Managing Wildland Fire in a Time of Global Change

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Crux of the problem

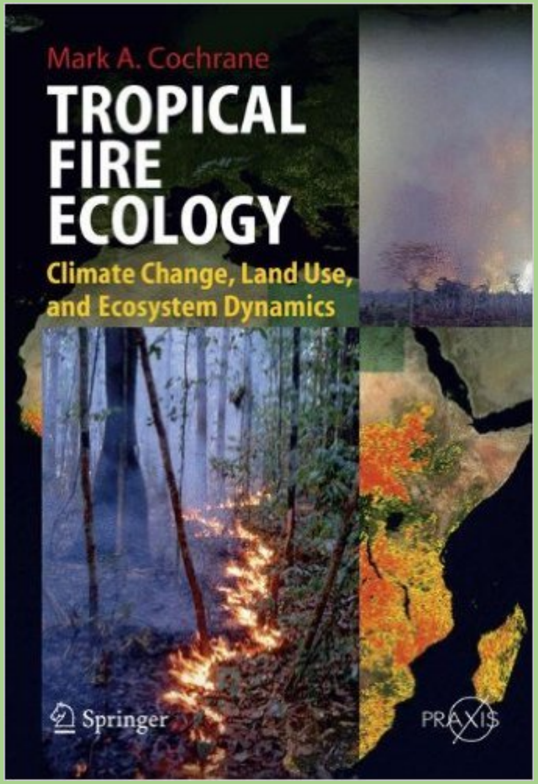
- More and more people are living in flammable landscapes
- Vulnerability of lives and property that humans value to wildfire yields changes in land use and management to reduce fire with the goal of protection
- However, the combination of both ecological changes from current land management practices (e.g. fire suppression) and/or altered climate patterns are increase fire risk in many locations
- Future fire and land management decisions need to be forward looking and adaptable to new and changeable conditions

Research

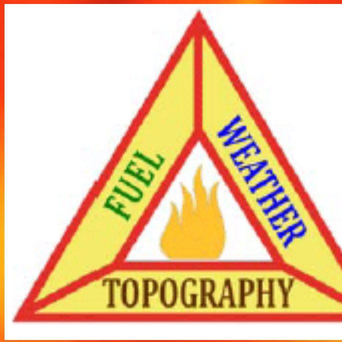
- My work focuses on how land cover, land use, land management and climate change interact to alter ecosystem dynamics

- Disturbances that I have studied include:
  - Fire
  - Forest management activities
  - Selective logging
  - Forest fragmentation
  - Insect outbreaks
  - Biodiversity loss

- Fire research is my forte
  - United States
  - Brazil
  - Australia
  - Indonesia
  - Ghana, Chile, India, Ecuador
  - Global



Fire – what is it?

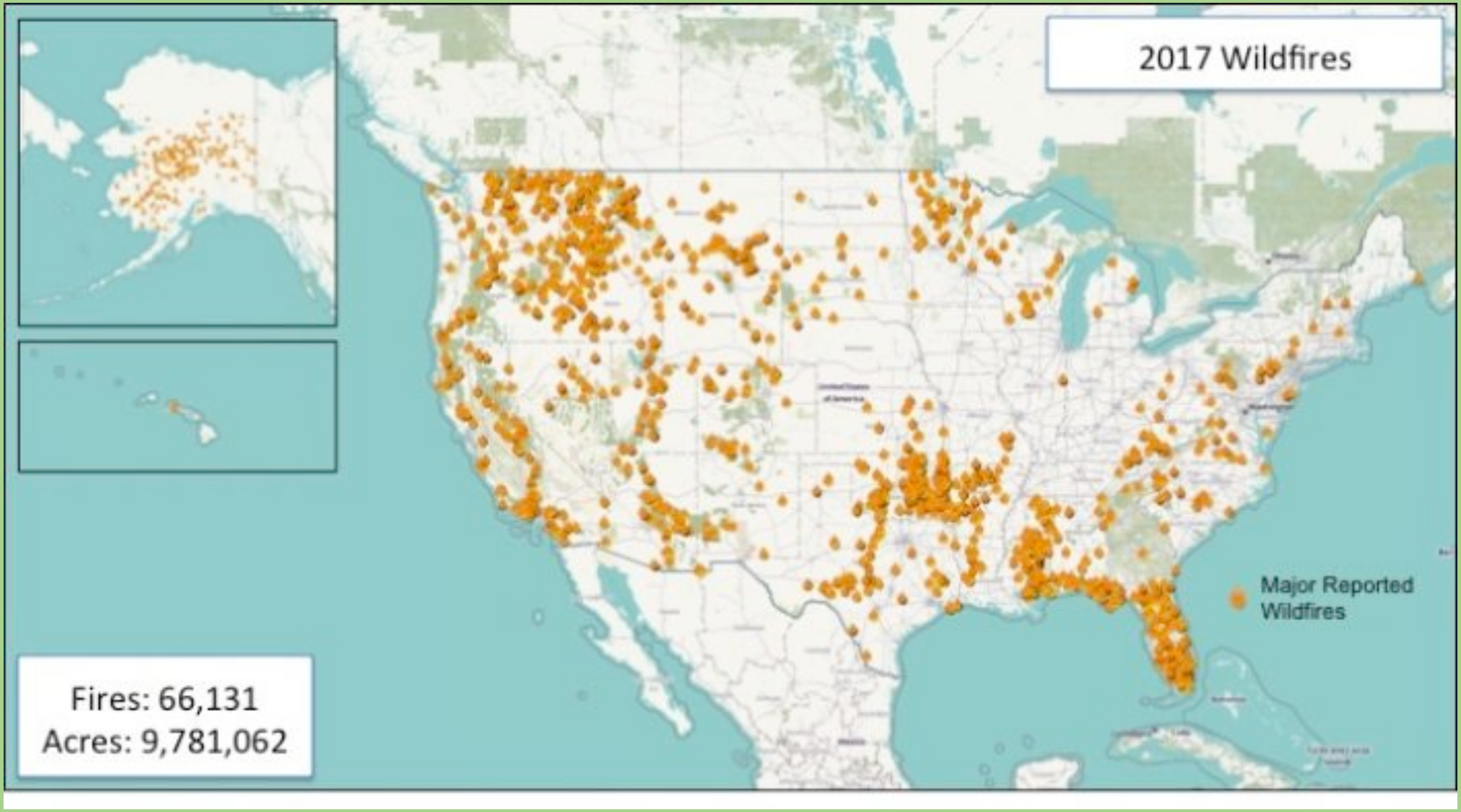


Fire ecology is the synthesis of fire science (engineering) and fire effects (ecology).

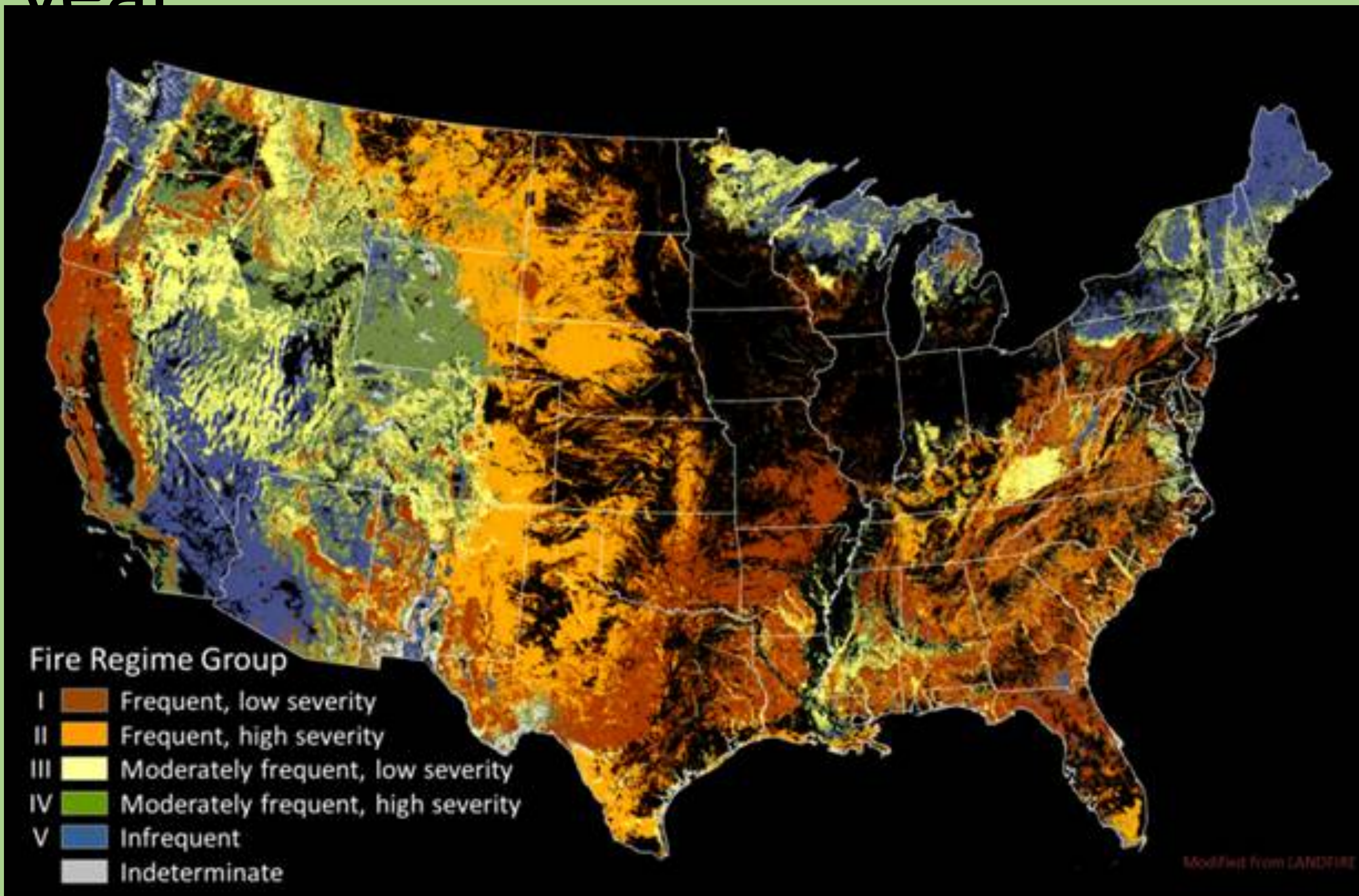
Fire integrates substances, landscapes, and cultures

I study it because it provides a window into dynamic systems

2017 Was Just Another Fire Year



Historical data indicate 5-20% of our land area should burn each year



How does fire impact vegetation?

- Intensity
- Duration
- Frequency
- Seasonality
- Size

Classic idea of fire severity – vegetation killed by the fire

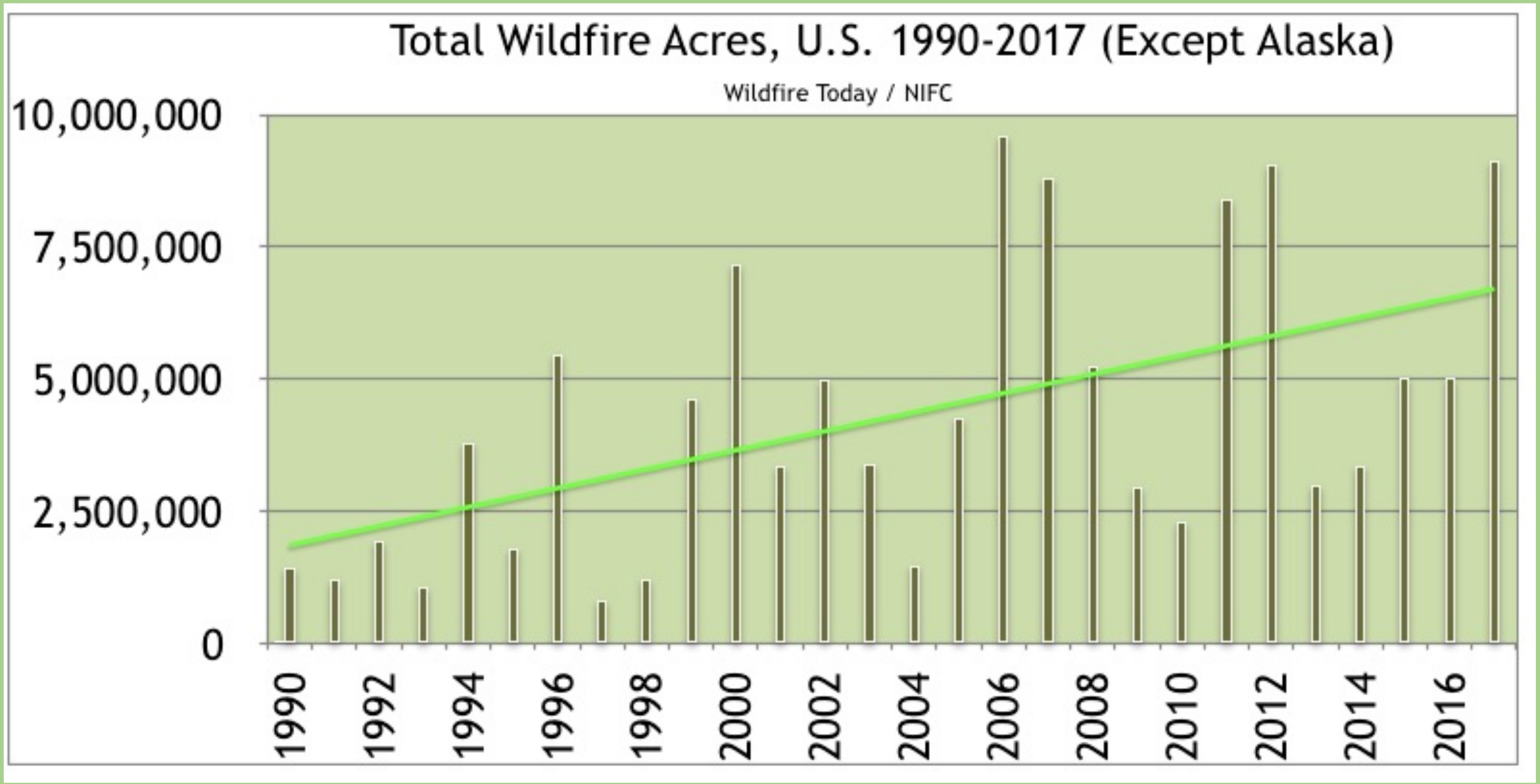
Severity in the sense of impact to the gene pool

The combination of these factors define the *Fire Regime* for a given ecosystem.

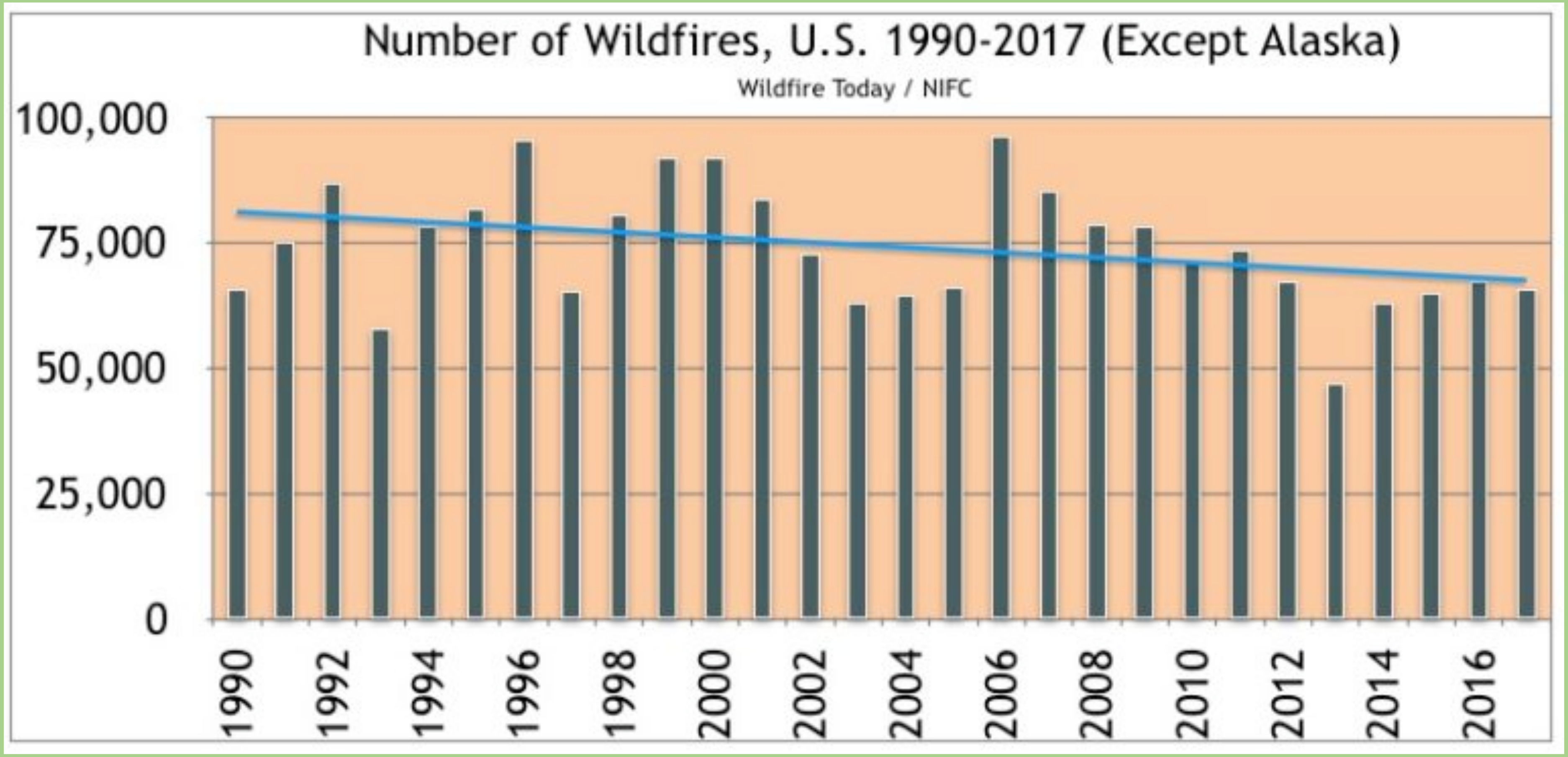
Changing the fire regime changes the vegetation just as altering the vegetation causes shifts in the fire regime (reciprocity)

- **You can't change one without changing the other**

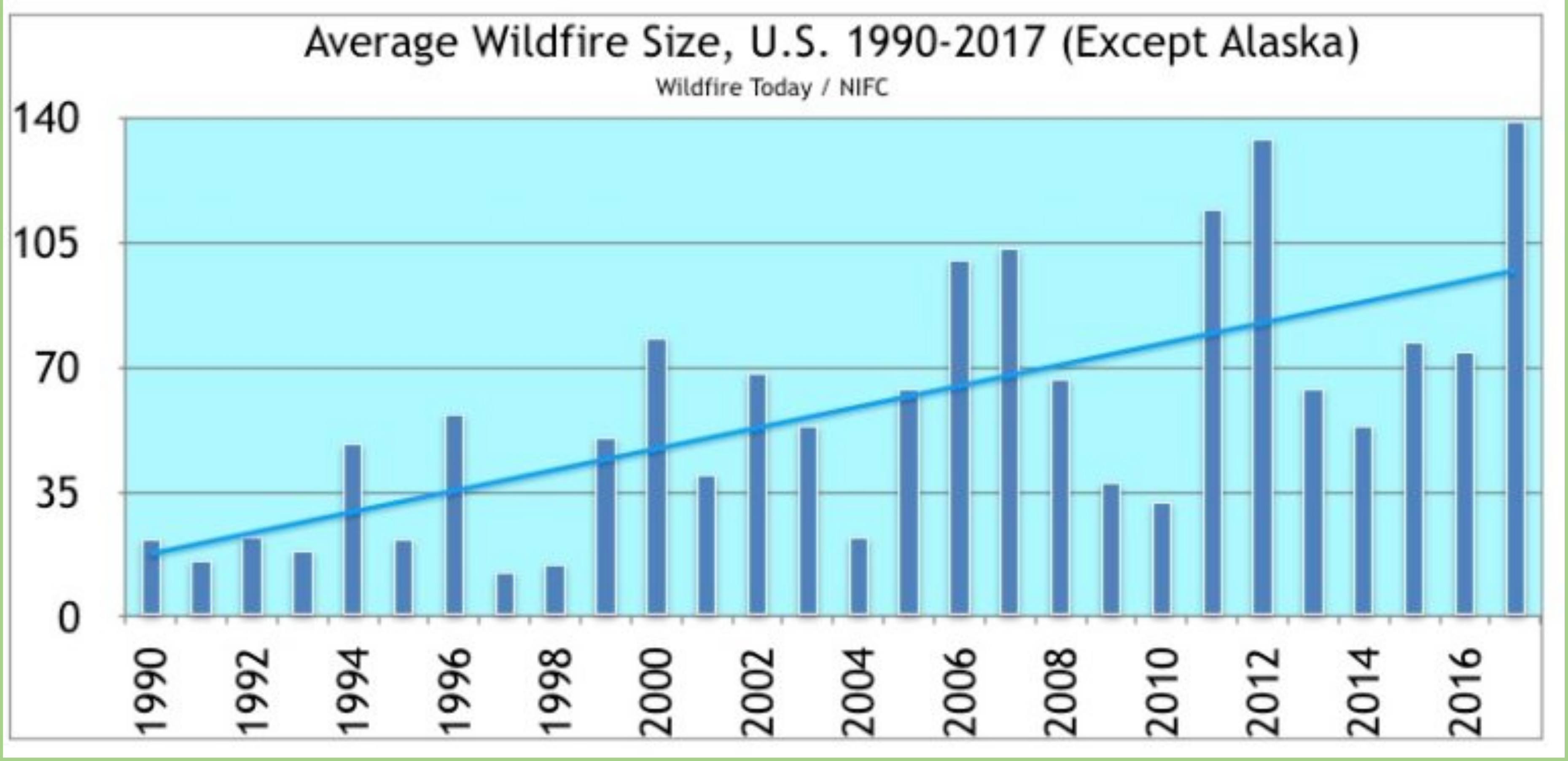
CONUS Trends in Burned Area



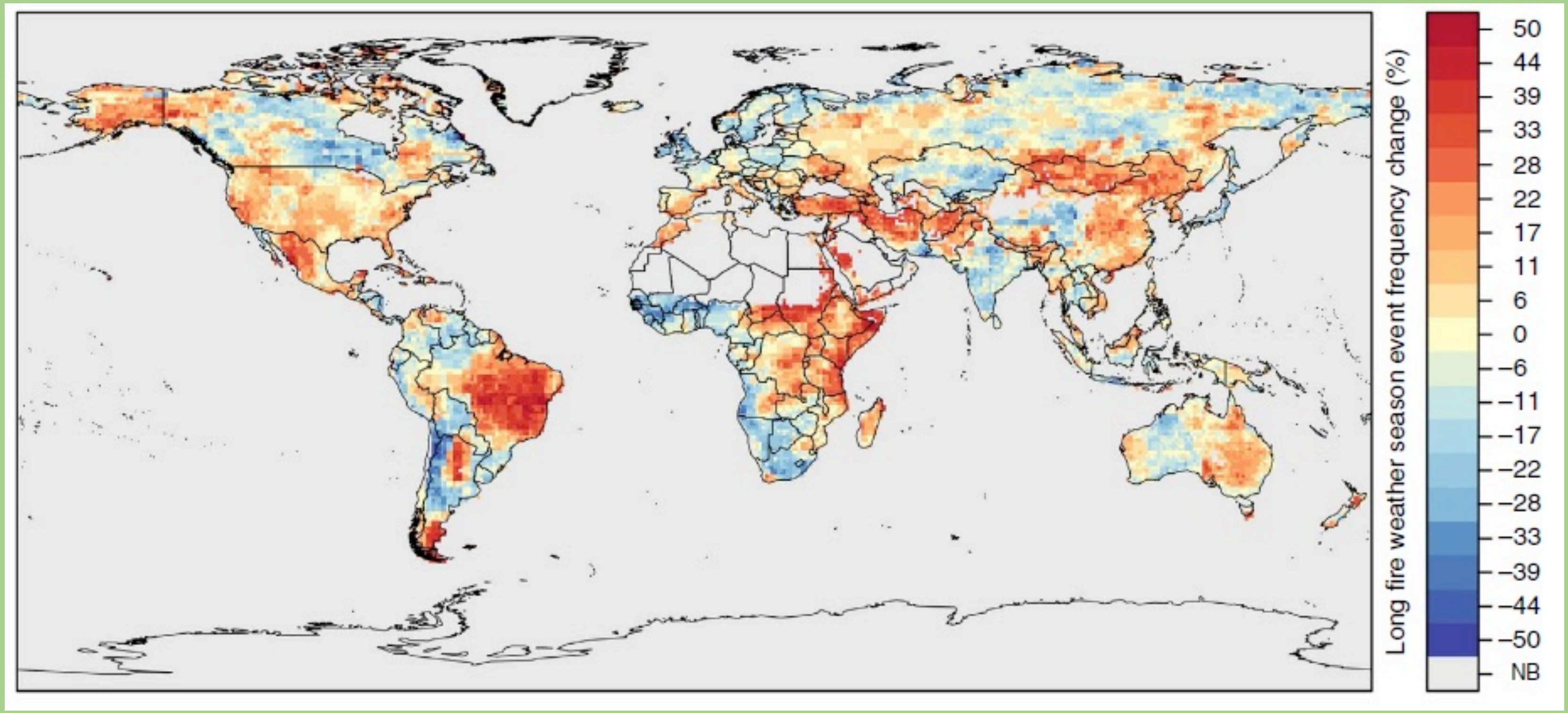
However Numbers of Fires are Decreasing



Meaning Average Wildfire Sizes are Increasing Substantially



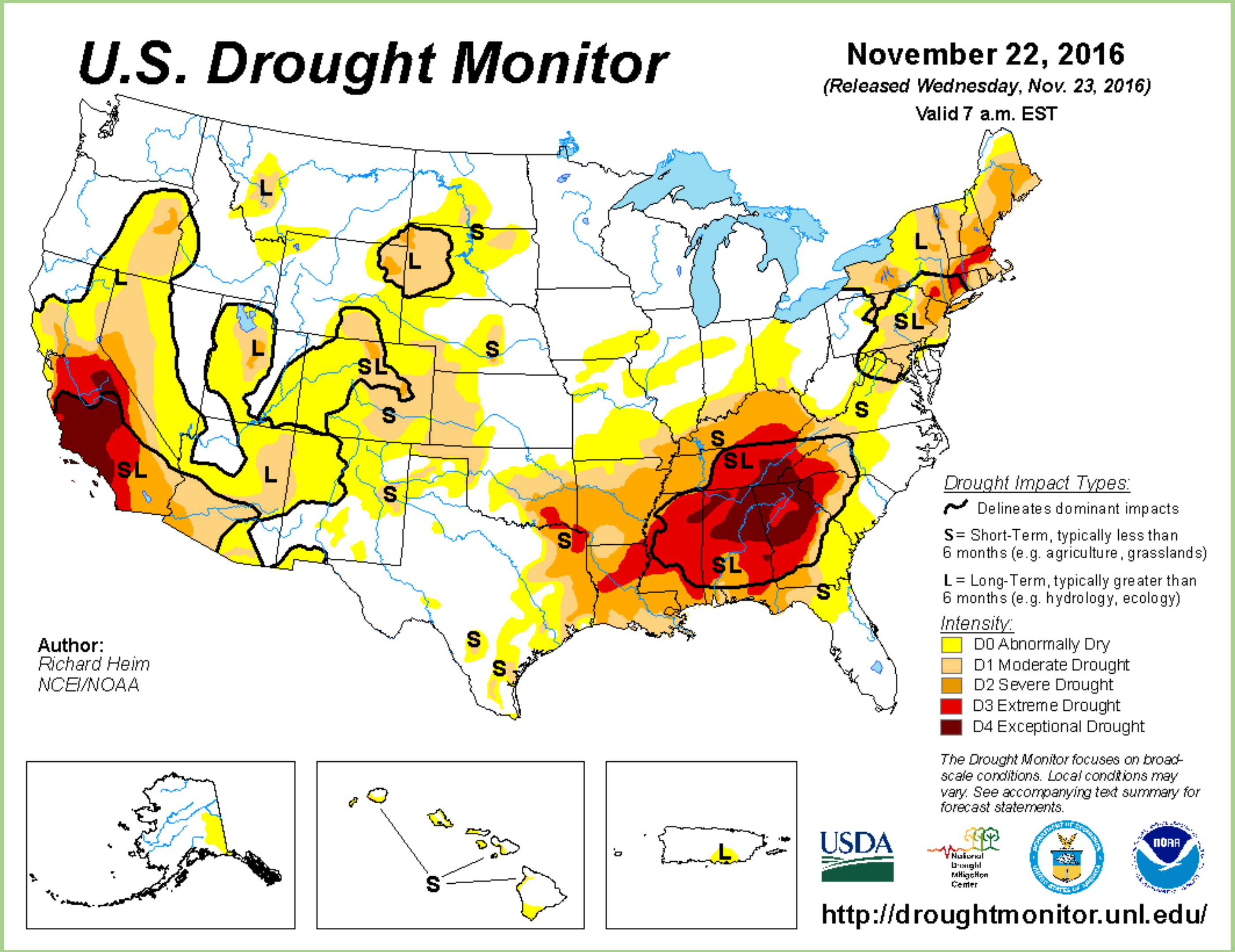
Changing frequency of long fire weather seasons 1979-2013



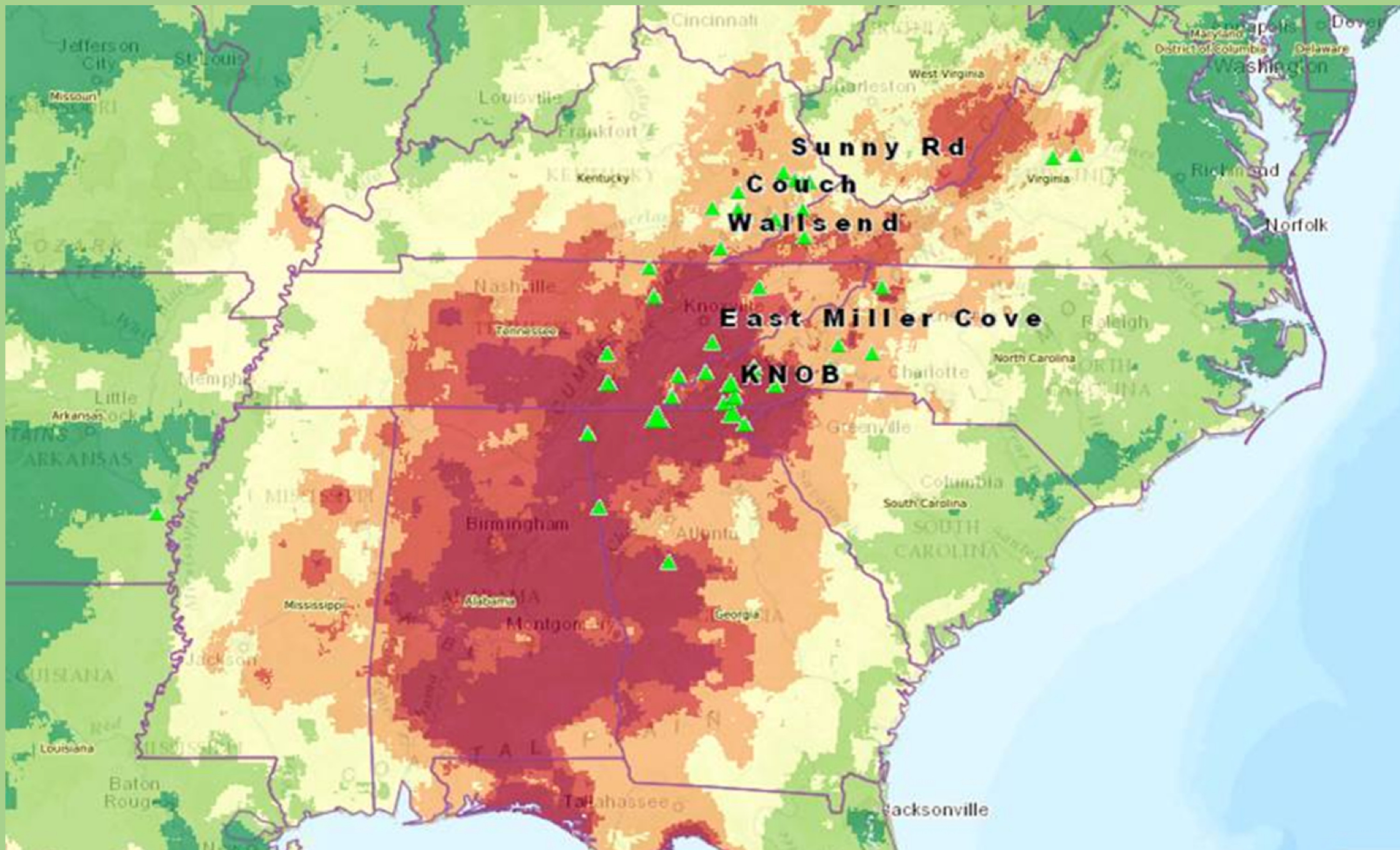
- Fire weather seasons have lengthened across 25% of the Earth's vegetated surface
  - 18.7% increase in global mean fire weather season length.
- Doubling (108.1%) of global burnable area affected by long fire weather seasons
- Increased global frequency of long fire weather seasons across 53% of vegetated lands

Jolly et al. 2015 *Nature Communications*

The Drought Situation Late 2016

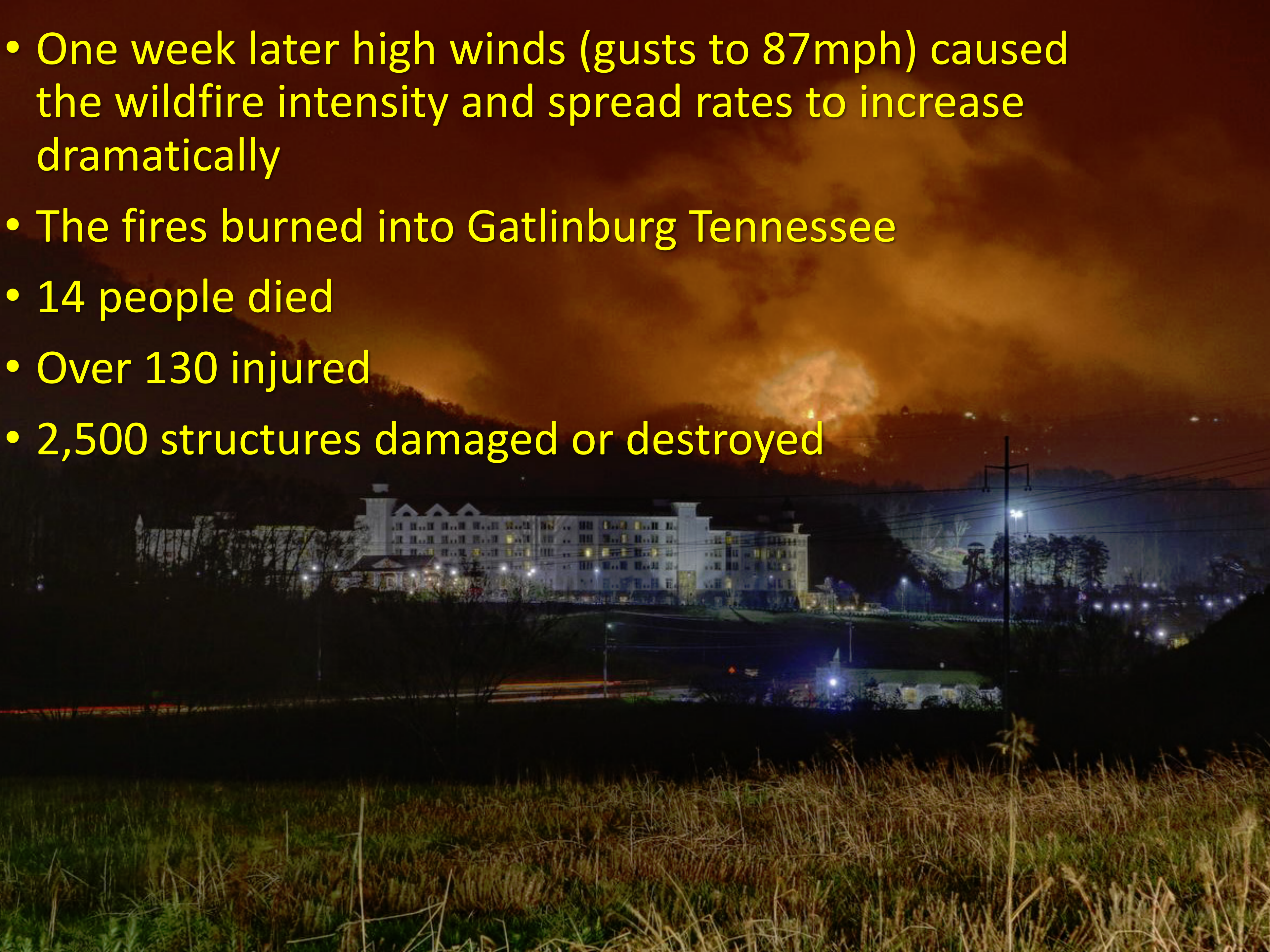


The Fire Situation at the Time

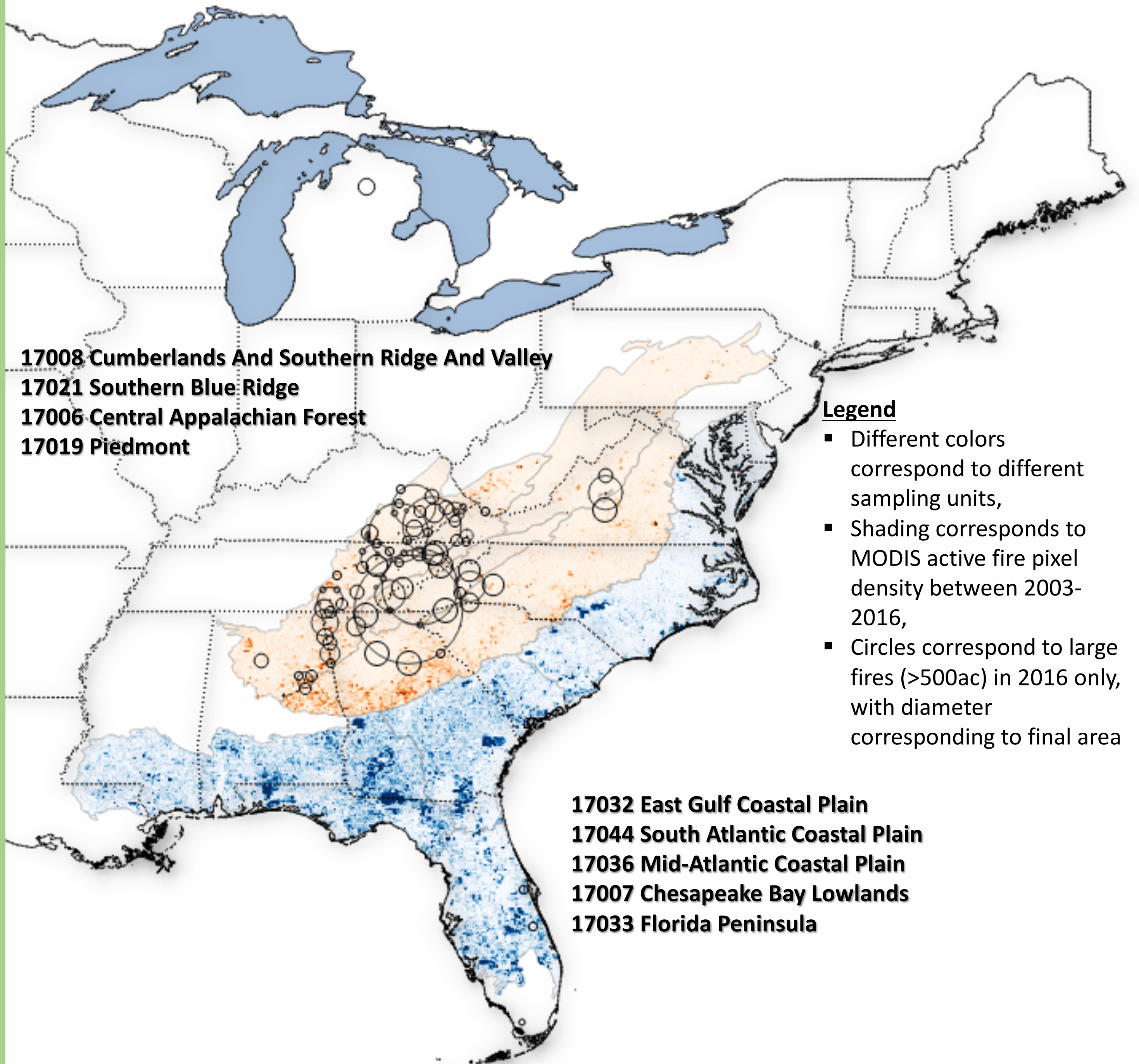


- Dark areas are above the 99th Percentile of measured fire risk (i.e. extremely dry fuels)
- Relative Humidity values reported to be as low as 5% in Atlanta
- Active fire spread is occurring 20 hours per day, primarily through leaf litter
- Leaves are still falling from the trees…

- One week later high winds (gusts to 87mph) caused the wildfire intensity and spread rates to increase dramatically
- The fires burned into Gatlinburg Tennessee
- 14 people died
- Over 130 injured
- 2,500 structures damaged or destroyed



There was a lot more burning in the Southern Appalachians beyond the Gatlinburg area

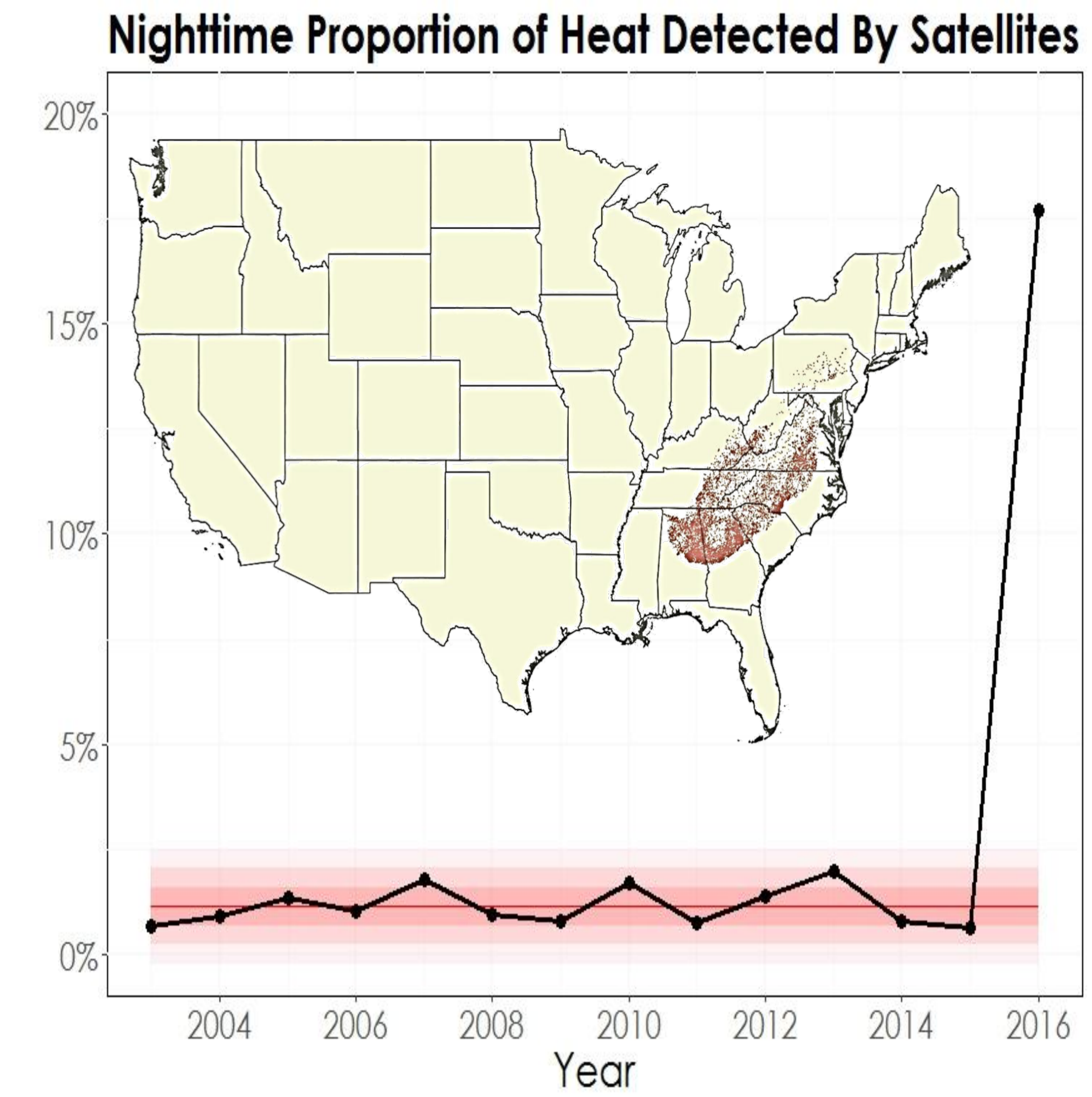


We can spot almost to the day when the ecological system 'broke'

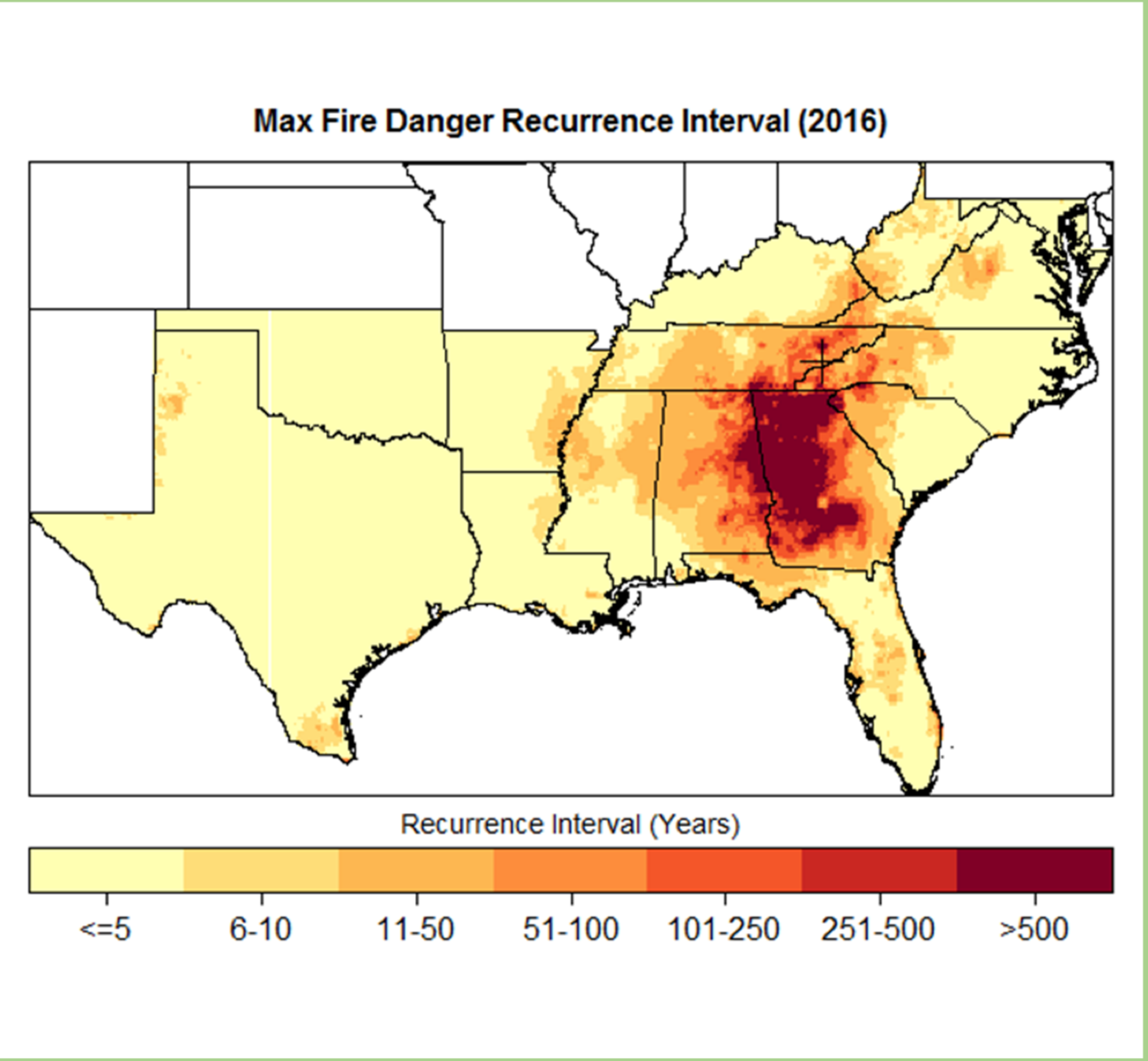
Normally there are few if any detectable fires at night

Starting in late November 2016 there were suddenly lots of night fires over a large region

There are obviously thresholds where the fire situation in Appalachia changes dramatically

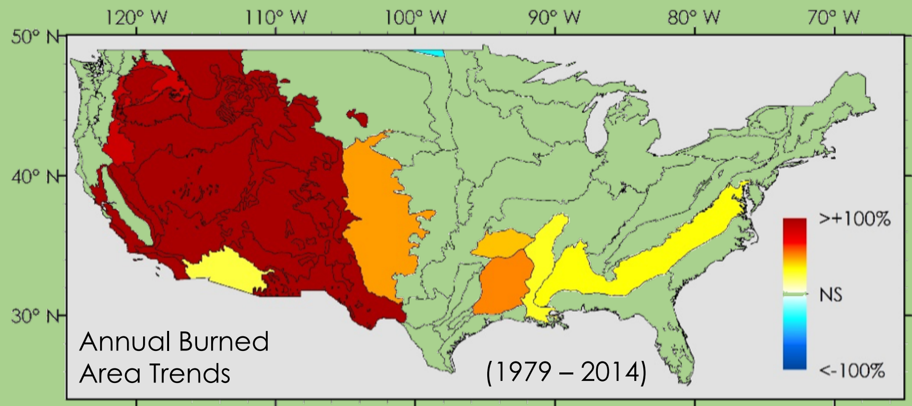


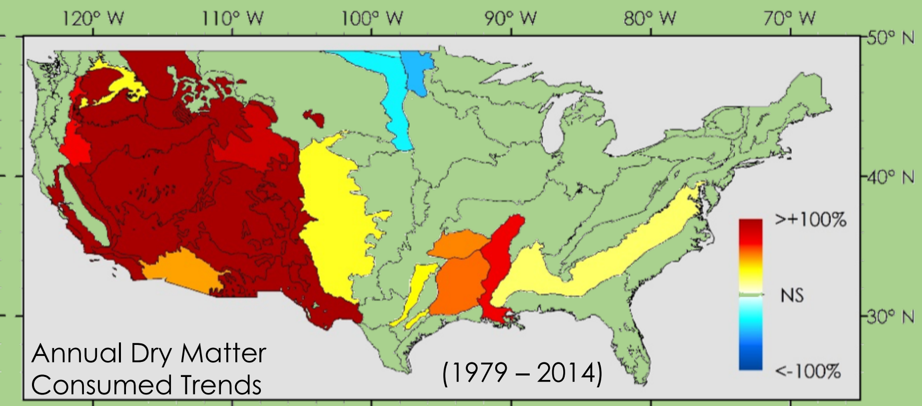
How unusual was the 2016 Fire Season?



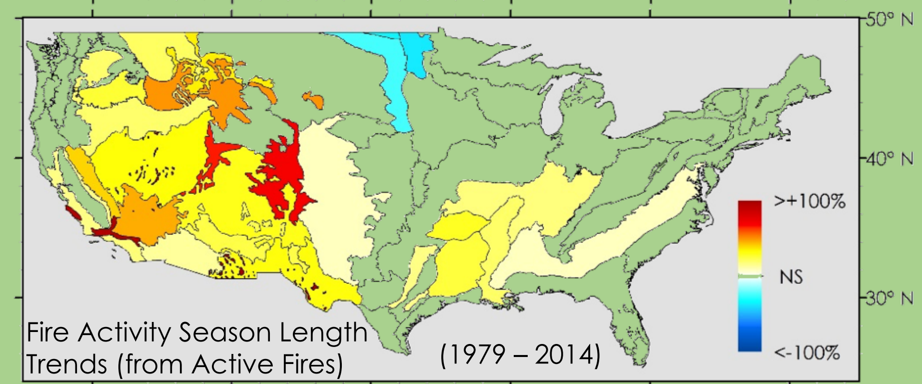
- Many areas witnessed fire danger conditions in fall of 2016 that exceeded 500 year return intervals
- Of course that presumes climate is stable

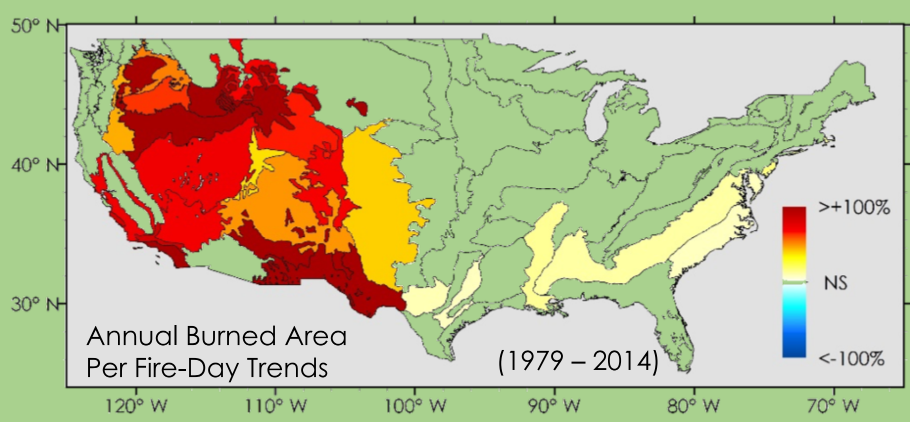
Trends in U.S. wildland fire activity from 1979-2014

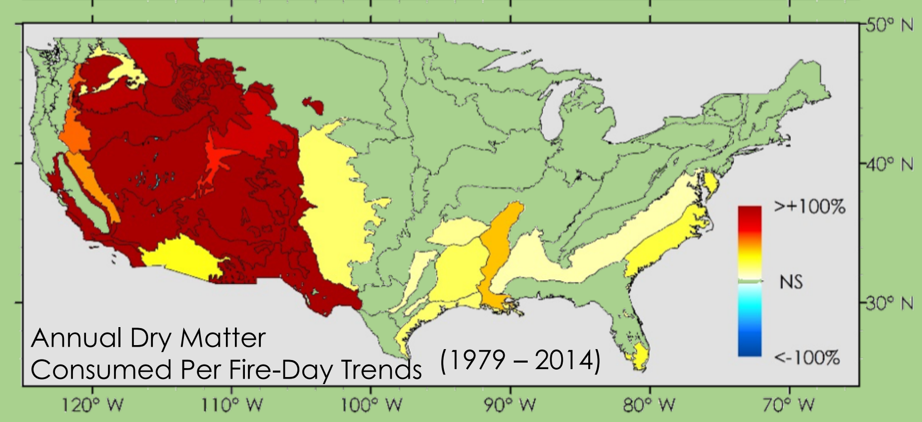




SE Mixed Forests (MD to MS) have been the bellwether of 35-yr trends of increasing fire presence, burned area, fire spread rates, and fire intensity in Eastern Forests.







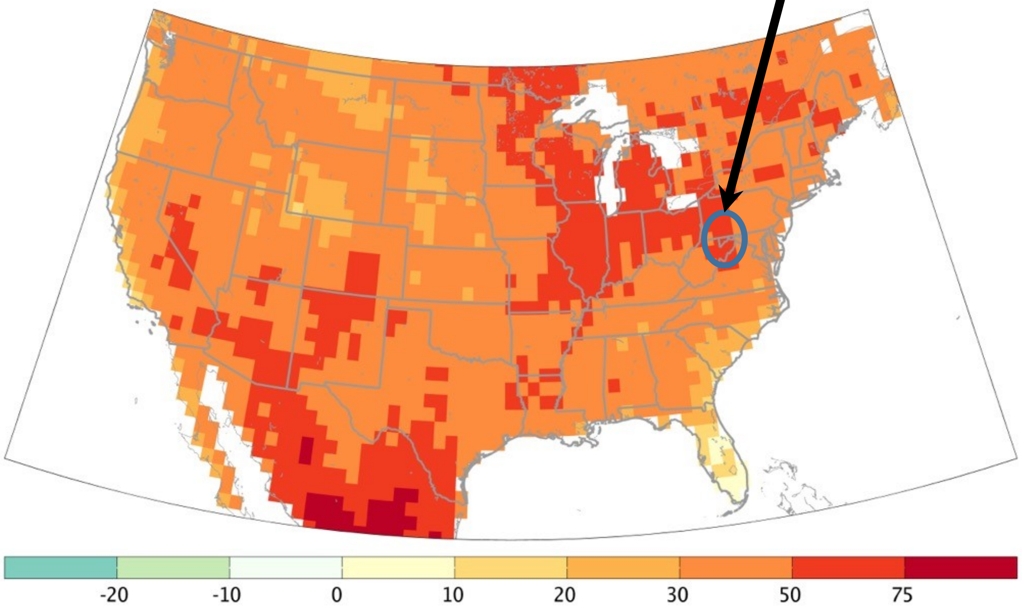
- 10.6 g m^{-2} yr^{-1} trend in fuel consumed per unit area
- +0.51 $Tgyr^{-1}$ trend in annual dry matter consumption

(Freeborn et al. 2016 *JGR Biogeosciences*)

Climate change projections show 50% to 75% increase in days conducive to extreme wildfire events in this region

23 global climate model ensemble (CMIP5)
Monthly means of
- daily 2-m max temp
- specific humidity
- 10-m wind speed
- precipitation

Projected changes in monthly means between the observational period (2000-2014) and mid 21st century (2041-2070) regridded to 0.75° used to recalculate Fire Weather Index (FWI)

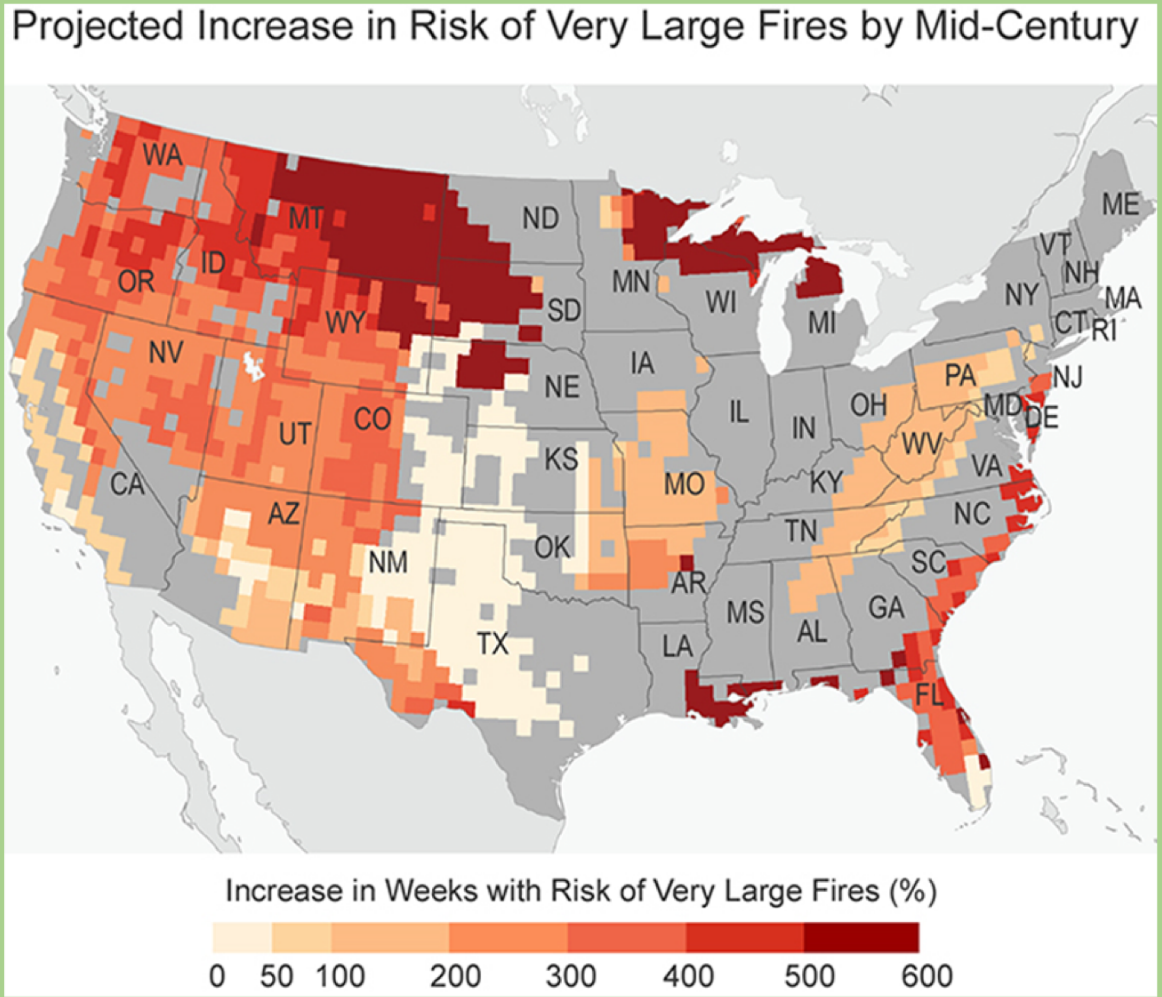


% increase in days with extreme fire weather conditions 2041-2070

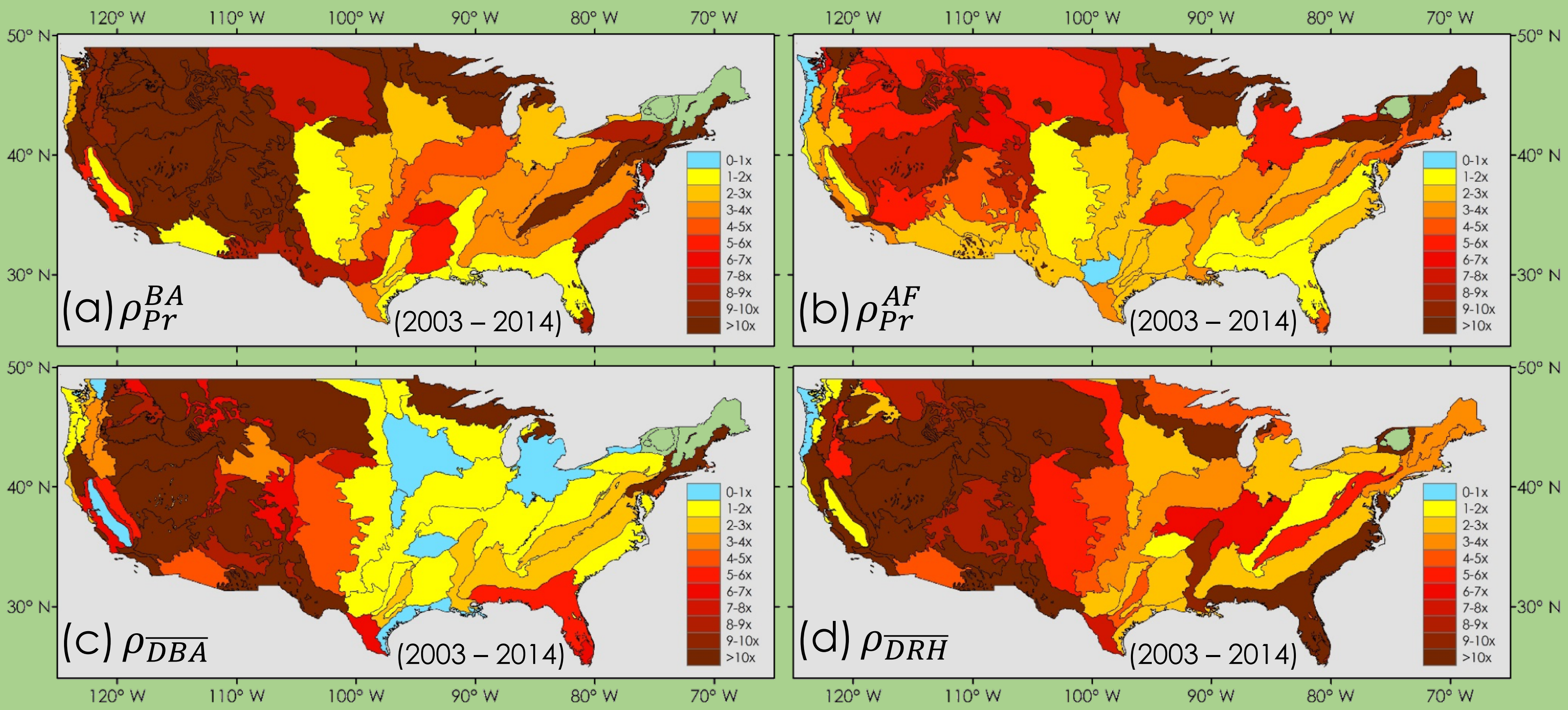
(Bowman et al. 2017 *Nature Ecology & Evolution*)

Percentage change in weeks with risk of very large fires by mid century (2041-2070)

- Similar approach using 17 models at higher resolution
- Gray areas have insufficient data to model changes from
- Note the coastal regions….
- (USGCRP 2016)

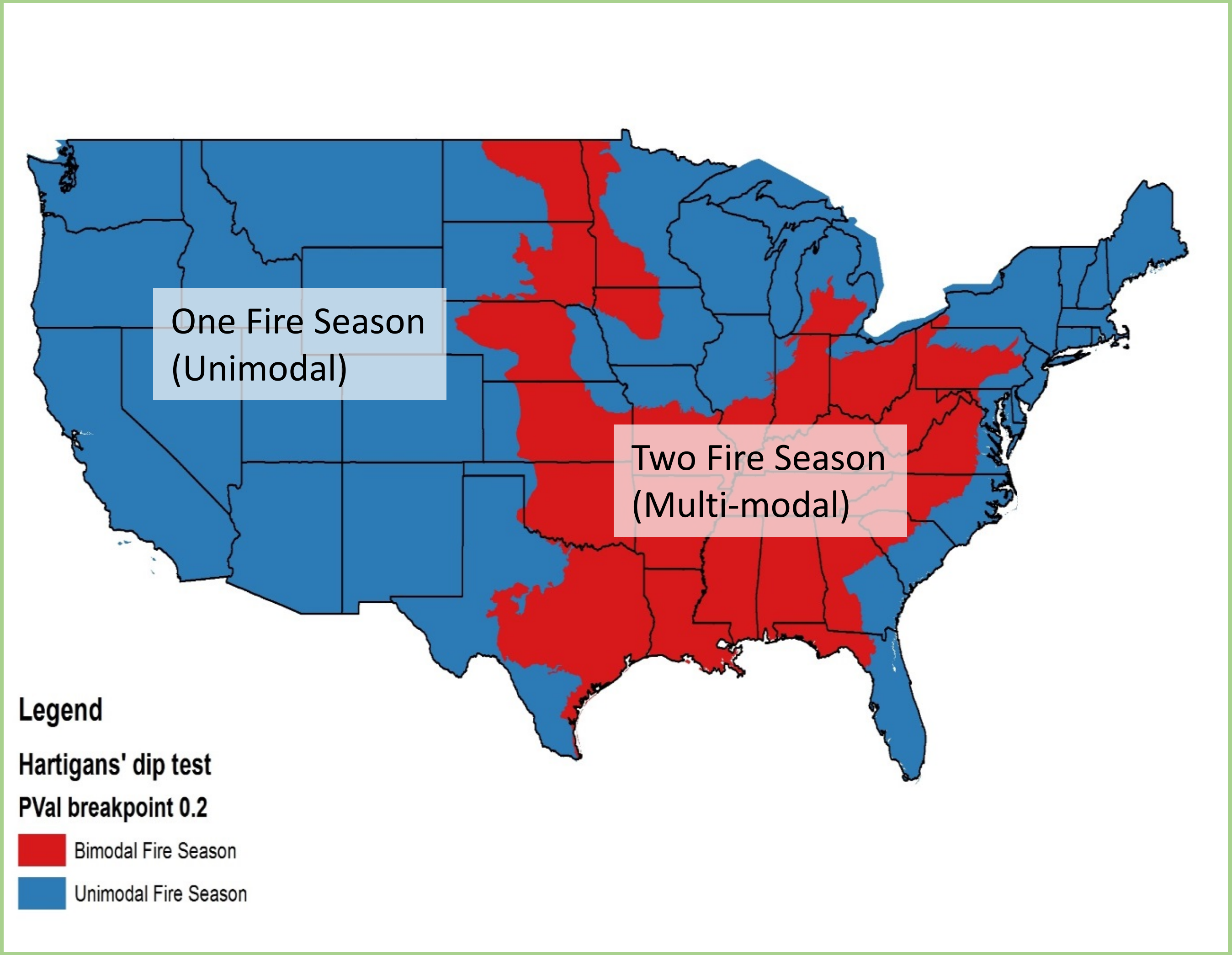


Sensitivity to Increasing Fire Danger

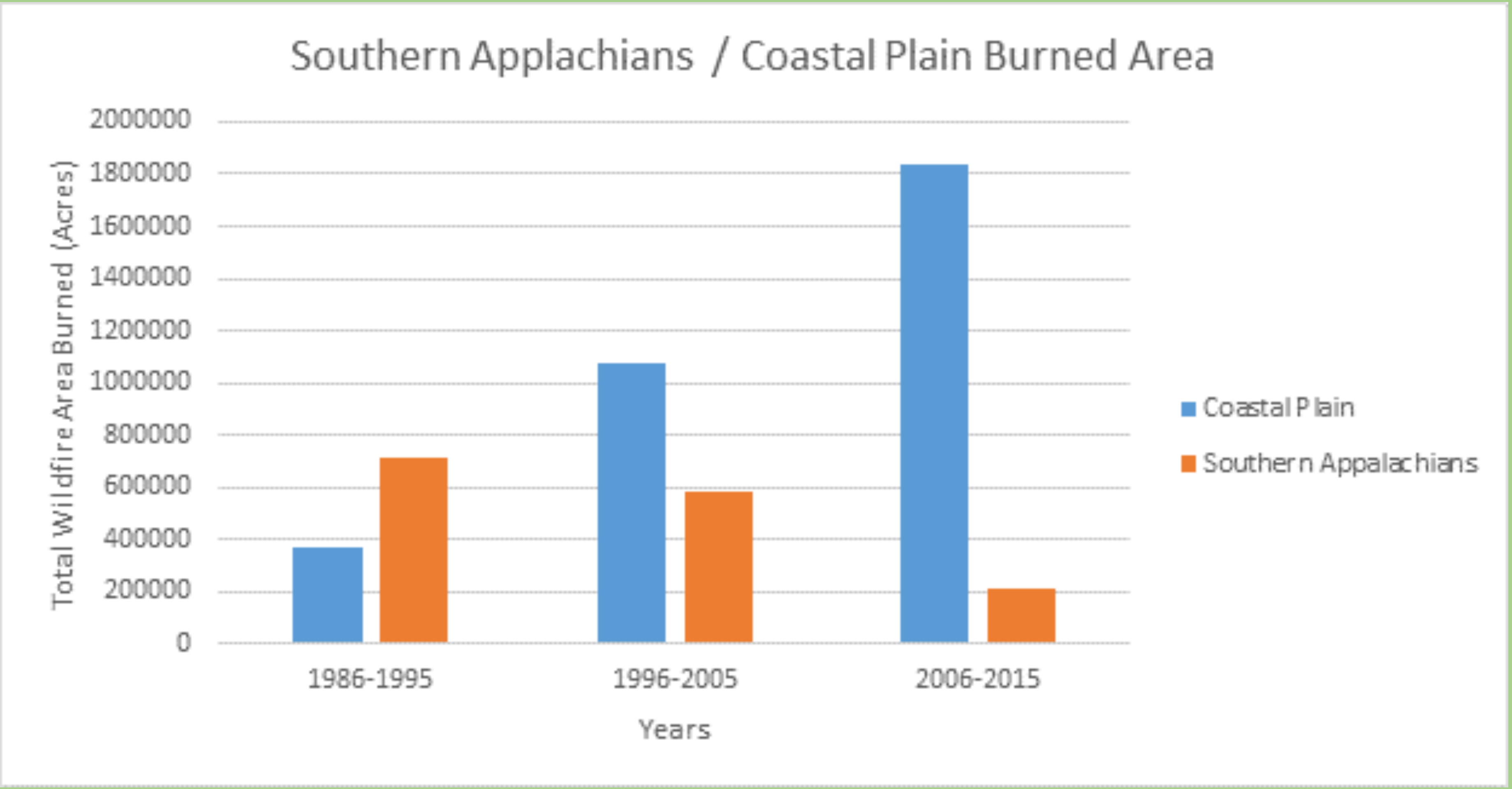


Ratios illustrate regional variations in the response of landscape fire activity to changes in fire danger. Ecoregions with Pr > 1.0 indicate MODIS is more likely to detect a burned area (BA) pixel (a) or an active fire (AF) pixel (b) on days with high fire danger. Ecoregions with DBA > 1.0 (c) and DRH> 1.0 (d) indicate greater daily burned area (DBA) and daily radiant heat release (DRH) on days with high fire danger.

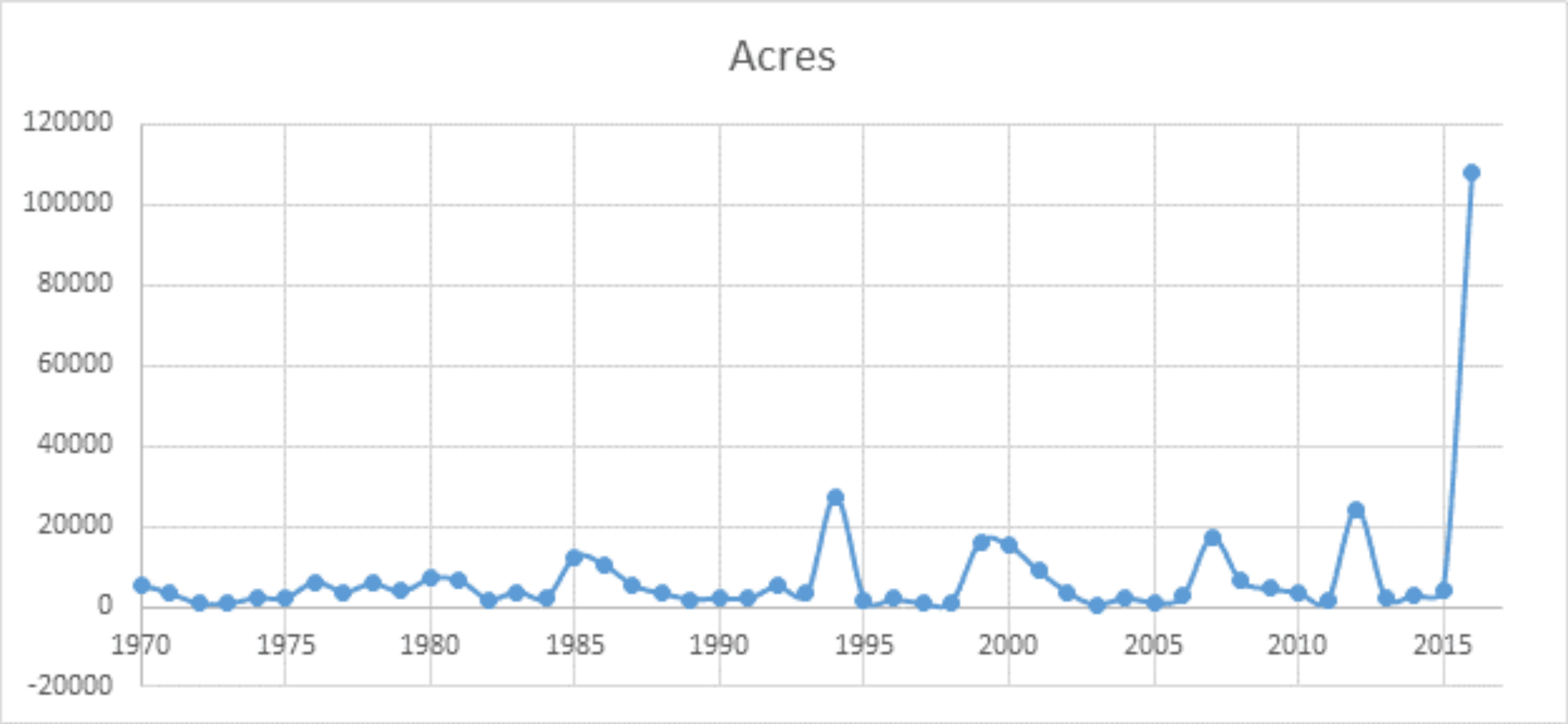
Not all fire seasons occur during the summer



Trending in different directions in recent decades….



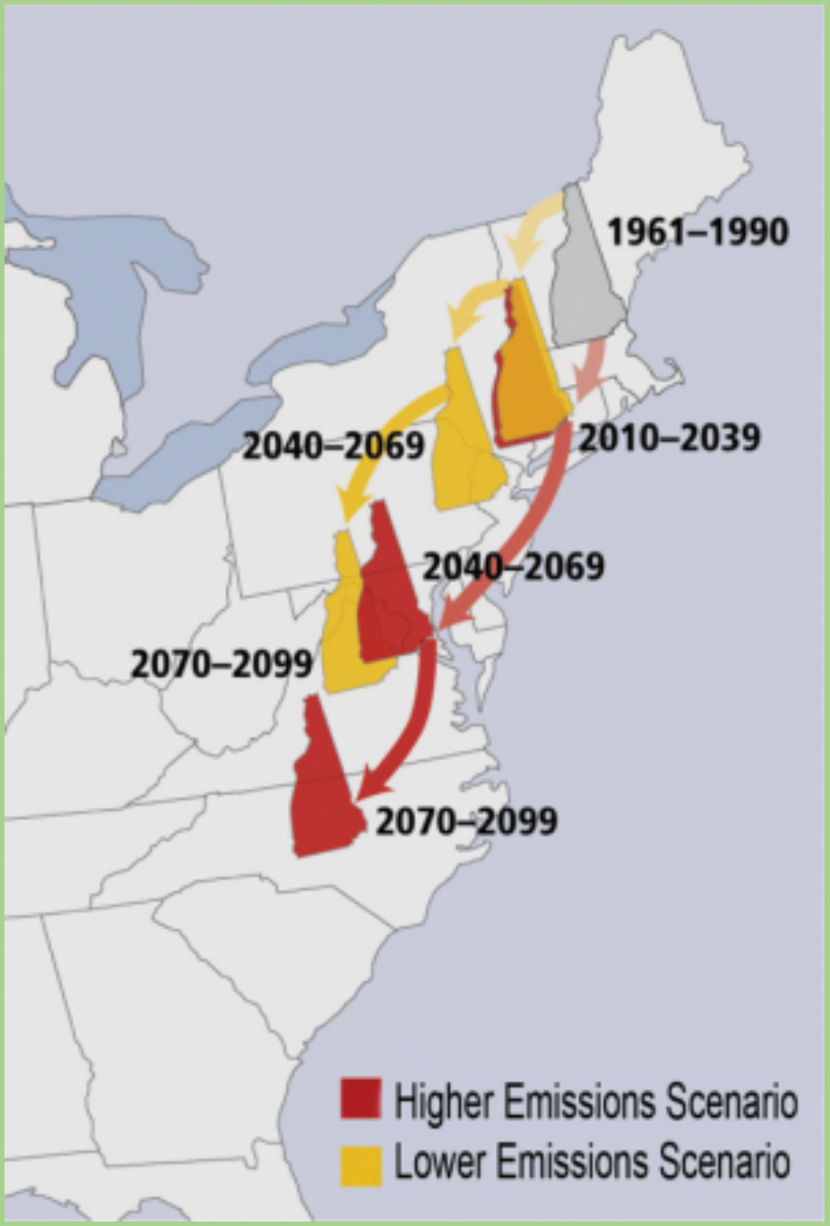
Things can change quickly though….



Moving to the area by mid-century ?

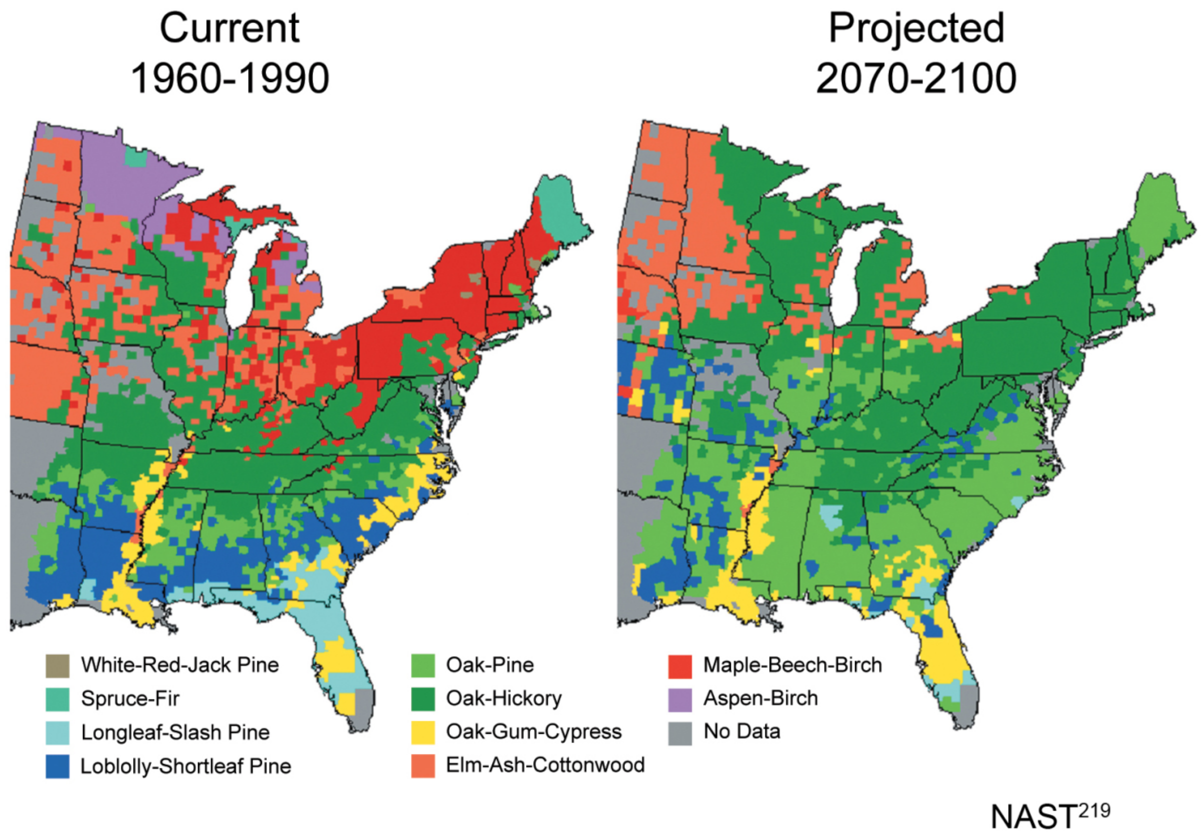
- Depicts what relative climate conditions will be like over time for lower and higher emissions scenarios

- If anything approximating this change in climate occurs there will have to be a lot more changes in the biota…

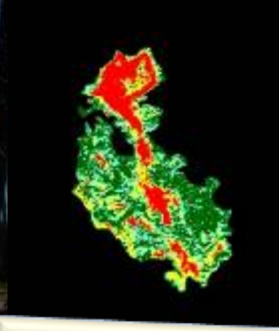


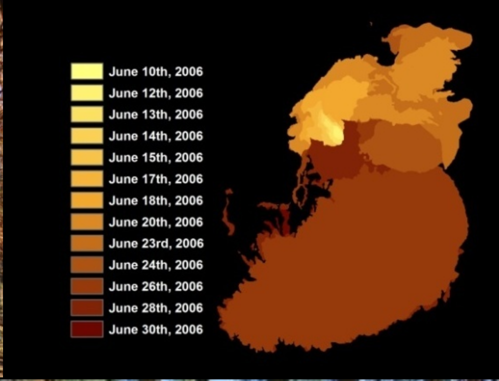
Models can’t begin to tell the story of ecological turmoil

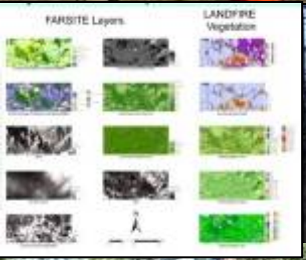
- Nothing approximating this transition occurs without a lot of fire, bug kill and other disturbance.
- Do we manage for existing forests or anticipated ones?



The maps show current and projected forest types. Major changes are projected for many regions. For example, in the Northeast, under a mid-range warming scenario, the currently dominant maple-beech-birch forest type is projected to be completely displaced by other forest types in a warmer future.[244]






FUEL TREATMENT EFFECTIVENESS in the UNITED STATES

Joint Fire Science Program

SDSU

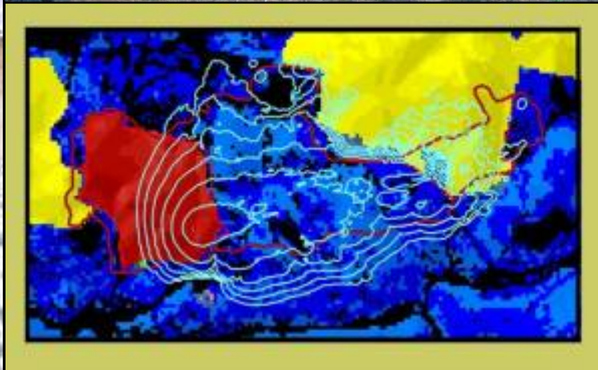
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

USGS science for a changing world

MTBS





FTEUS Project Overview

- GOAL:
  - Quantify the effectiveness of fuels treatments across the nation in terms of their measurable effects on:
    - fire severity (site)
    - and fire spread (landscapes)

Fuels Treatments are Accomplished via:

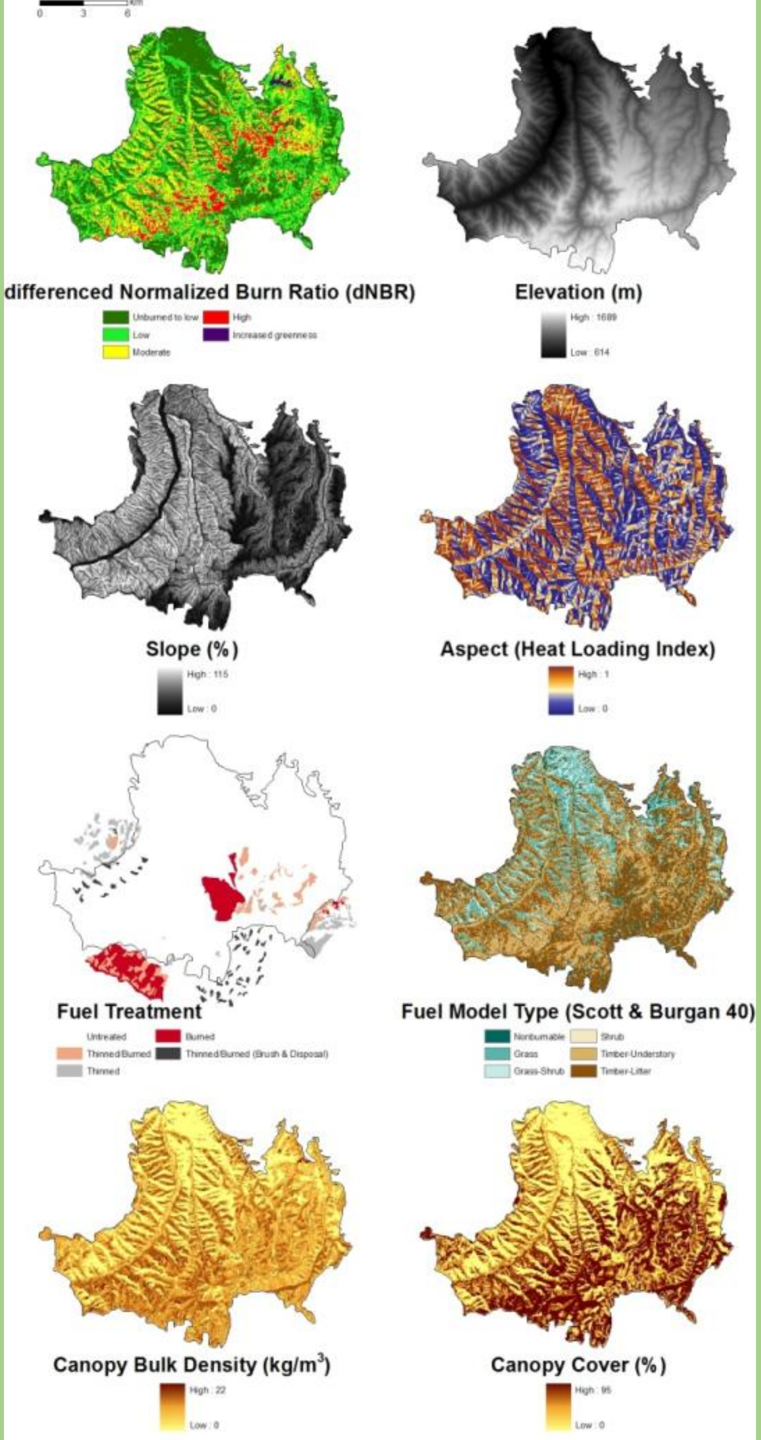
Prescribed Burning

Mechanical Thinning

and Mulching

Data Sources

- Monitoring Trends in Burn Severity (MTBS) Project Data
- LANDFIRE data layers
- Weather/wind from Remote Automated Weather Stations (RAWS)
- National database of fuel treatment polygons
  - Developed from contacts with 1000's of federal land managers
  - Collaborating with LANDFIRE Refresh



Site Visit Example: Field Validation

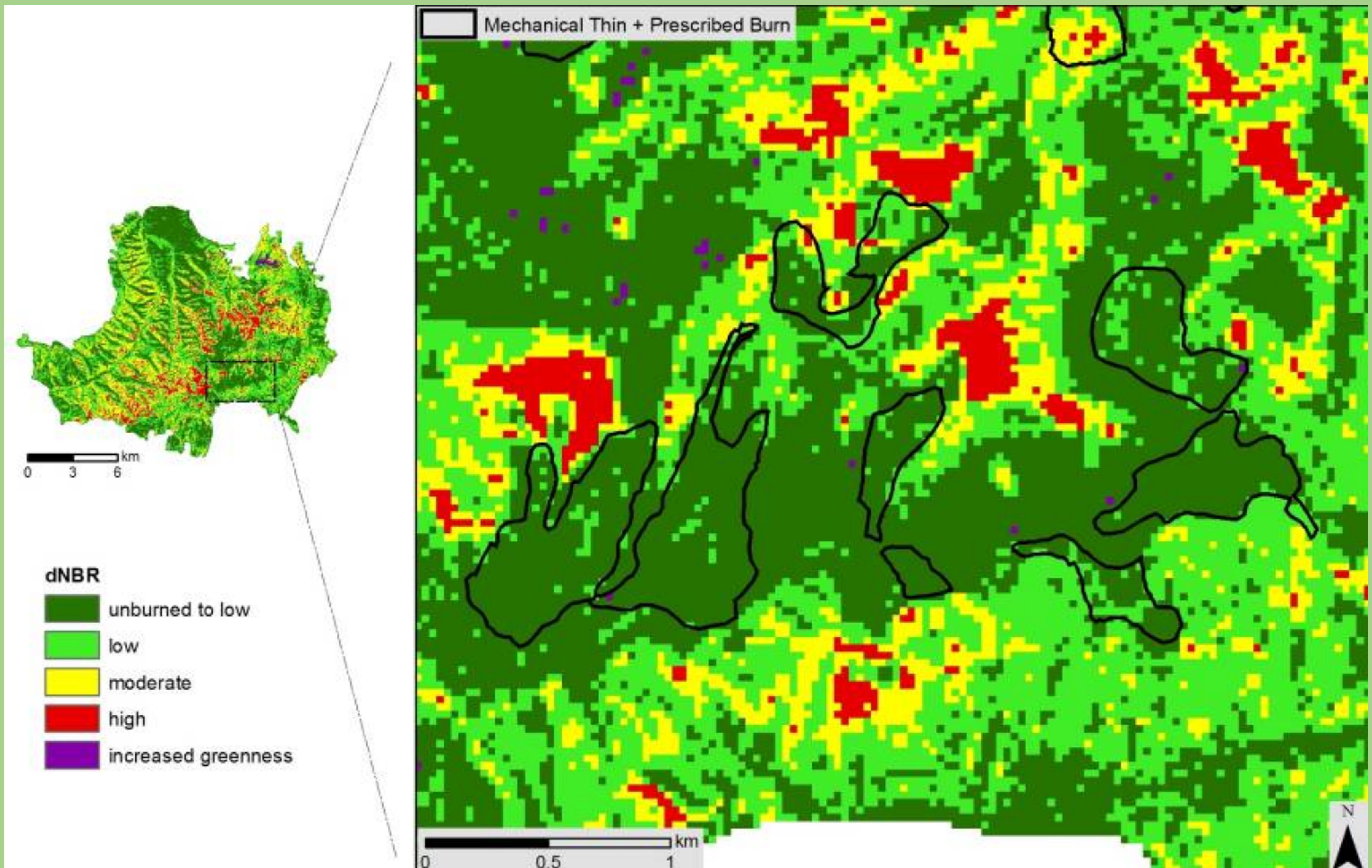
Numerous Composite Burn Index (CBI) plots were collected all treatment types and untreated areas for 14 wildfires across the United States.

Untreated forest

Mechanically thinned and prescribed burn

Forest Service personnel provided extensive tours of wildfires, provided their own burn severity and fire progression maps as well as all treatment locations.

Detailed view of dNBR map in affected fuels treatments



Rinse and Repeat

For several hundreds of wildfires

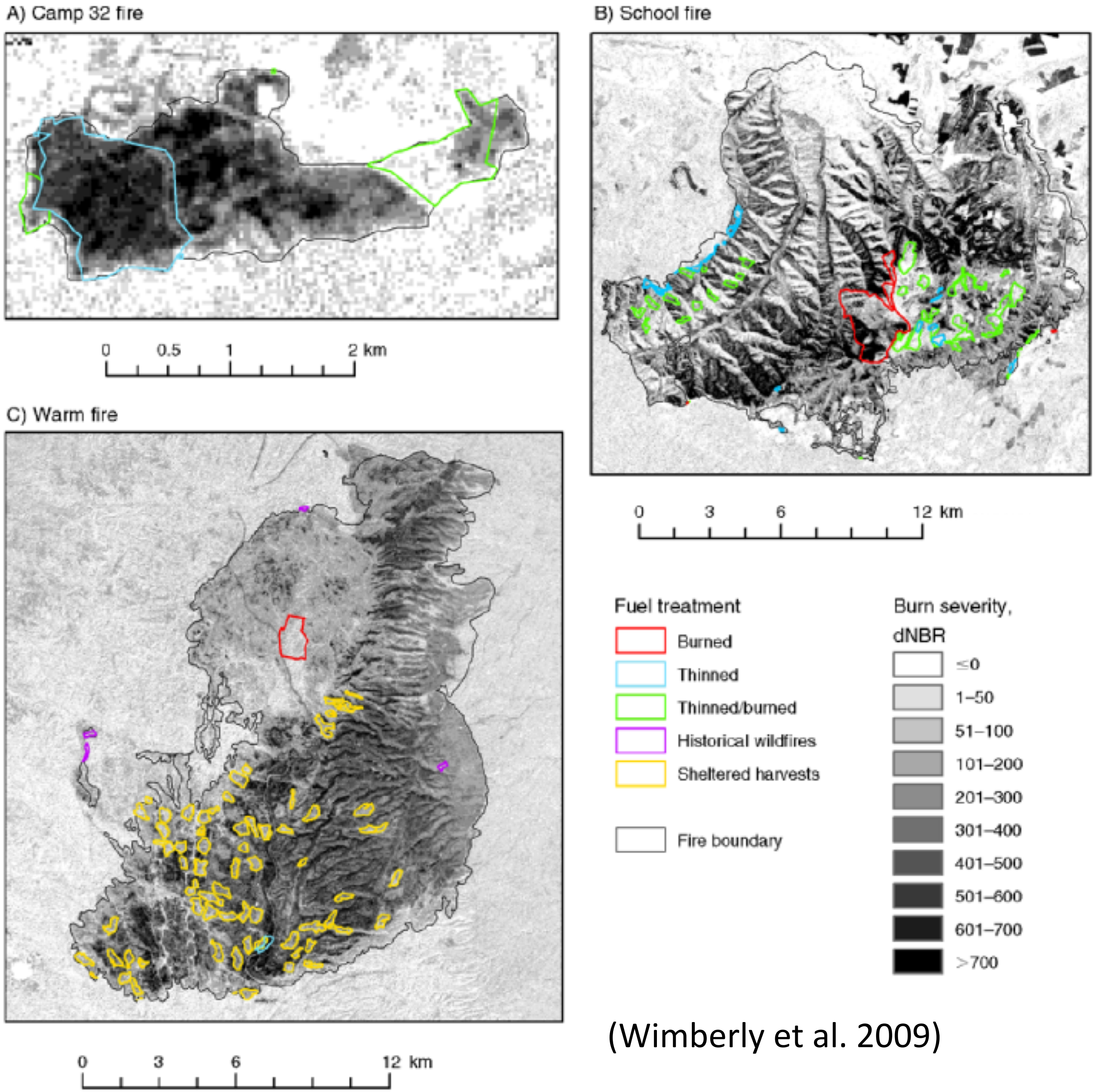
And many thousands of fuels treatments

Adjust fuels to account for:

Treatment type and intensity

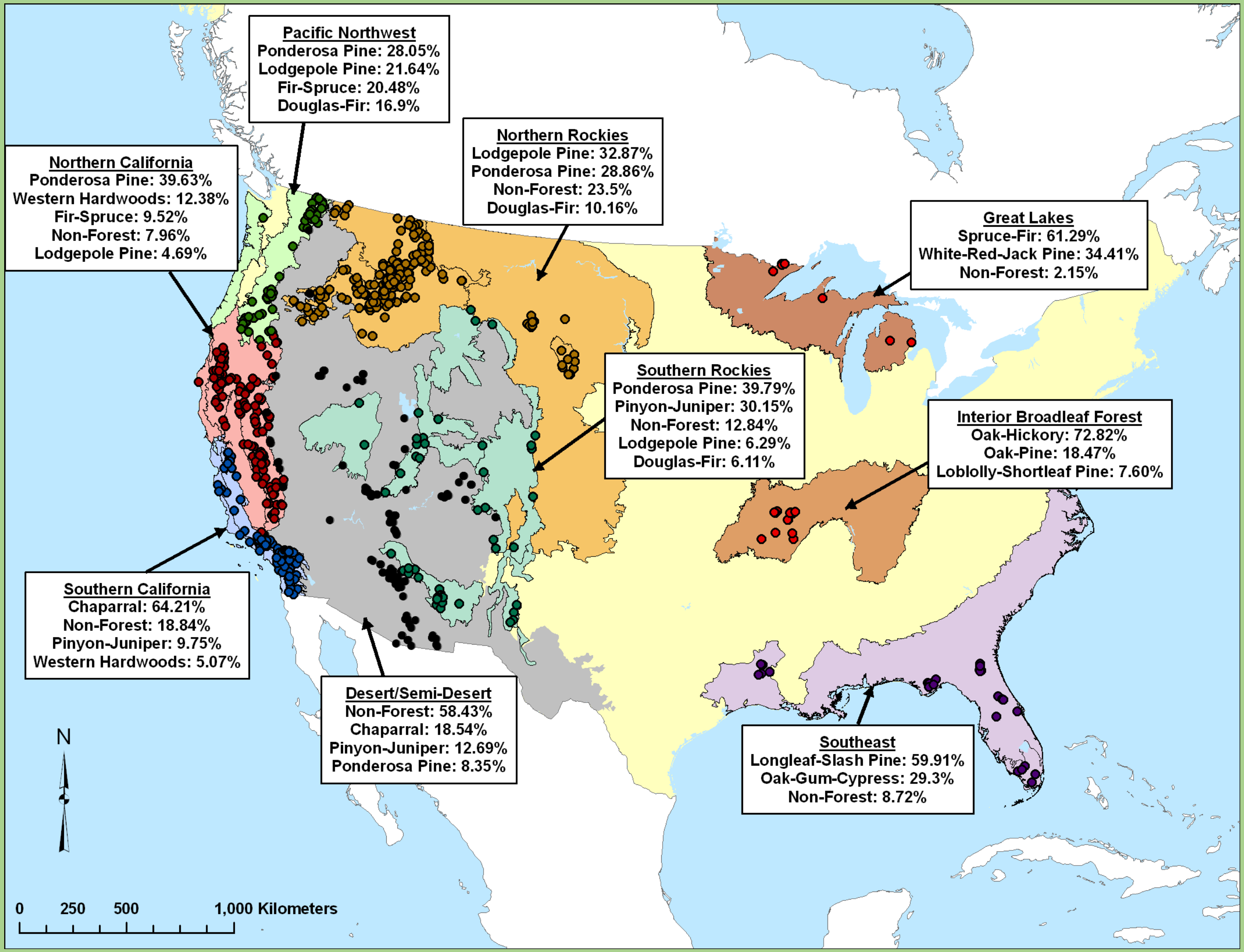
Treatment history

Time since treatment



(Wimberly et al. 2009)

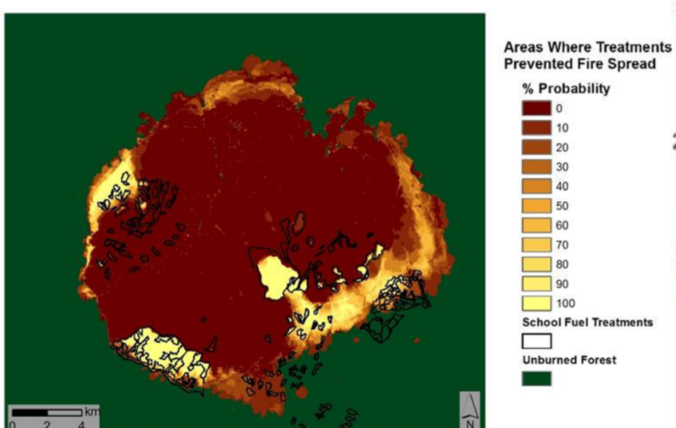
Locations of studied wildfires involving fuels treatments grouped by eco-provinces

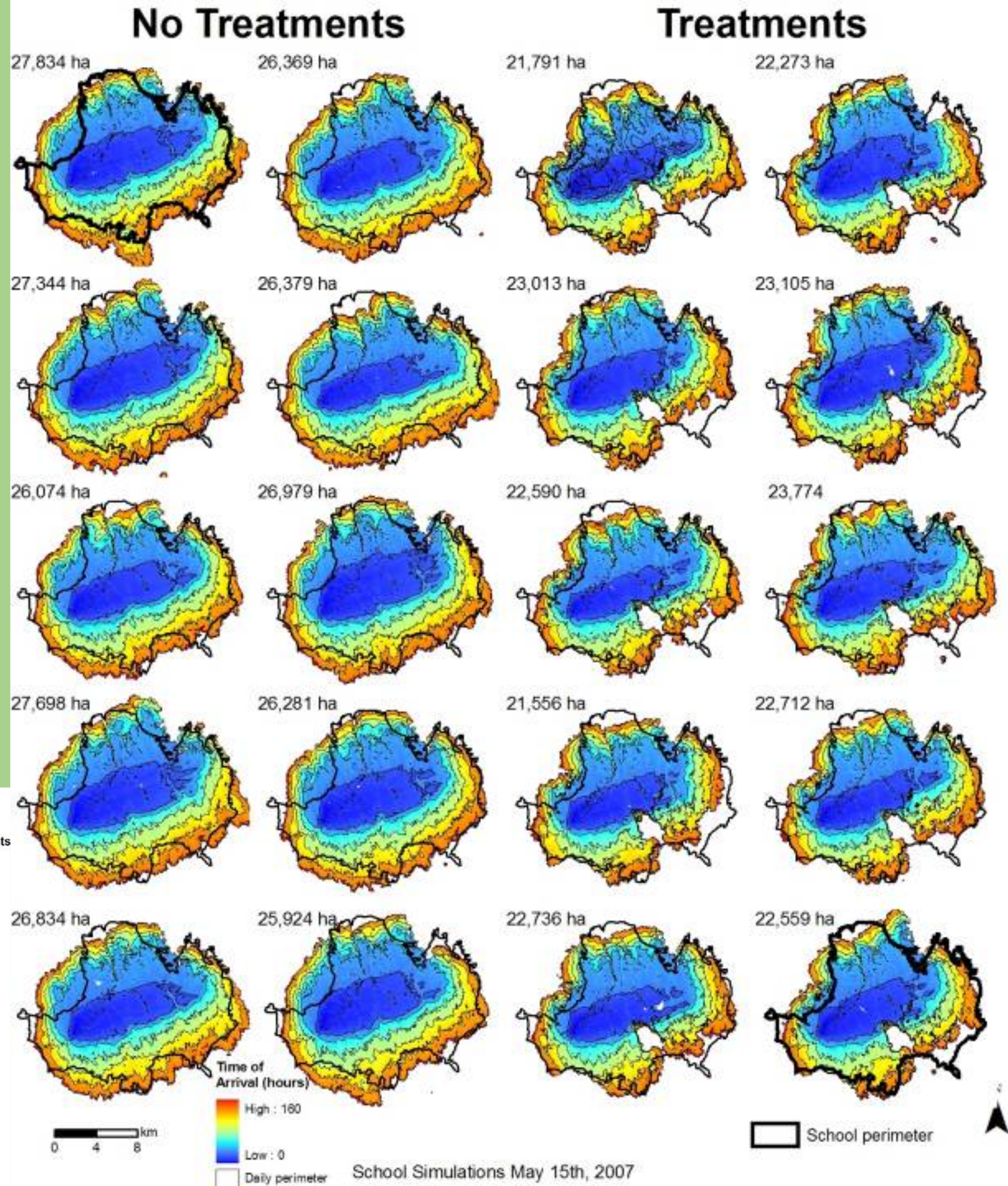



Should have been straightforward except
for this little detail

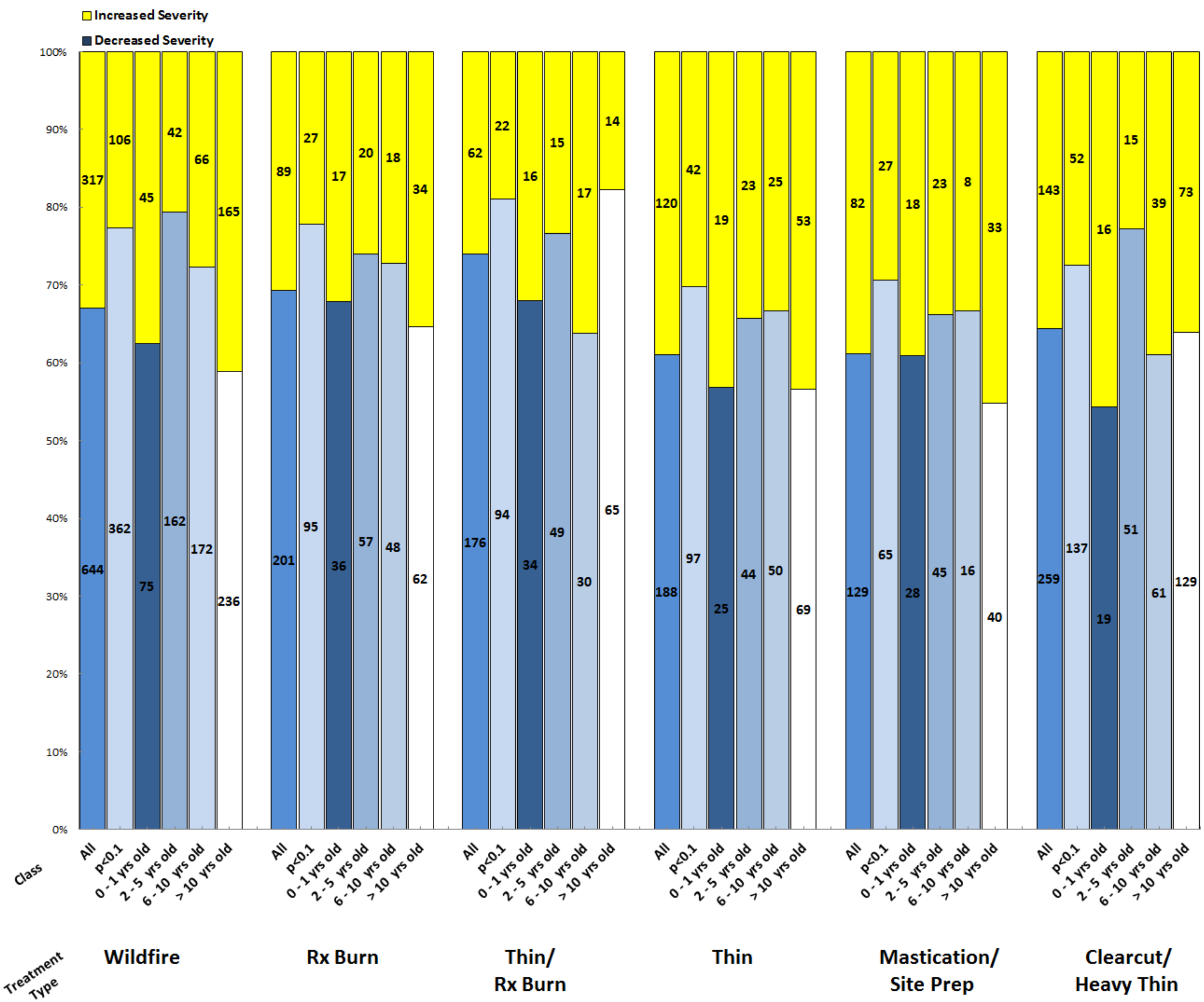
Due to the stochastic nature of fire spread, each fire simulation in FARSITE was run multiple times.

The simulations were repeated 10-30 times both with and without fuels treatments in the fuels data layers.





CONUS



Increased Severity
Decreased Severity
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Class
All
p<0.1
0 - 1 yrs old
2 - 5 yrs old
6 - 10 yrs old
> 10 yrs old
Treatment Type
Wildfire
Rx Burn
Thin/ Rx Burn
Thin
Mastication/ Site Prep
Clearcut/ Heavy Thin
317
106
45
42
66
165
644
362
75
162
172
236
89
27
17
20
18
34
201
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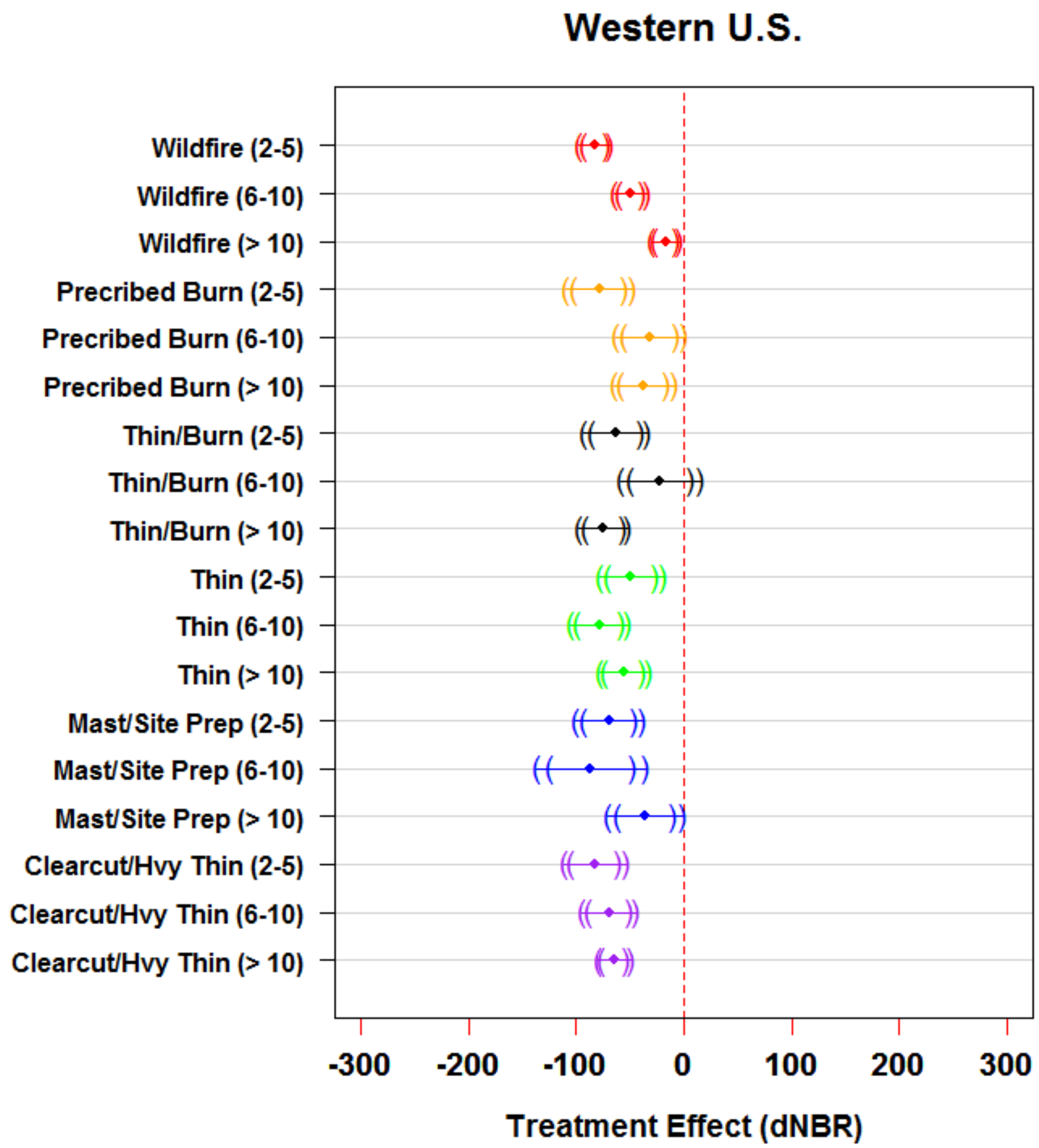
51
61
129

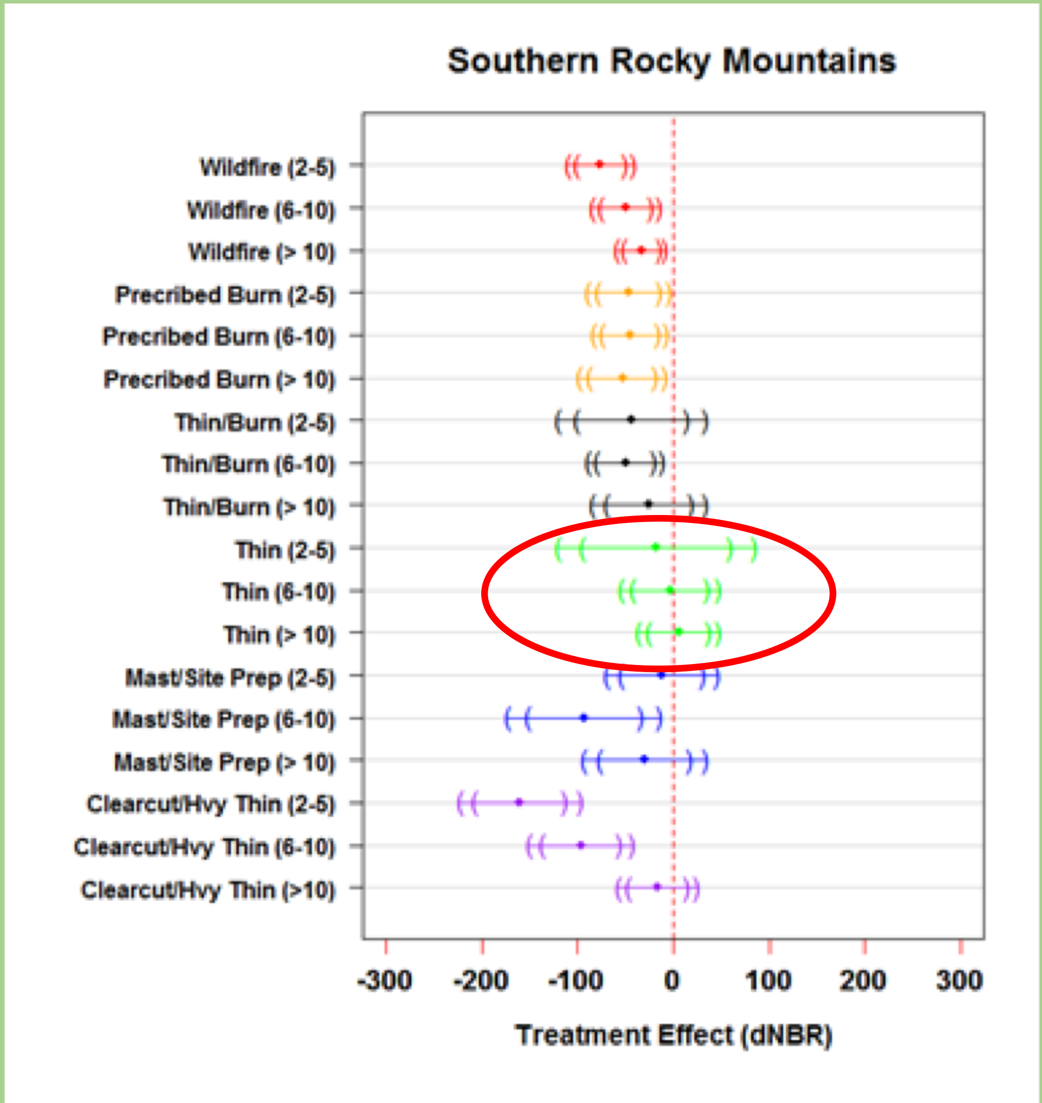
Do we see reductions in severity?

- Yes!
- But…
- Devil is in the details



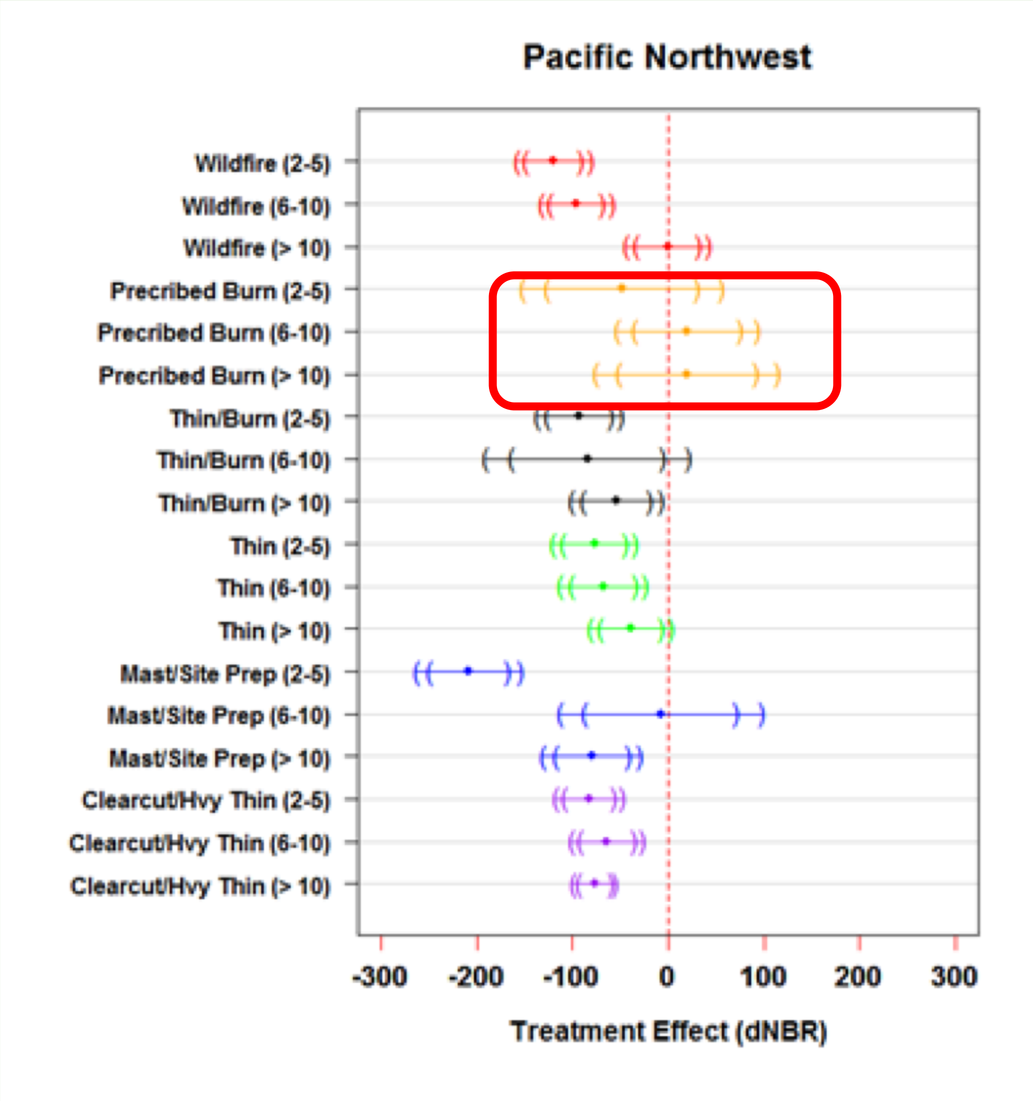
Southern Rockies Fuels Treatments

- Prescribed burning is dependably effective
- Thinning alone is ineffective!
- Must burn to treat landscape



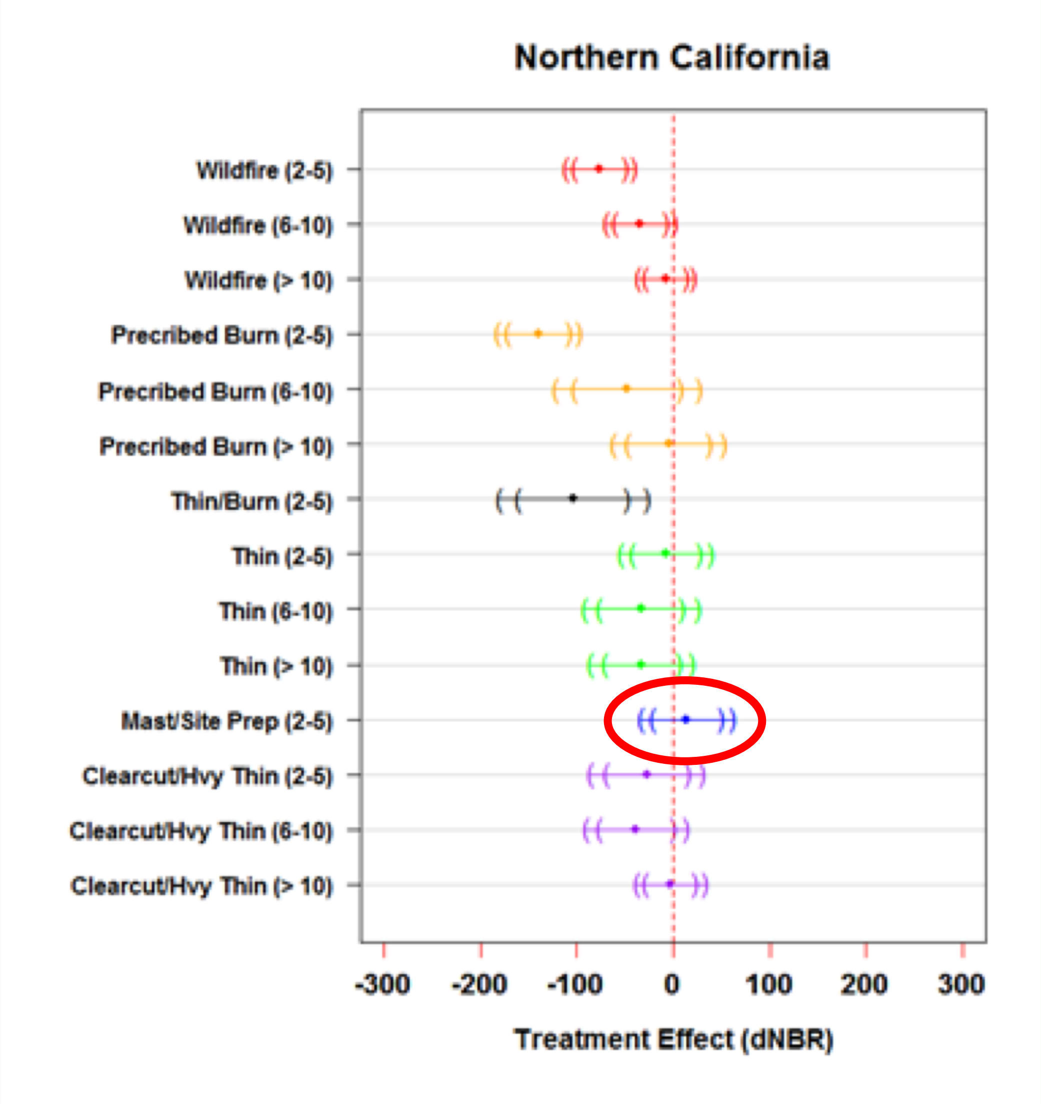
Pacific Northwest Fuels Treatments

- Previous wildfires effective for < 10 yrs
- Prescribed burns ineffective unless thinned first
- Thinning provides most consistent reductions

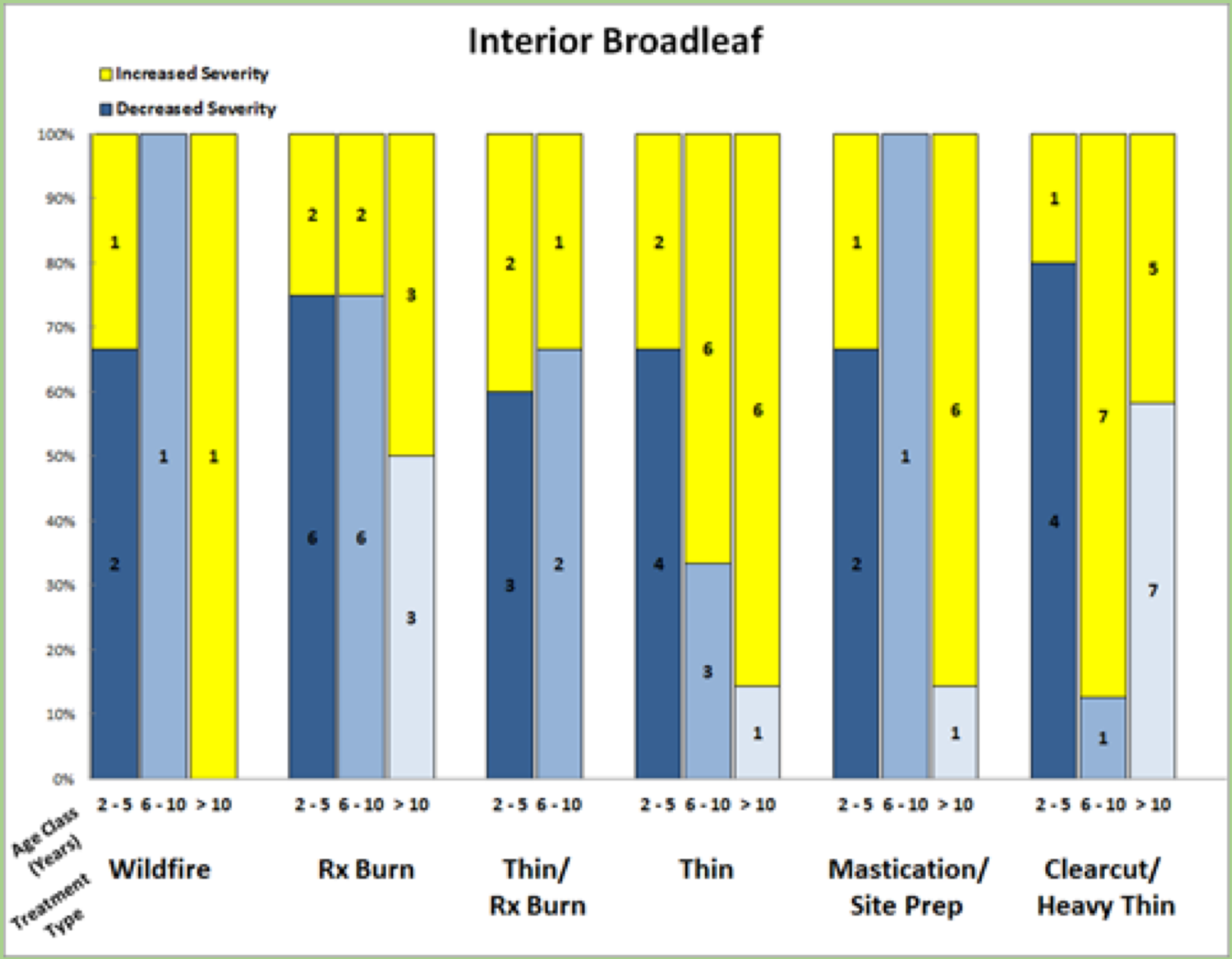


Northern California Fuels Treatments

- Wildfire and Rx burns of little effect > 10yrs
- Thinning alone only marginally effective
- Thinning + Rx fire shows promise but unknown long term
- Mastication is most prevalent recent treatment….

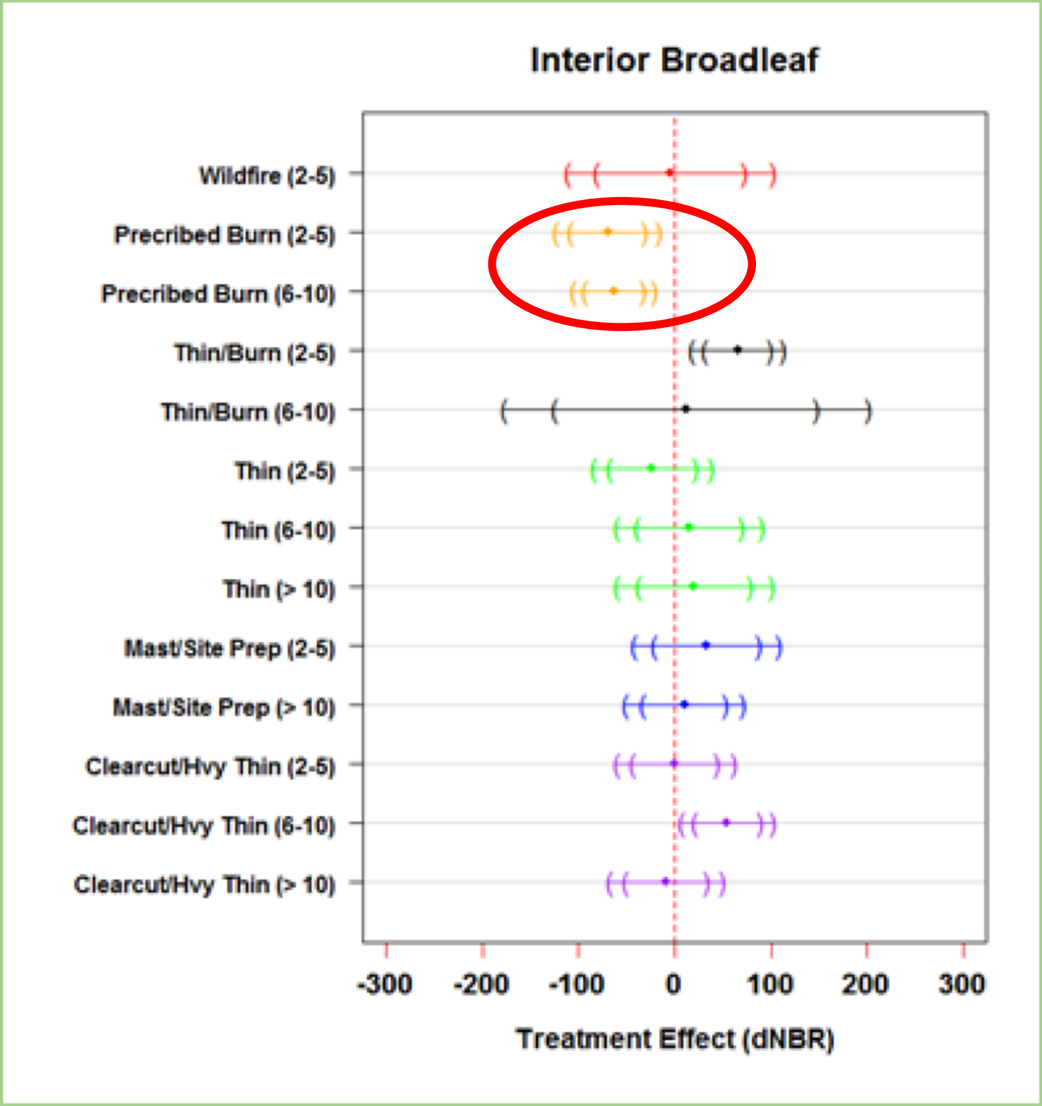


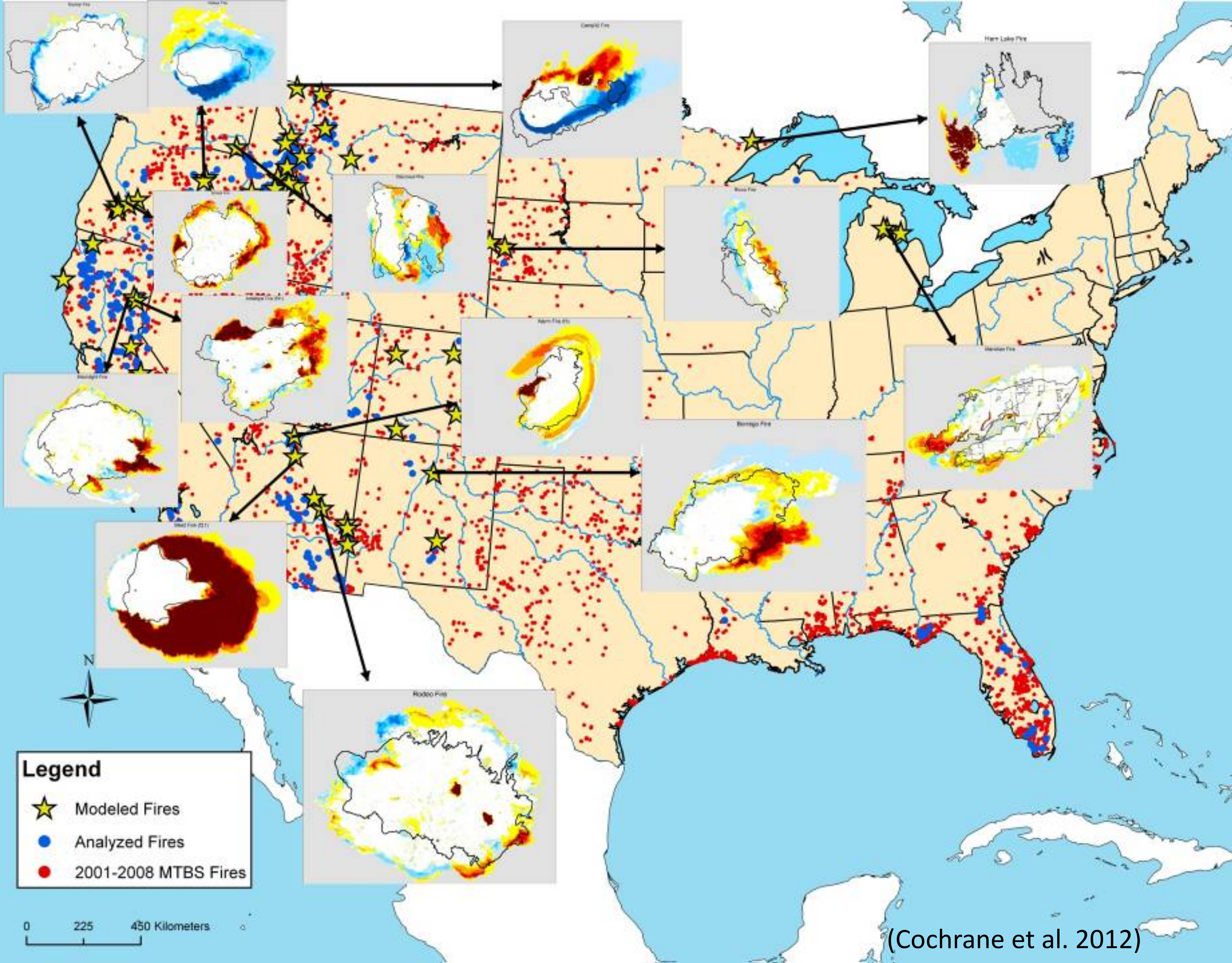
Interior Broadleaf



Interior Broadleaf Fuels Treatments

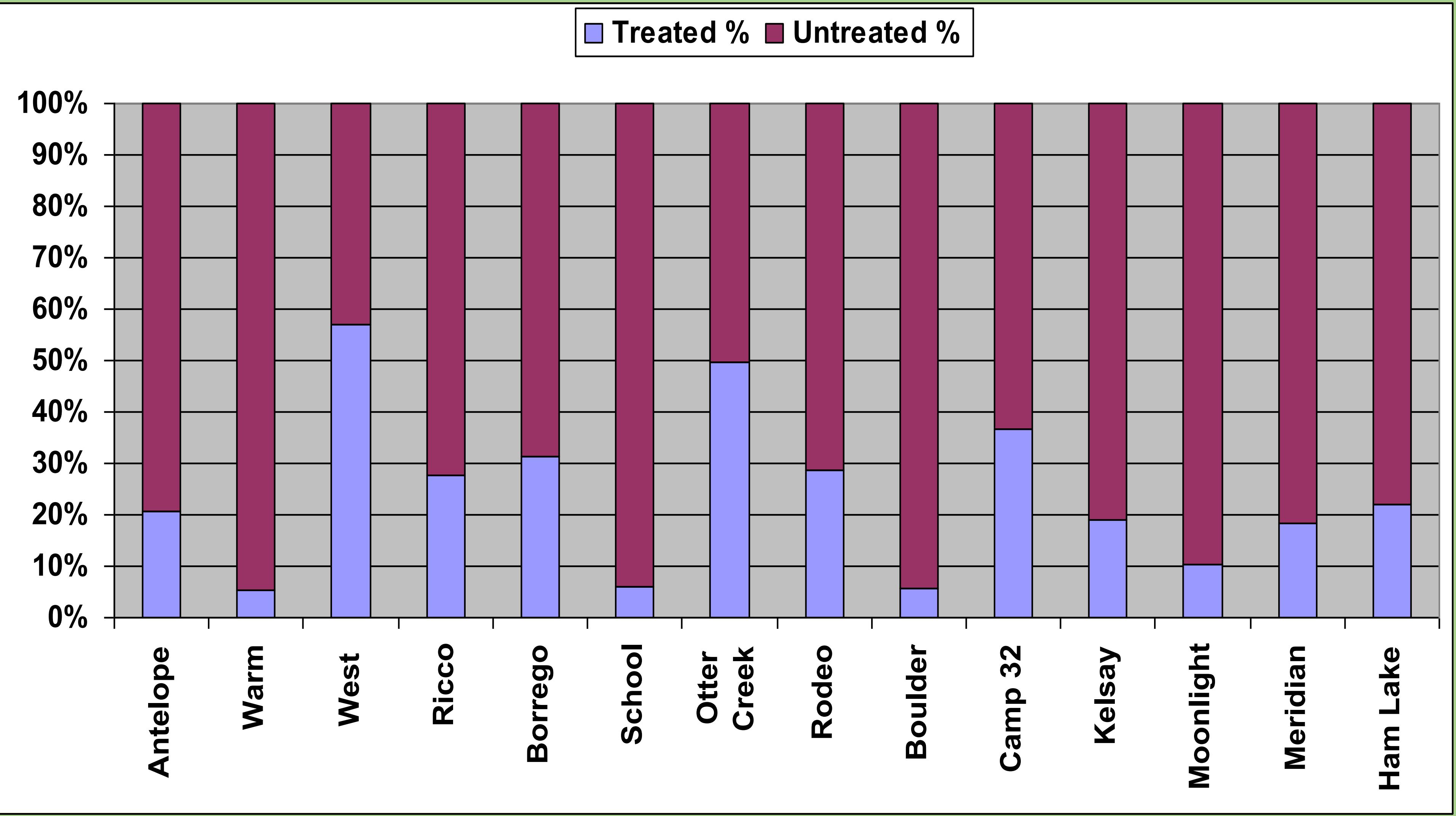
- Prescribed fires are **<u>not</u>** at all like wildfires.
- However, prescribed burning is the **<u>only</u>** effective treatment type for reducing future fire severity.
- (at least as measured using dNBR)





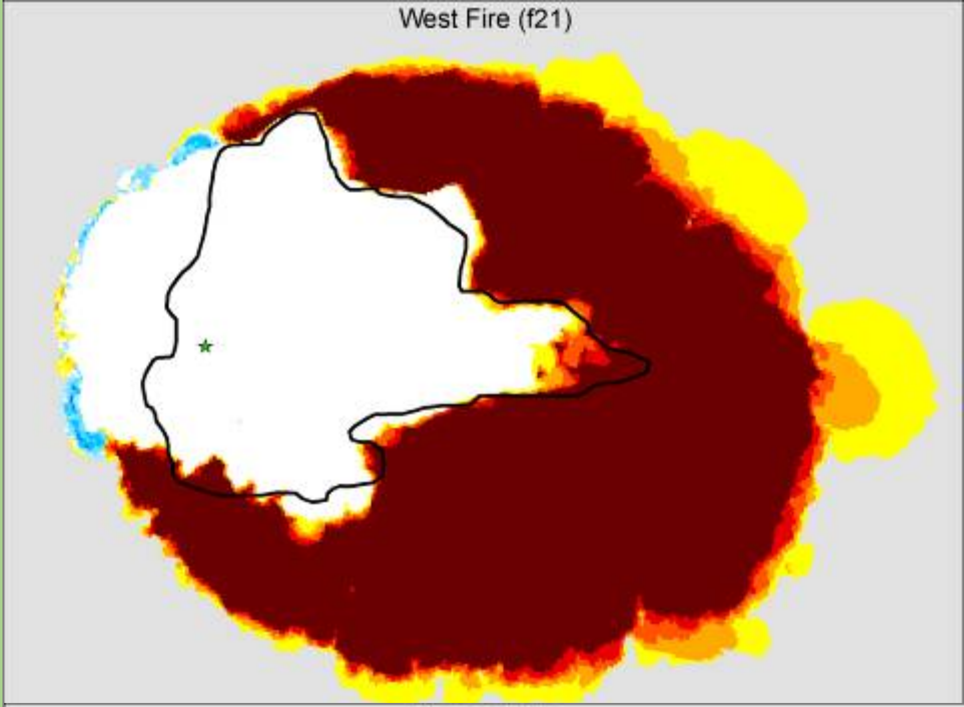
(Cochrane et al. 2012)

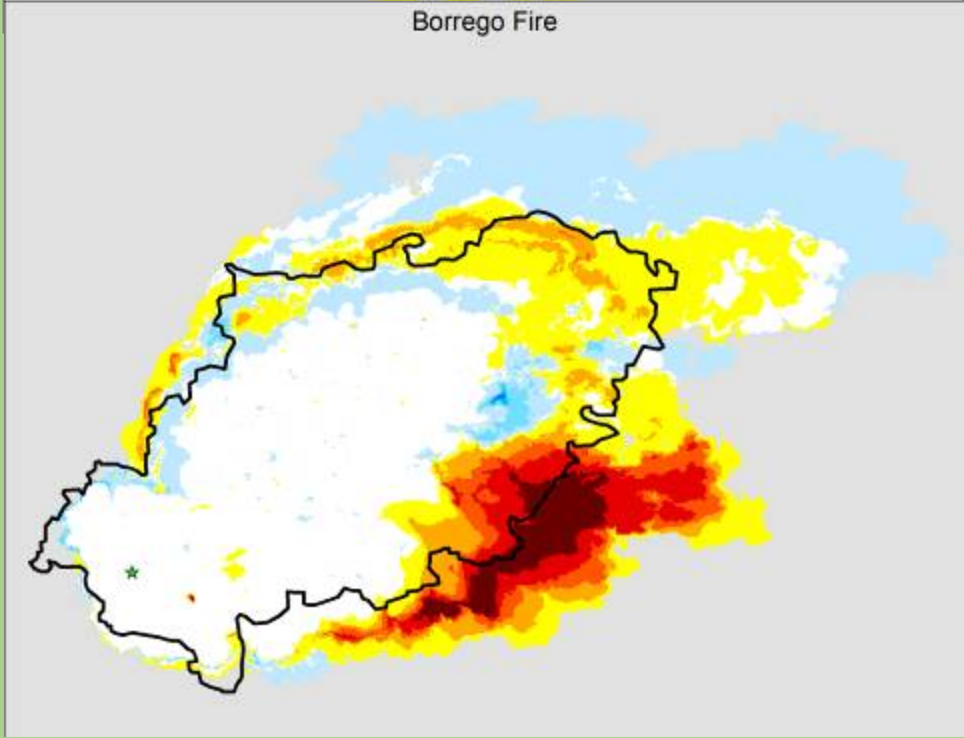
Wildfires in this study



What have we learned?

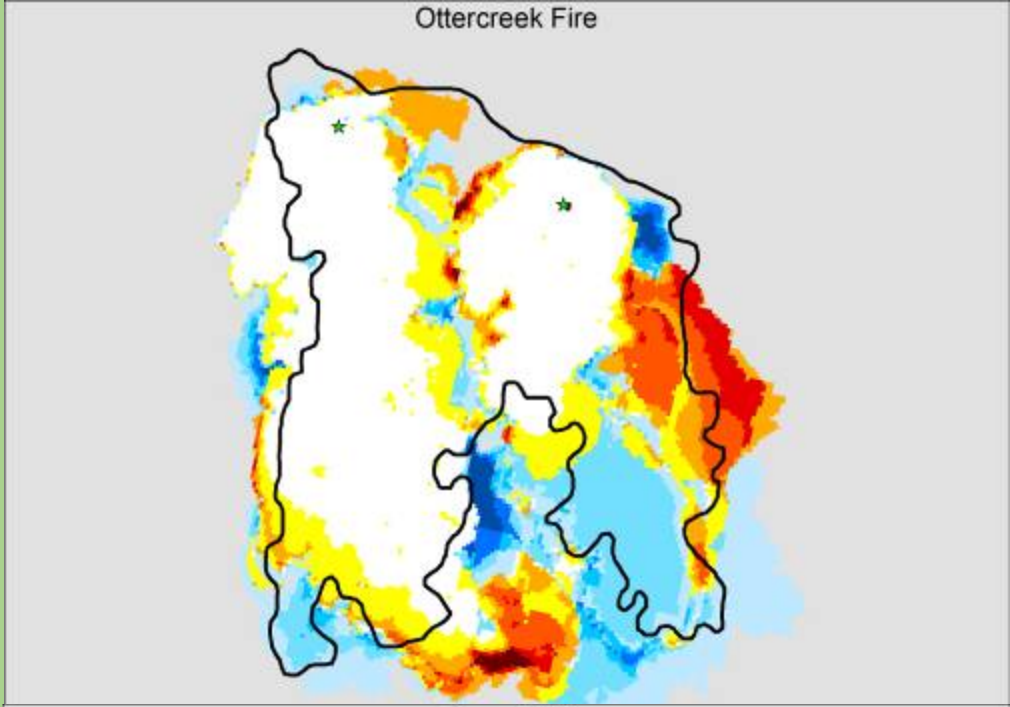
- There are some clear cases where fuels treatments have helped limit fire spread
- Several others where treatments have obviously been helpful

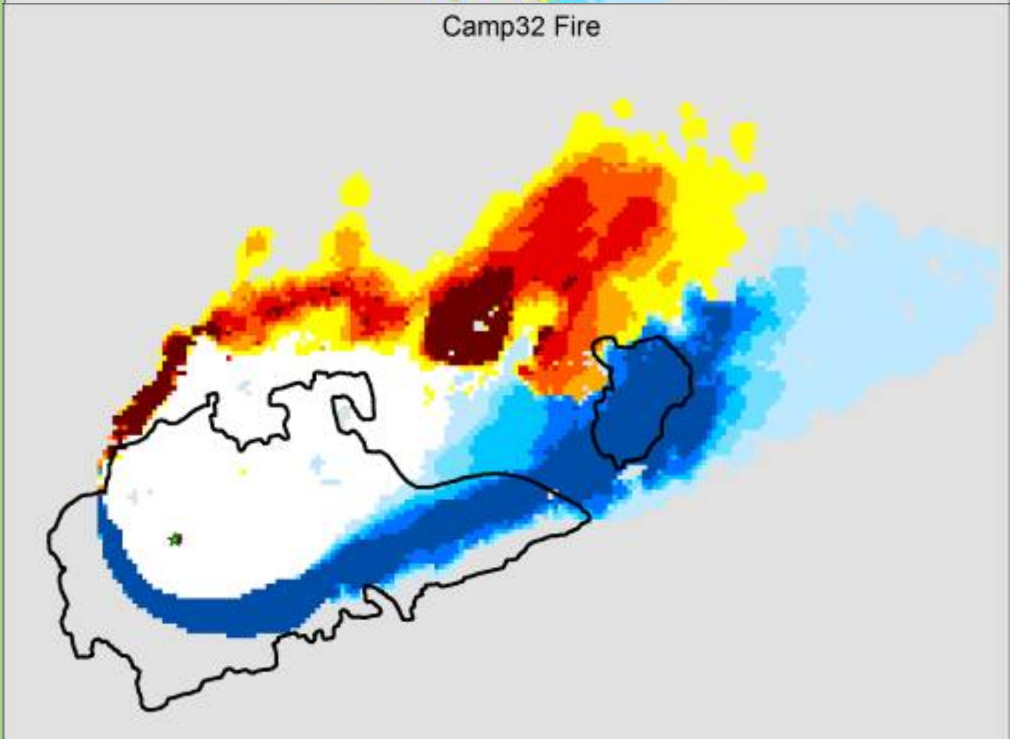




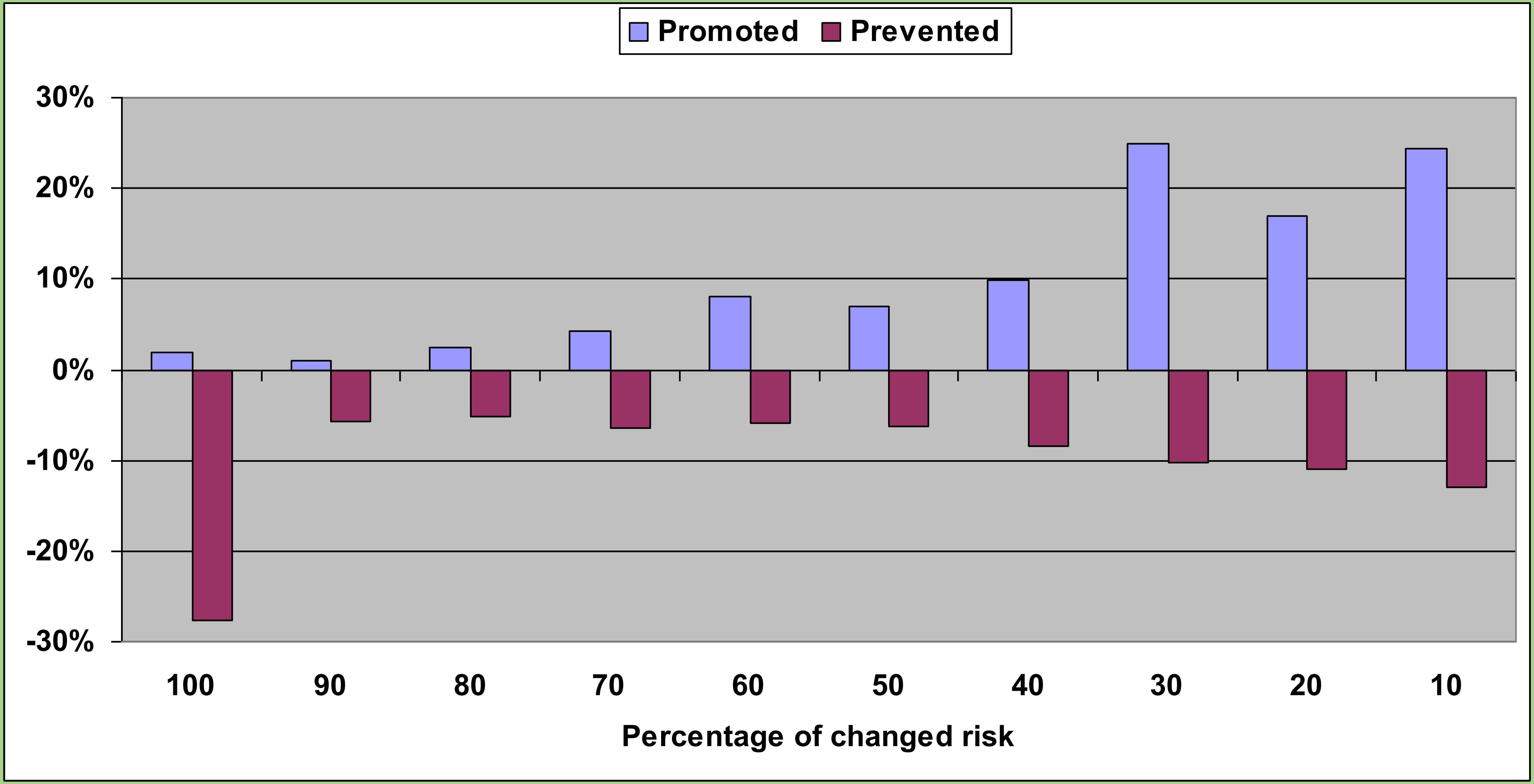
What else have we learned?

- In many cases fuels treatments have been more ambiguous in their effects
- Or potentially detrimental to fire management

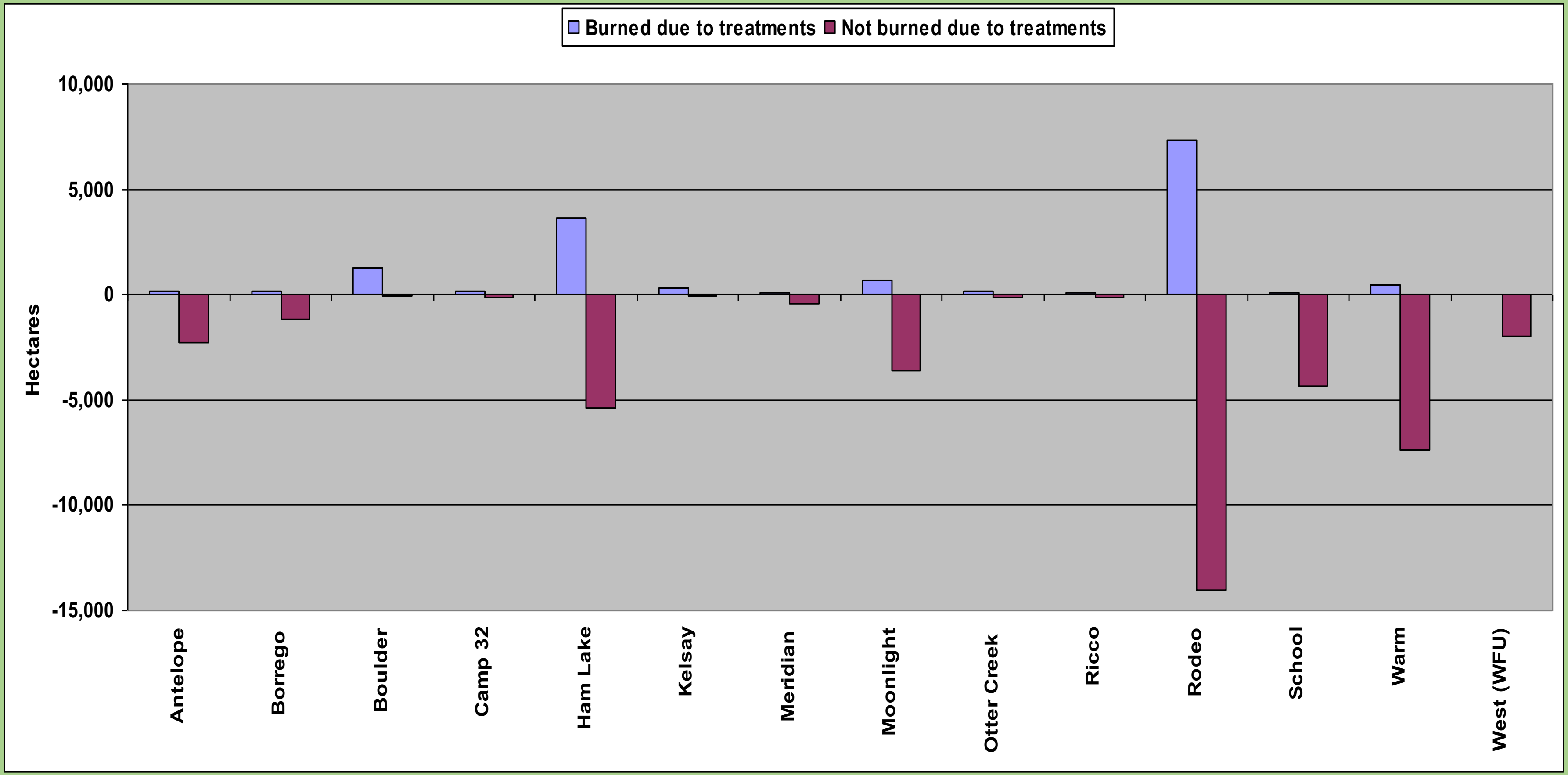




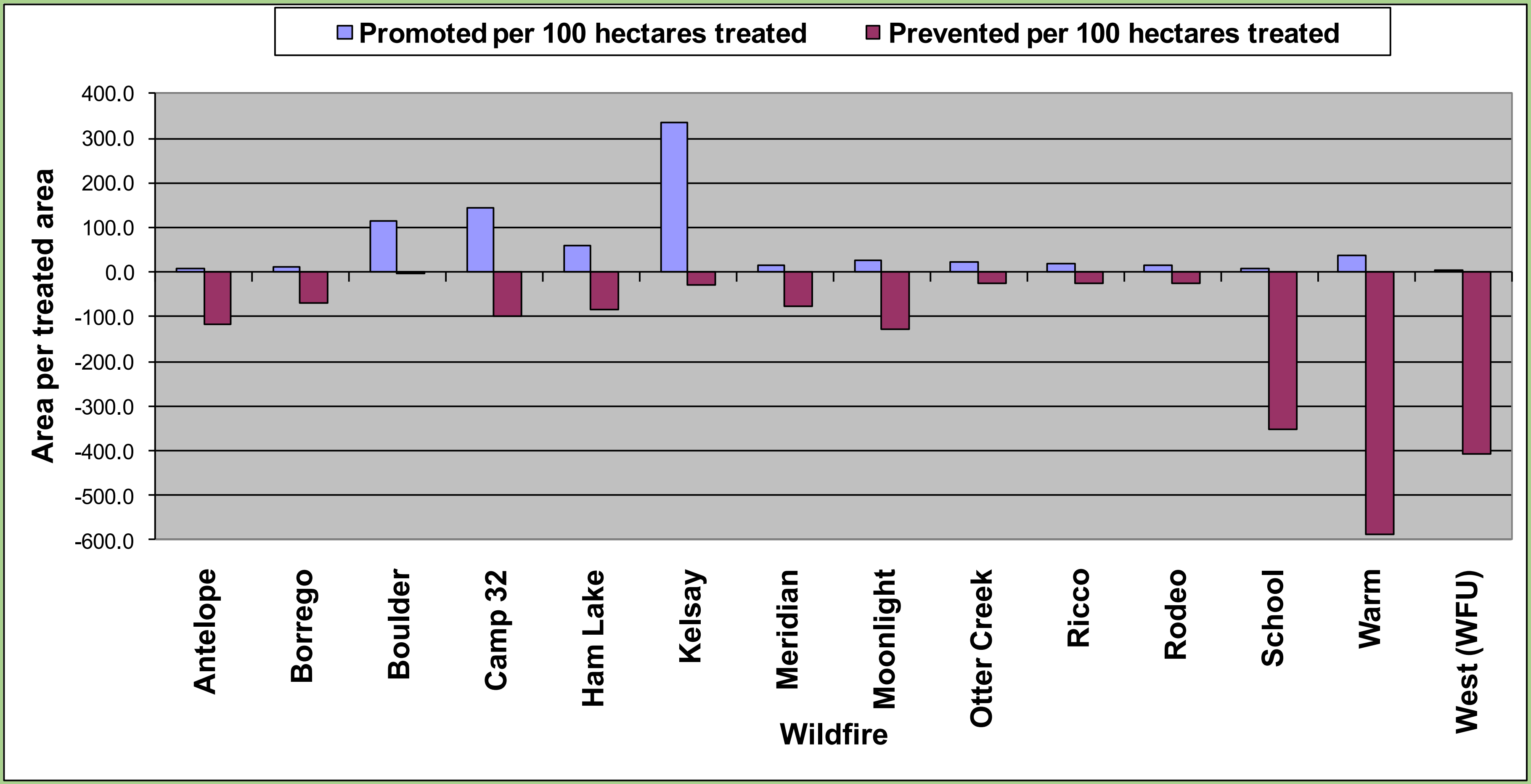
Balancing Risk



Weighting Risk



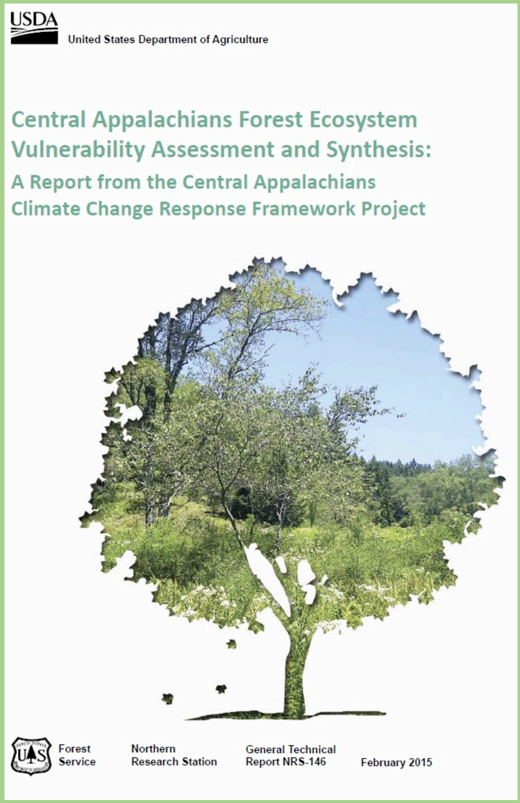
Estimating Fuel Treatment Effectiveness?



Central Appalachia

Current major stressors and threats to forest ecosystems in the region are:

- Fragmentation and land-use change
- Shifts in natural disturbance regimes
  - (e.g., shifts in drought or flood frequencies)
- Forest diseases and insect pests
- Nonnative plant species invasion
- **Shifts in fire regime**
- Mineral, gas, and wind energy development
- Erosion and sedimentation



(General Technical Report NRS-146 2015)

Pertinent Points Raised

- **Climate conditions will increase wildfire risk by the end of the century**
- **Increased fire frequency and harvesting will accelerate shifts in forest composition across the landscape**
- **Fire-adapted ecosystems will be more resilient to climate change**

- **Fire could have a greater influence because it can be a catalyst for change in vegetation, perhaps prompting more rapid change than would be expected based only on the changes in temperature and moisture availability**
- **Climate change is projected to increase the intensity, scope, or frequency of some stand-replacing events such as wildfire, ice storms, and insect outbreaks, promoting major shifts in species composition where these events occur**

(General Technical Report NRS-146 2015)

Maryland Greenhouse Gas Emissions Reduction Act

- Adopted in 2009
  - Reduce GHG by 25% by 2020
  - Reauthorized in 2016 and extended to reduce GHG by 40% by 2030
  - Must support healthy economy and create new jobs
- **Forestry expected to account for 13% of these reductions**
  - Managing forests to capture 1.80 $MMtCO_2e$
  - Planting forests in MD (1.79 $MMtCO_2e$)
    - 30,000 acres now, 47,000 acres by 2020
- Expecting little carbon sequestration from the western part of the state given its mature forests
- **Not currently factoring in any aspect of climate change for forestry estimates**

Thoughts

- The future will be a time of increasing ecological stress due to climate change (in addition to ongoing land use and management issues)
- There will be growing climate pressure on forests to alter composition and/or locations as disturbance regimes and climate niches shift
- Times of rapid change are <u>not</u> periods of increasing carbon accumulation in long-lived forests
- Existing fire regimes favor ‘fire-sensitive’ species, meaning future fires may result in unexpectedly high mortality rates
- Management efforts will have to become more spatial, adopting localized and site-specific approaches that account for forests that are less resilient to future disturbances
- Managers also need to account for future climate conditions. Does it makes sense to manage for today or tomorrow?

Questions?