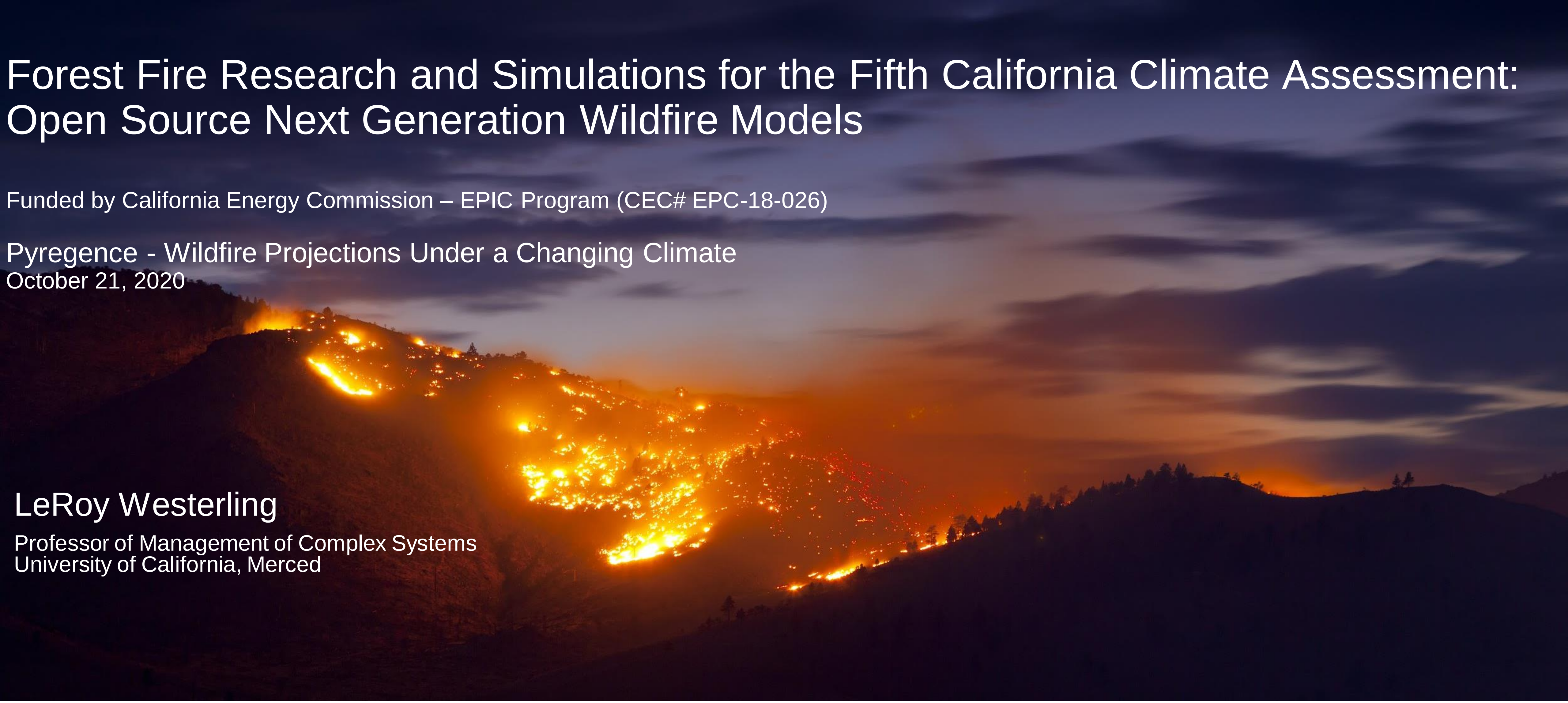


Forest Fire Research and Simulations for the Fifth California Climate Assessment: Open Source Next Generation Wildfire Models

Funded by California Energy Commission – EPIC Program (CEC# EPC-18-026)

Pyregence - Wildfire Projections Under a Changing Climate
October 21, 2020

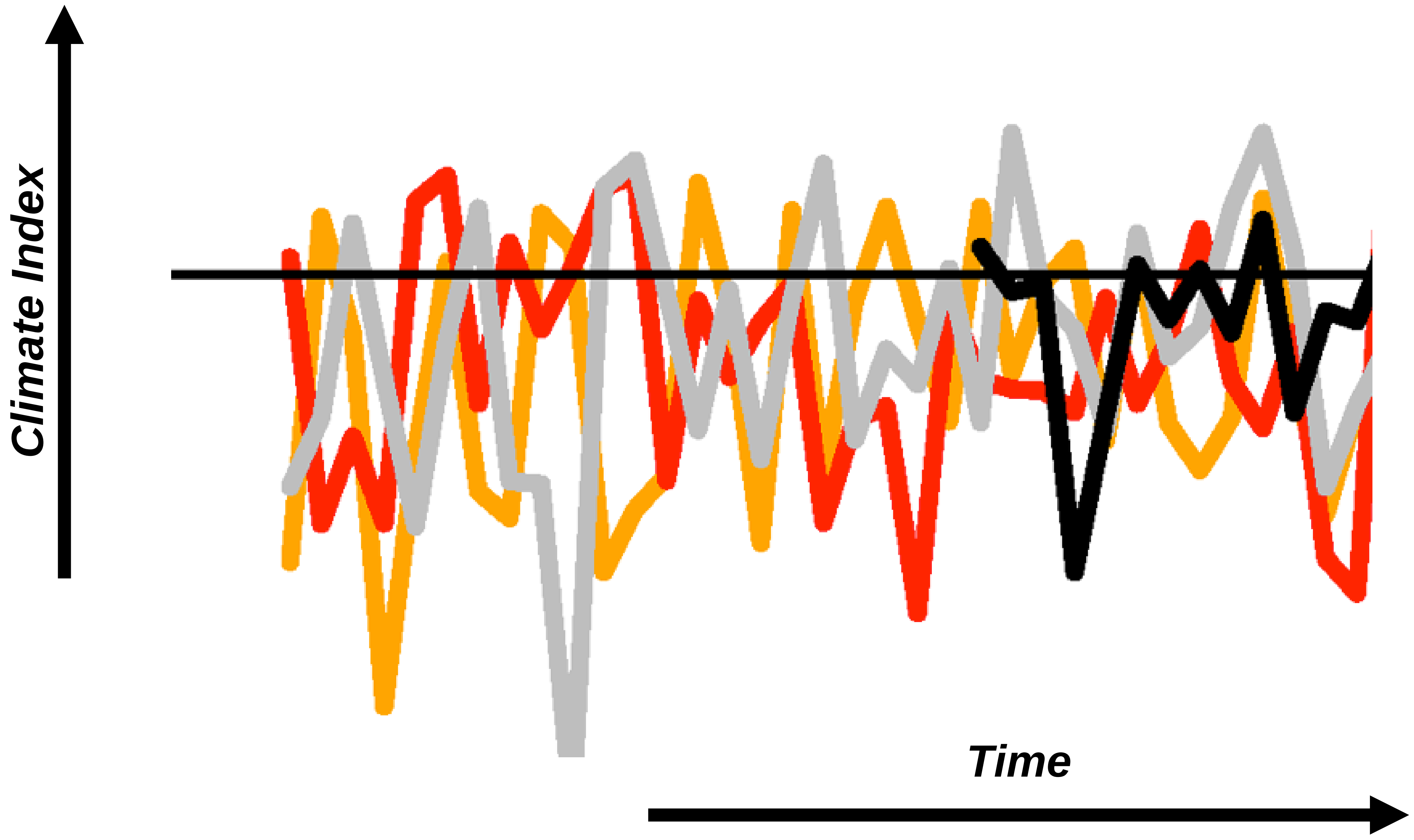
LeRoy Westerling

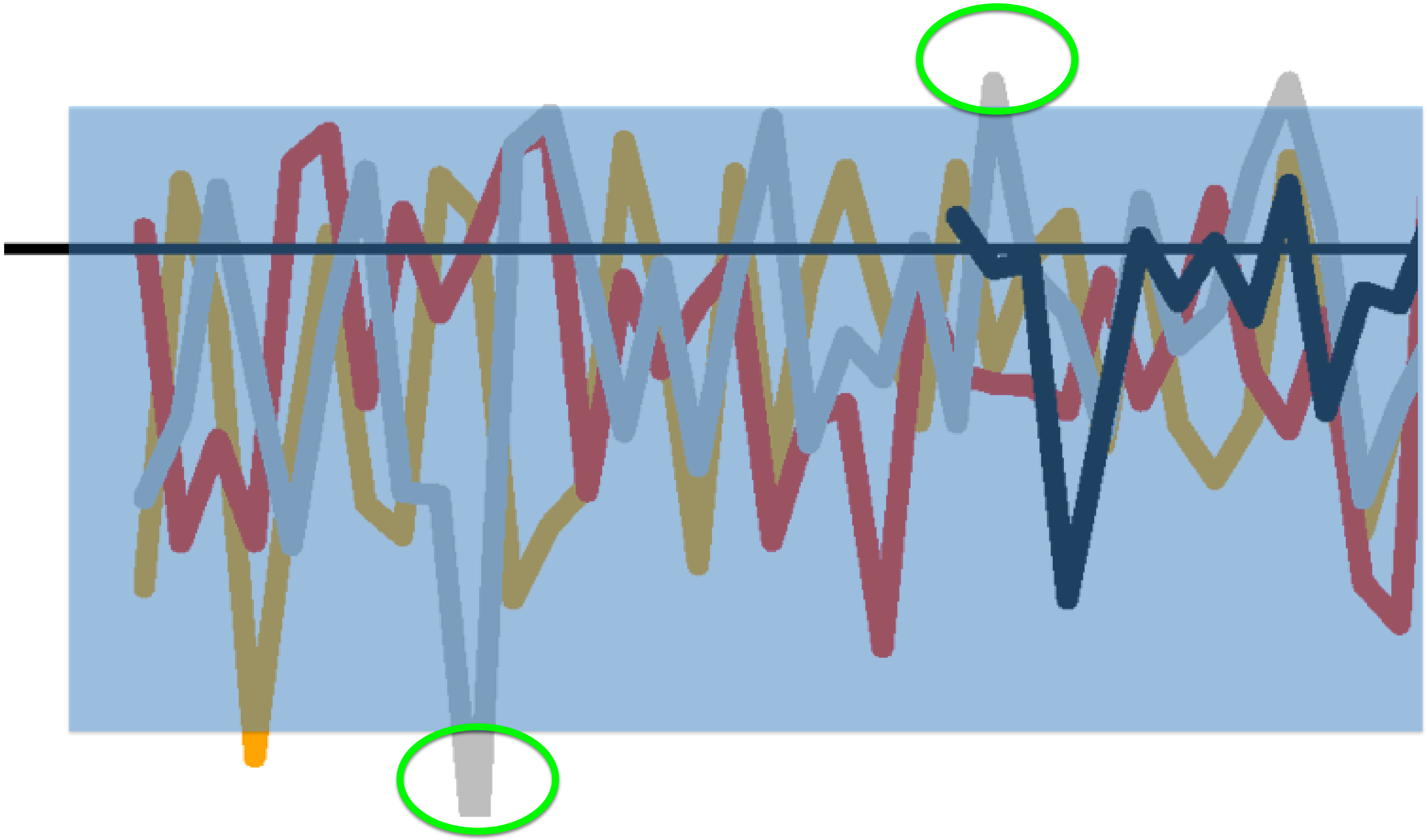
Professor of Management of Complex Systems
University of California, Merced

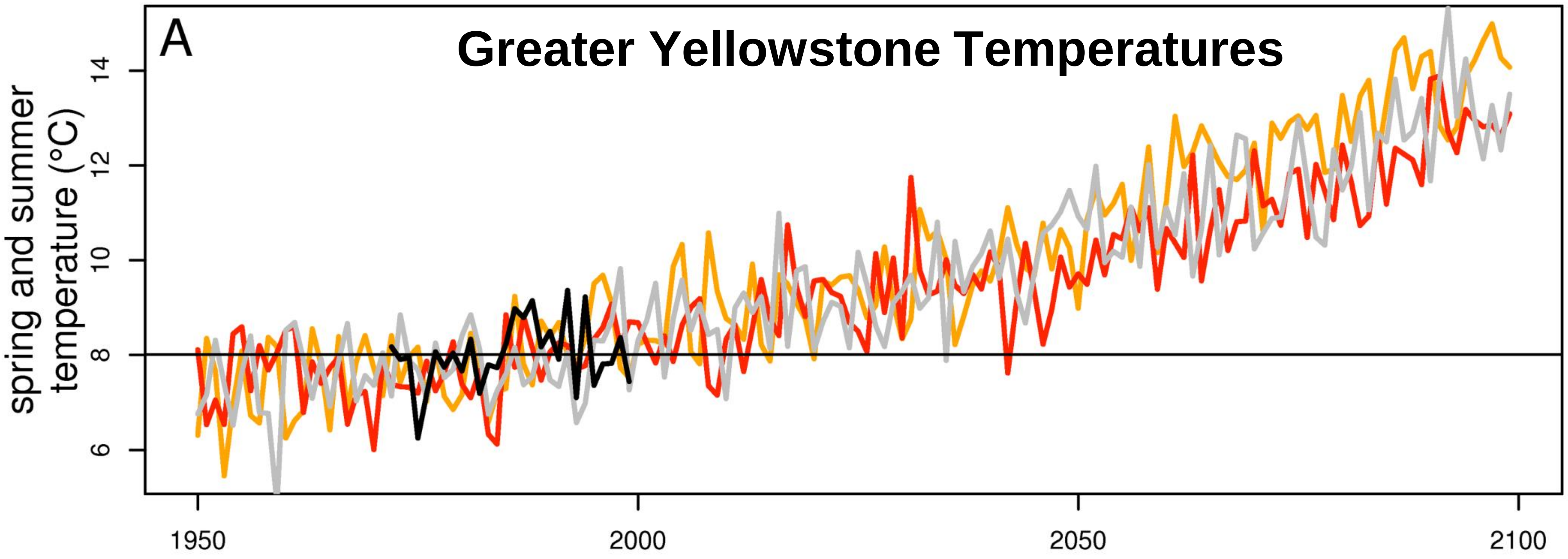
PYREGENCE™

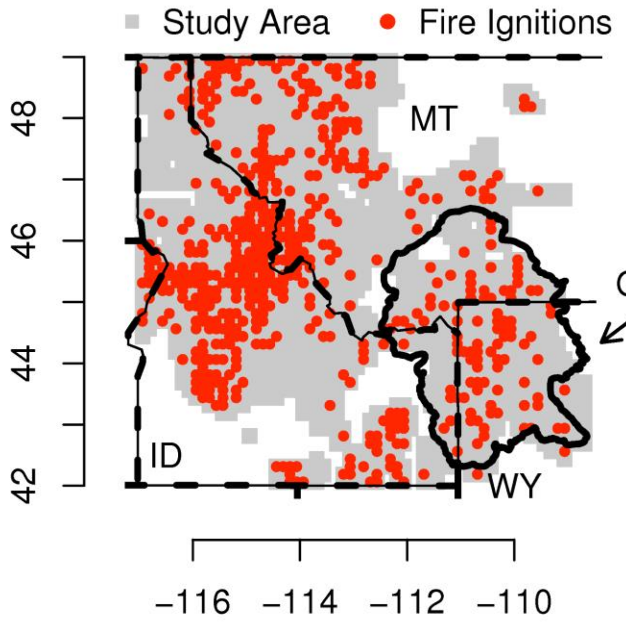
STATE OF CALIFORNIA ENERGY COMMISSION

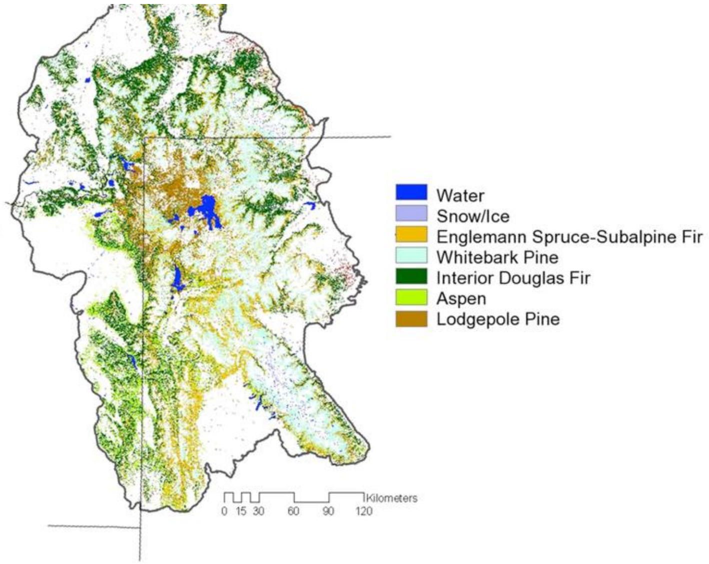
Lake Powell


Climate Index
Time

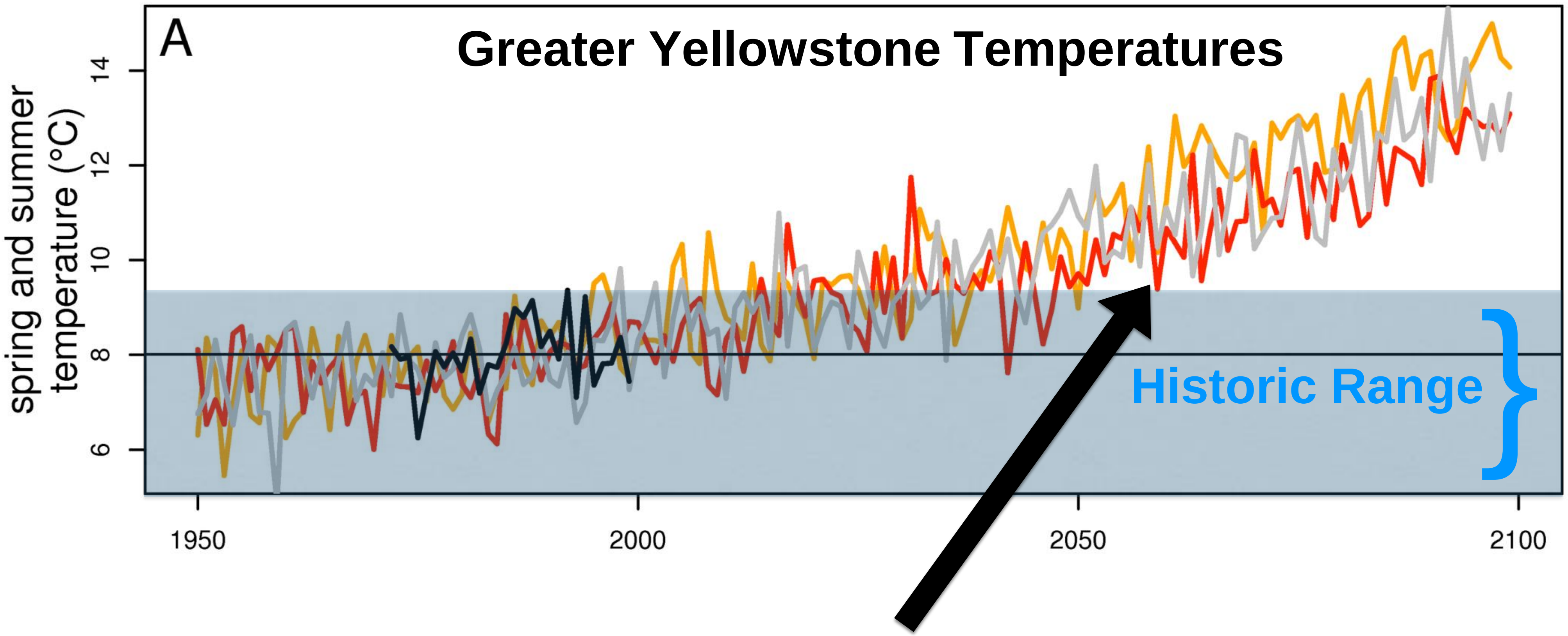








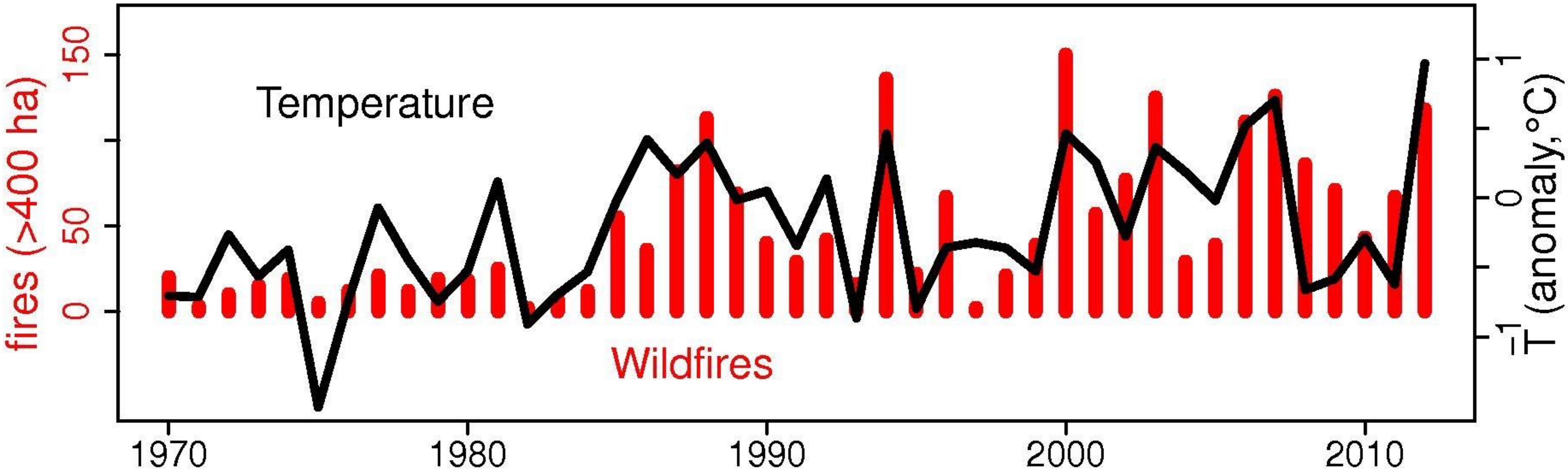
Westerling et al 2011 PNAS



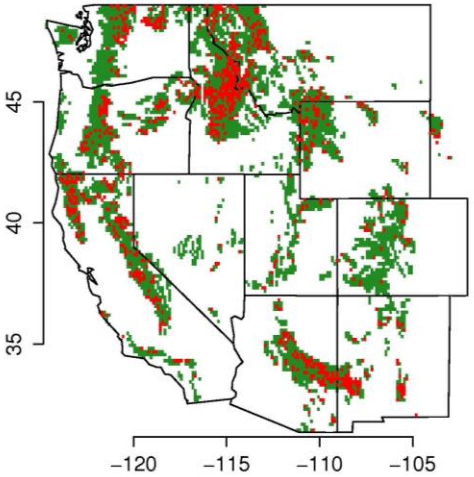
After 2050: The coldest year in the future is always hotter than the hottest year in history!

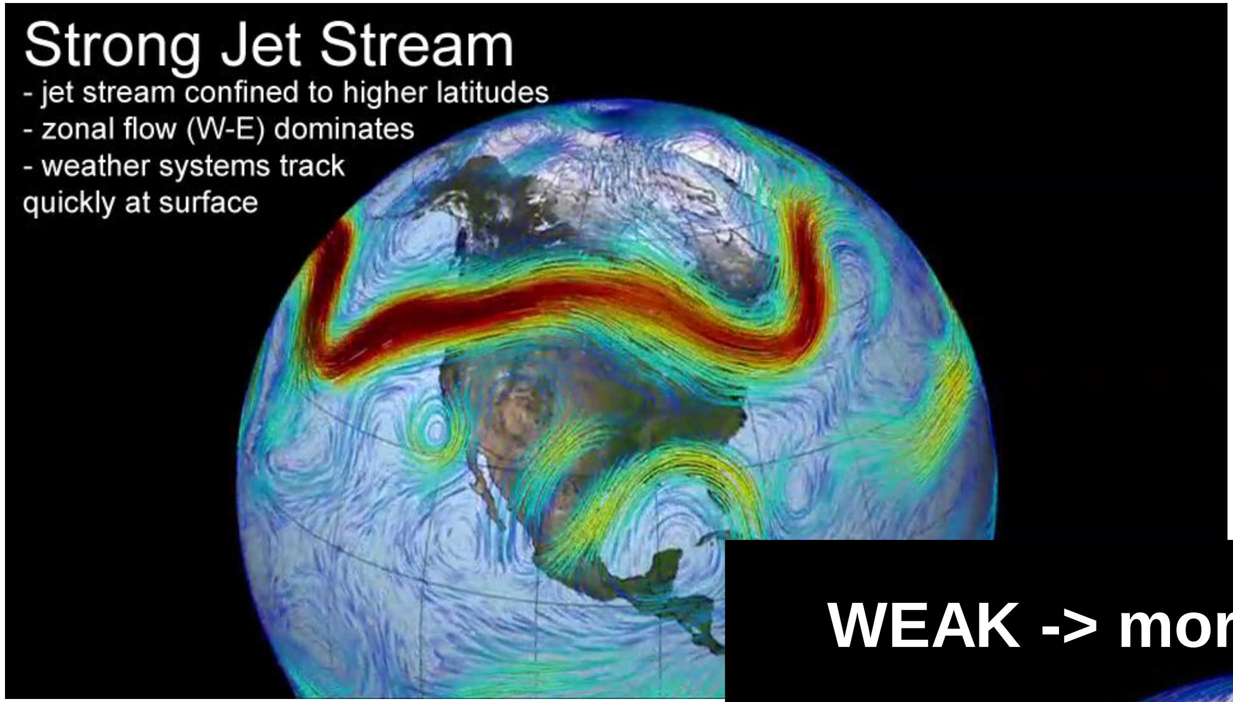
Westerling et al 2011 PNAS

Western US Forest Wildfires and Spring–Summer Temperature

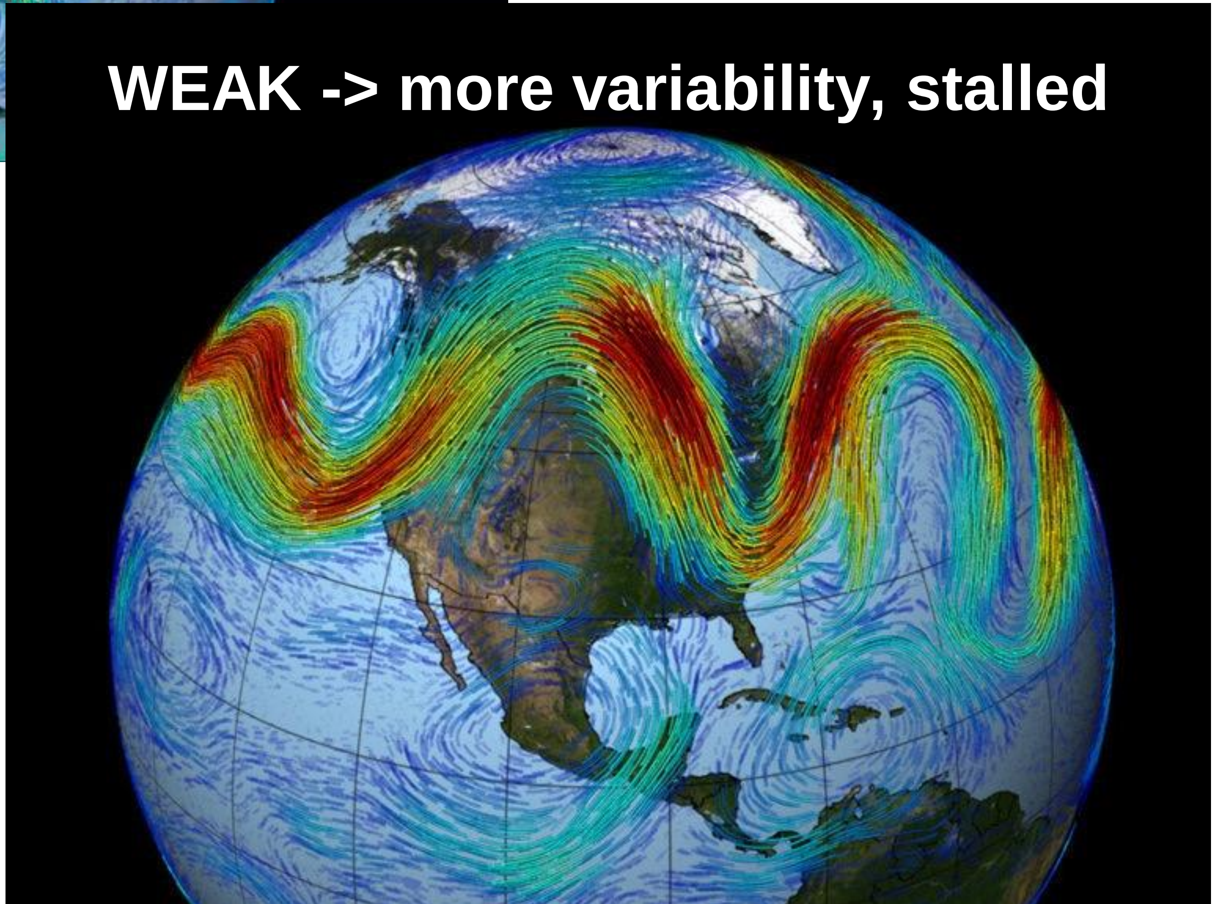


Westerling et al 2006,
Science
+
Westerling 2016,
Phil. Trans. Royal Soc. B

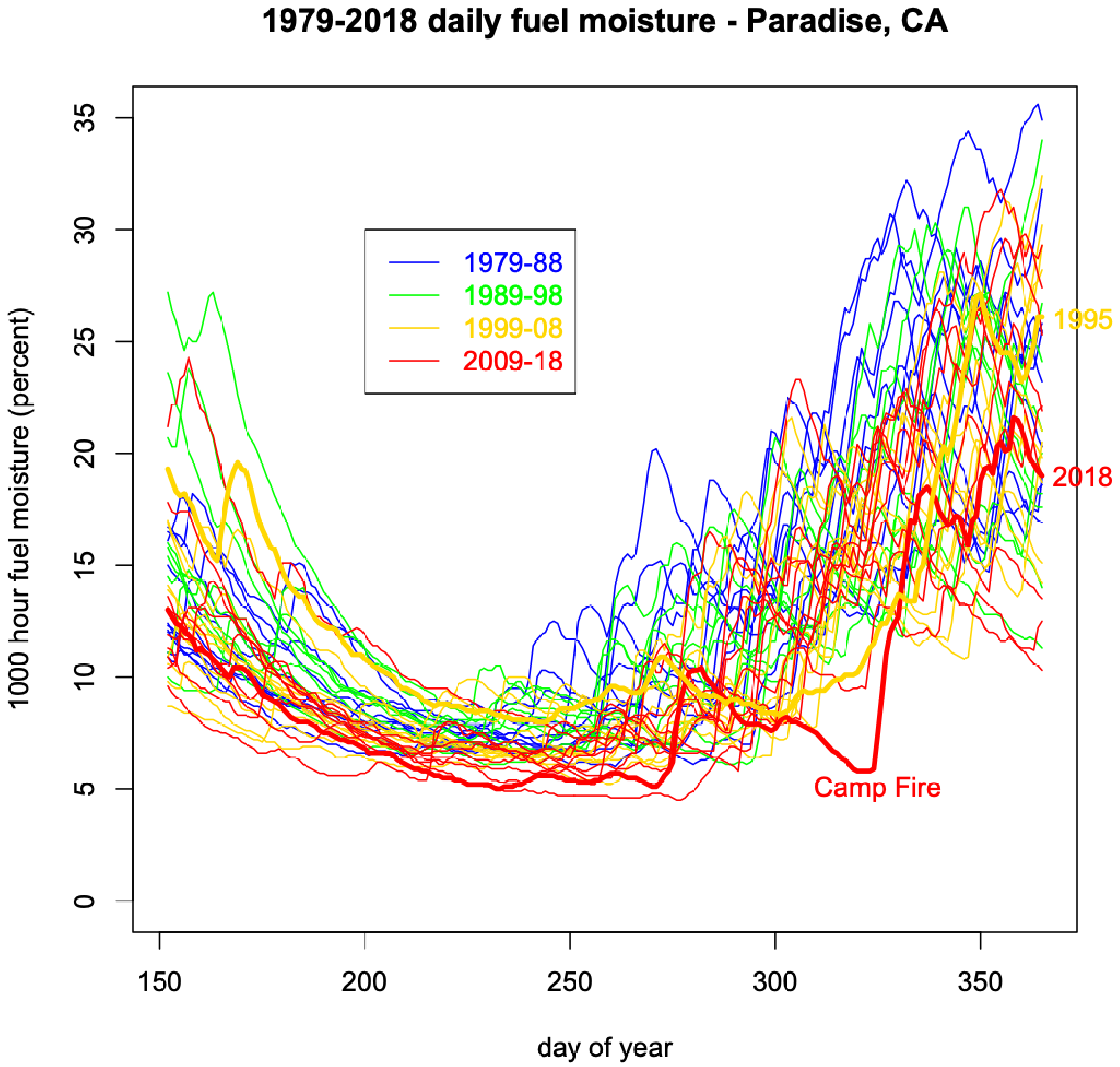




Precipitation is becoming more variable…



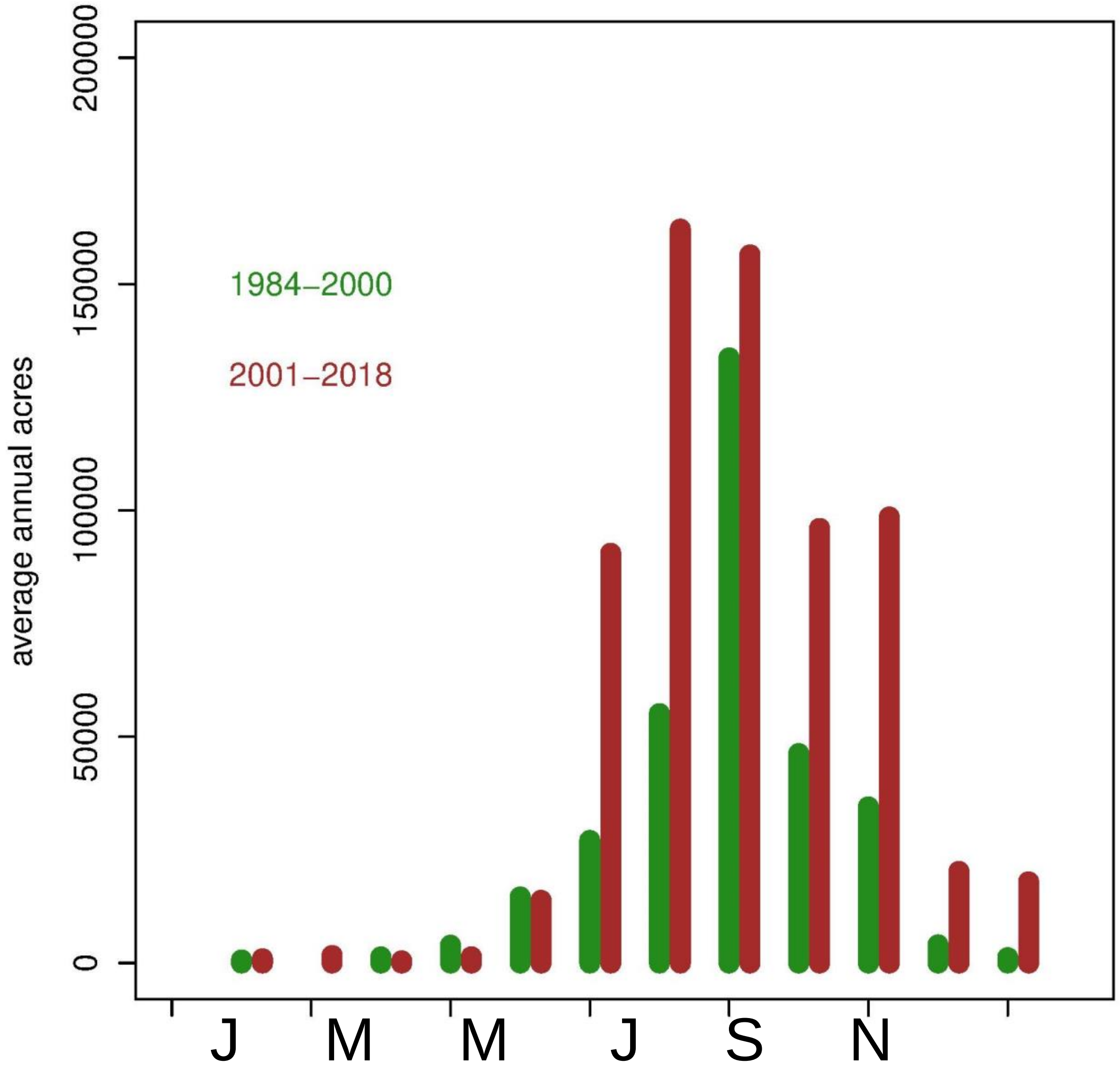
as the pole warms faster than the equator, the jet stream slows and weather patters become more persistent

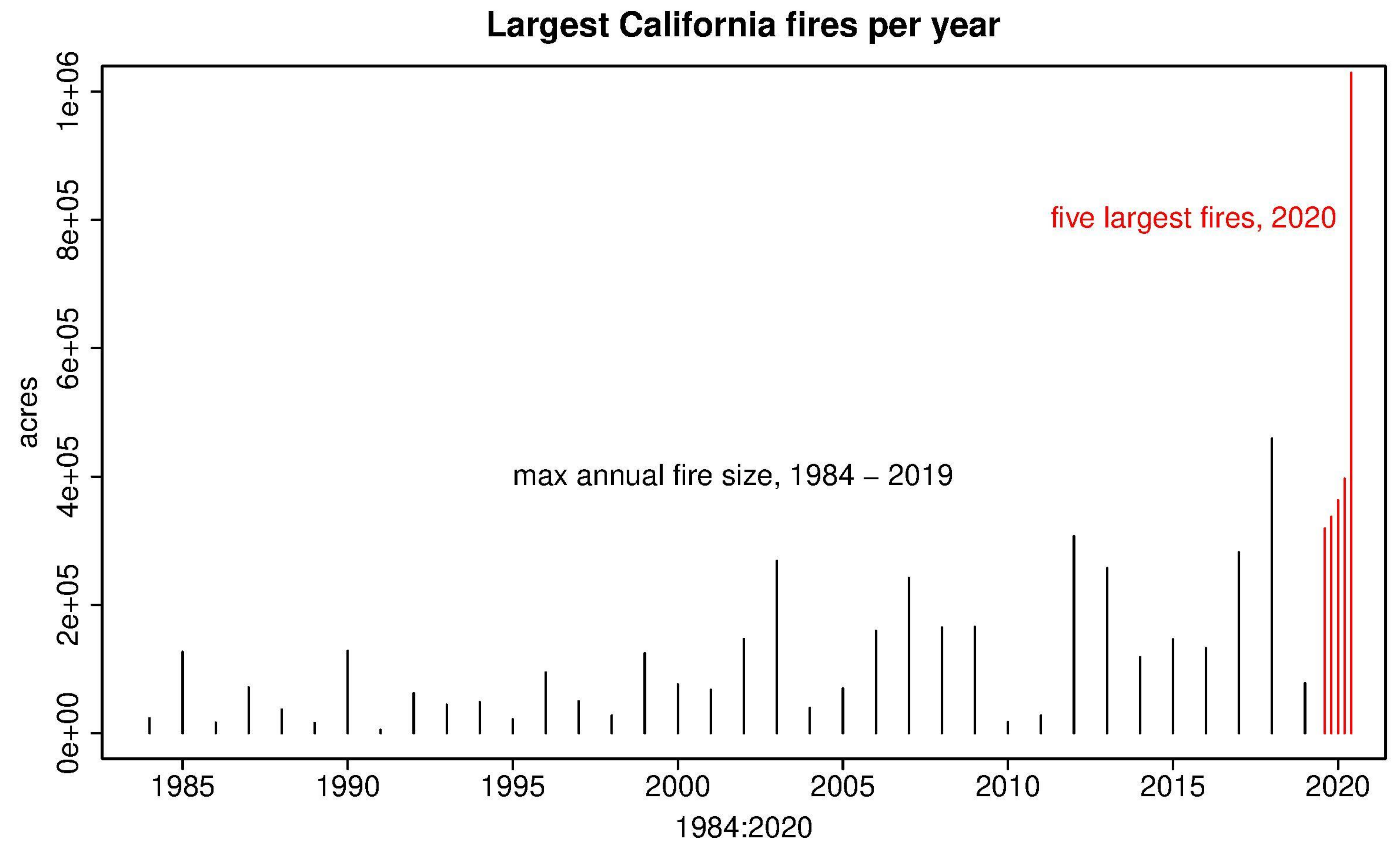


1979-2018 daily fuel moisture - Paradise, CA
1000 hour fuel moisture (percent)
day of year
1979-88
1989-98
1999-08
2009-18
1995
2018
Camp Fire
0
5
10
15
20
25
30
35
150
200
250
300
350

Paradise, CA

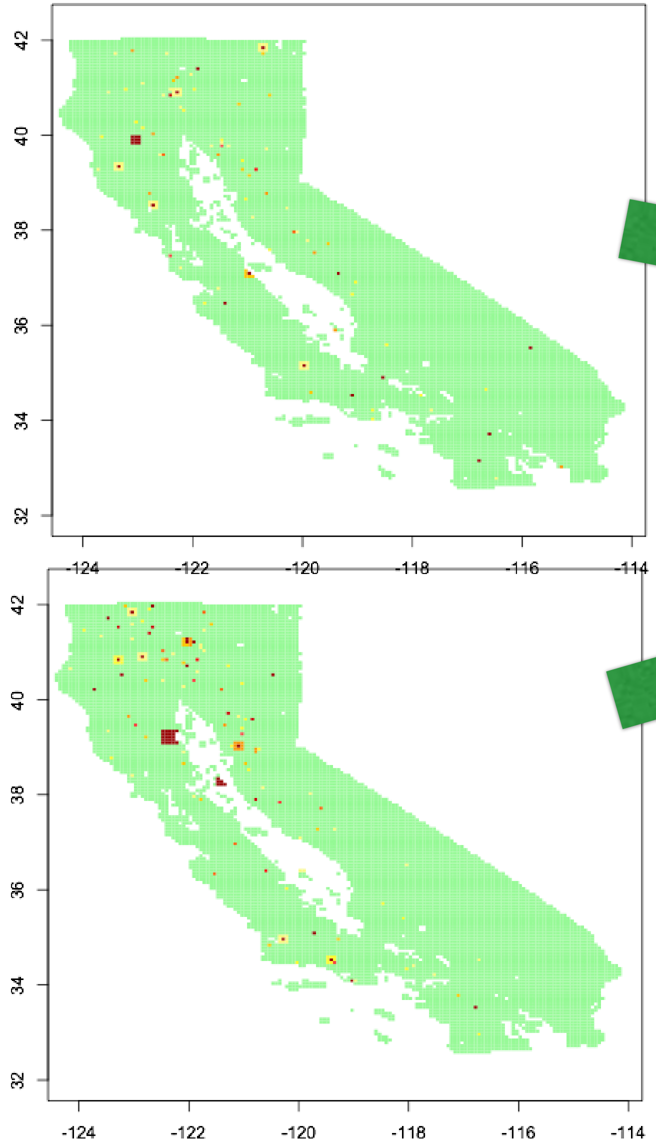
California's shifting fire season: area burned



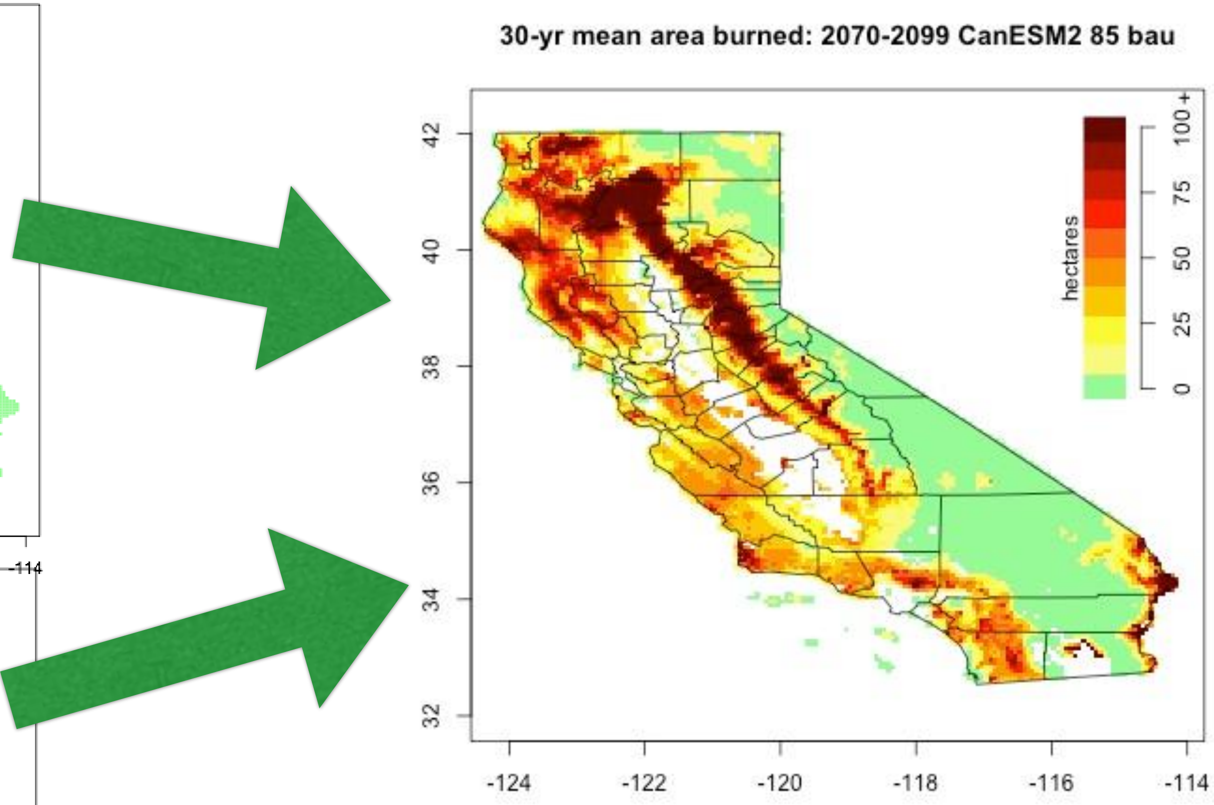


Largest California fires per year
five largest fires, 2020
max annual fire size, 1984 – 2019
acres
0e+00
2e+05
4e+05
6e+05
8e+05
1e+06
1985
1990
1995
2000
2005
2010
2015
2020
1984:2020

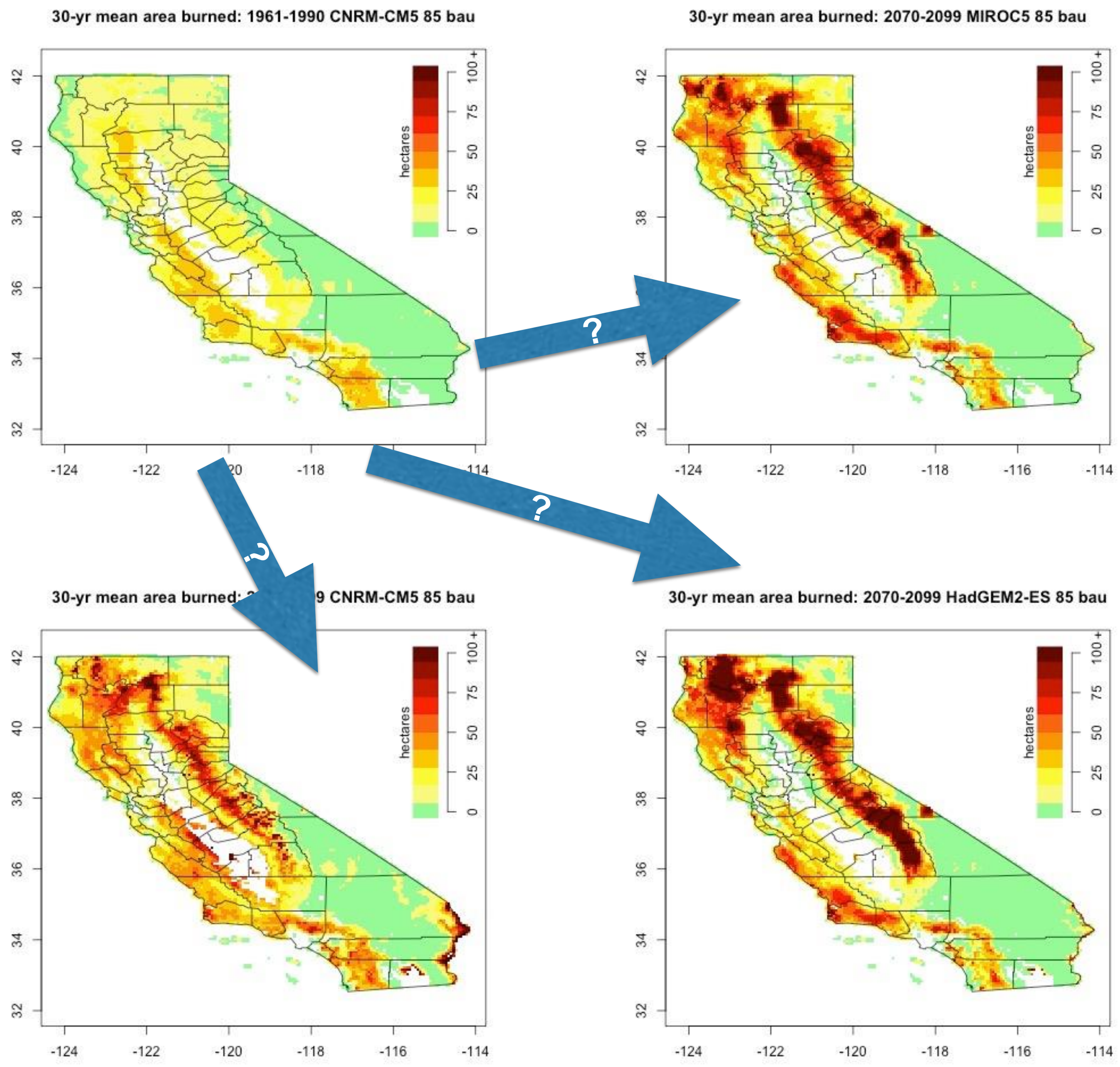
Annualized, allocated simulations multiple realizations per scenario, year

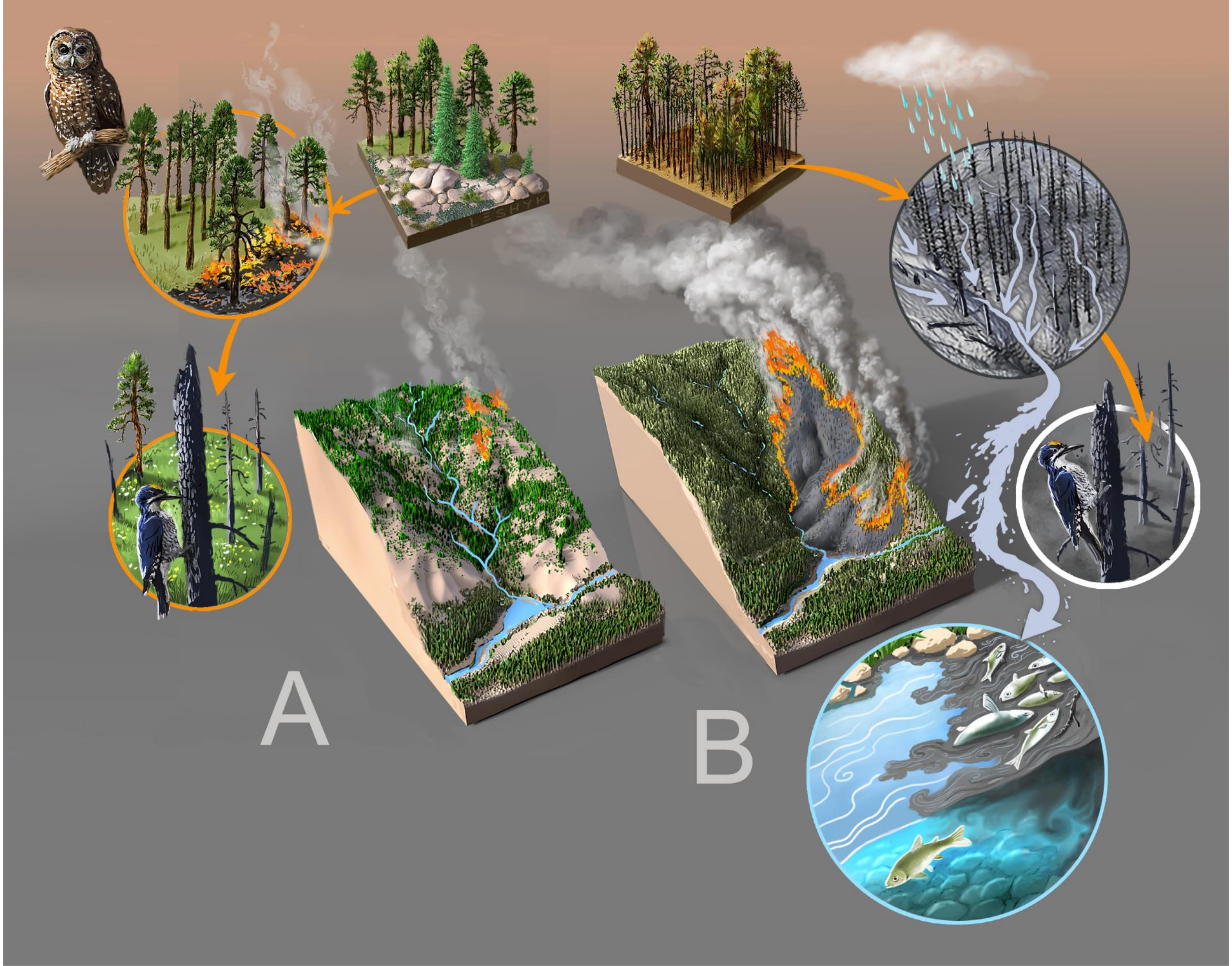


Cumulate over time, scenario(s) to obtain mean, compound distribution

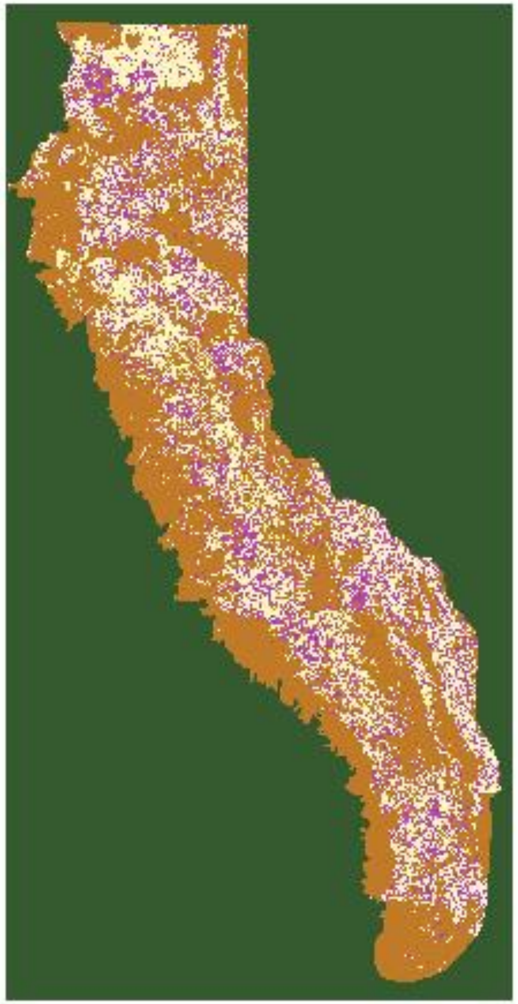


Westerling *(In Review)*
Wildfire simulations for the Fourth California Climate Assessment: projecting changes in extreme wildfire events with a warming climate.

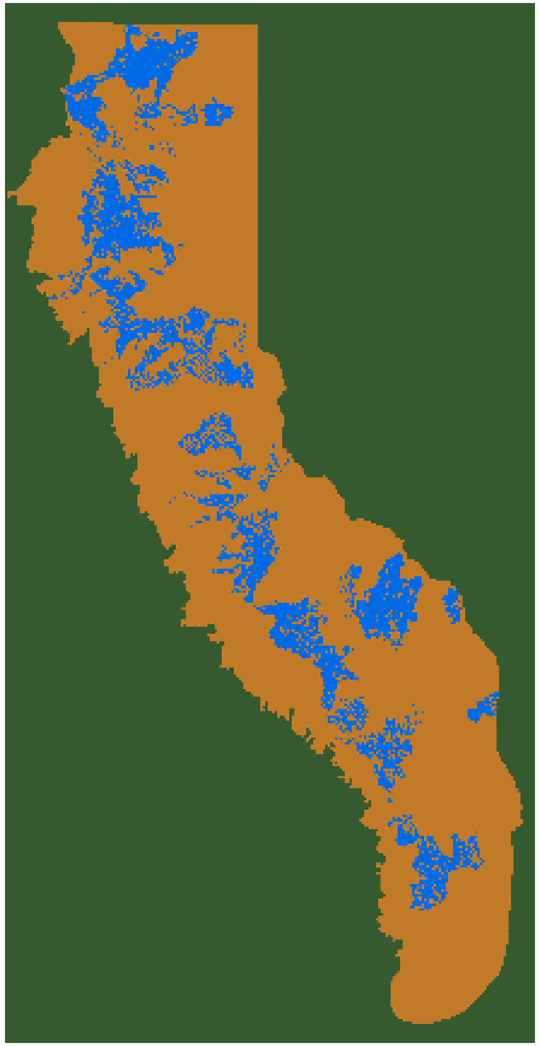

30-yr mean area burned: 1961-1990 CNRM-CM5 85 bau
30-yr mean area burned: 2070-2099 MIROC5 85 bau
30-yr mean area burned:
9 CNRM-CM5 85 bau
30-yr mean area burned: 2070-2099 HadGEM2-ES 85 bau
hectares
0
25
50
75
100+
?
?
?


A
B

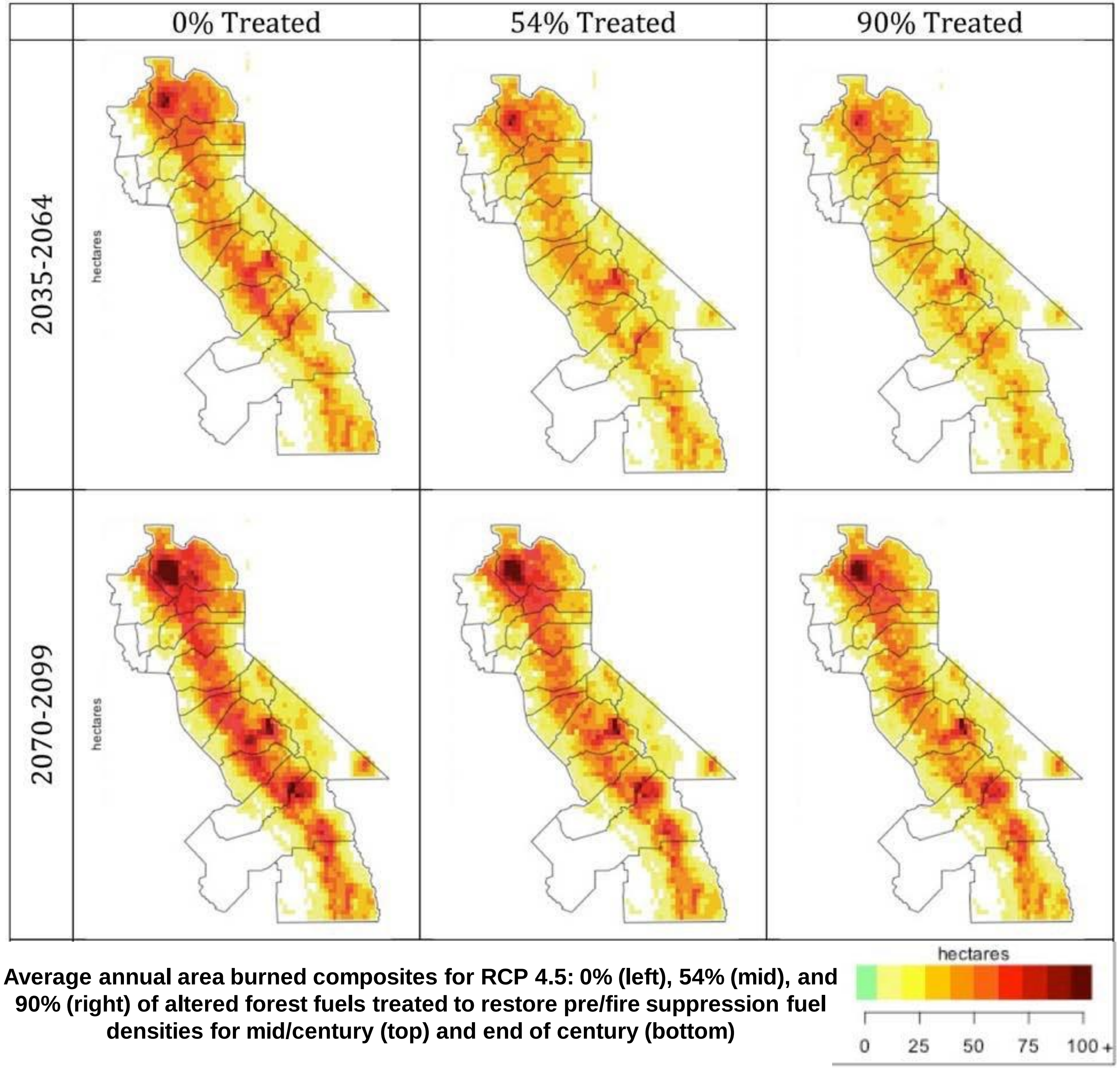
"30%" Treatment by Administrative Unit



"100%" Treatment by Conservation Objective



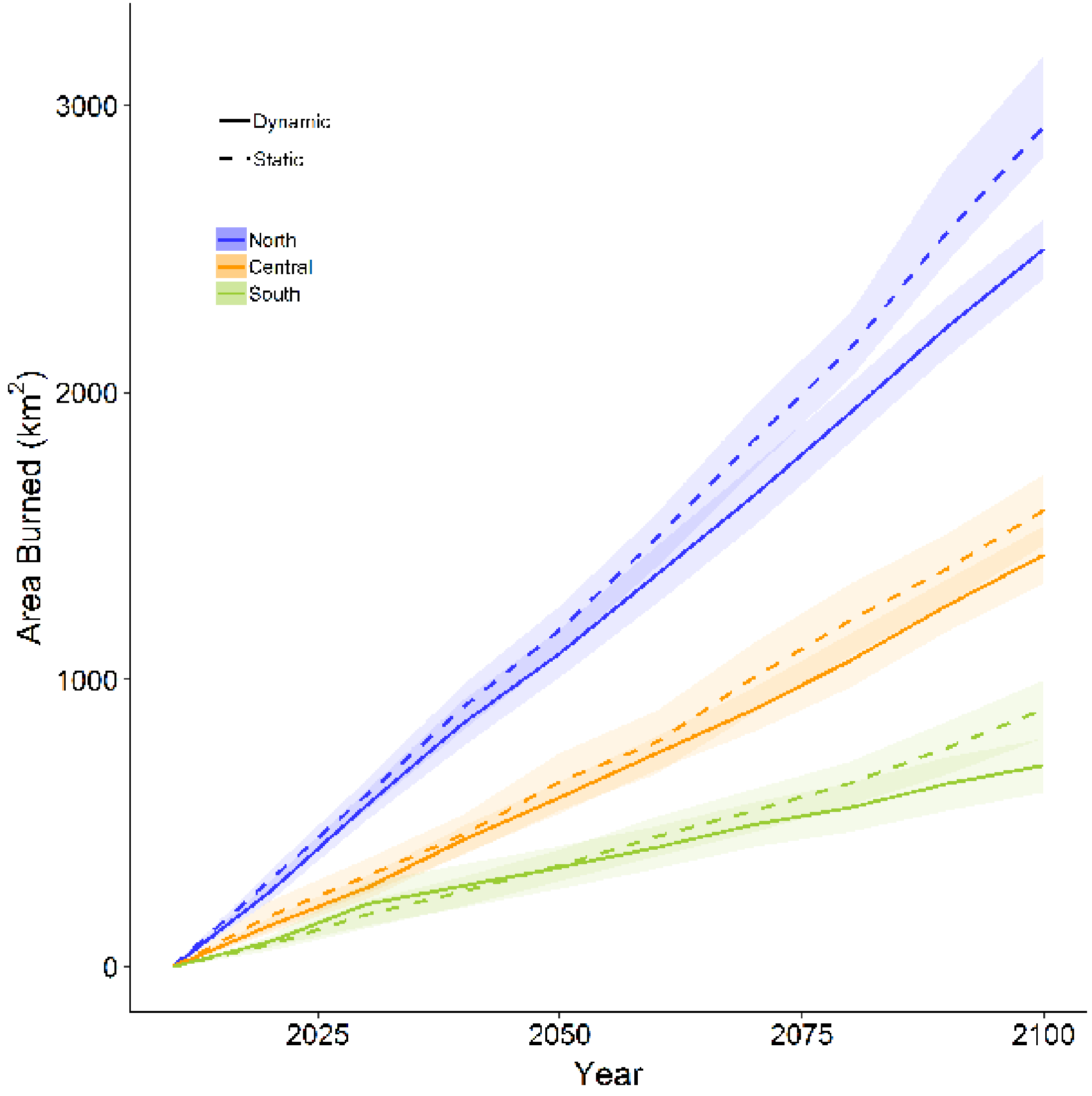
Provided by JoAnn Fites-Kaufman & April Brough USDA Forest Service, Region 5

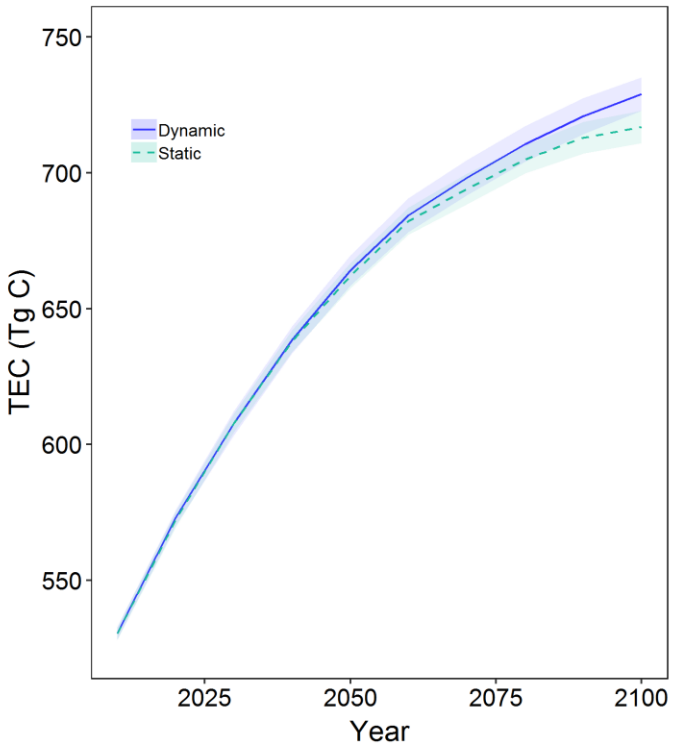


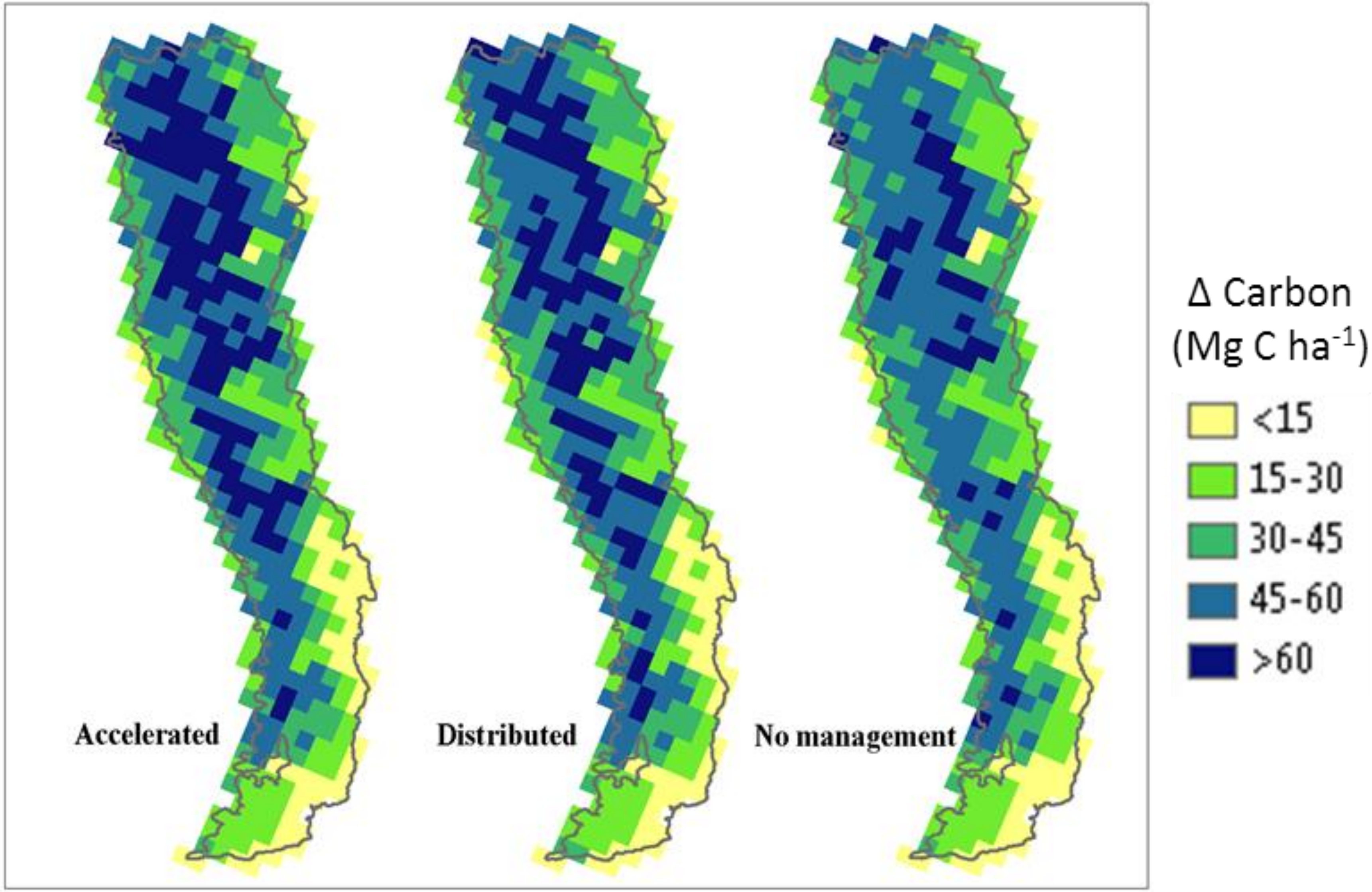
Average annual area burned composites for RCP 4.5: 0% (left), 54% (mid), and 90% (right) of altered forest fuels treated to restore pre/fire suppression fuel densities for mid/century (top) and end of century (bottom)

Hurteau, Liang, Westerling, Wiedinmyer “Vegetation-fire feedback reduces projected area burned under climate change” Scientific Reports 2019

Effects of dynamic vegetation on area burned and total C

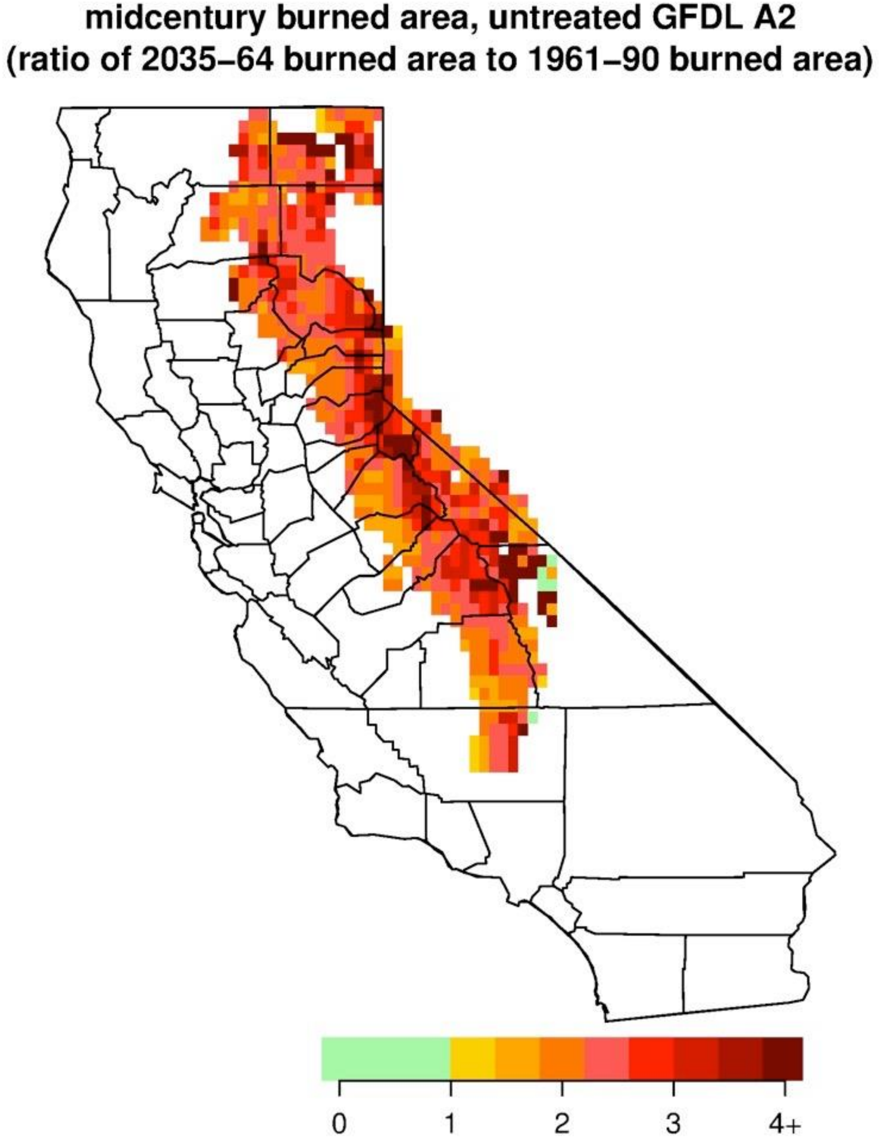


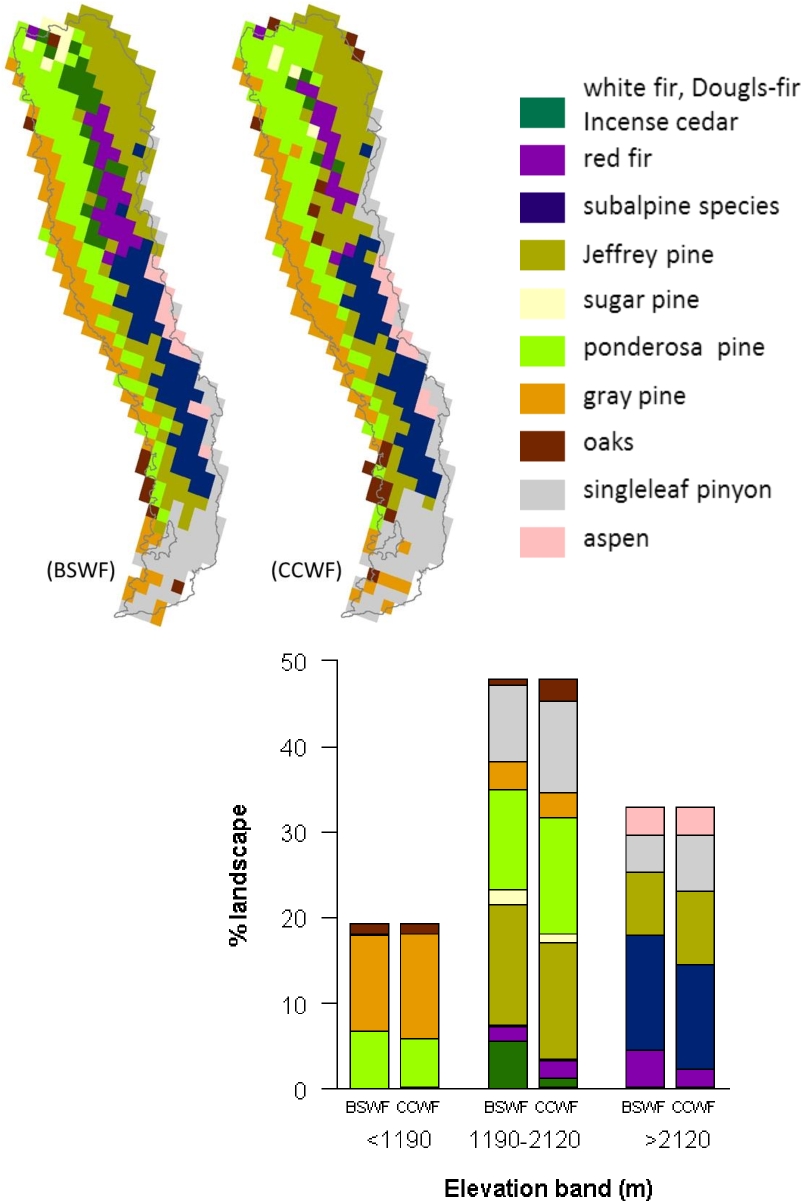


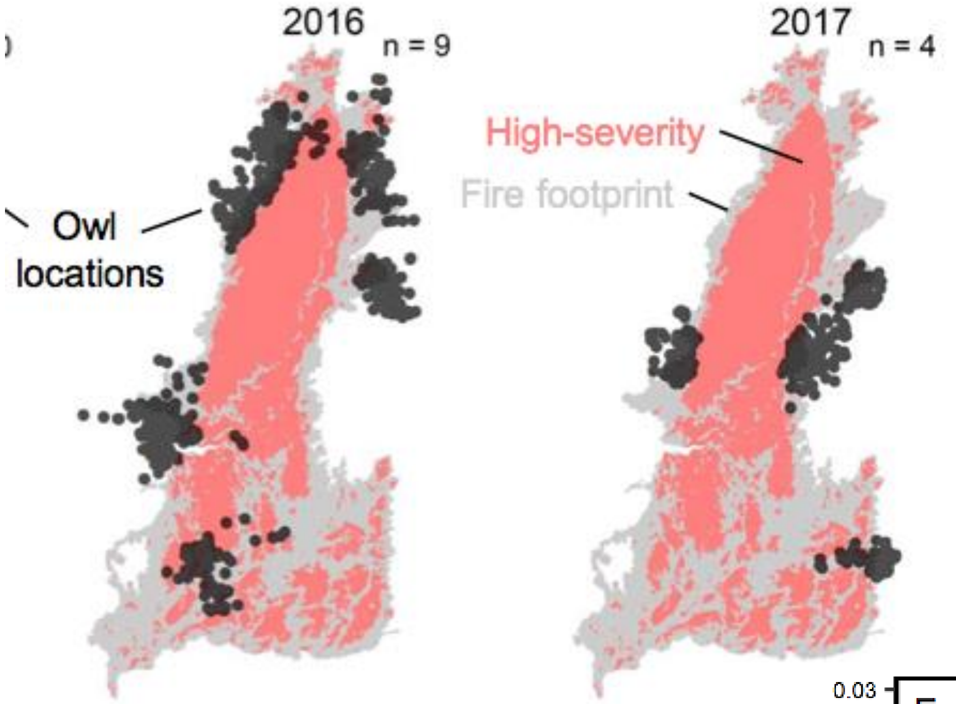


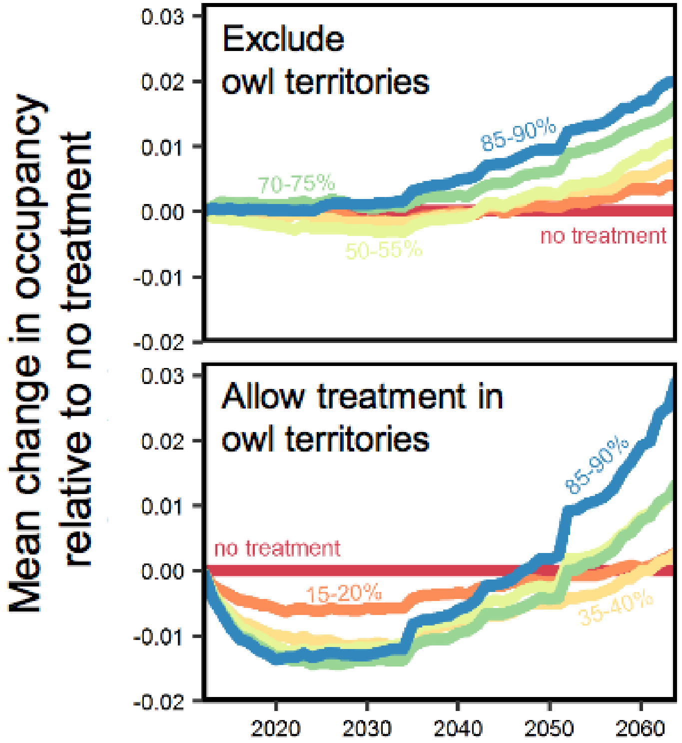
Liang, Hurteau, Westerling, 2018 *Frontiers in Ecology and the Environment 16(4): 207-212.*

Liang et al, 2017



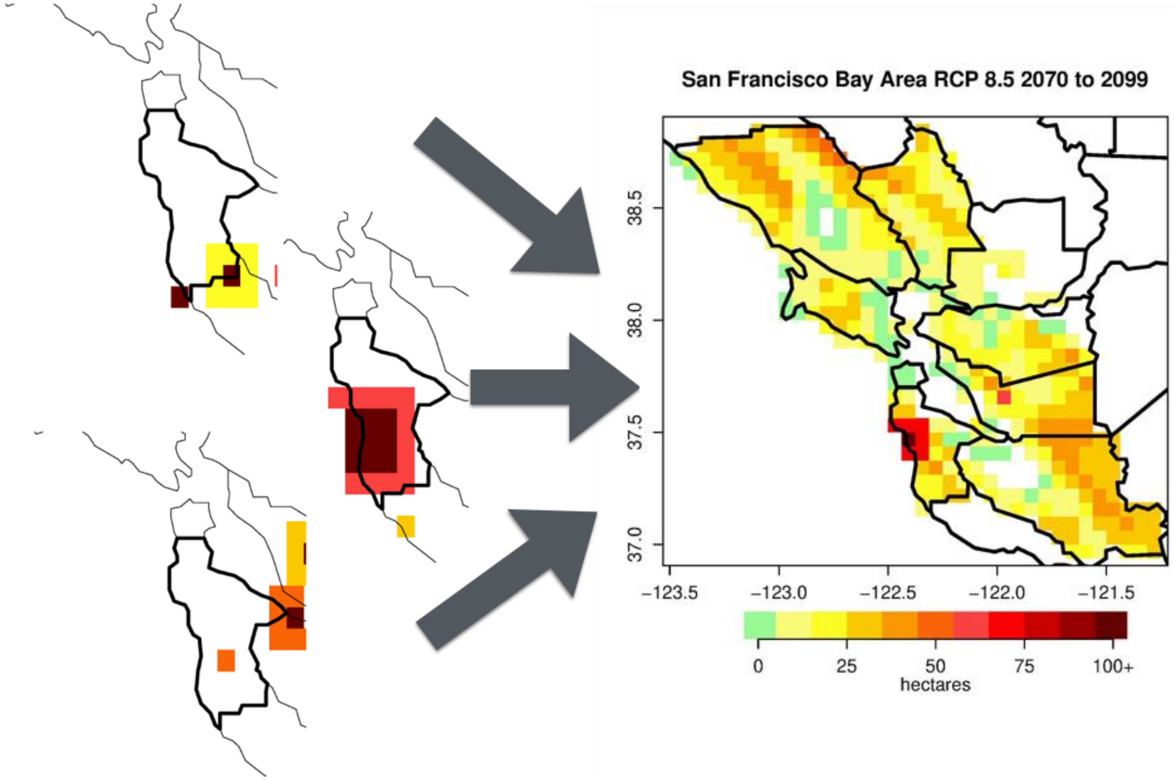




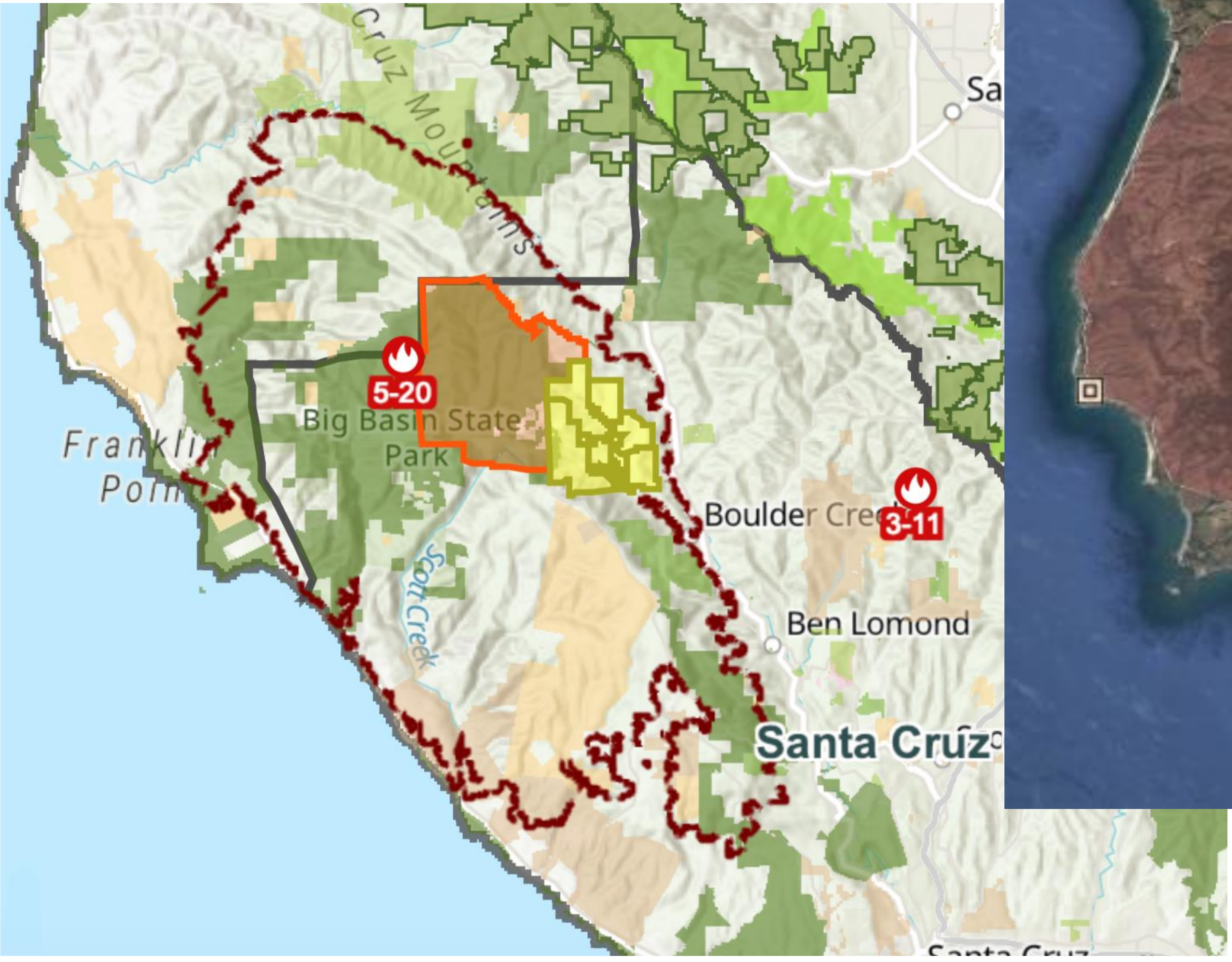


Forest Management for Spotted Owl Habitat

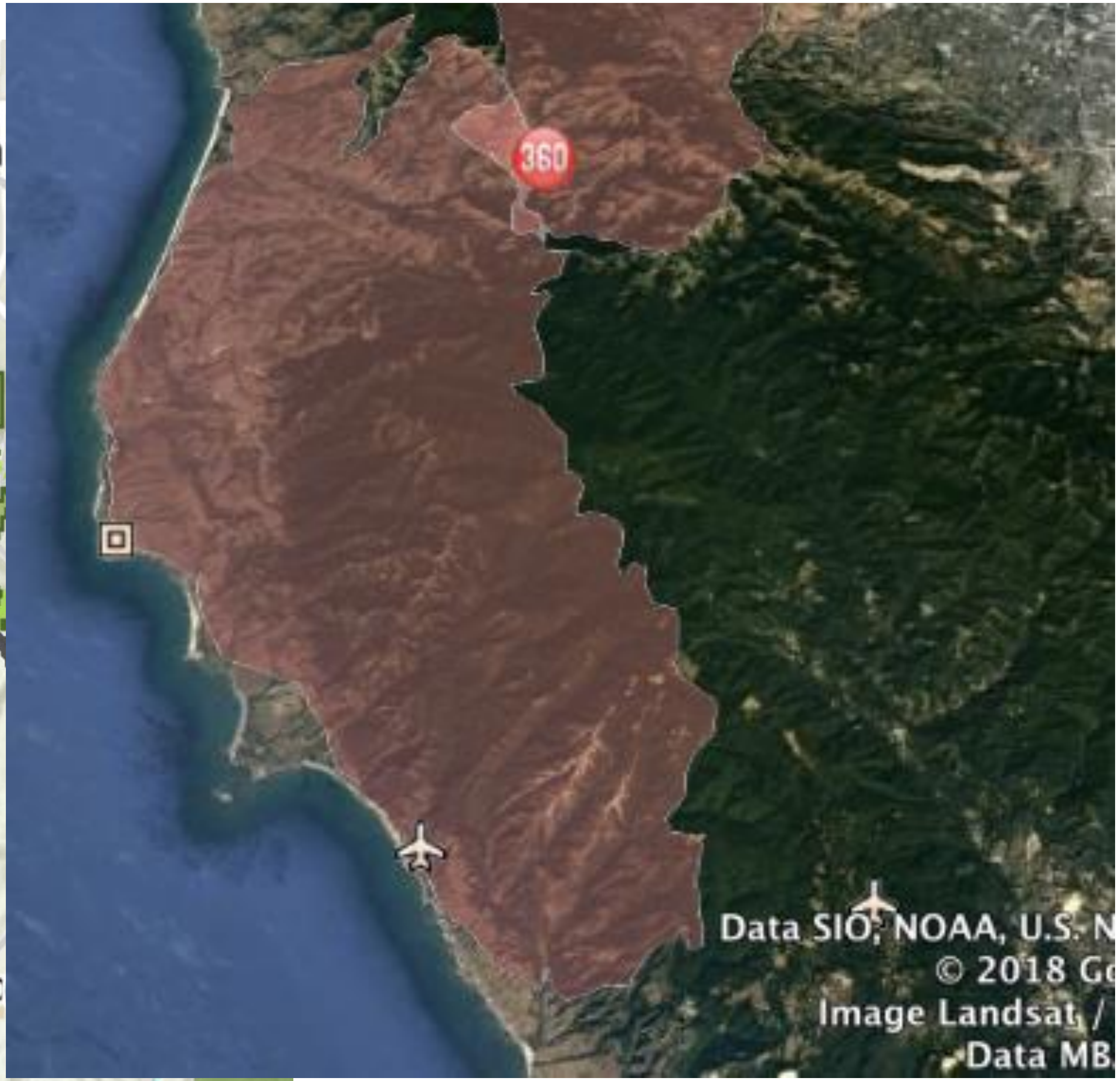
Jones Keyser Westerling Baldwin Gutiérrez Sawyer Keane Clare Peery 2019



Vulnerability Assessment & Adaptation Planning Support for San Mateo County



Cruz Mountains
Sa
5-20
Big Basin State Park
Franklin Point
Boulder Creek
3-11
Scott Creek
Ben Lomond
Santa Cruz
Santa Cruz



360
Data SIO, NOAA, U.S. N
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Image Landsat /
Data MB

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Free and open access to the next generation of wildfire risk models for grid resiliency

Research Collaborators

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Berkeley
UNIVERSITY OF CALIFORNIA

UNIVERSITY OF CALIFORNIA
MERCED

NCAR | NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

REAX
ENGINEERING

THE UNIVERSITY OF NEW MEXICO

SALO

FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE

USGS
science for a changing world

UNIVERSITY OF SAN FRANCISCO
CHANGE THE WORLD FROM HERE

UNIVERSITY OF CALIFORNIA SANTA BARBARA
LET THERE BE LIGHT

STi

DEER CREEK
GIS

PROMETHEUS™
Fire Consulting Services

Lumen | Energy Strategy

PYROLOGIX

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UCSD

Collaborating across four workgroups

Spatial Informatics Group

PRINCIPAL INVESTIGATOR (PI)
& PROJECT MANAGER (PM)

WG1

UCAR

USF

WG2

Berkeley
UNIVERSITY OF CALIFORNIA

WG3

REAX ENGINEERING

WG4

UNIVERSITY OF CALIFORNIA
MERCED

EXTREME WEATHER

Janice Coen

FIRE
BEHAVIOR
Scott Stephens

FORECAST TOOLS

Chris Lautenberger

SCENARIO
ANALYSES
LeRoy Westerling

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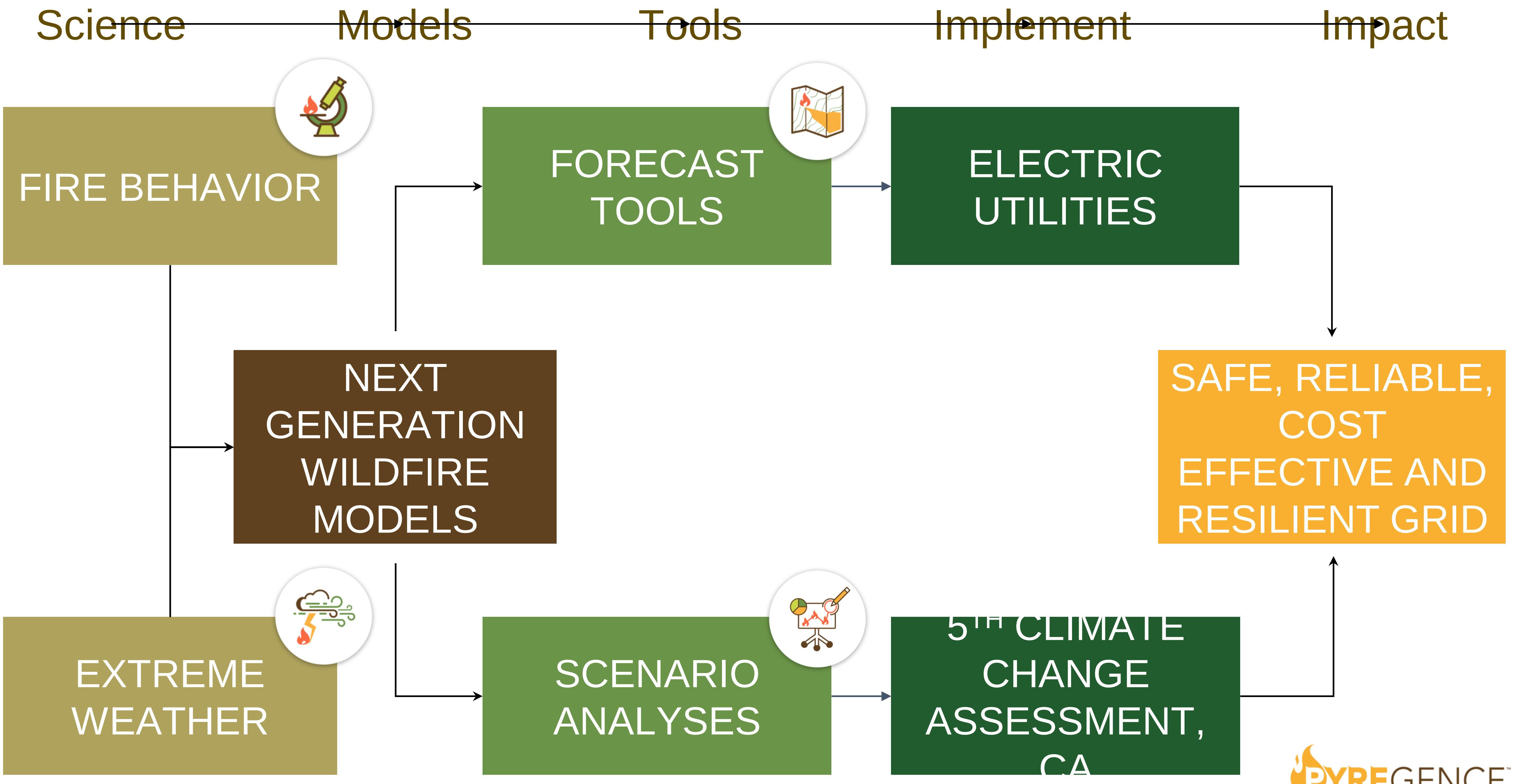
Science
Models
Tools
Implement
Impact
FIRE BEHAVIOR
EXTREME WEATHER
NEXT GENERATION WILDFIRE MODELS
FORECAST TOOLS
SCENARIO ANALYSES
ELECTRIC UTILITIES
5TH CLIMATE CHANGE ASSESSMENT, CA
SAFE, RELIABLE, COST EFFECTIVE AND RESILIENT GRID

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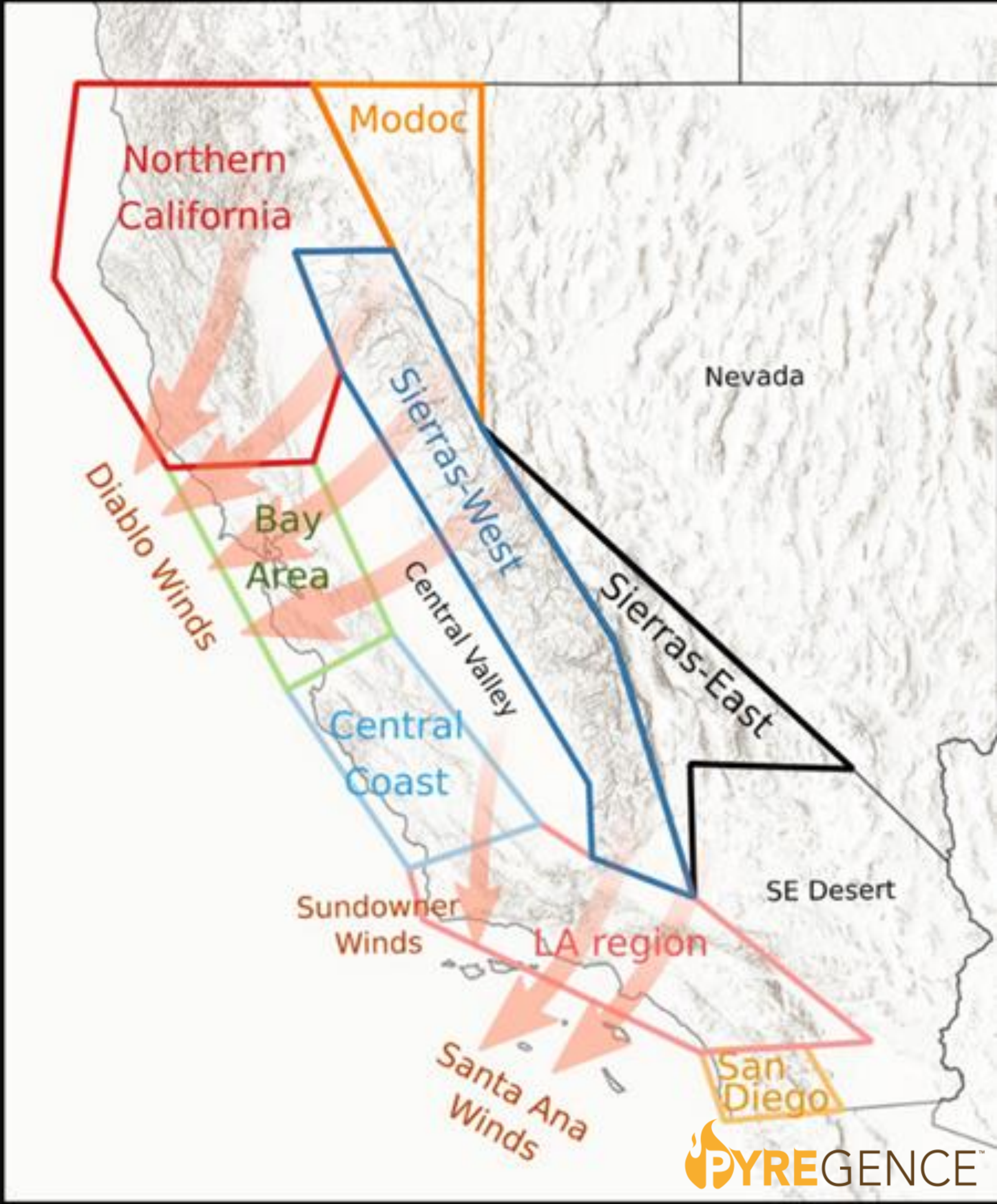
Extreme Weather and Weather Stations

- Analytical approach for optimizing the placement of weather stations
- Pilot Testing of Upper Air Profiler for situational awareness
- Algorithm to identify regional archetypal weather conditions associated with rapid fire growth.
  - Based on analysis of historic fire-weather data
  - 8 weather regions
  - Regional analysis is refined by hyper-local coupled airflow - fire modeling.
  - Finding - days with the most fire growth are associated with two or three extreme weather types.



PYREGENCE

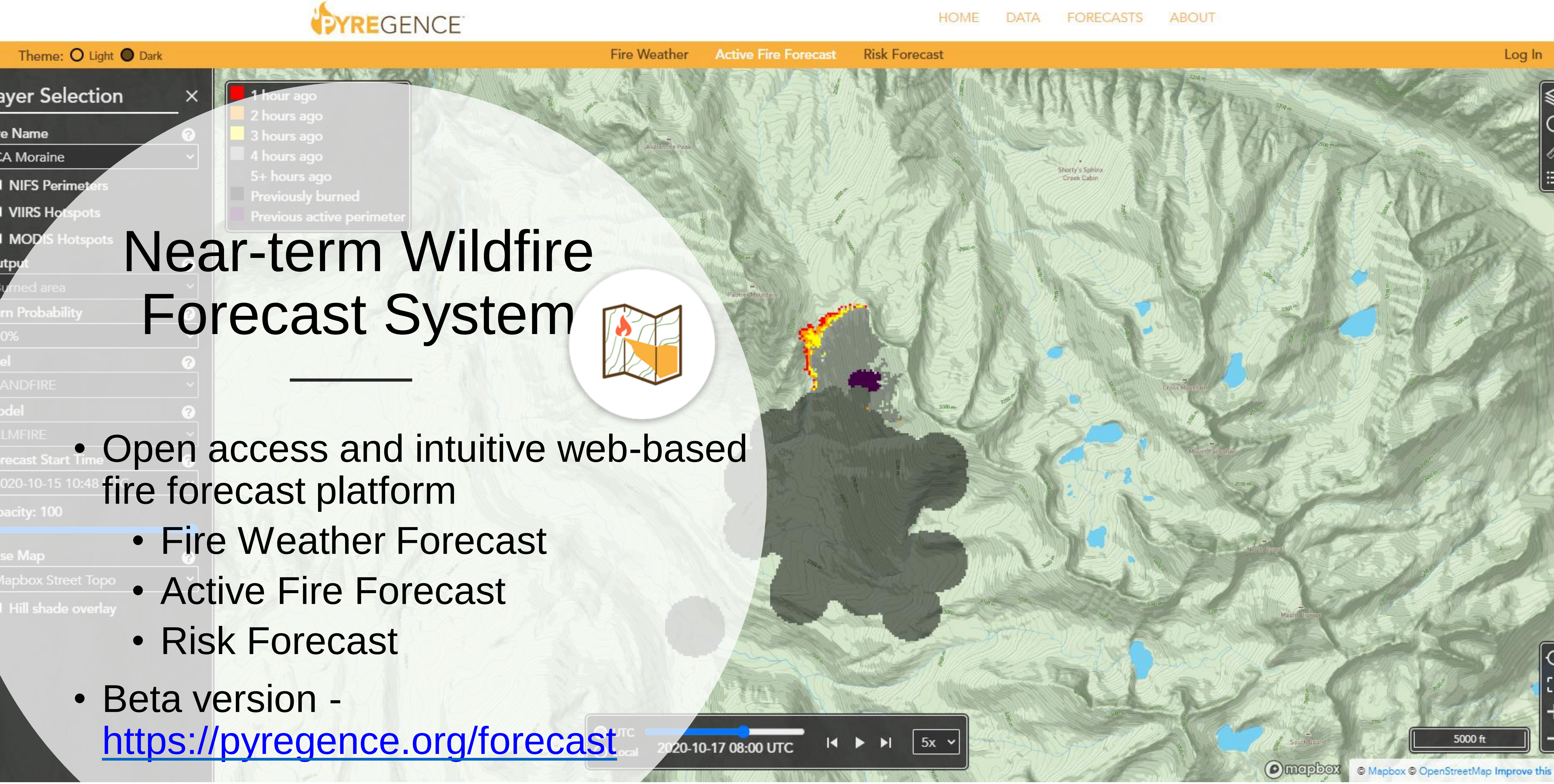
Fire Behavior

- Predicting heat release rates across the range of fuel structures and environmental conditions found in wildland areas
- New fuel measurement and mapping system
- Map current and projected future fuel conditions in areas of elevated tree mortality
- Develop fire model that includes large fuels (> 3 inches diameter), solid phase combustion, and buoyancy

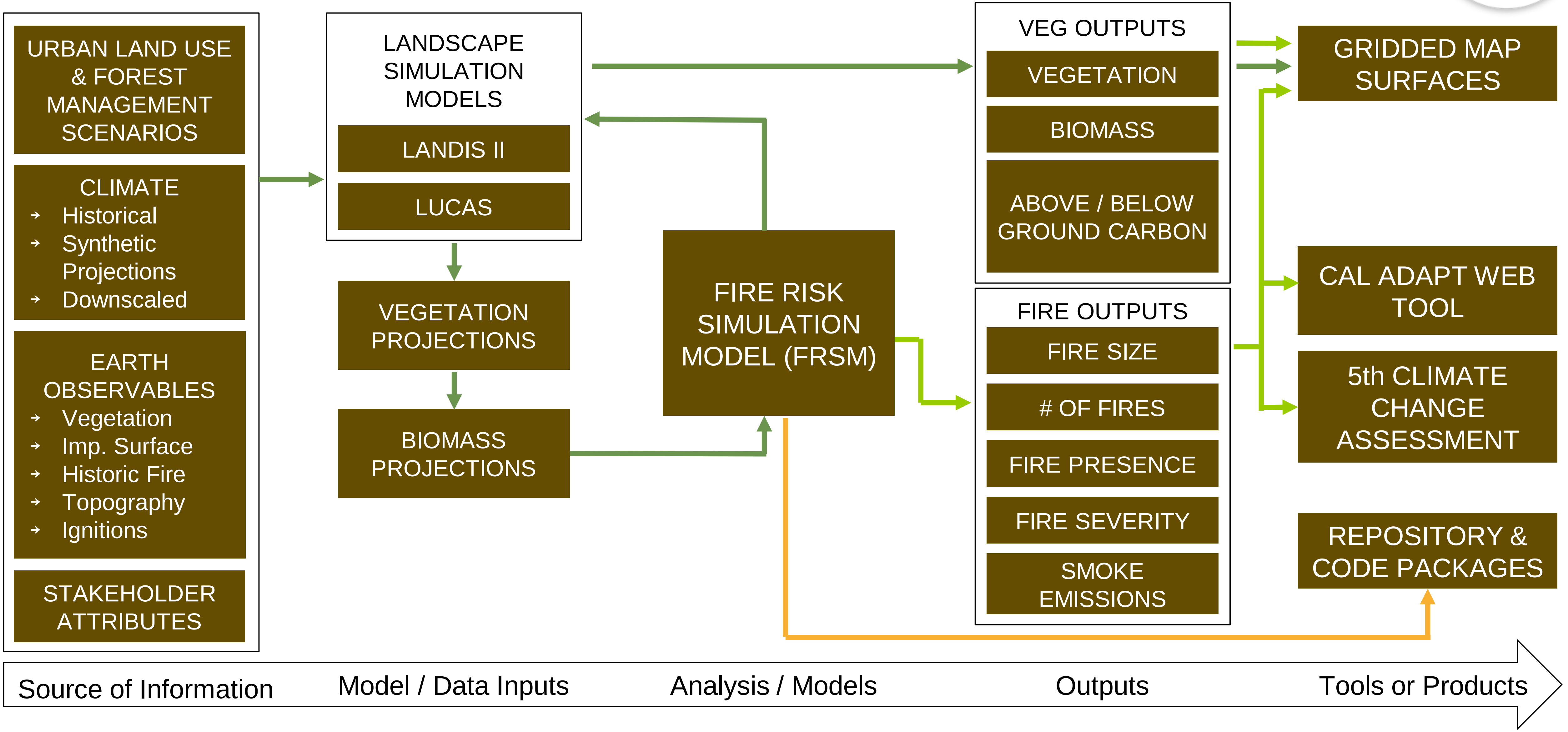
PYREGENCE

Near-term Wildfire Forecast System

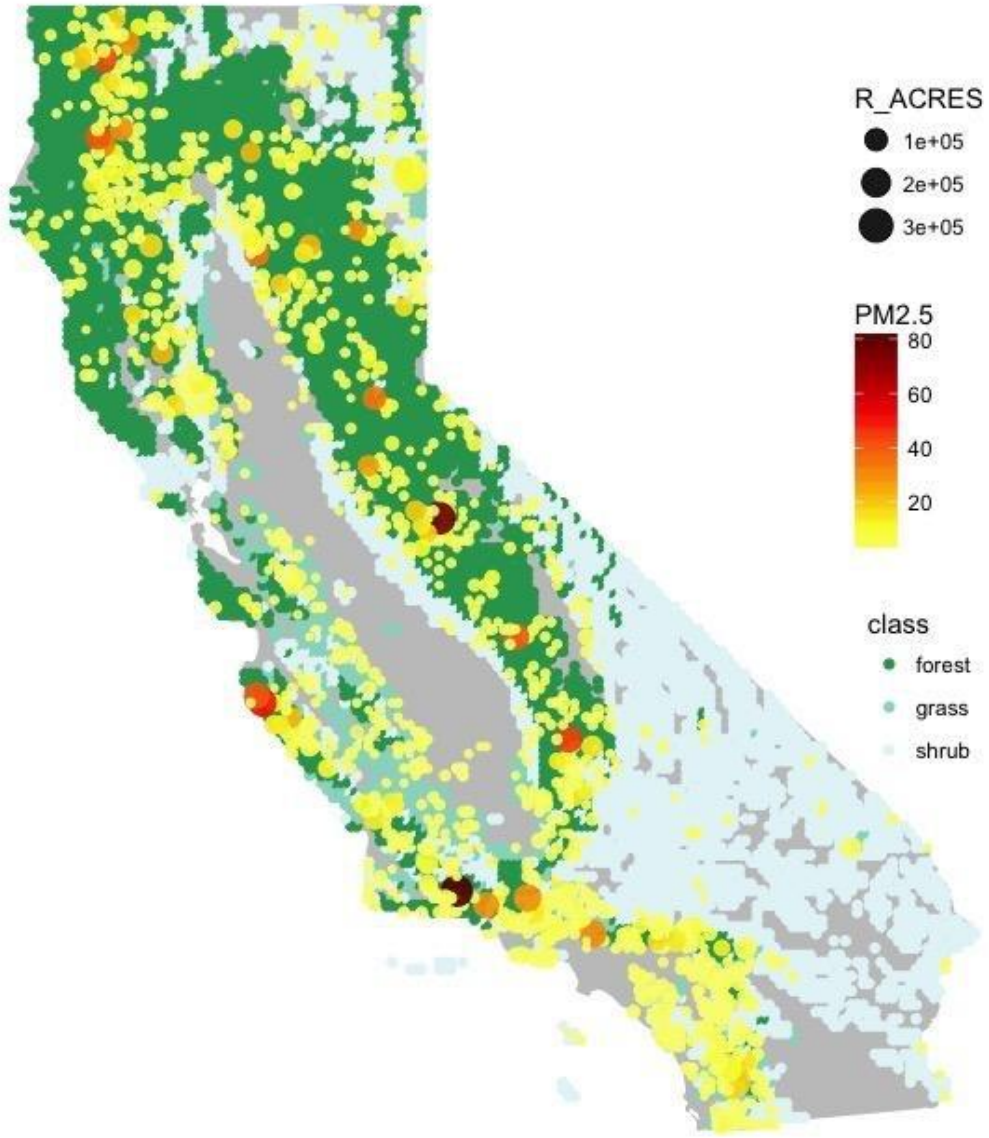
- Open access and intuitive web-based fire forecast platform
  - Fire Weather Forecast
  - Active Fire Forecast
  - Risk Forecast
- Beta version - https://pyregence.org/forecast



5th Assessment - Long-term Wildfire Projectio



PM2.5 and land cover



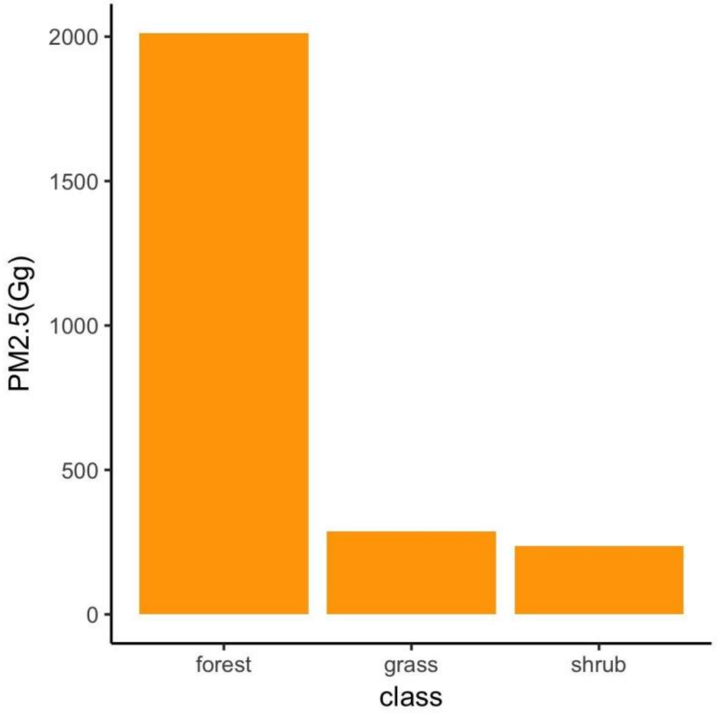
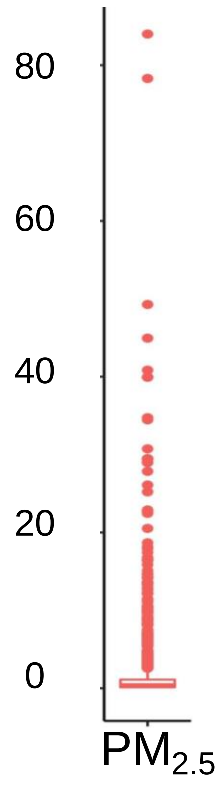


Fig.4 PM2.5 emissions in forest, shrub, and grass land in California (1984-2016) (Gg)

$PM_{2.5}$ of the largest 15 wildfires contributed 22% percent of total emissions



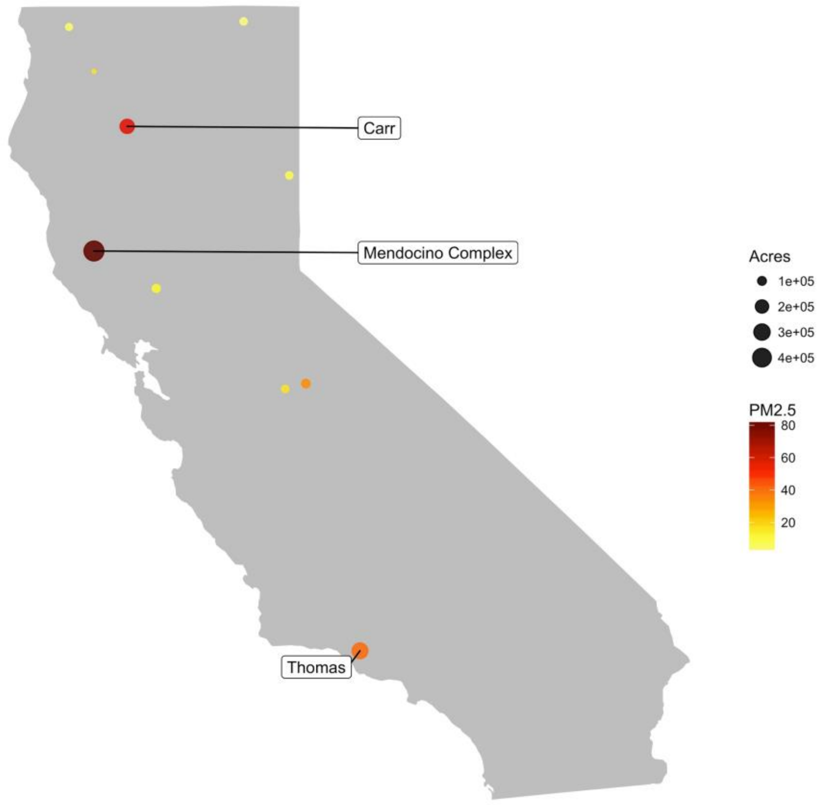


Fig.3 $PM_{2.5}$ range for each fire (Gg) (left); Map of $PM_{2.5}$ emissions of the largest 10 fires during 1984-2018 (right)

Since the 21st century, there has been an increasing in $PM_{2.5}$ emissions, an earlier and longer wildfire emission season

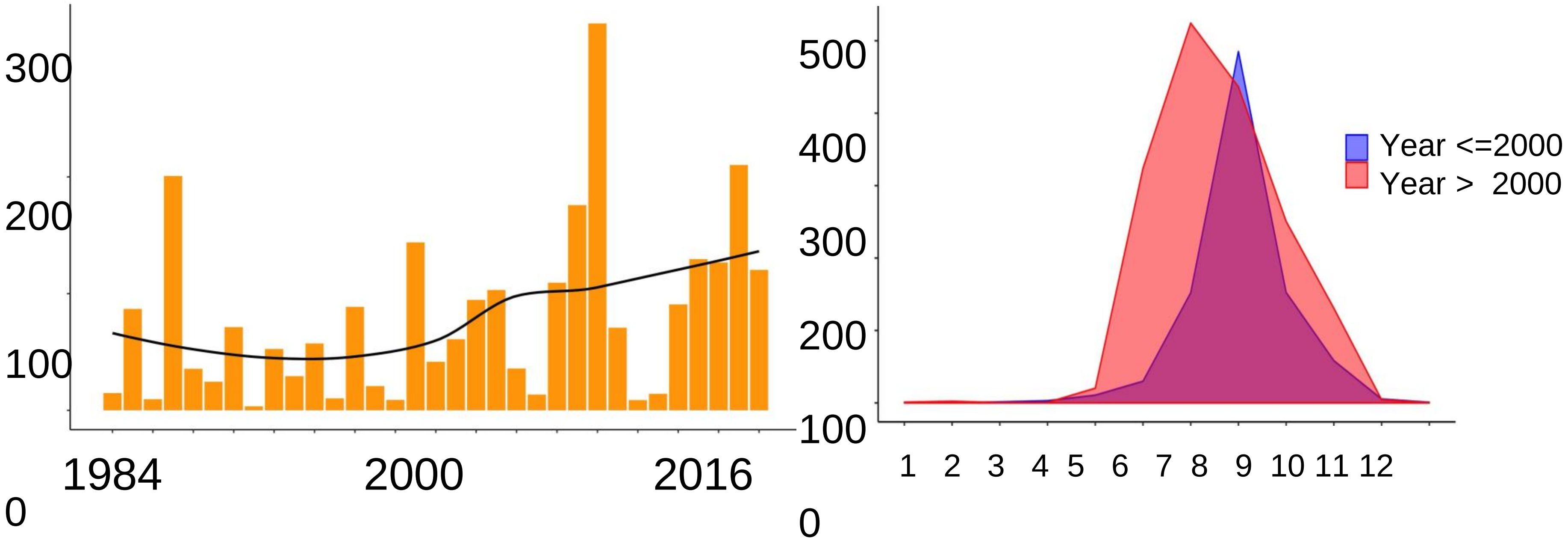


Fig.4 $PM_{2.5}$ annual (left) and monthly (right) trends aggregated over the state of California, monthly data also aggregated for historical 1984-2016(Gg)

Methods - fire severity prediction

(1) Spatial and temporal domain of analysis

- 1/24 latitude/longitude grid
- 1984-2017
- California statewide, 3 sub regions (Sierra Nevada, Northern Coastal California, Southern Coastal California)

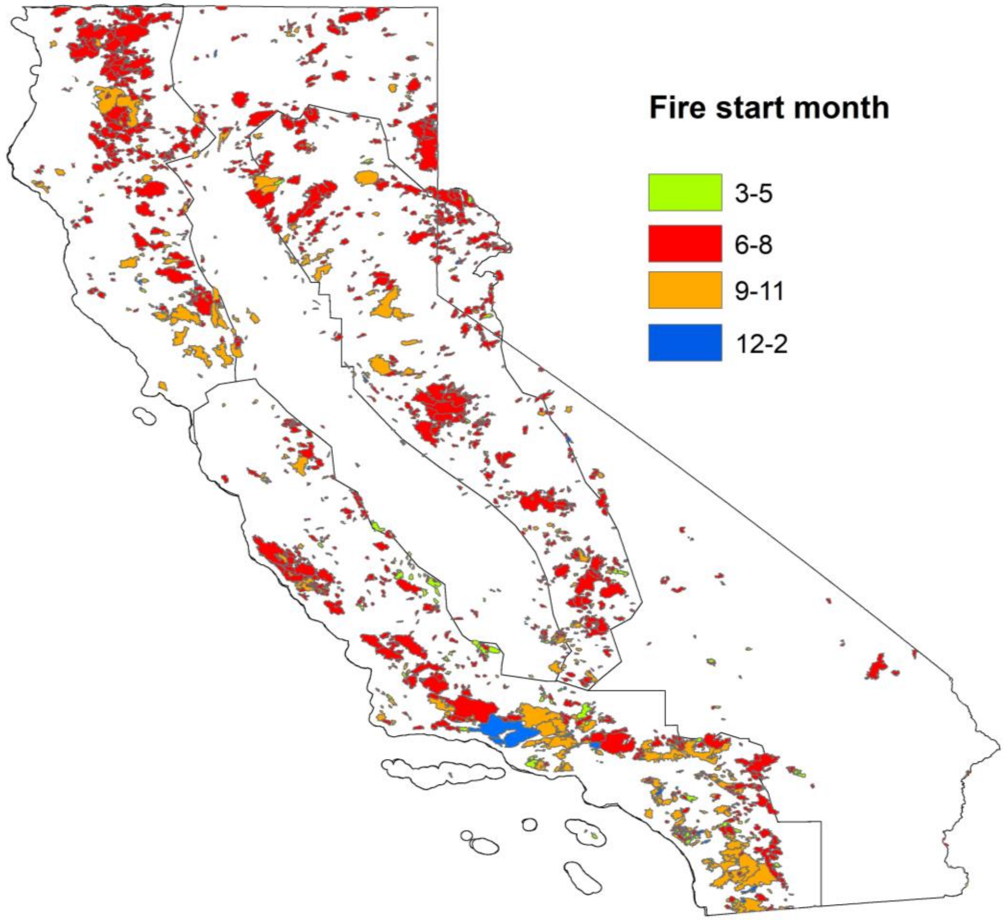


Fig.1. Wildfire perimeters and fire start month in California during 1984-2017.Data source: MTBS

(3) Modeling framework

Random Forest
- Variable importance

Generalized Pareto Distribution model (GPD)
- Total area burned

Generalized Additive Model
- Fraction of area burned in 3 severity classes

(3) severity fraction—result from GAM model

High severity

Moderate severity

Low severity

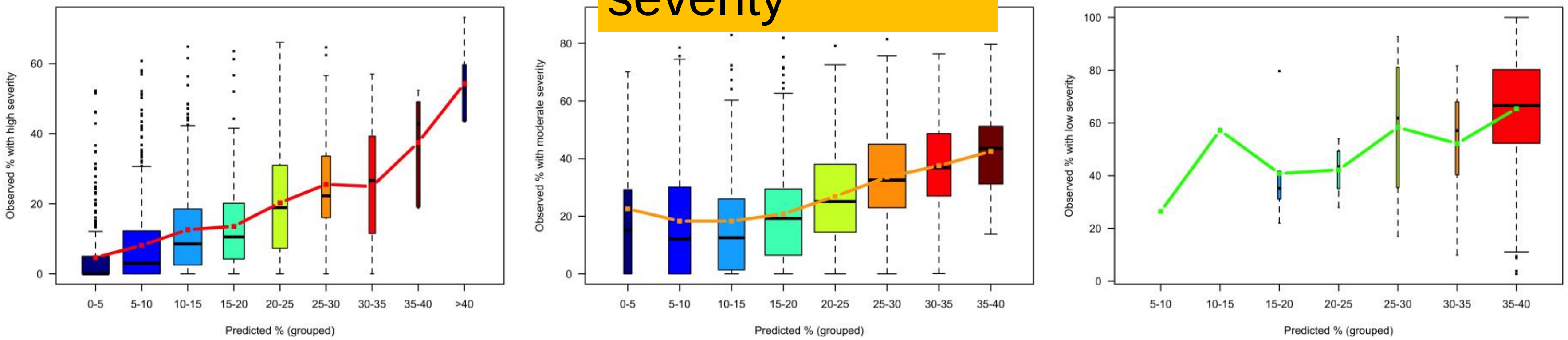


Fig.3. Predicted severity fractions versus observed severity fraction distribution and observed mean fraction for each group (line) in California

"avgTJJA",”avgTMAM”,”sum”, “cprec”
R-sq.(adj) = 0.476

“firemonthVPD”,”forest”, ”elevation”
R-sq.(adj) = 0.234

“forest”, “cprec”, “avgTJJA”
R-sq.(adj) = 0.371

(1) 30 meter resolution

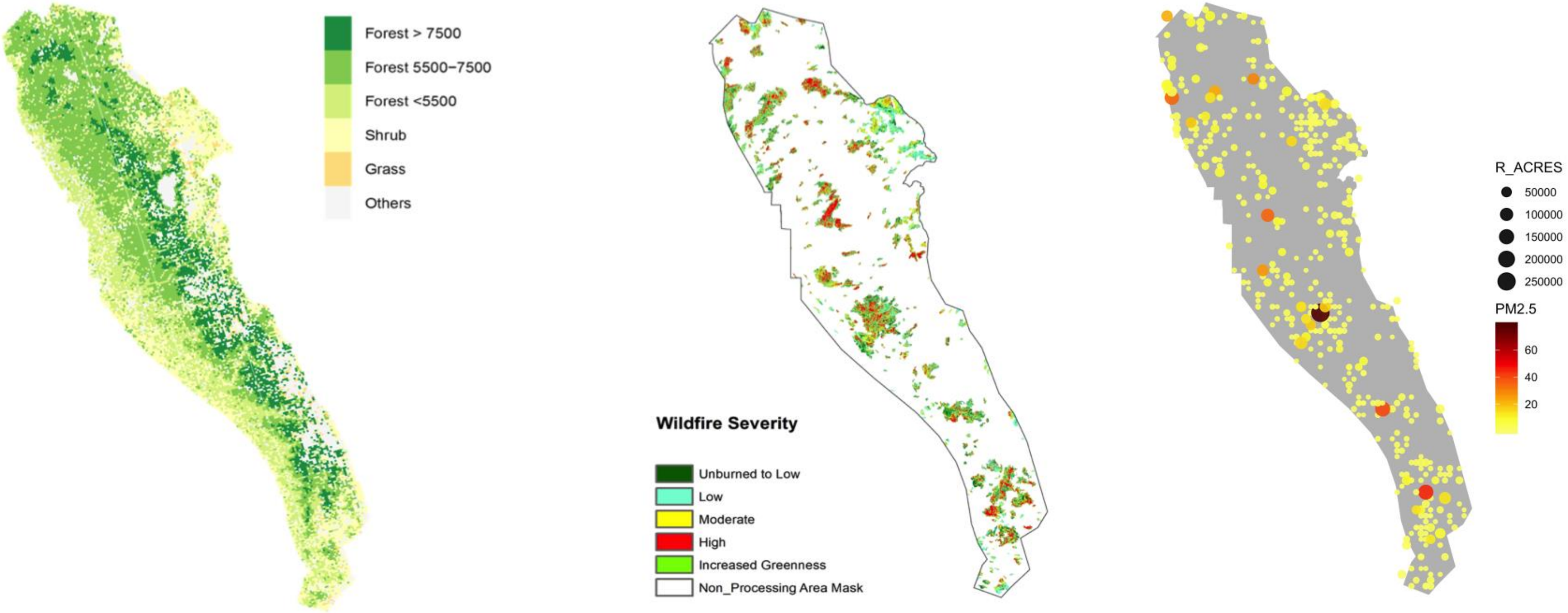
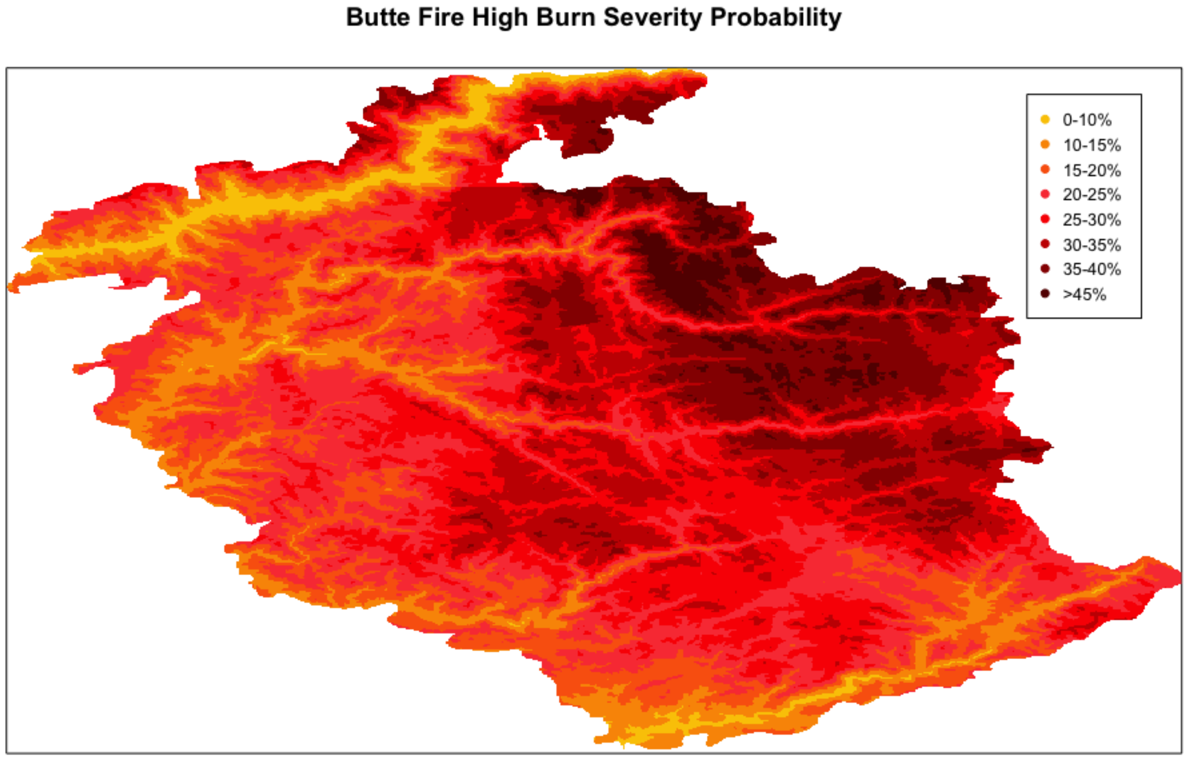
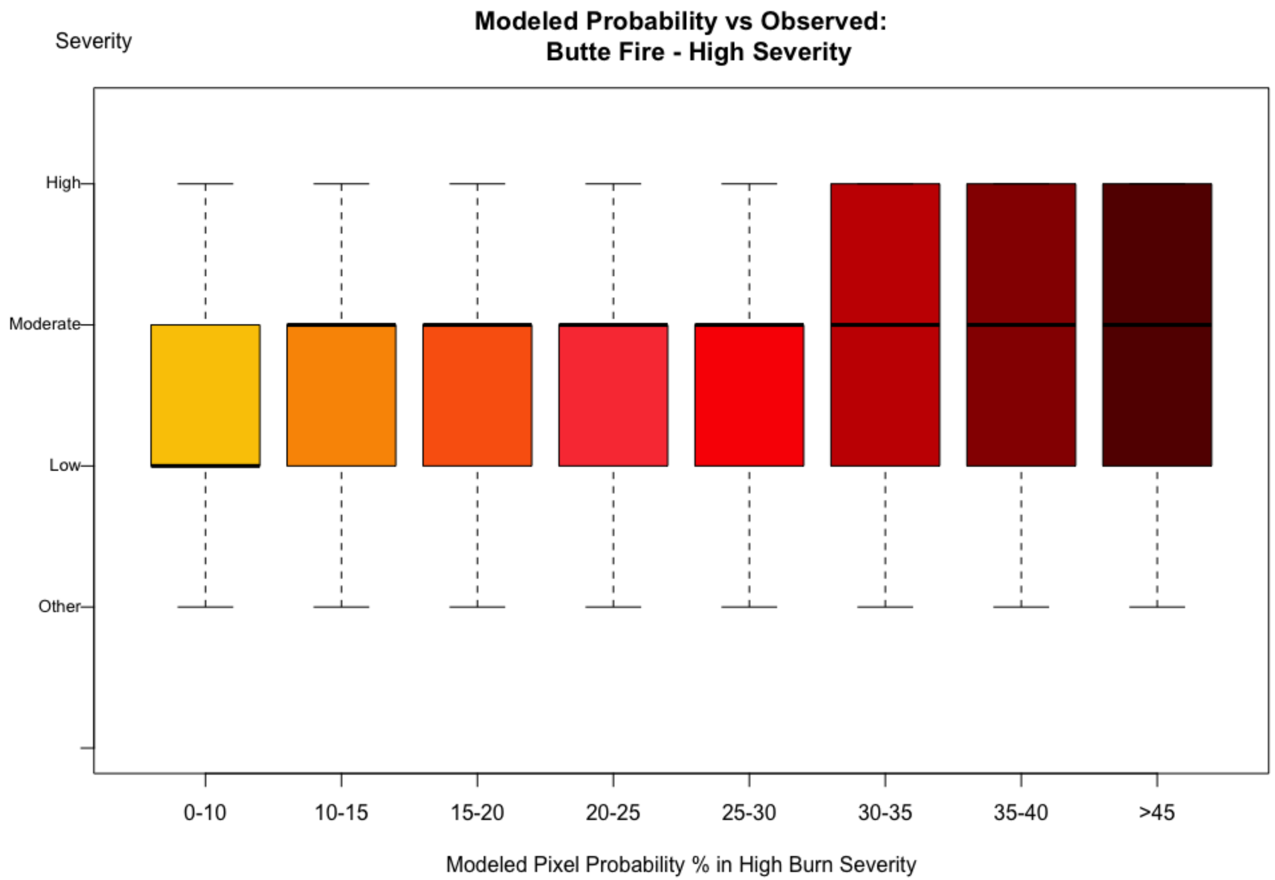


Fig.6 Vegetation classes in Sierra Nevada (left); Fire severity of wildfires (middle);
PM2.5 emissions from each wildfire (right)

5th California State Climate Assessment for Wildfire

Butte Fire example: High severity pixel probabilities





Jonathan Sam

Thank You

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