Fuels modeling and fuel management strategies

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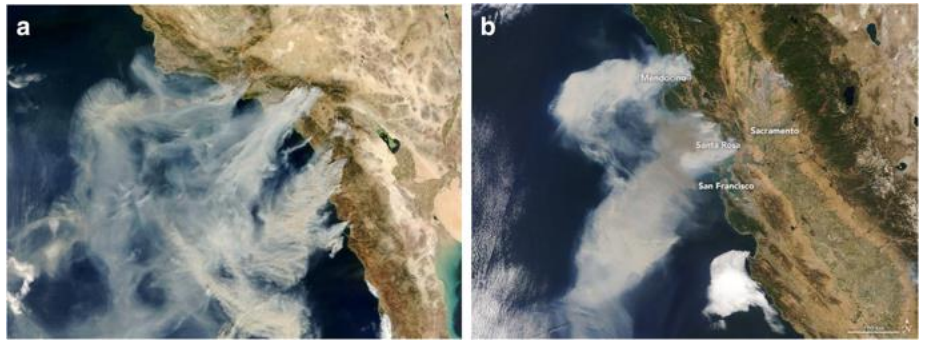
Outline

- Fuels, plants, and vegetation types
- What fuels models exist?
  - LandFire, ongoing projects
- Strategies for improving representations of fuels
- Fuel management tools and trends

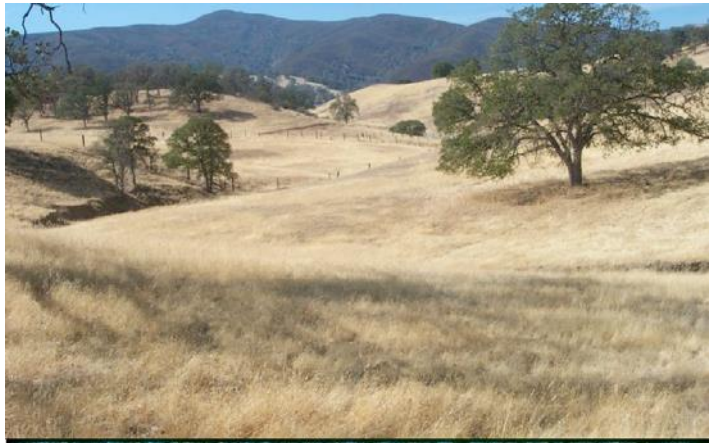
Fuels are (mostly) plants

Fuel buildup or climate change causing surge in fire?
– of course it's both
– how they interact depends on the vegetation type



Keeley & Syphard 2019
https://fireecology.springeropen.com/articles/10.1186/s42408-019-0041-0

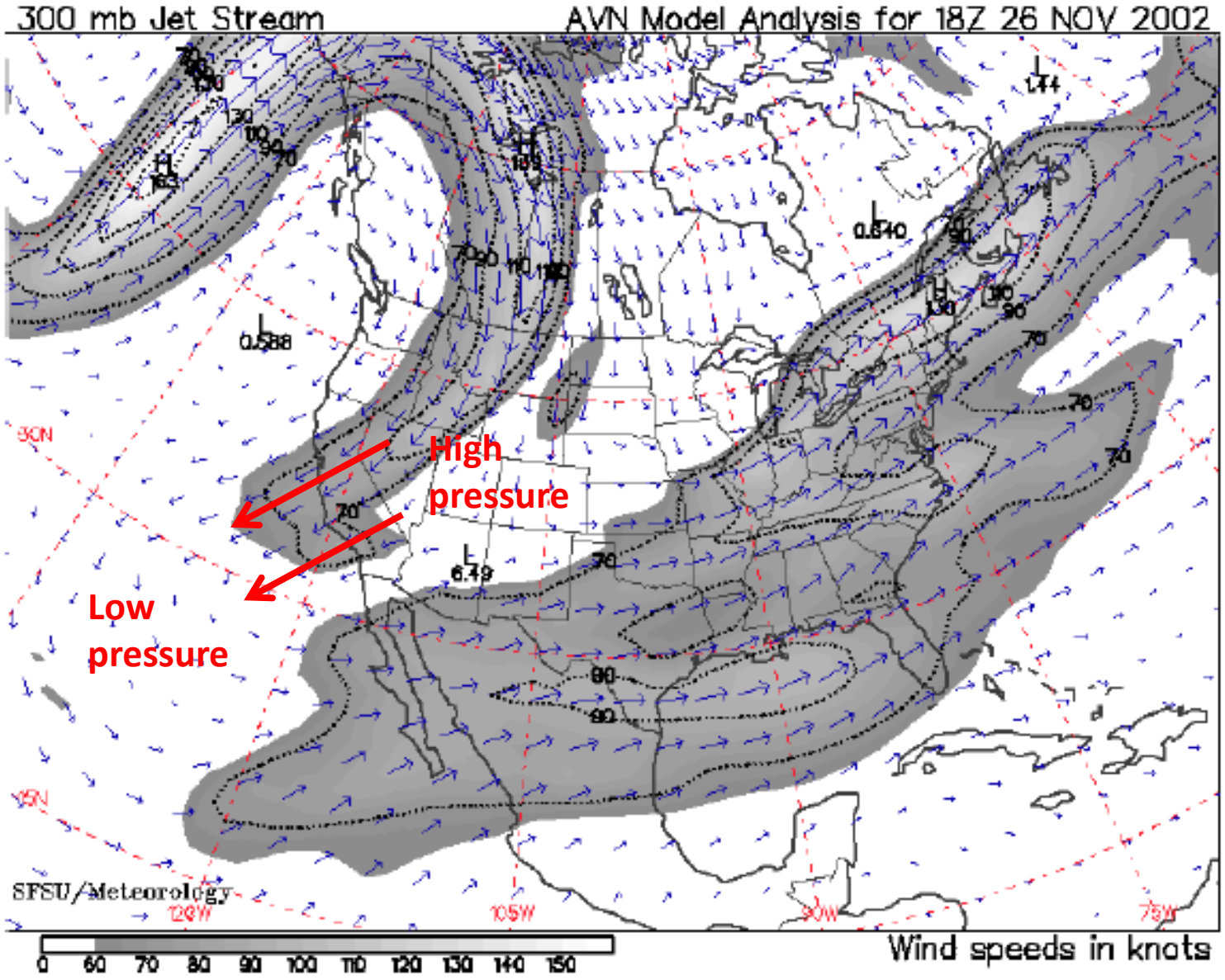
Grasslands -- fine, fast-growing continuous, mostly dead fuels, little fuels buildup.



Photos: Truman Young

Chaparral – fine continuous crown fuels, mostly live, so fuel moisture high more of the year

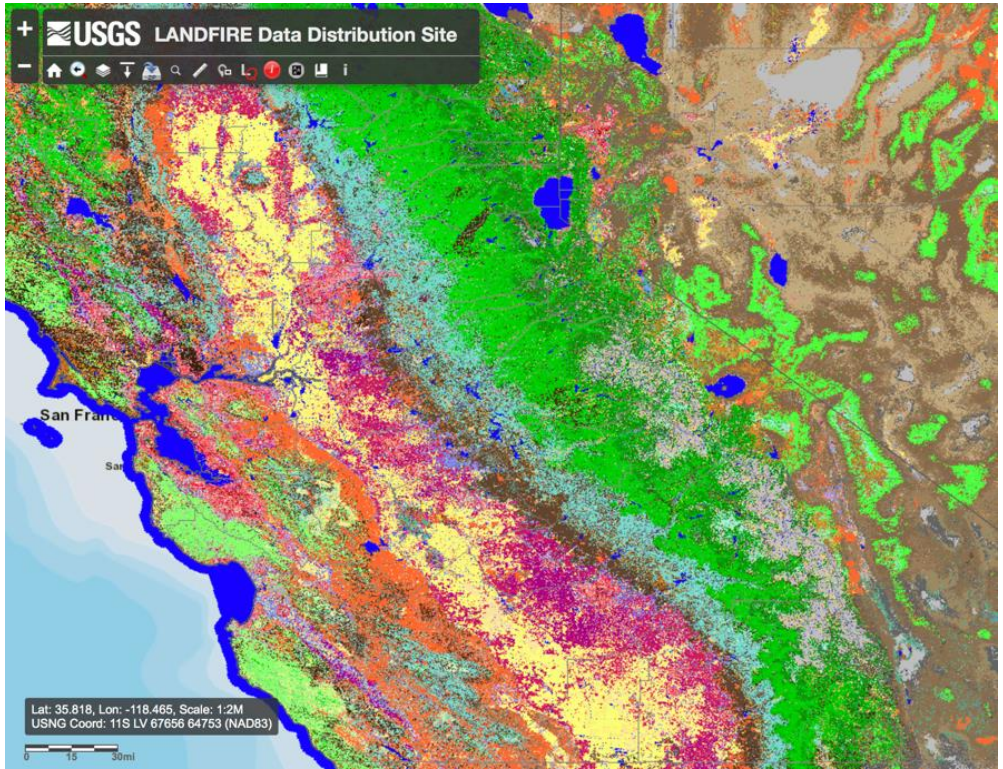
Shrubland fires in foehn wind conditions are uncontrollable, less influenced by fuel amount



Forests – multilayered fuels with complex, multimodal fire behavior. Most room to modify fire behavior via fuels management & fire use

Current fuels models

- LandFire: 30m grid with many fuels attributes at that resolution
  - E.g. vegetation type, canopy bulk density, inputs to fire behavior models.
- Westerling's 1/16 degree LULC, fuels and carbon layers
- And more, plus:
- Ongoing concurrent projects (e.g. CEC)



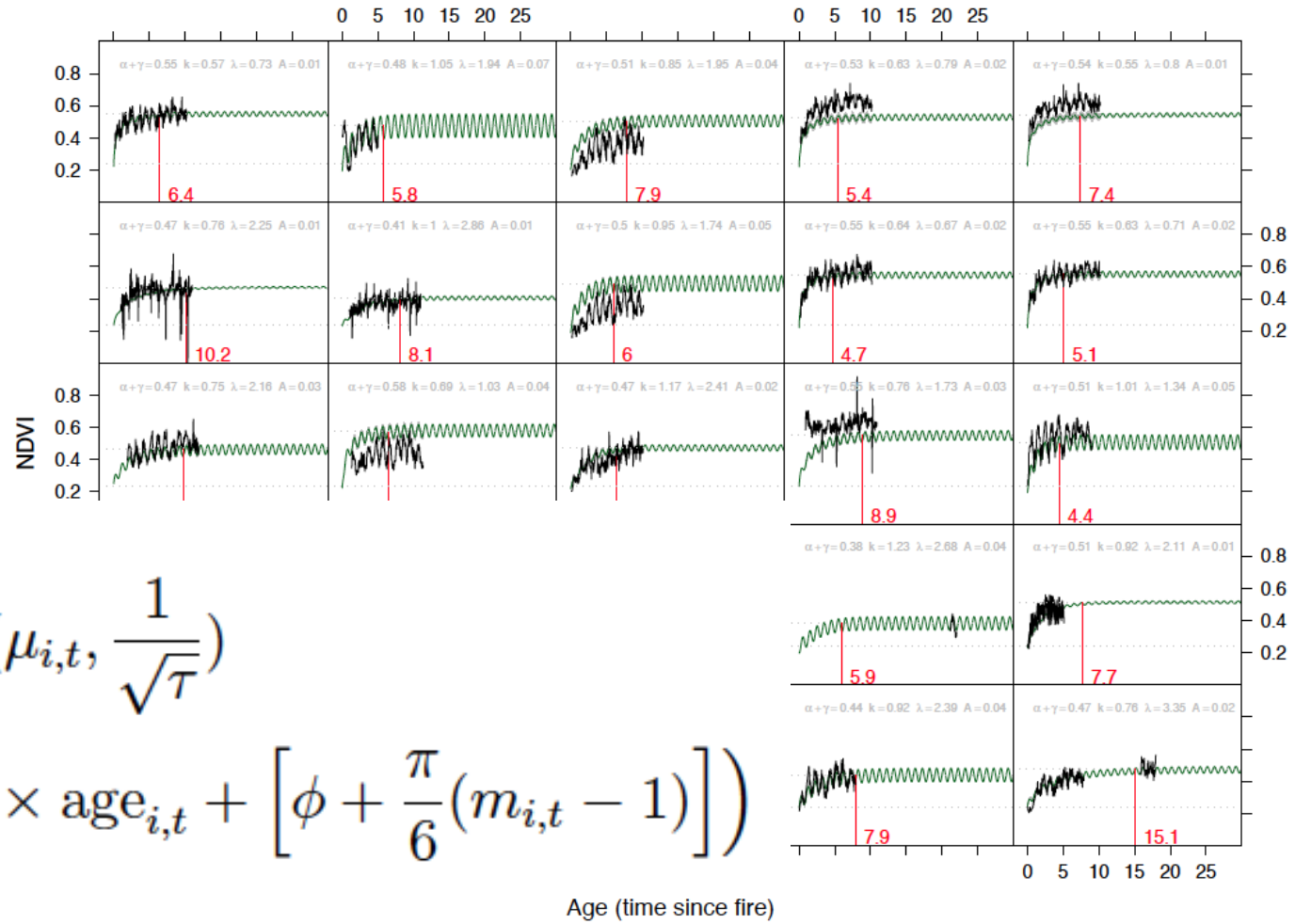
Ideas about how to improve resolution and accuracy of fuels models

- Increase accuracy of CA vegetation maps (Ustin, Koltunov)
- Better predict regrowth rates and fuels buildup after fire within vegetation types
- Represent fuel structure in a way that's useful to higher-resolution fire models (LiDAR, machine learning / image processing)
- Considering flammability, vulnerability, and arrangement of buildings

Remote sensing:
Watching plants grow from space

- Maps of fires

Time series for individual pixels after fire events

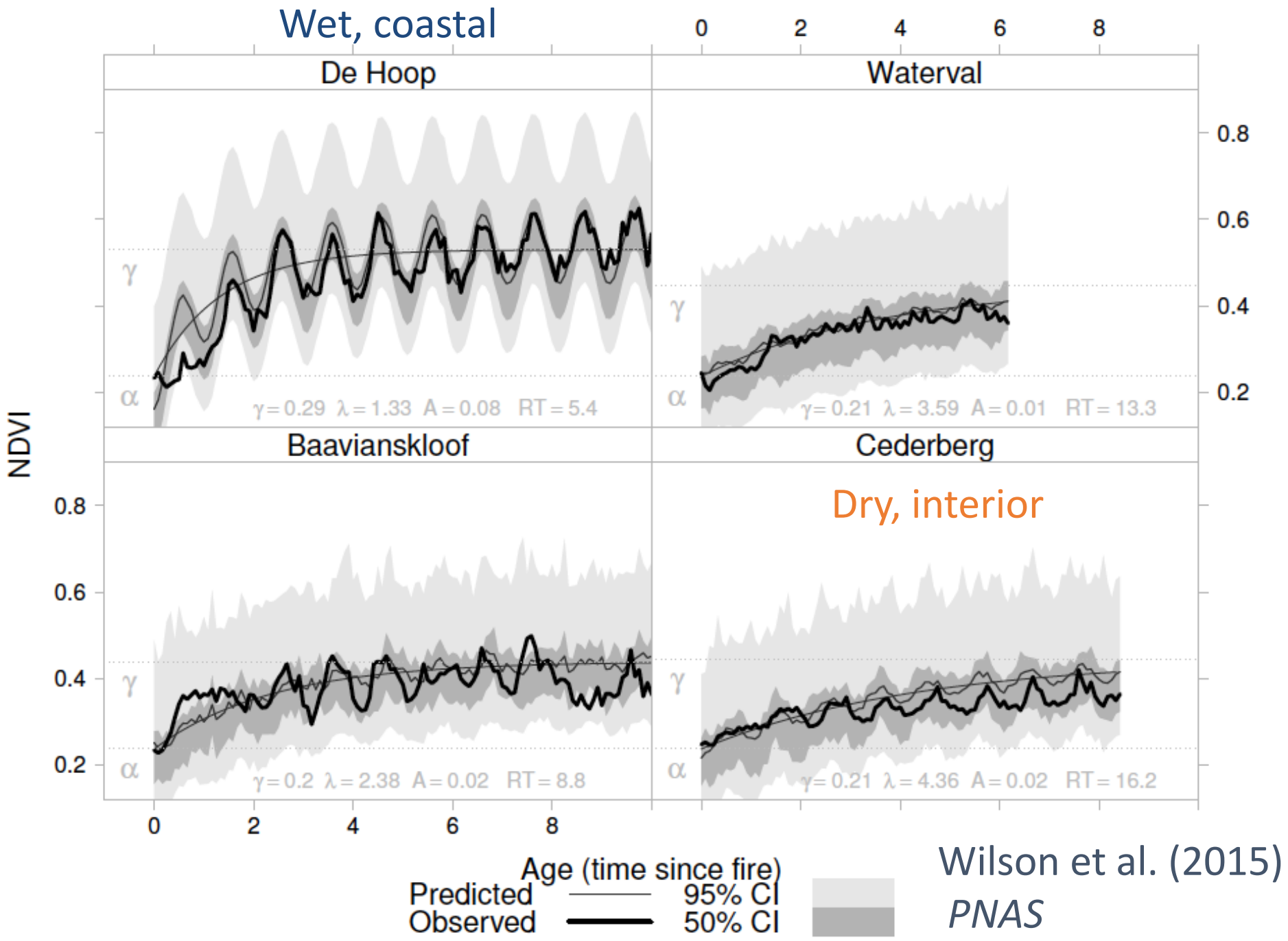


Fitted statistical models

$$\mathrm{NDVI}_{i,t} \sim \mathcal{N}(\mu_{i,t}, \frac{1}{\sqrt{\tau}})$$

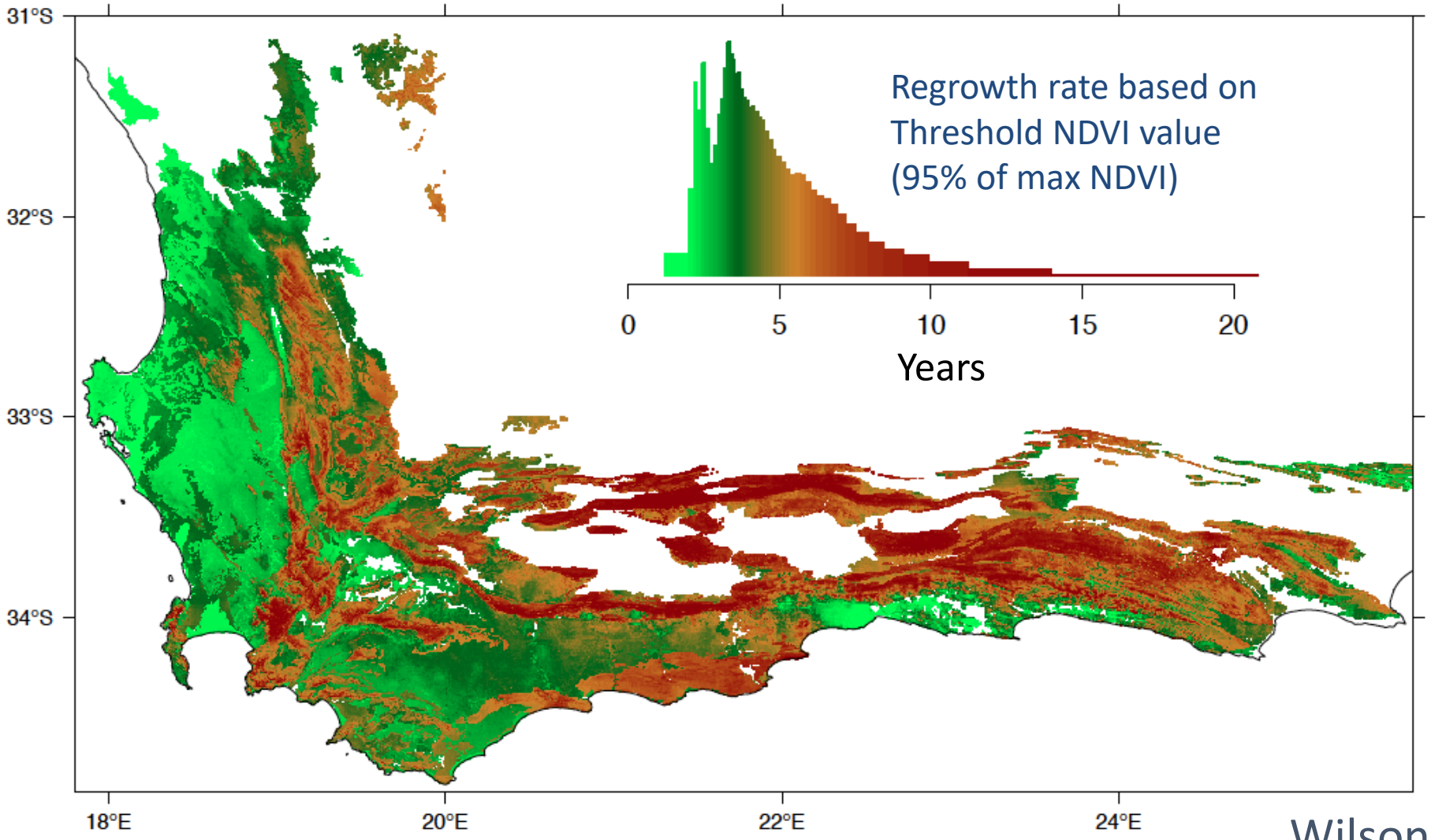
$$\mu_{i,t} = \alpha_i + \gamma_i\left(1 - e^{-\frac{age_{i,t}}{\lambda_i}}\right) + A_i \sin\left(2\pi \times \mathrm{age}_{i,t} + \left[\phi + \frac{\pi}{6}(m_{i,t} - 1)\right]\right)$$

Inference: Climate-driven variation in regrowth rates



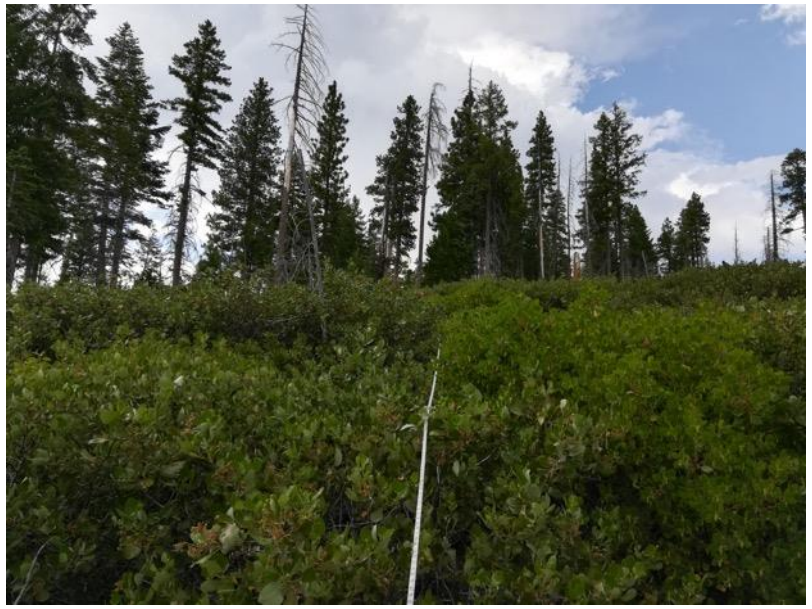
Wilson et al. (2015)
PNAS

Modeling spatial variation in shrubland regrowth rates



Wilson et al. (2015)
PNAS

Machine learning: Image classification & regression



- Thousands of plots with ground-based fuels measurements AND photographs
  (US Forest Service Region 5 ecology program, our lab, other labs)
- Paired ground fuels measurements (by hand, by surface LiDAR) and drone photography
- Exploring using convolutional neural nets to predict attributes of fuel (image regression)

Photos: Derek Young, Ashley Gruppenhoff, Hugh Safford

WUI fuels: characteristics of buildings can dominate fire behavior and damage

Paradise after the Camp Fire
https://www.sacbee.com/news/california/article230015334.html

What to do: fuels management approaches

- **Prescribed burning** – Can be less expensive than mechanical treatments, more ecologically effective
- But produces smoke itself
- California planned to ramp up “pace and scale” by 20x this year

- Mechanical fuels treatments

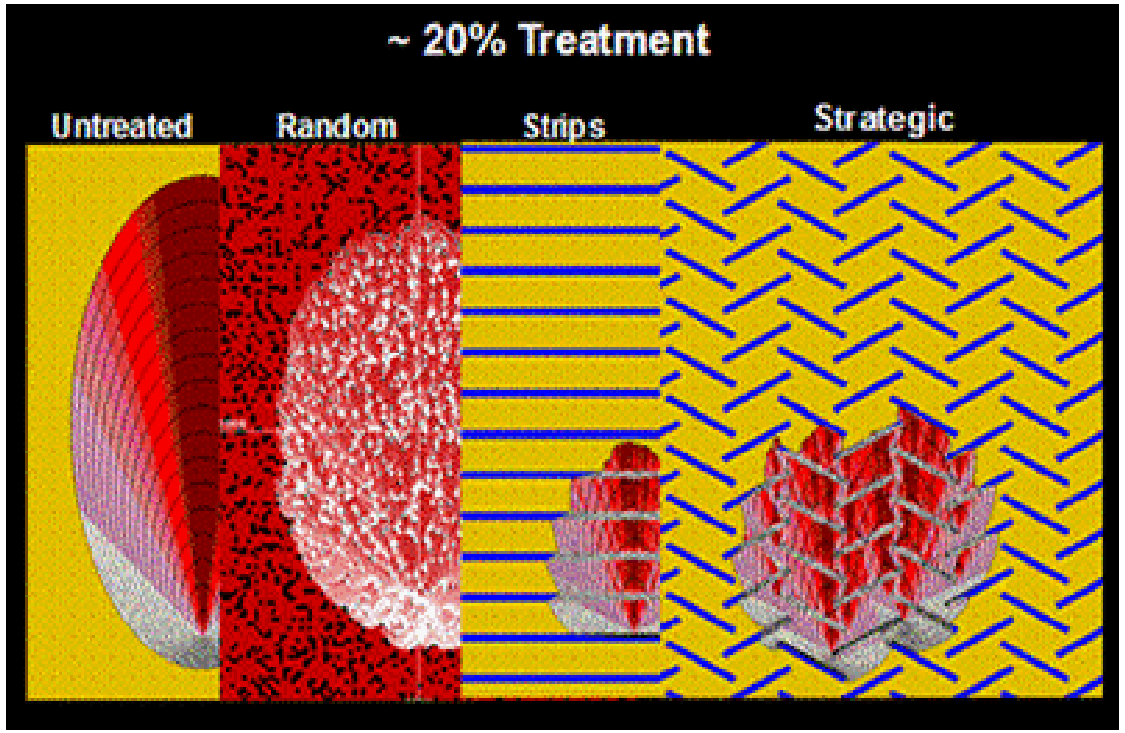
- Wildland fire use

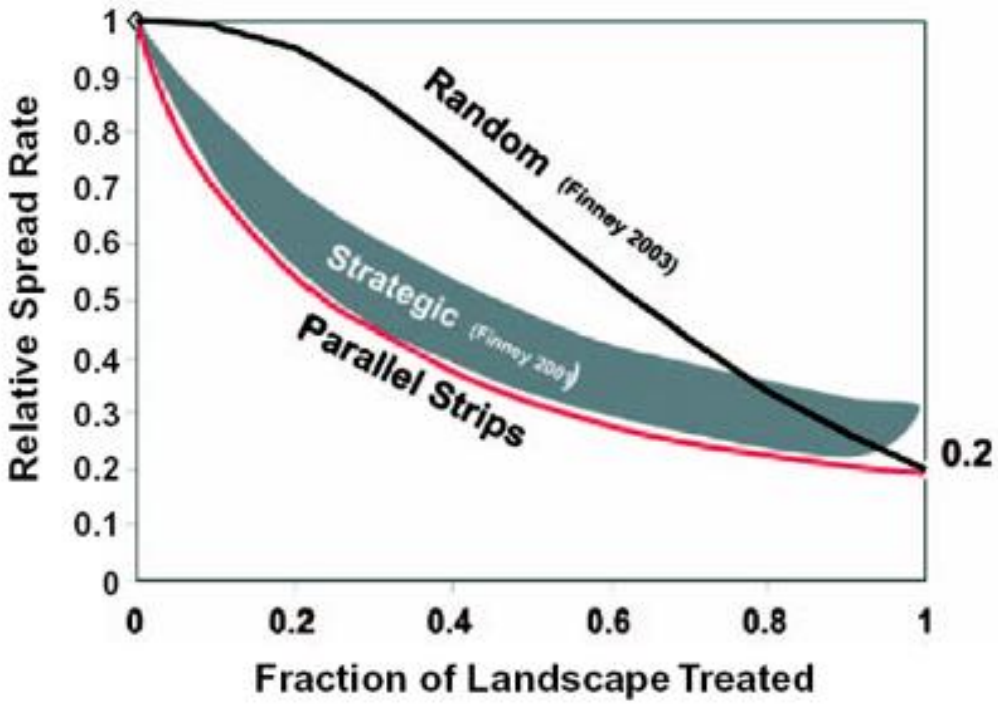
Do Fuel Treatments Work?
Angora Fire, Lake Tahoe Basin

UNTREATED

TREATED

Landscape Treatment: Model simulations of fire spread with different placements of thinning treatments (Finney)



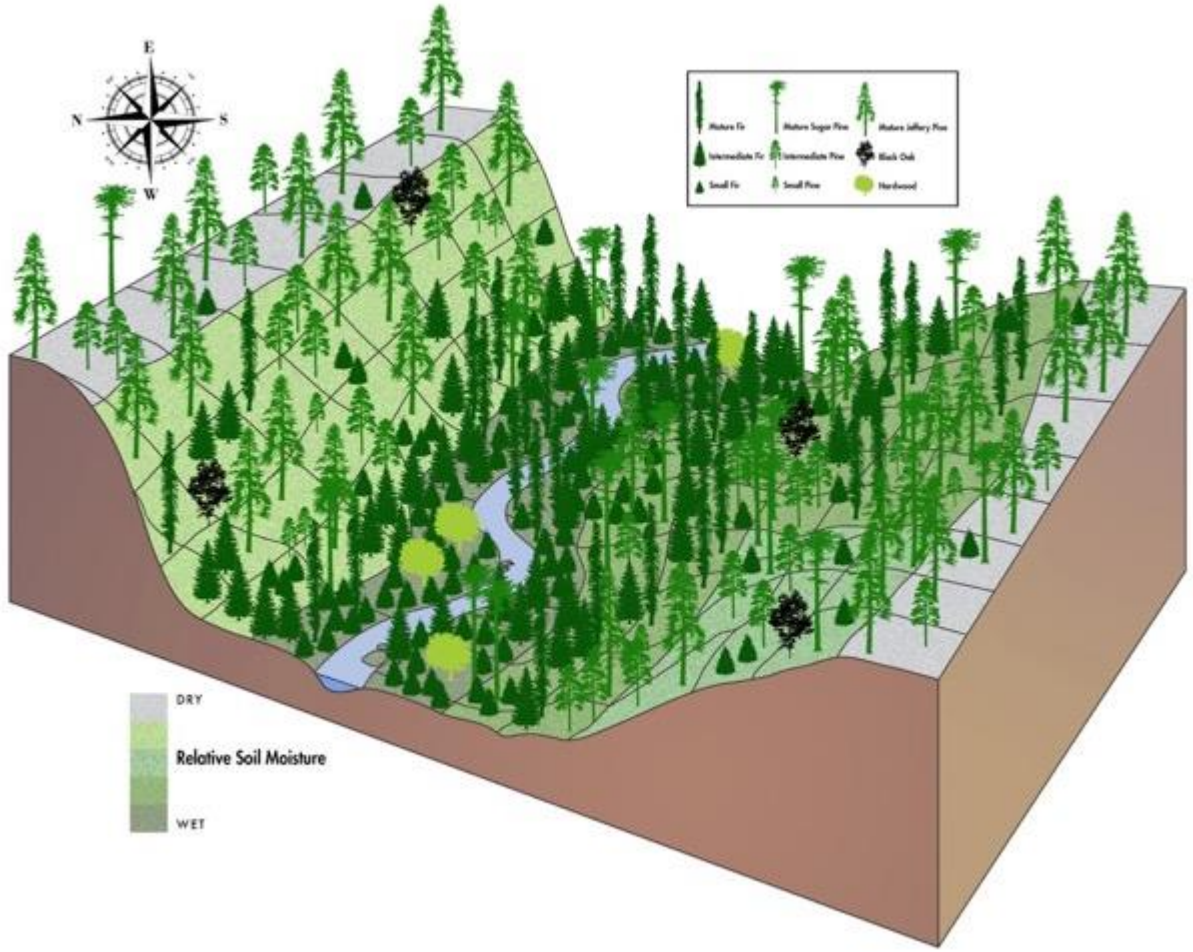


a) untreated, homogenous fuel conditions
b) random treatments,
c) parallel strip treatments,
d) strategic, slanted overlapped treatments

Potential strategy at local scale:
Use topography to arrange fuels treatments

Variable density forest matching historical conditions with frequent fire.

Higher and lower-density landscape facets.



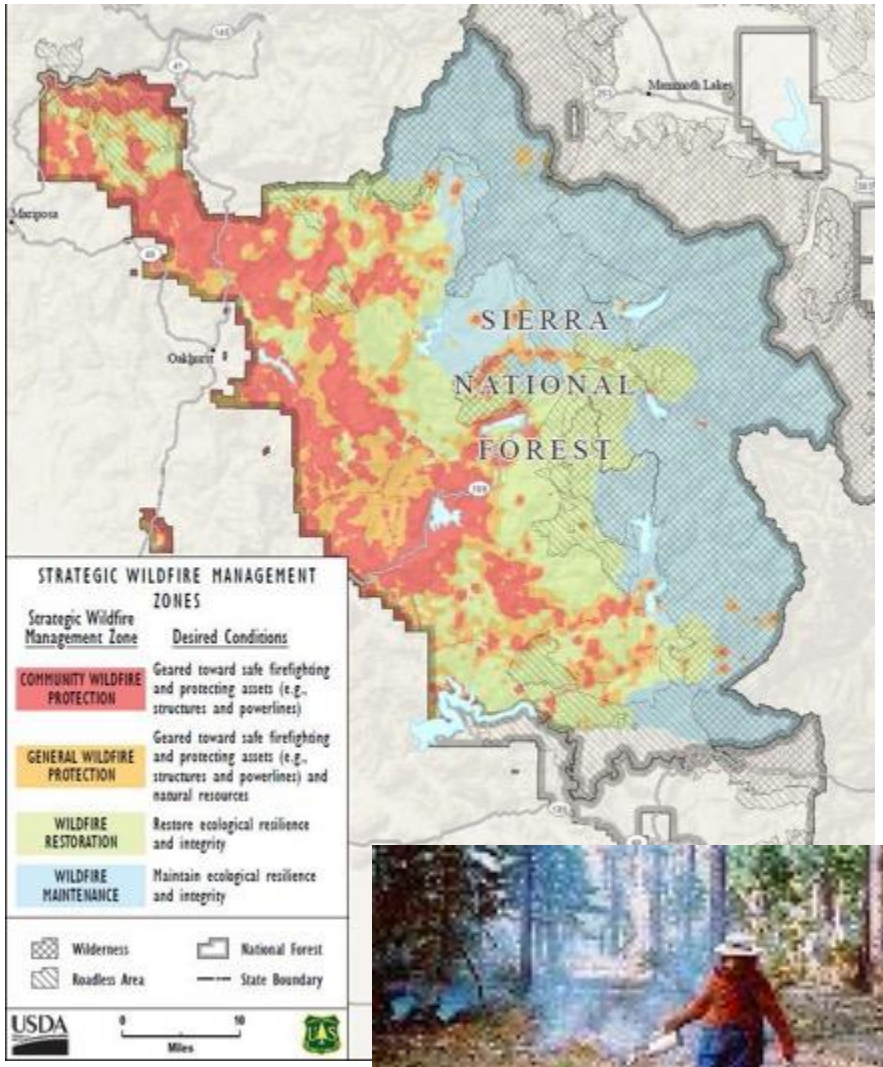
Adapted from Malcolm North (USFS and UC Davis)

Potential strategy at the large scale: Treatment and wildfire use zoning

National forest plan revisions

Blue area on map: Presumption to let fires burn unless strong reason not to.

Red area: Full suppression, intensive fuels reduction around people and infrastructure.



Thank you