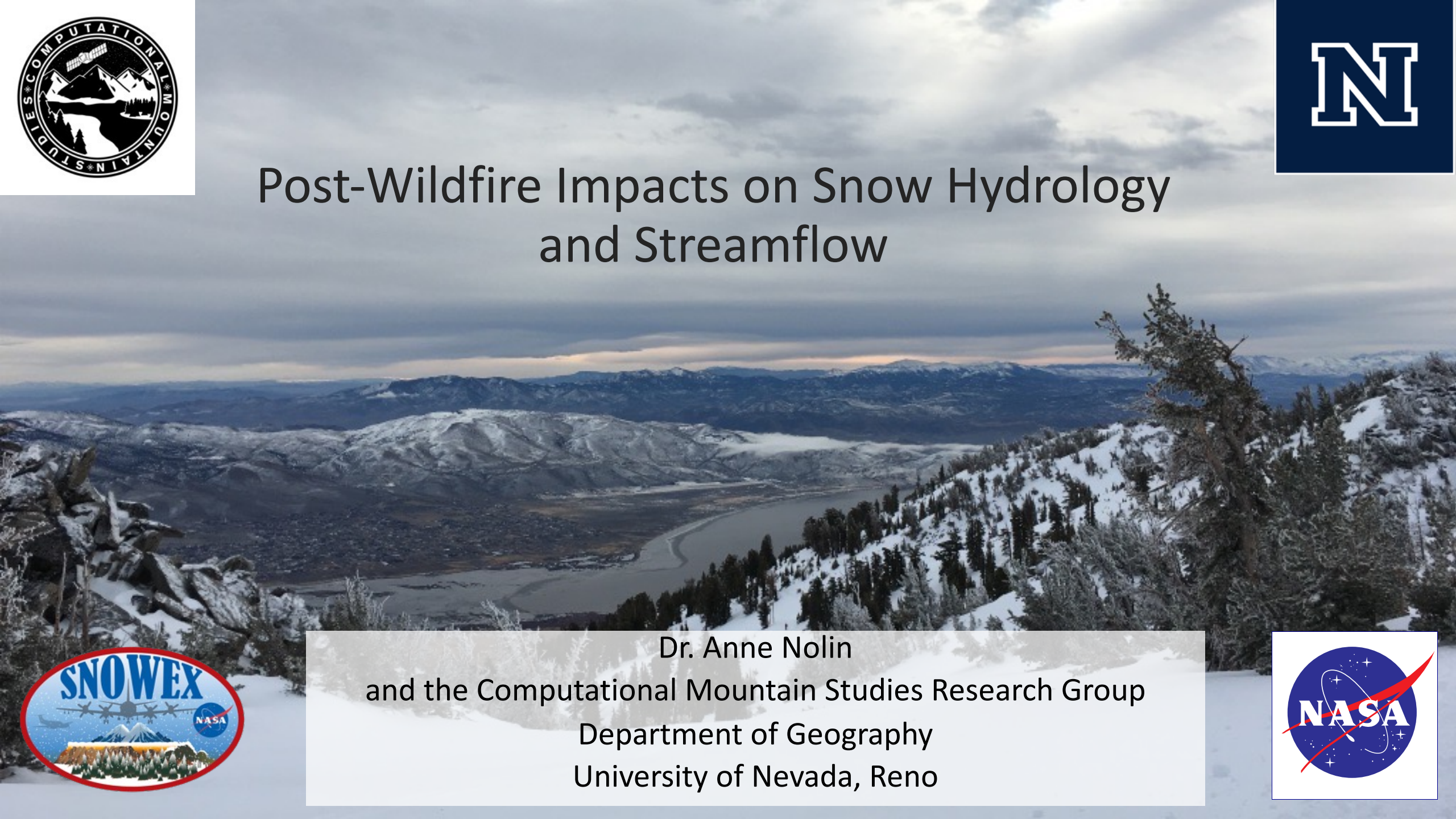
Post-Wildfire Impacts on Snow Hydrology and Streamflow



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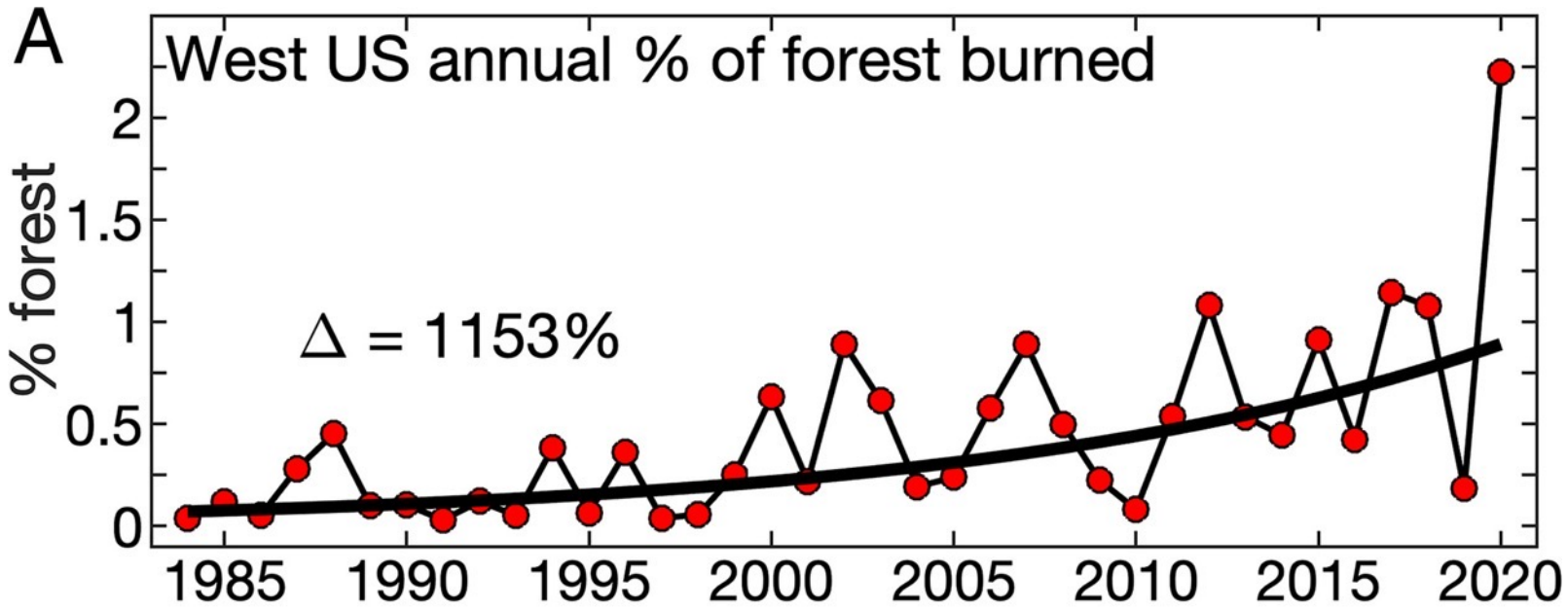
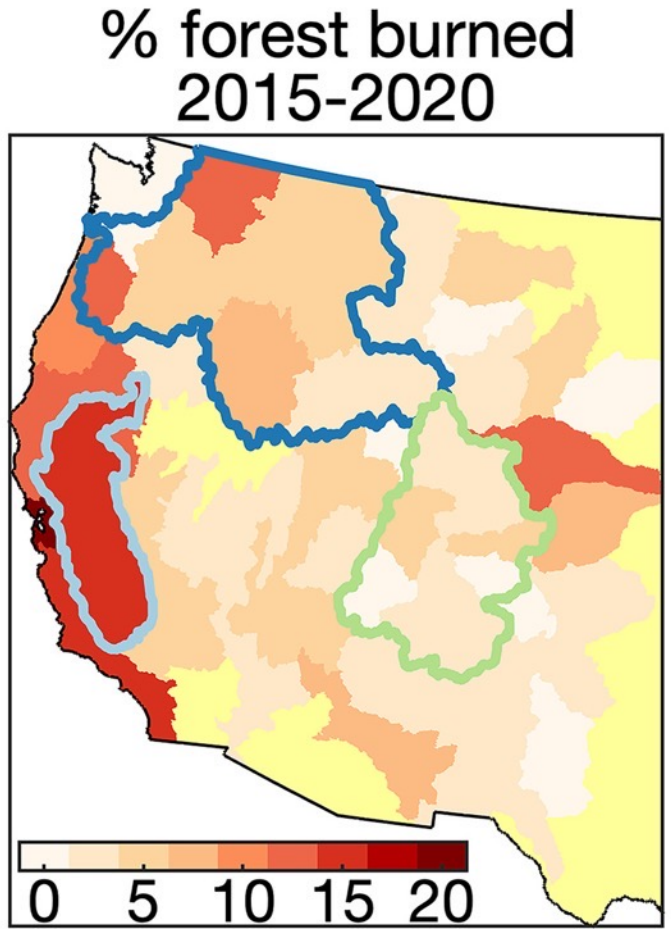
Motivation

- Snowpacks are declining across the mountain West
- Forests are experiencing moisture stress and their health is declining
- Forest wildfires are increasing in size/frequency, etc. and are burning into the seasonal snow zone
- Hydrologic impacts have focused on streamflow but have not been disaggregated

Research Questions

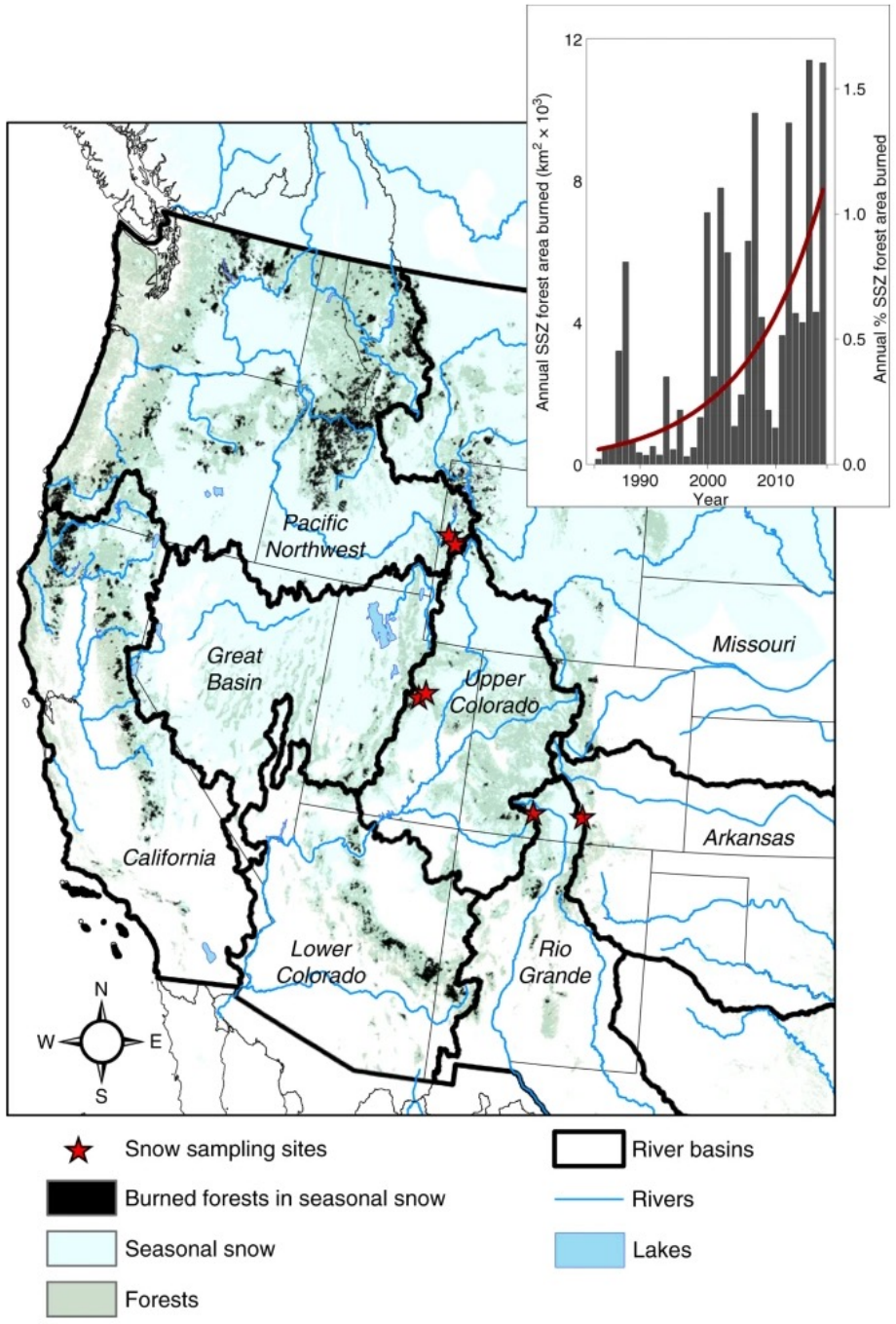
1. Pre-fire: Can we detect a relationships between declining snowpacks and forest moisture stress?
2. Post-fire: How is snow influenced by burned forests after a fire?
3. Post-fire: Are there changes in post-fire hydrology?





Burned forest fire area has increased by >1,100% from 1984 to 2020 (Williams 2022)
In the Sierra Nevada, most of the largest wildfires on record occurred in the last 3 years. (6% of the whole forest!)

Fig. 1



Fires are Increasingly Burning into the Seasonal Snow Zone

From 1984–2020, the burned area in the SSZ increased 9% per year

Gleason et al. 2019 (Nature Comm.)

Pre-fire: Can we detect a relationship between declining snowpacks and forest moisture stress?

We use satellite remote sensing data from NASA's MODIS instrument(2000-2022) and Sen's slope statistical test to measure trends in:

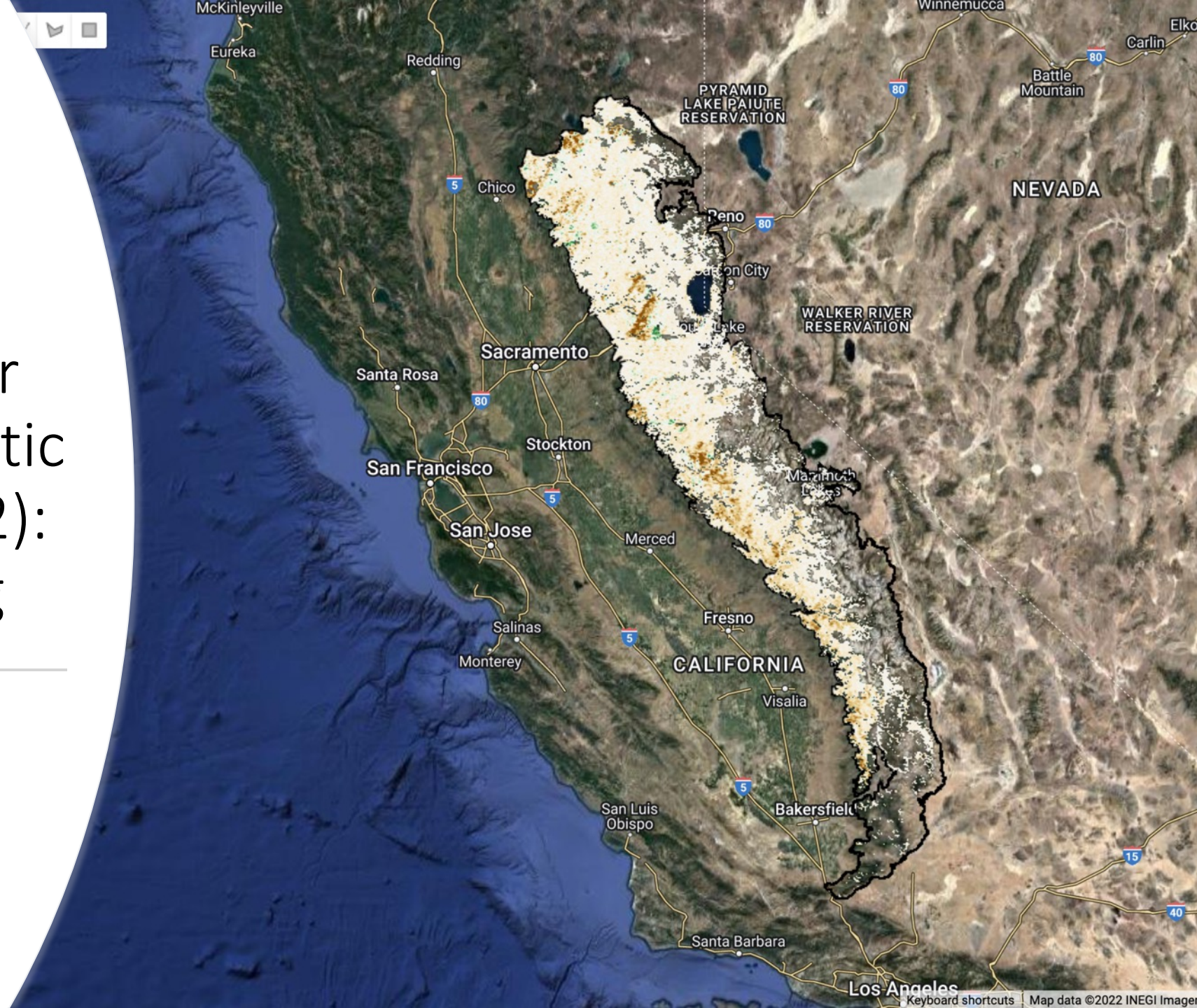
- Snow Disappearance Date (SDD)
- Late summer photosynthetic activity in evergreen forests (browning/greening)

We use gridded meteorological data (GridMet) to measure trends in:

- Summer vapor pressure deficit, etc.

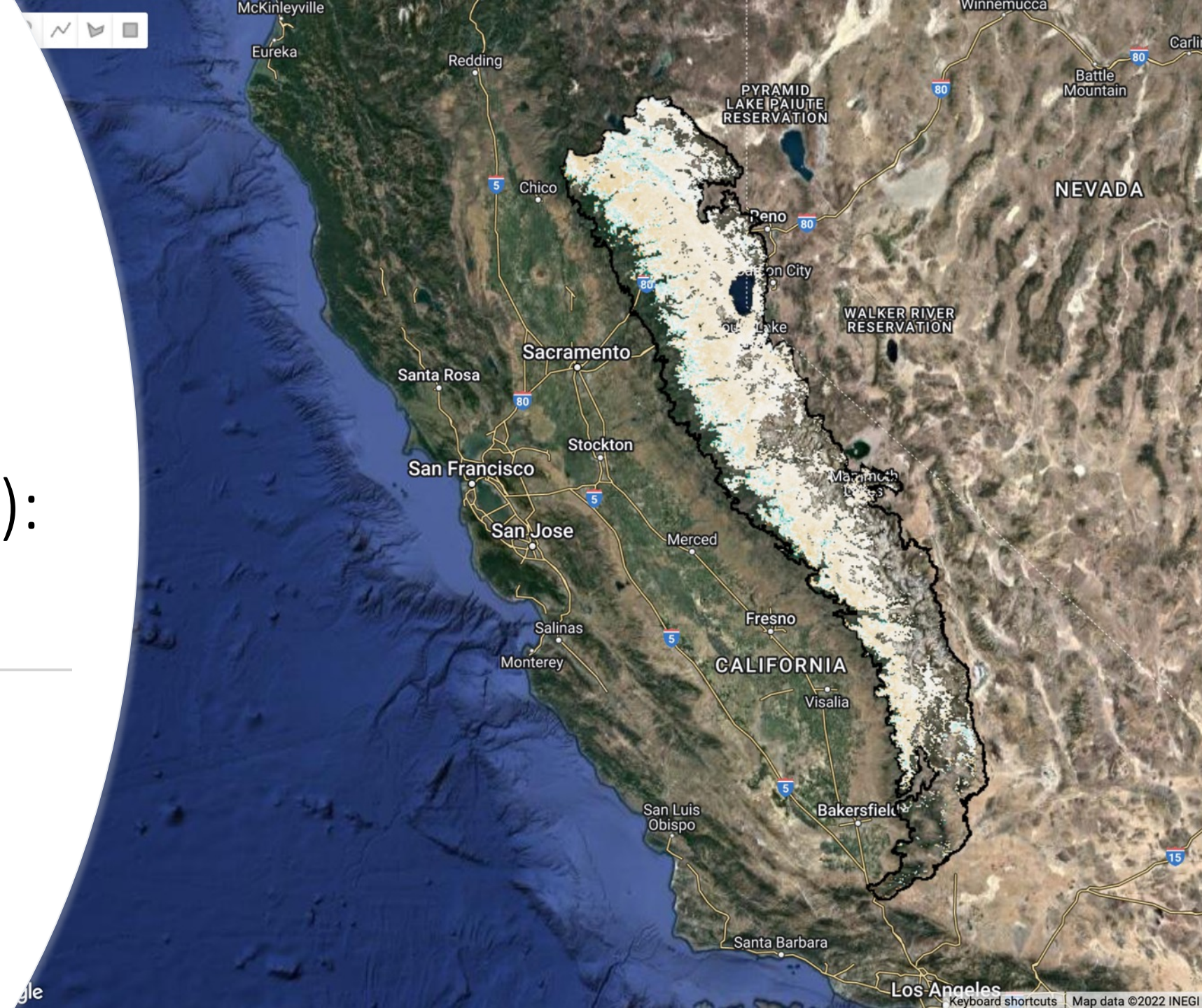
Trend in September forest photosynthetic activity (2000-2022): browning/greening

Brown = less photosynthetic activity
Green = more photosynthetic activity

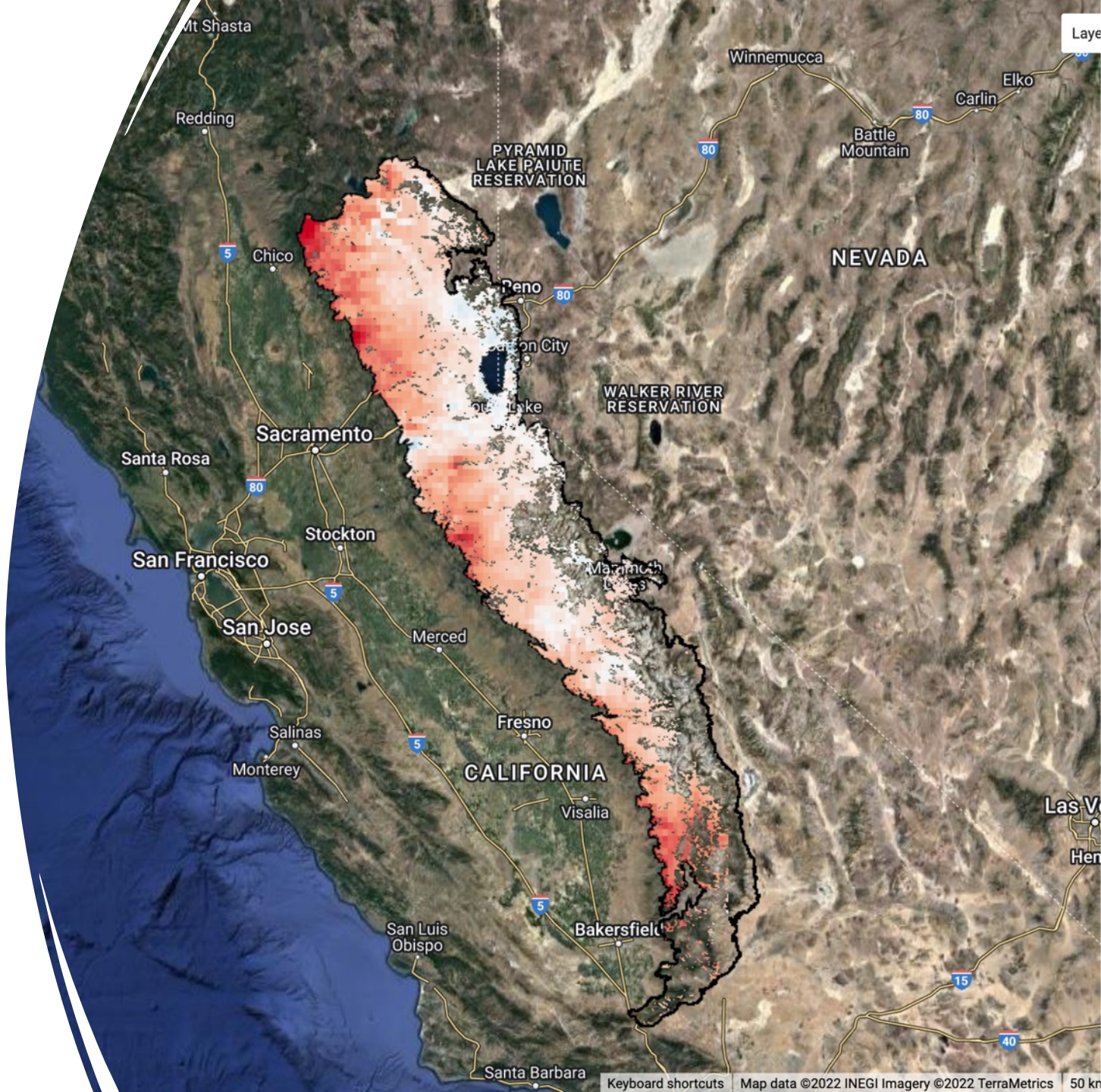


Trend in Snow Disappearance Date (2000-2022): earlier/later

Brown = earlier SDD
Green = later SDD

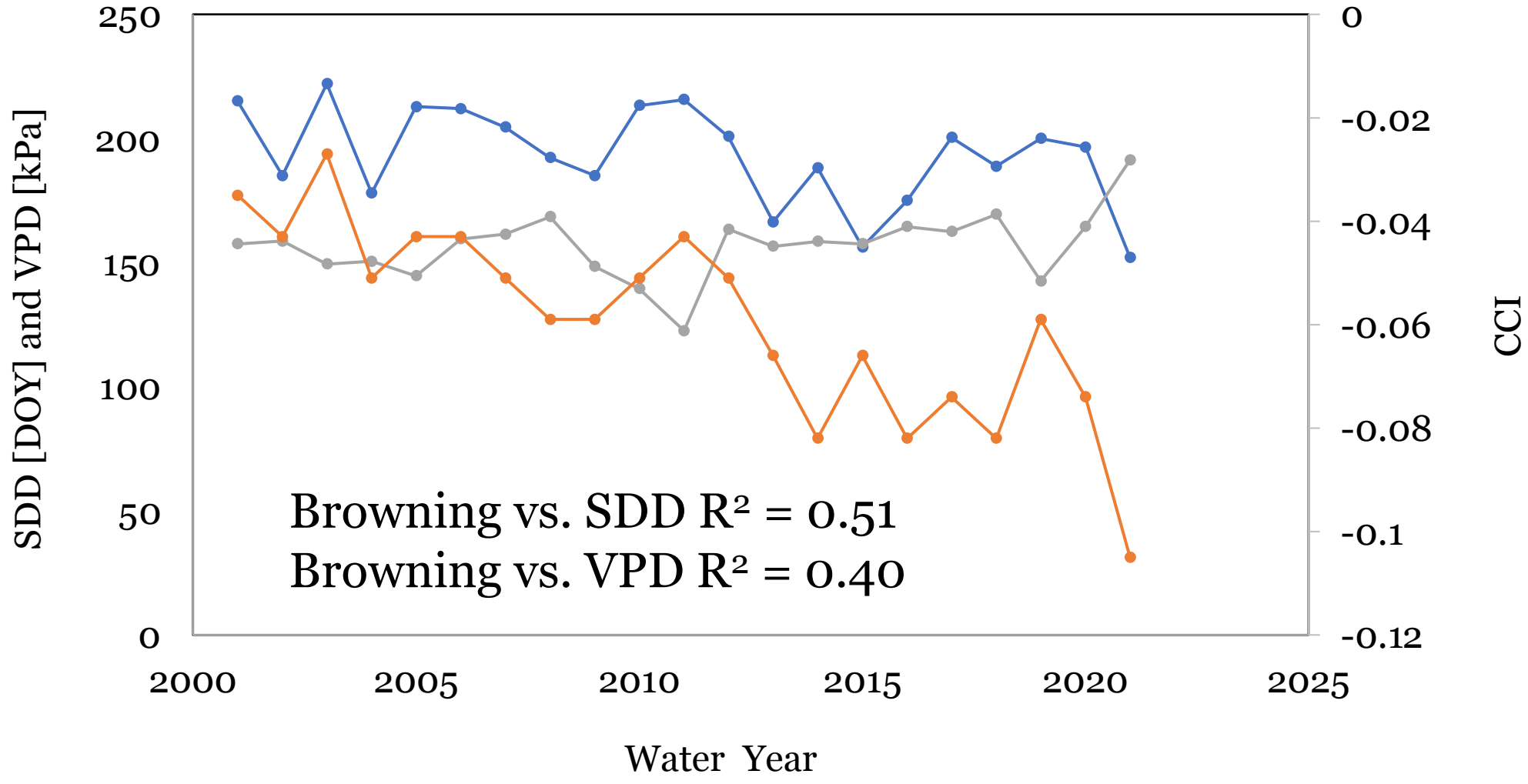


Trend in June-August Vapor Pressure Deficit (2000-2022): drier/wetter



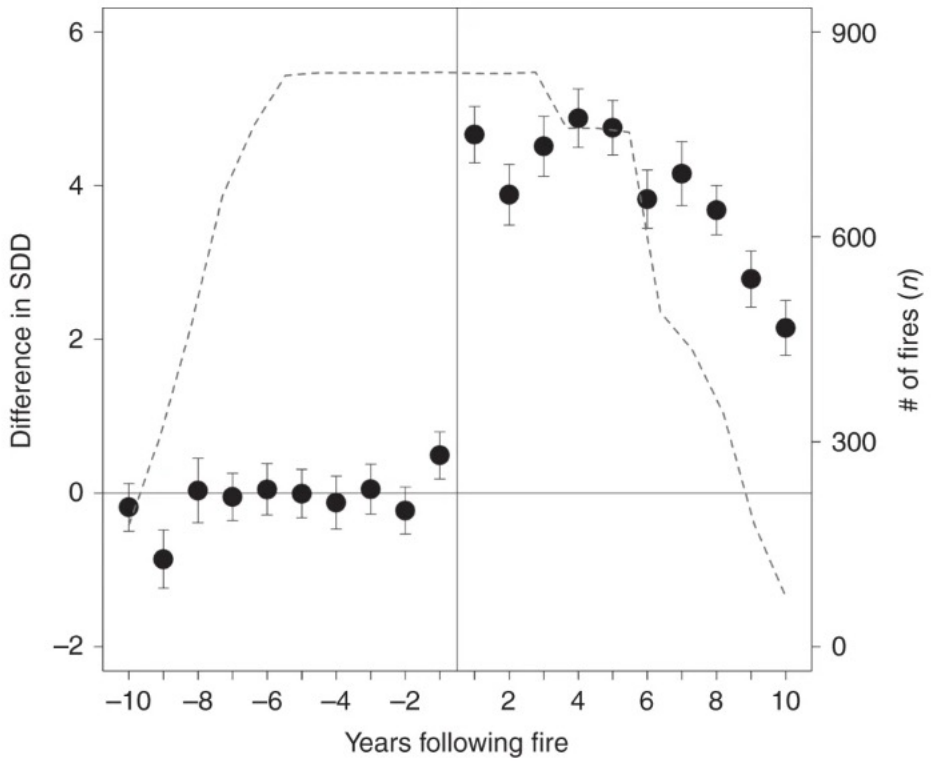
Red = drier atmosphere
Blue = wetter atmosphere

Yearly SDD, CCI and VPD: Sierra Nevada Ecoregion



Post-fire: How is snow influenced by burned forests after a fire?

Fig. 2



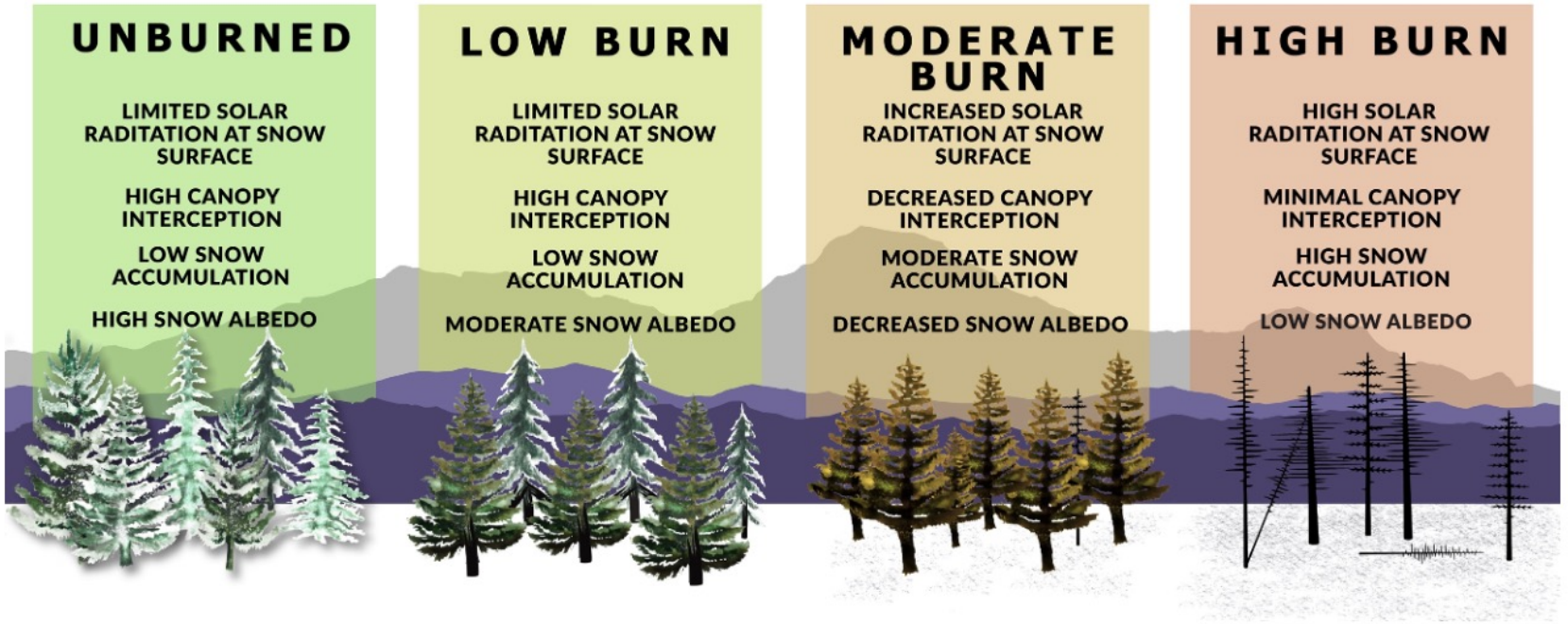
Change in mean snow disappearance date (SDD) before and after fire. SDD was evaluated for all burned forests (n = 841; dashed line) located in the western U.S. seasonal snow zone using 2000–2016 MODIS satellite measurements. Forest fire resulted in a clear and immediate shift in SDD, with impacts of fire starting to decline after ~8 years but persisting for >10 years. Error bars indicate the standard error of the mean

After a severe wildfire, the snow is covered with black carbon, which absorbs solar energy, causing the snow to melt weeks earlier than otherwise.

15-y

Gleason et al., 2013; https://doi.org/10.1002/grl.50896
Gleason & Nolin, 2017; https://doi.org10.1002/hyp.10897
Gleason et al. 2019; https://doi.org/10.1038/s41467-019-09935-y

a.



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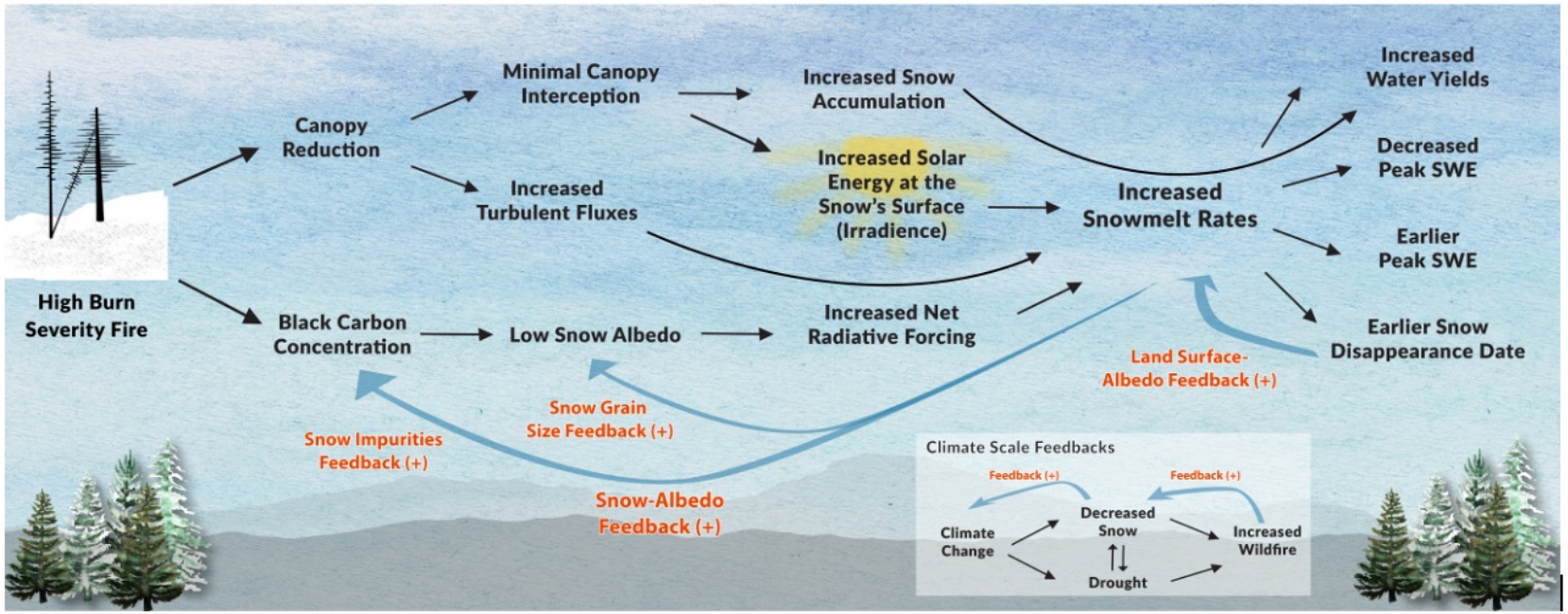
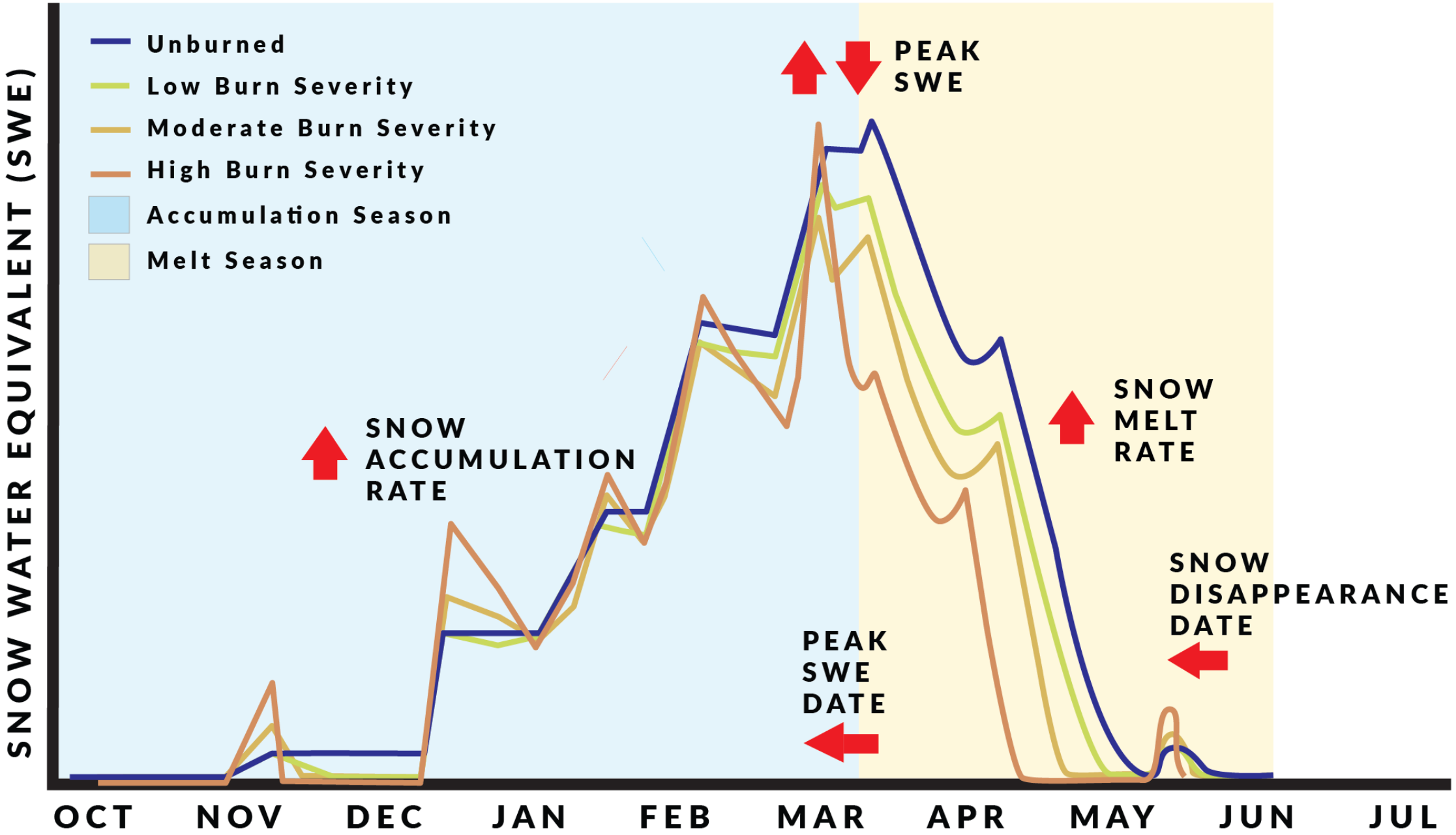


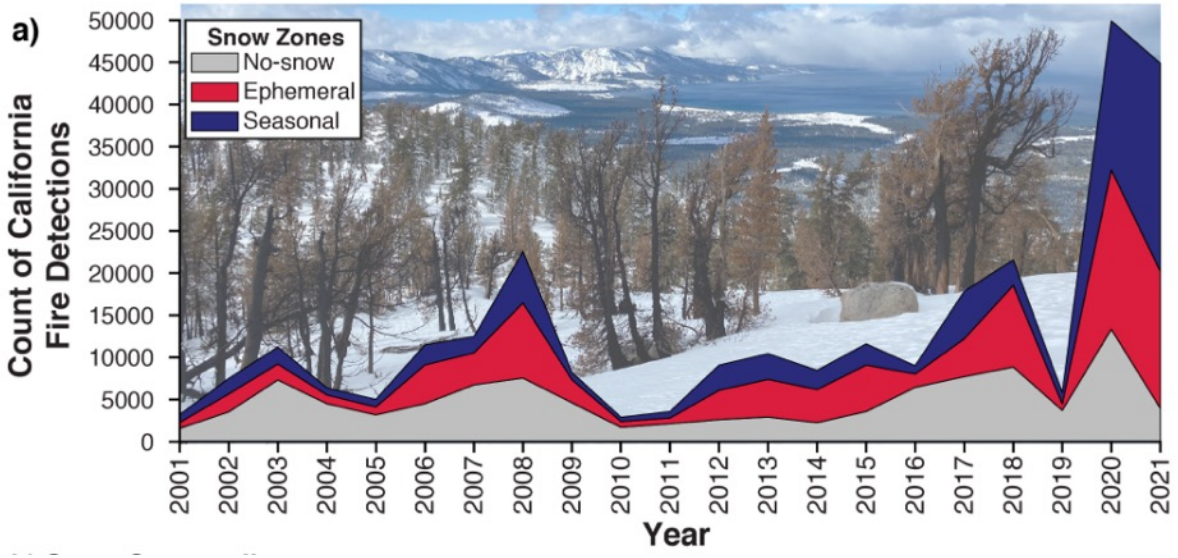
Koshkin et al., 2022

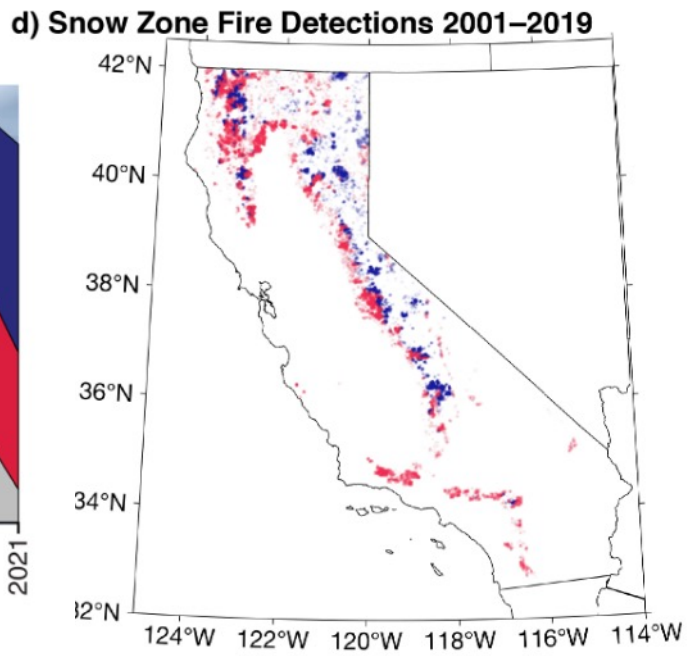
Post-fire: How is snow influenced by burned forests after a fire?

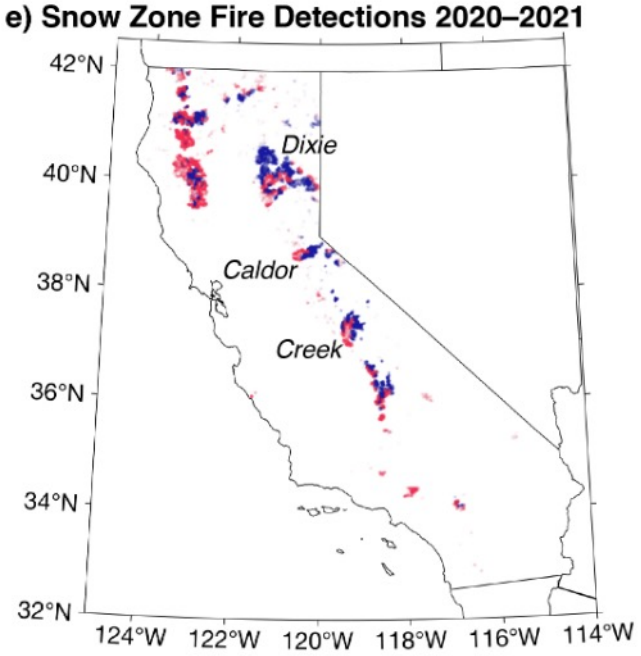


Koshkin et al., 2022

CA fires in the seasonal snow zone increased 9.8x in 2020-2021 compared with 2001-2019

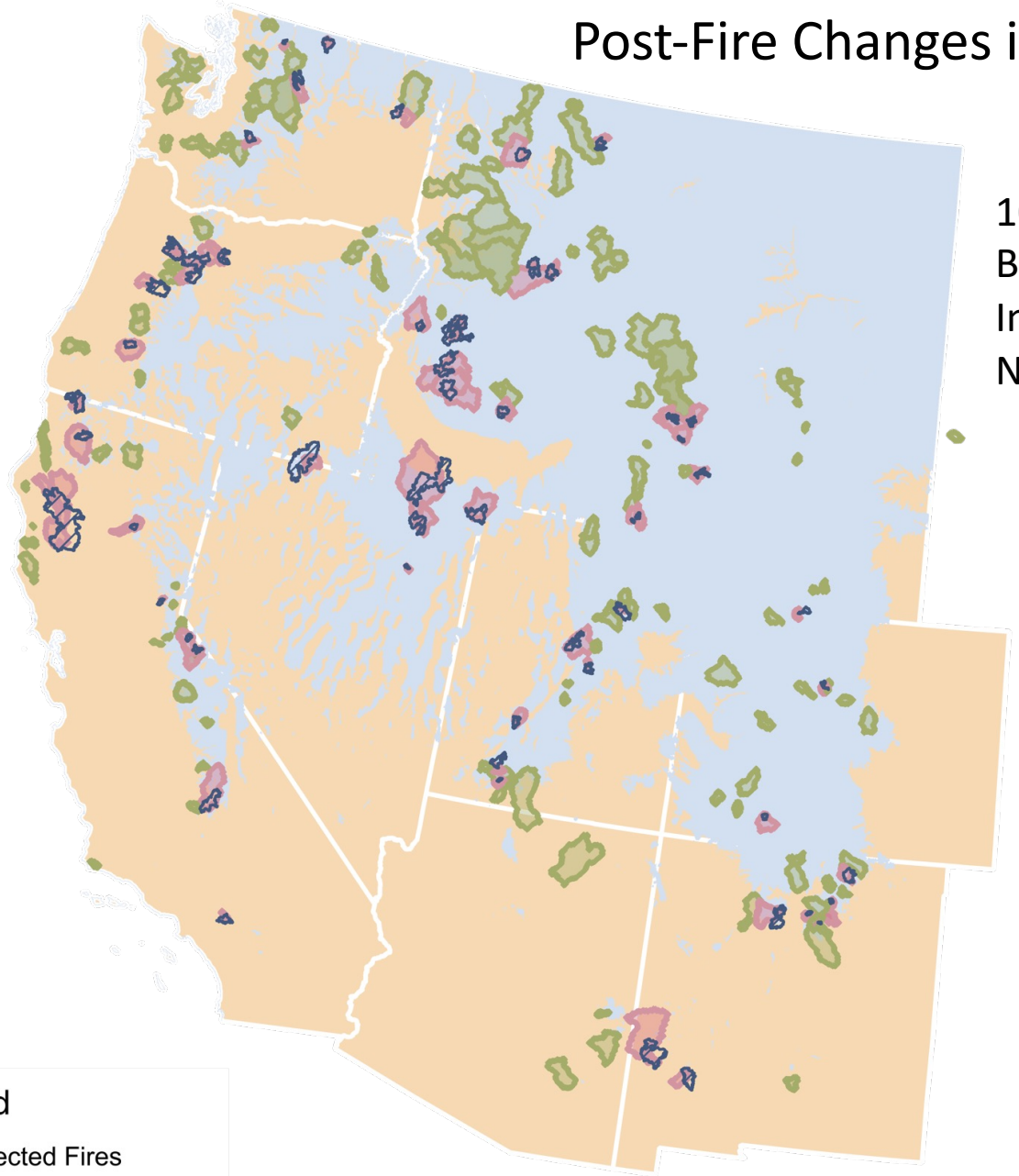






***In winter 2022, mid-winter dry spells amplified snowpack ablation (Hatchett eet al, 2023)**

Post-Fire Changes in Watershed Hydrology for Snowy Watersheds



103 watersheds
Burned and unburned
In and outside of the seasonal snow zone
Normalized by pre and post-fire temperature and precipitation

Legend

Selected Fires

Selected Watersheds

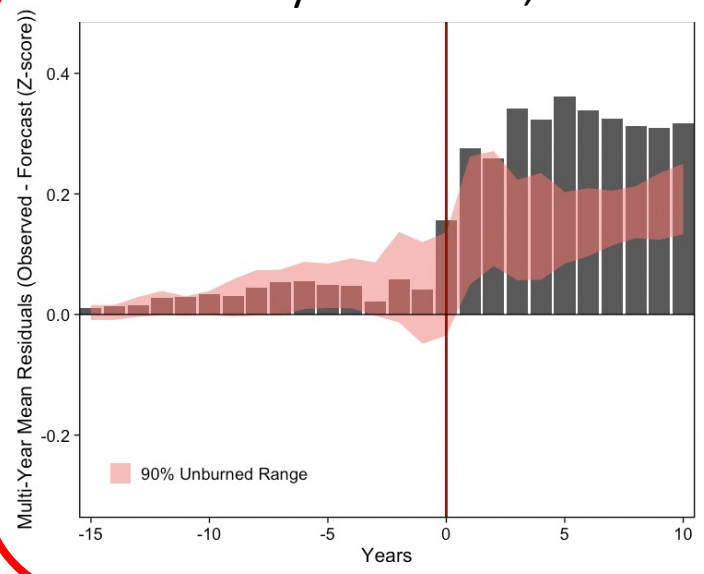
Burned

Unburned

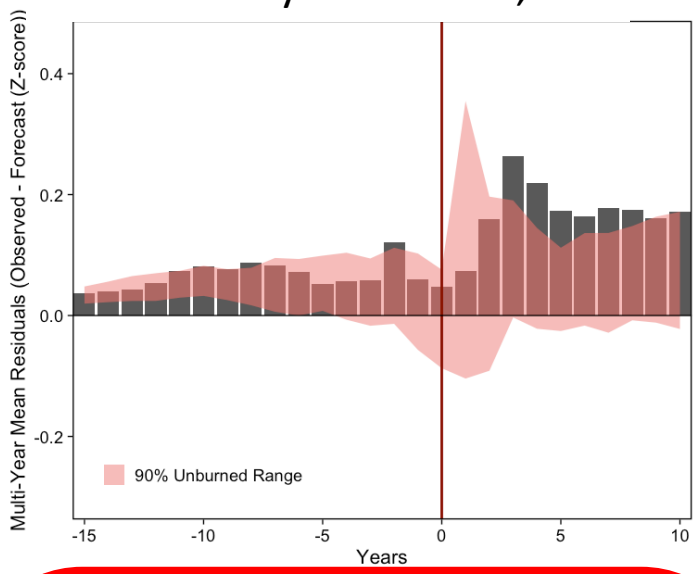
Seasonal Snow Zone

The mean residual hydrologic response of 103 burned watersheds for 4 streamflow metrics

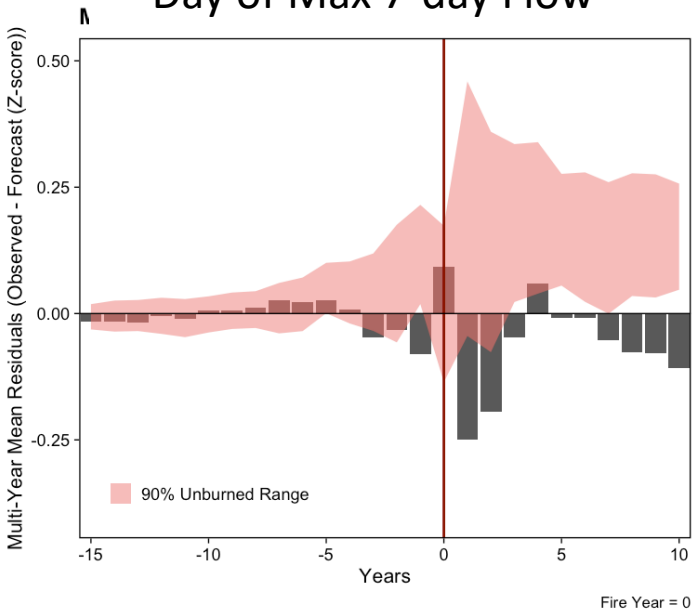
Min of 7-day mean flow, JJASON



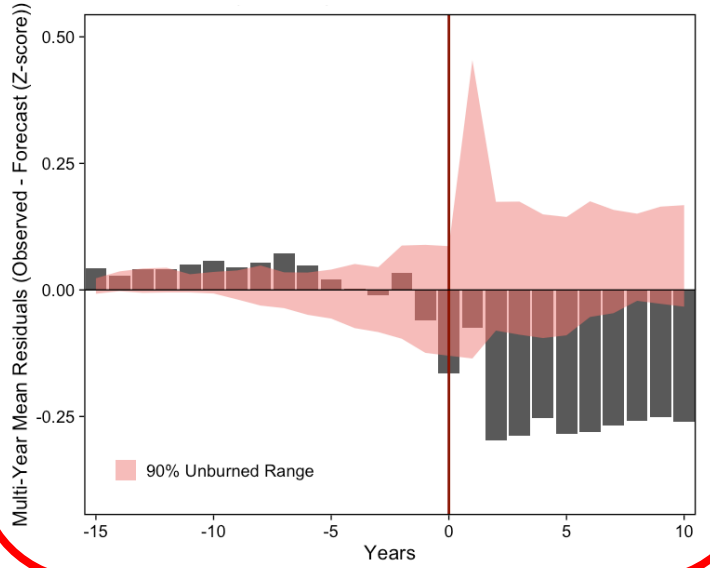
Max of 7-day Mean flow, WY

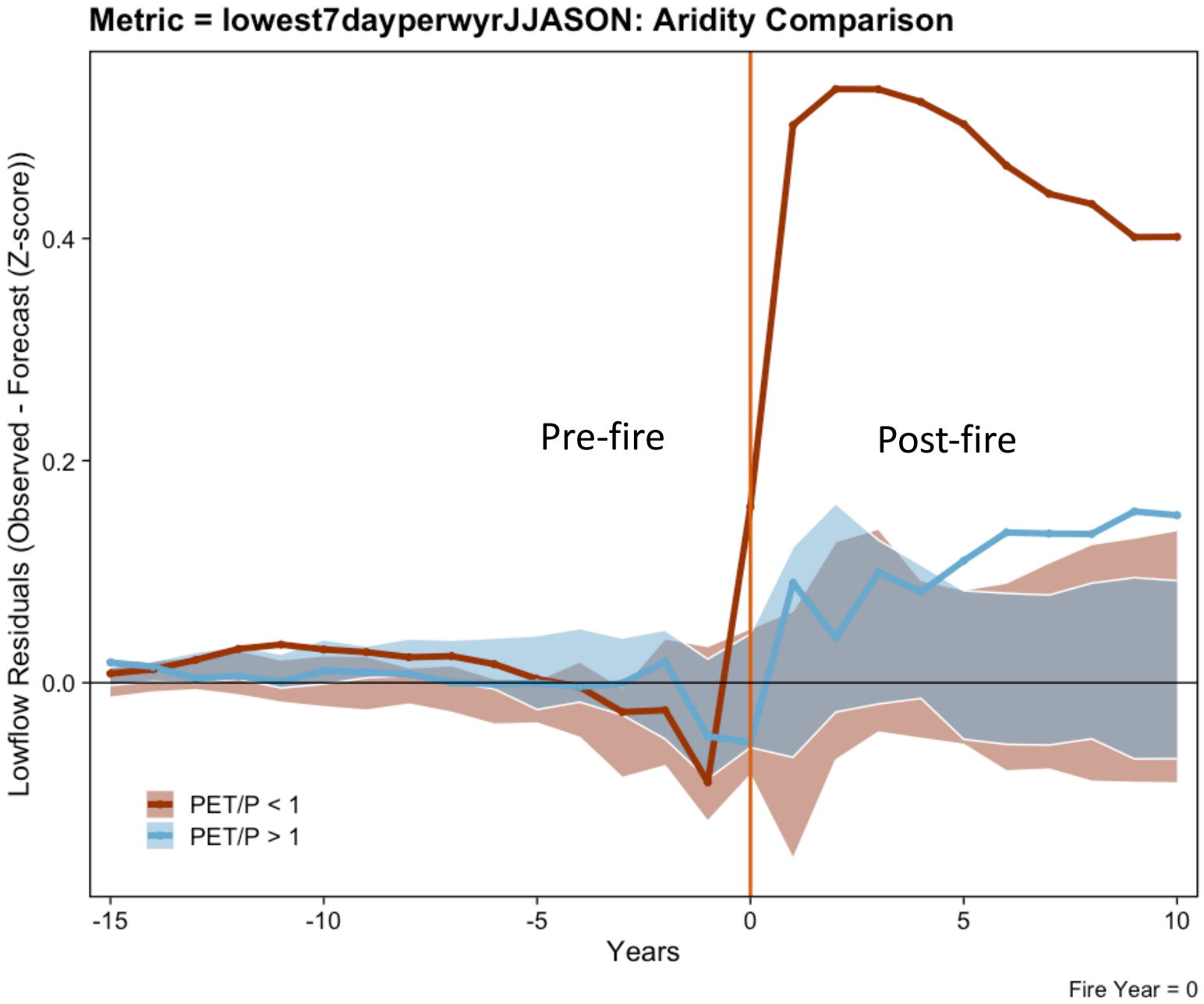


Day of Max 7-day Flow



Day of Springmelt Flow Onset

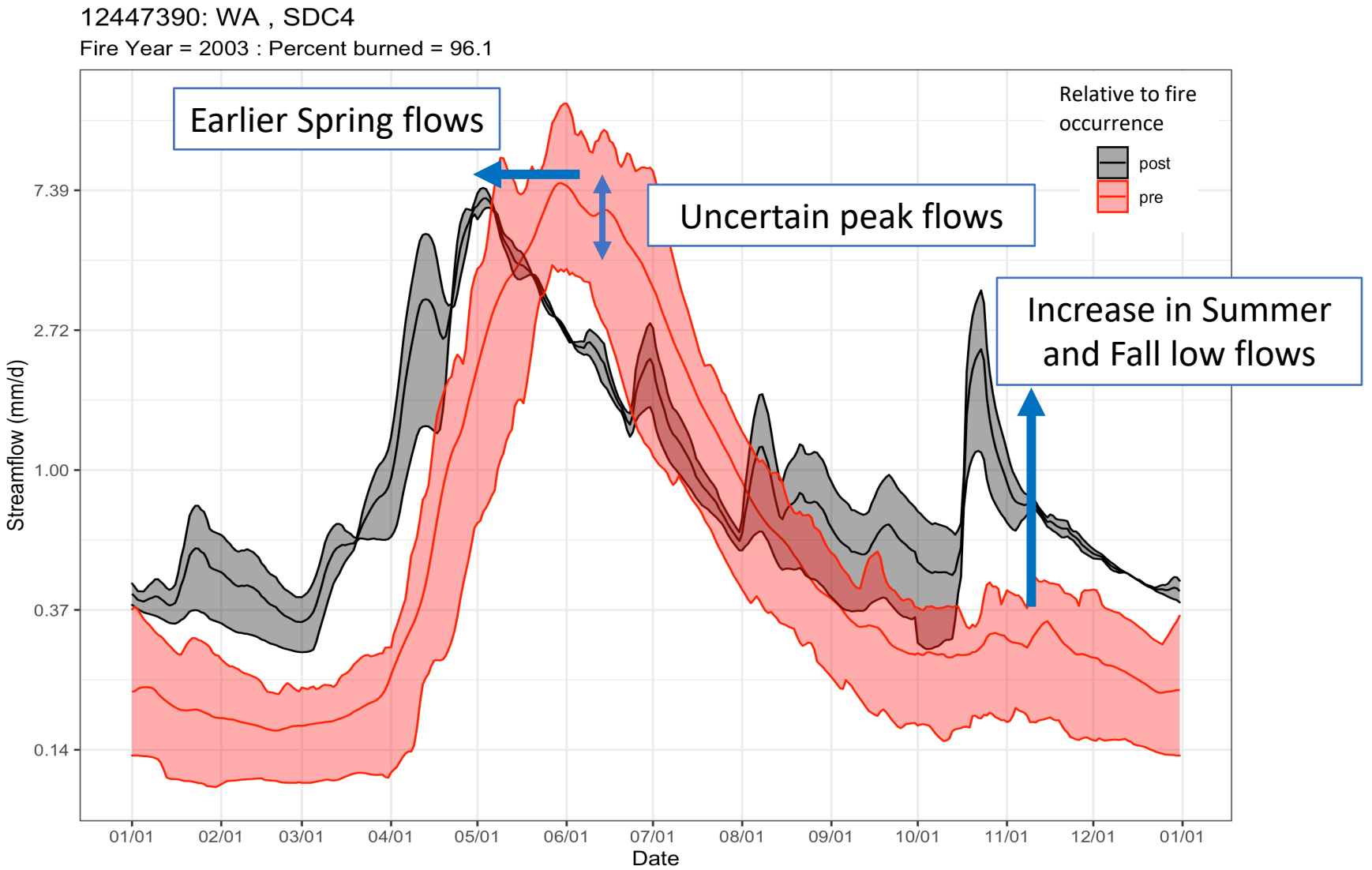




Snow-dominated watersheds in more arid regions show a significant post-fire increase in the 7-day low flow metric

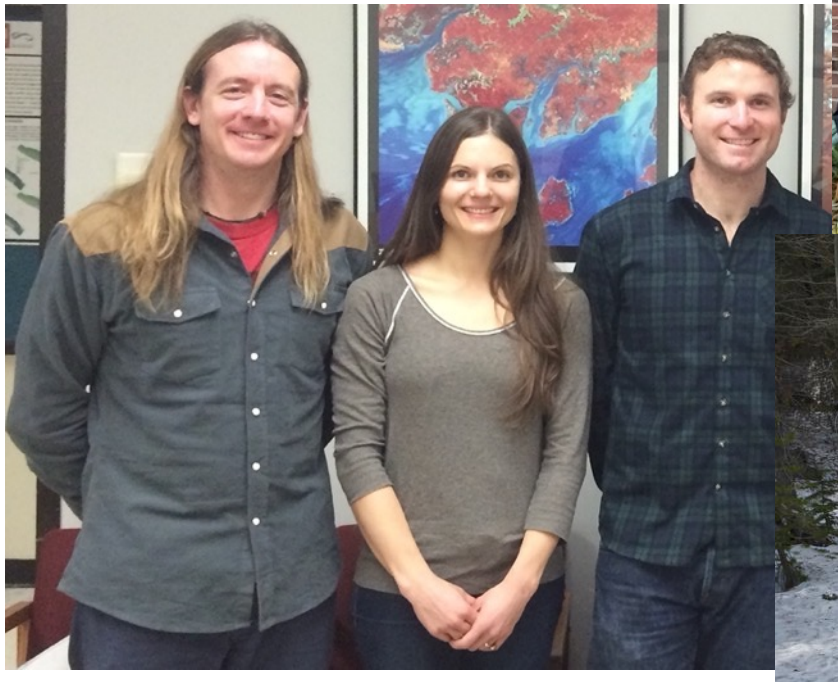
The brown solid line represents dry watersheds with an aridity index < 1 (PET/P < 1), whereas the blue line represents wet watersheds with an aridity index > 1 (PET/P > 1). Shaded areas represent the 90th confidence interval of the low flow residuals for unburned watersheds.

Summing it up: Post-fire shift in a Snow-dominated Hydrograph



There is much more that we need to measure, learn, understand, and communicate…

Thank you!



Not shown:
Dr. Ben Hatchett and co-authors