Ecology: Fuels, Fire, and Smoke

AMSET
ADAPTIVE MANAGEMENT SERVICES ENTERPRISE TEAM
U.S. Forest Service

Carol Ewell, USFS, AMSET, FBAT

Fire Behavior Assessment Team

Reference Fire Regimes

Ecological Background

Fire Regime

repeated patterns of fire over time

Time

- Frequency/Return Interval
- Seasonality

Space

- Scale (how big are fires)
- Spatial pattern (patchiness)

Magnitude

- Intensity – heat/smoke
- Severity – mortality/structure

Reference fire regime groups (website: http://frames.nbii.gov)
Fire Regime Condition Class Guidebook (FRCC 2010)

Fire Regime Group	Frequency	Vegetation Severity	Severity Description
I	0-35 years	Low - mixed	Generally **low-severity** fires **replacing less than 25% of the dominant** overstory vegetation; can include mixed severity fires that replace up to 75% of the overstory
II	0-35 years	Replacement	High-severity fires **replacing greater than 75% of the dominant overstory**
III	35-200 years	Mixed - low	Generally mixed-severity; can also include low-severity fires
IV	35-200 years	Replacement	High severity fires
V	200+ years	Replacement - any severity	Generally replacement-severity; can include any severity type in this frequency range

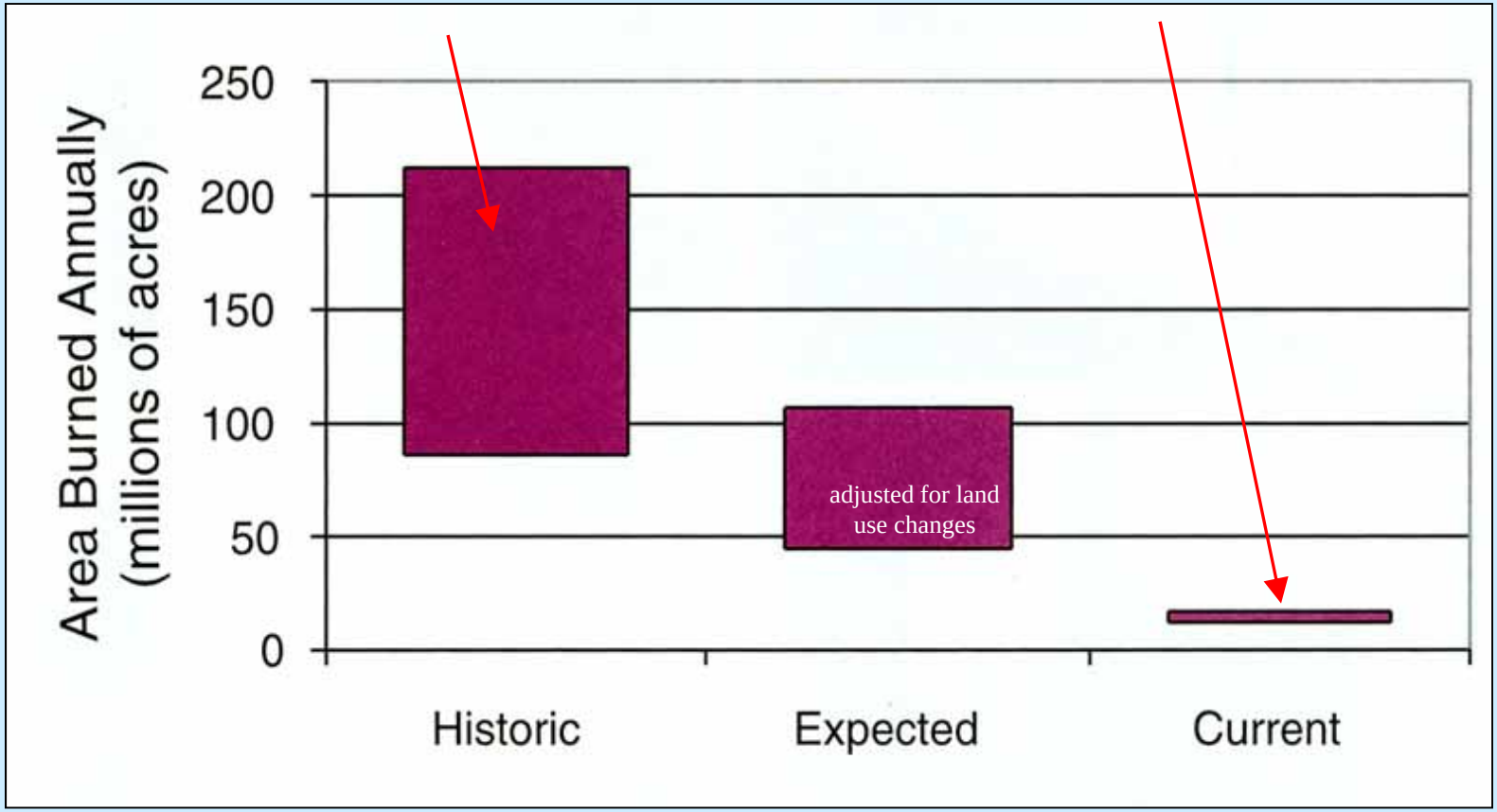
Historical air quality records & information

Frequent fires contributed to **lower fuel loading, fuel continuity** and capacity for **smoke production** in average years

- Old diaries from the 1800s describe **days upon days of smoke and haze in the air**
- When the Spanish arrived in the **Los Angeles Basin, hazy smoke was prevalent**

Estimated Acres Burned

200-400 years ago vs. current era

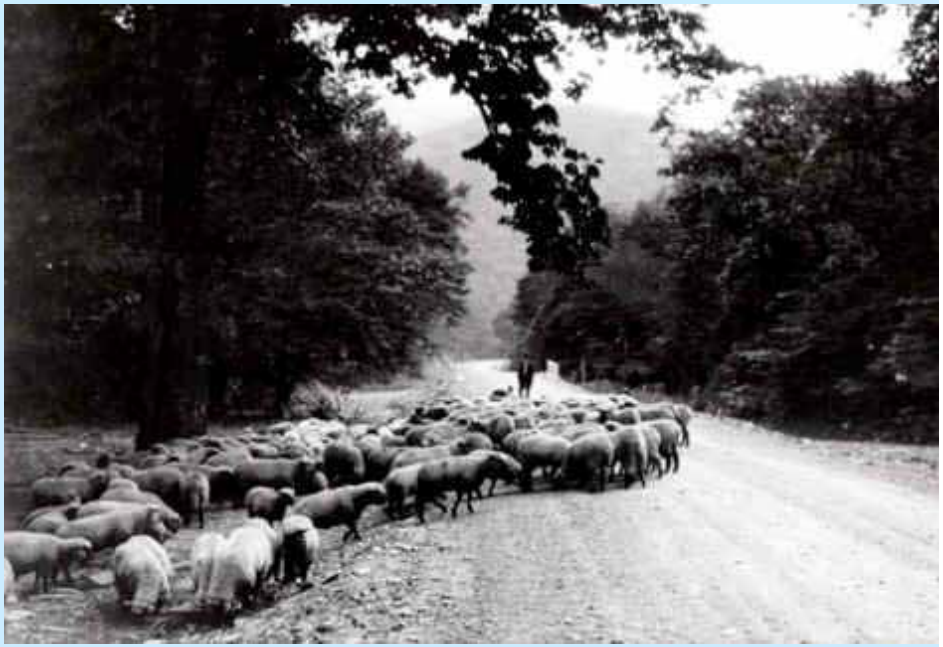


- Historically, 10 times more area & 8 times more biomass burned

Leenhouts (1998)

Background to current situation

- Pre-settlement fires: mostly lightning & indigenous burning
- Indigenous burning prohibited: *threatened* agricultural, ranching, timber & gold mining activities of new settlers (1st regulation in 1793)
- European Settlement & Land use trends - used fire for land clearing & increase forage for grazing (decreased surface fuels & fire occurrence), vs. timber industry risks



Policy & Perspectives

- **Regional fire years in early 1900s**
  - Forest Fires Emergency Act (1908, suppression cost reimbursement)
  - 10 AM policy (1935)
  - Full suppression & reduction in annual acres burned
  - Emphasis on protecting timber reserves
- **Air operations & suppression skills grew**
  - Smoke jumpers (1940), hotshots (1948), inmate crews (1949), water, retardant & helicopter use (1956)
- **Smoke was not a major national issue until 1970s**
  - Increase in the number of people living in the wildland urban interface

Policy & Perspectives (con.)

- **Ecological importance of fire acknowledged**
  - **Wilderness Act (1964)**
  - **“fire use” initiated (1971)**
  - **10 a.m. policy abandoned (1978)**
  - **Forest Fires Emergency Act repealed**
  - **prescribed fire (1940s, 1961)**
- **Yellowstone fires of 1988**
  - **public outcry, 1 year suspension of fire use, slow recovery of fire use program**
  - **fire management plan requirements established**
- **National Fire Plan (2000), Healthy Forests Restoration Act (2003) & National Cohesive Strategy (2011)**

Early Observations

1943 Harold Weaver reported:

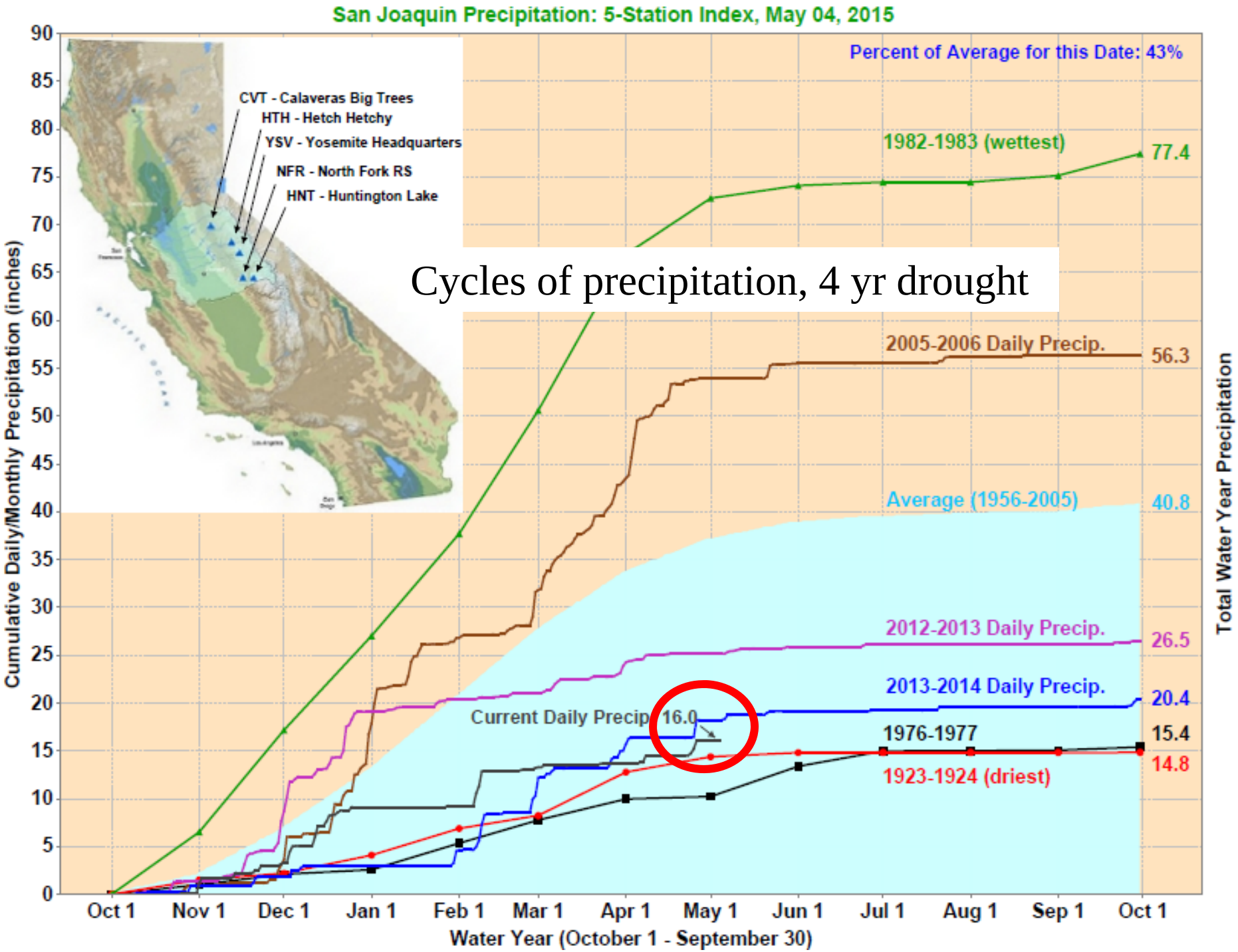
"complete ***prevention of fires*** *in the ponderosa pine region has certain* ***undesirable ecological*** *and silvicultural effects and that conditions are* ***already deplorable*** *and* ***becoming increasingly serious*** *over large areas"*

Recurring fires are often an essential component of the natural environment

*Many ecosystems in North America are **fire dependent**,* and **periodic burning** is ***essential*** for healthy ecosystem function

Rim Fire, site 9

Current Conditions & Challenges



Cycles of precipitation, 4 yr drought

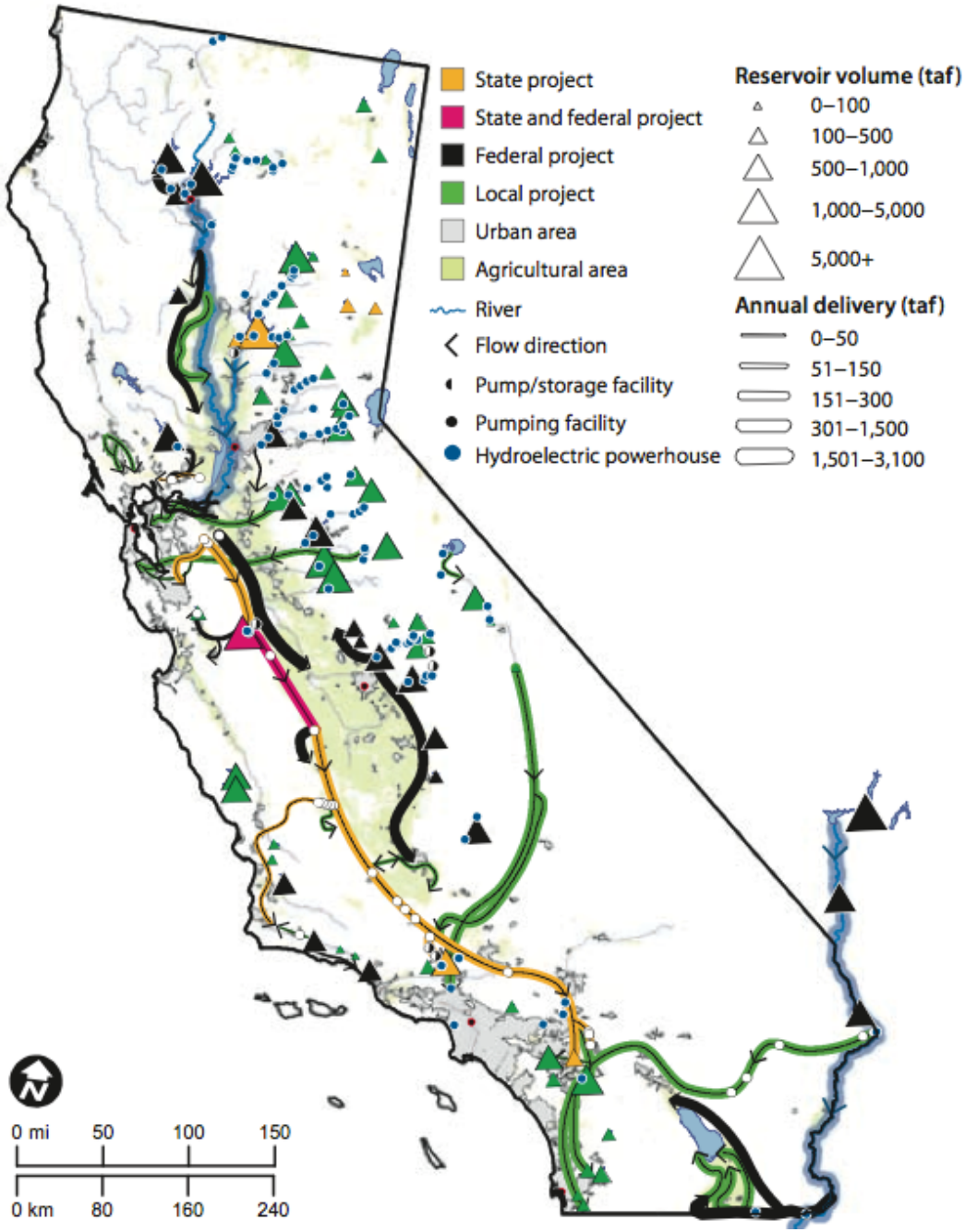
Current CA Situation (con.)

Water Supply at Risk

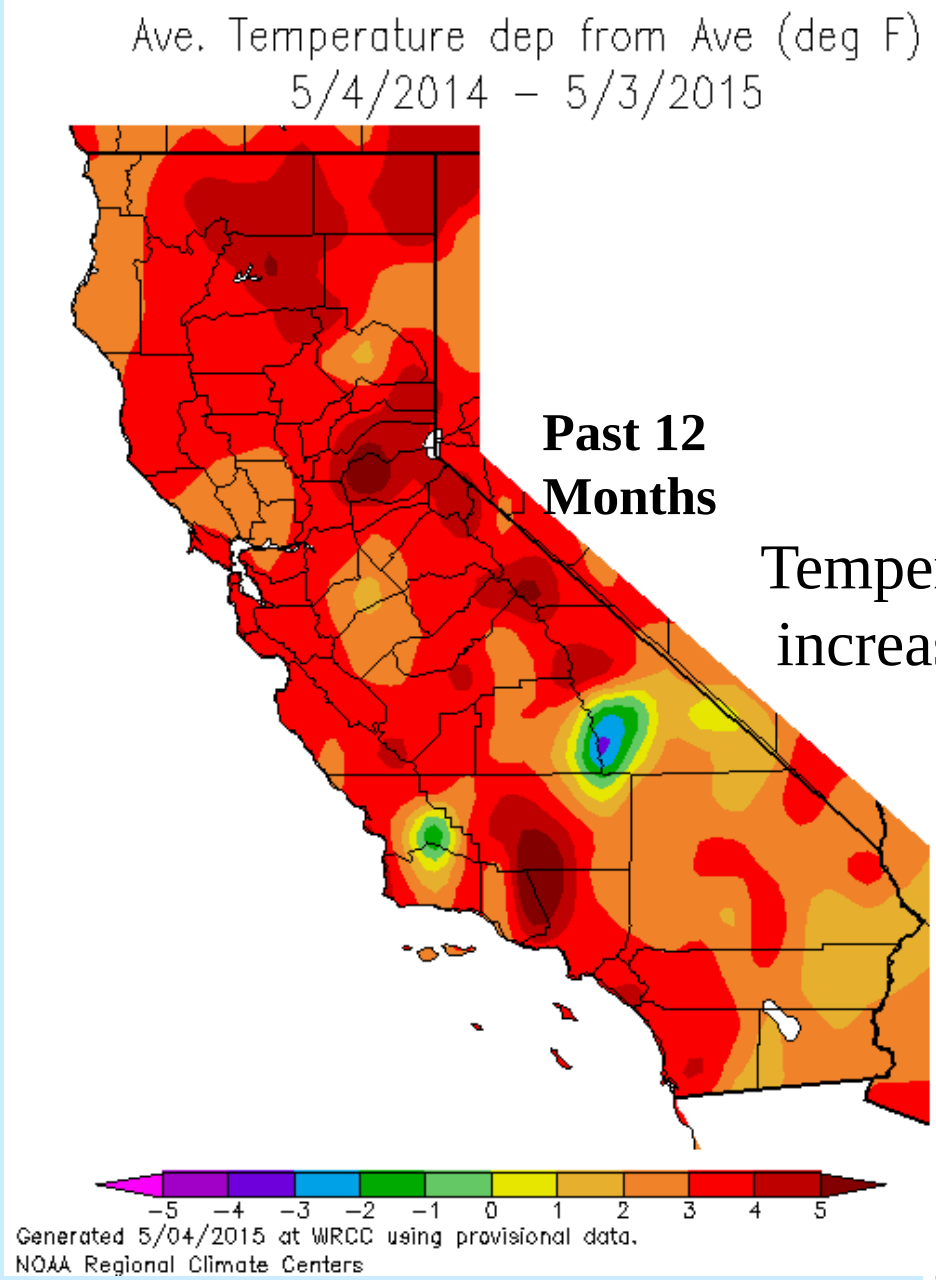
Sierra Nevada Region has more than 60% of CA developed water supply

http://users.humboldt.edu/ogayle/hist383/Water.html

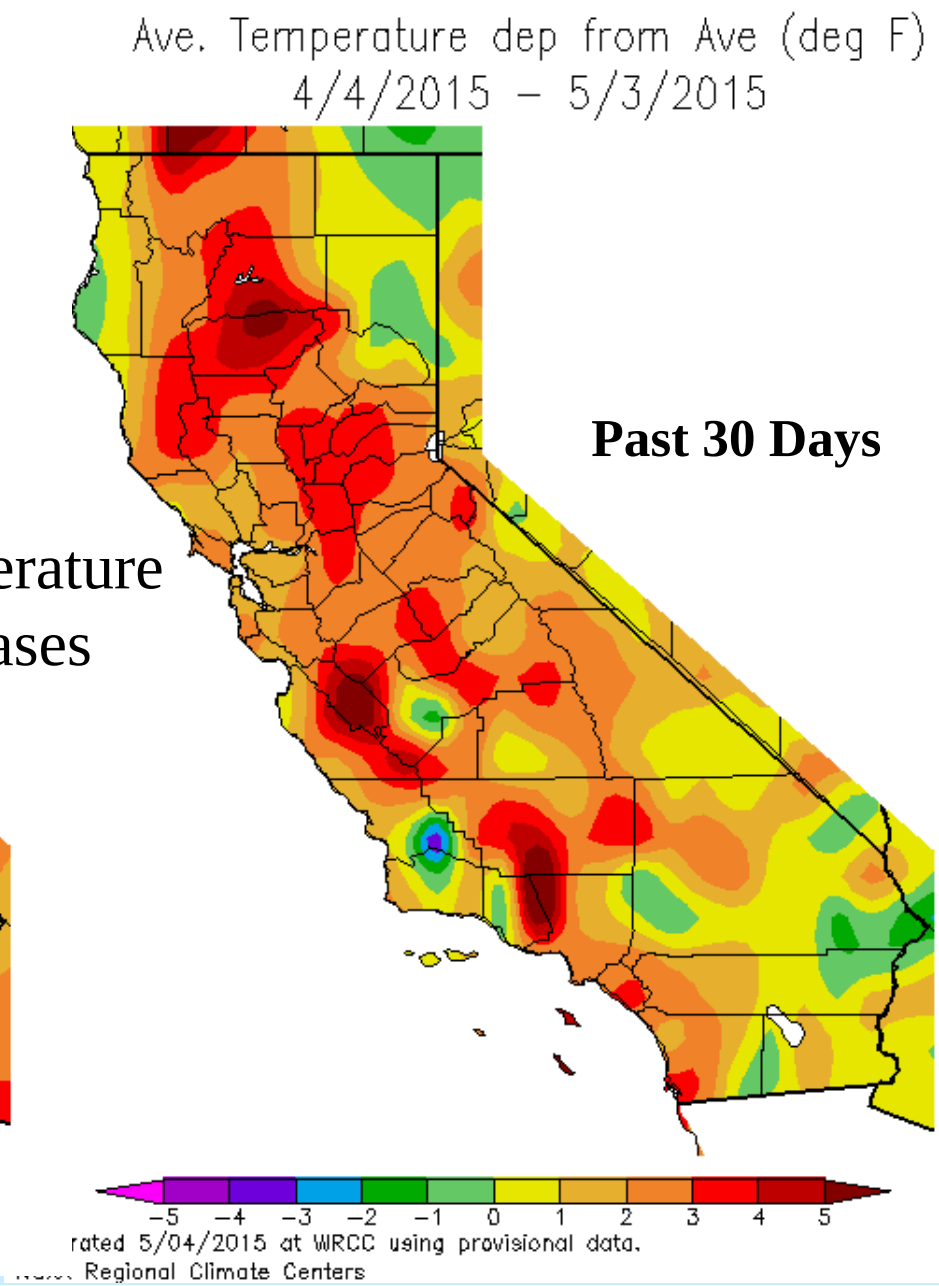
California has an elaborate network of conveyance and storage infrastructure, controlled by different agencies



Temperature Departure from Average



Temperature increases



Current CA Situation (con.)

Loss in carbon storage from tree mortality

•high severity/large wildfires

•drought/insect caused tree death *(USFS Forest Health Protection Survey, April 2015)*

Ponderosa and gray pine mortality south of Sonora near the Stanislaus NF.

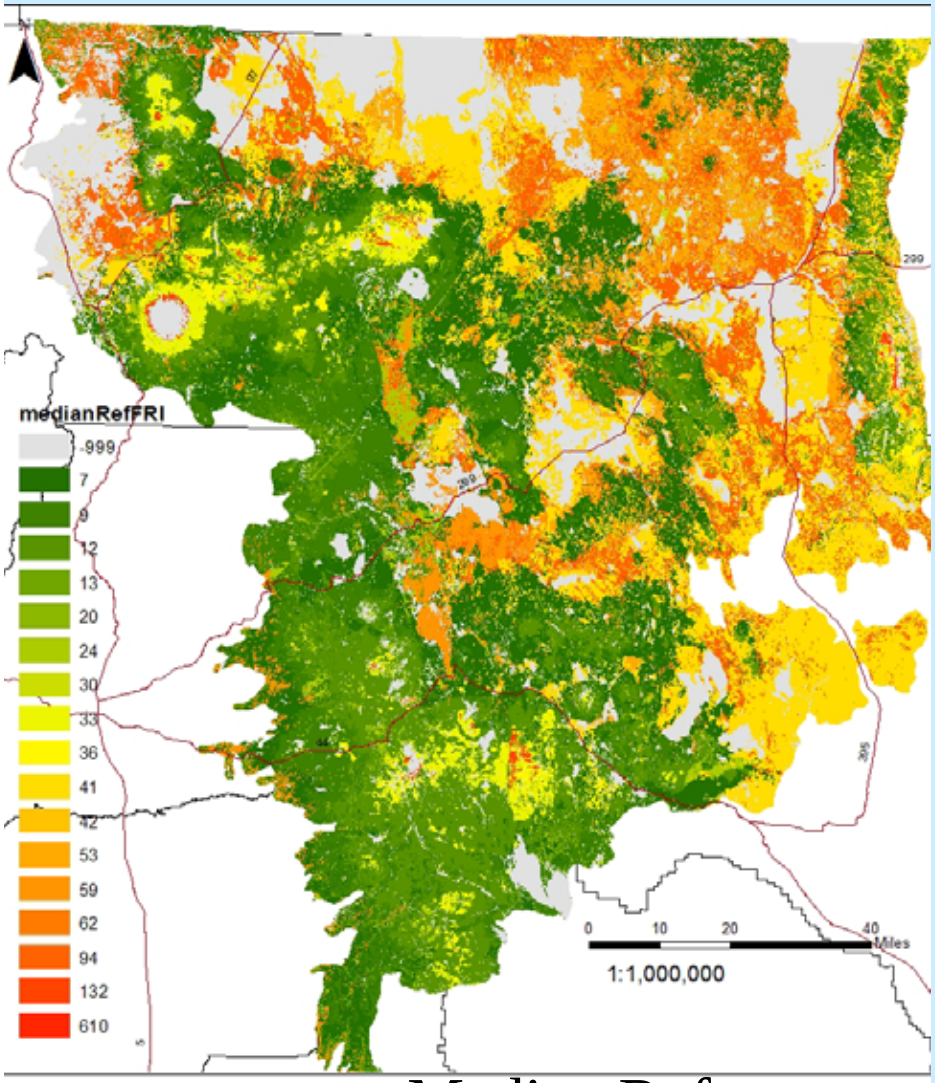
Figure 2. Intense pine mortality near Goodmill on the Hume Lake Ranger District of the Sequoia NF .

Current Conditions: fuels

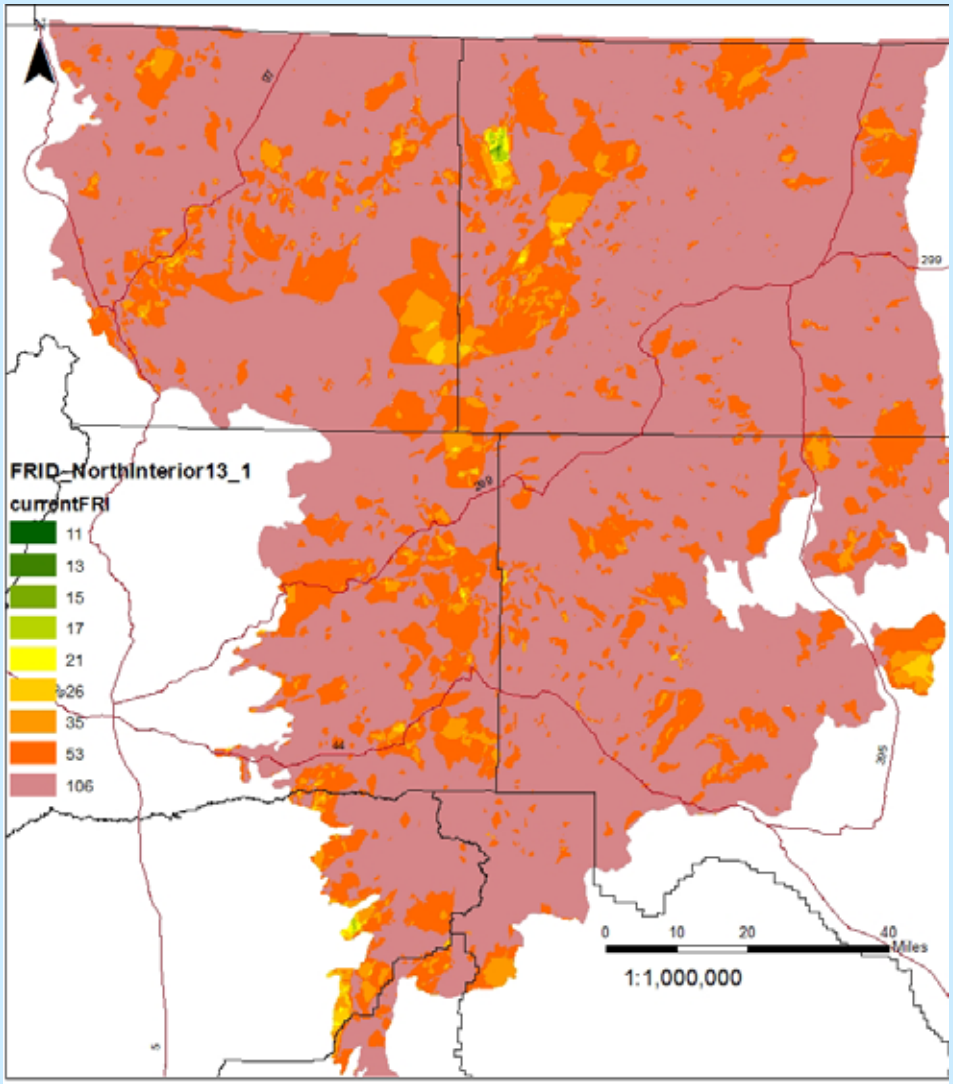
- **More fuels**
  - live fuels – understory & overstory
  - surface fuels – activity & natural
  - duff loading, 1000 hour+ fuels
- **Increased fuel continuity**
  - within stands & across landscapes

CA Fire Regime Patterns

Northern Interior section, **Fire Regime Intervals**



Median Reference



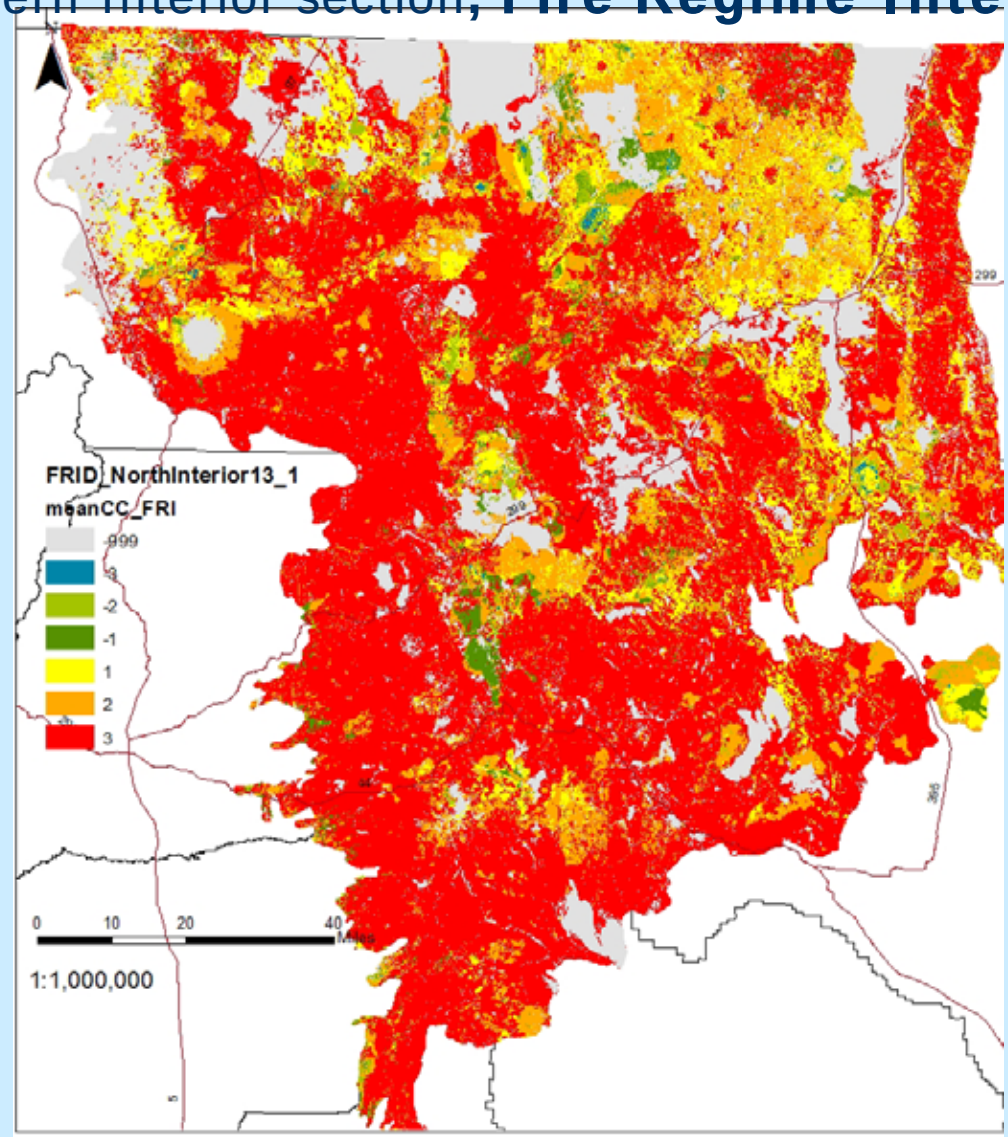
2013

http://www.fs.usda.gov/main/r5/landmanagement/gis

CA Fire Regime Patterns

Northern Interior section, **Fire Regime Intervals**

Mean Condition Class



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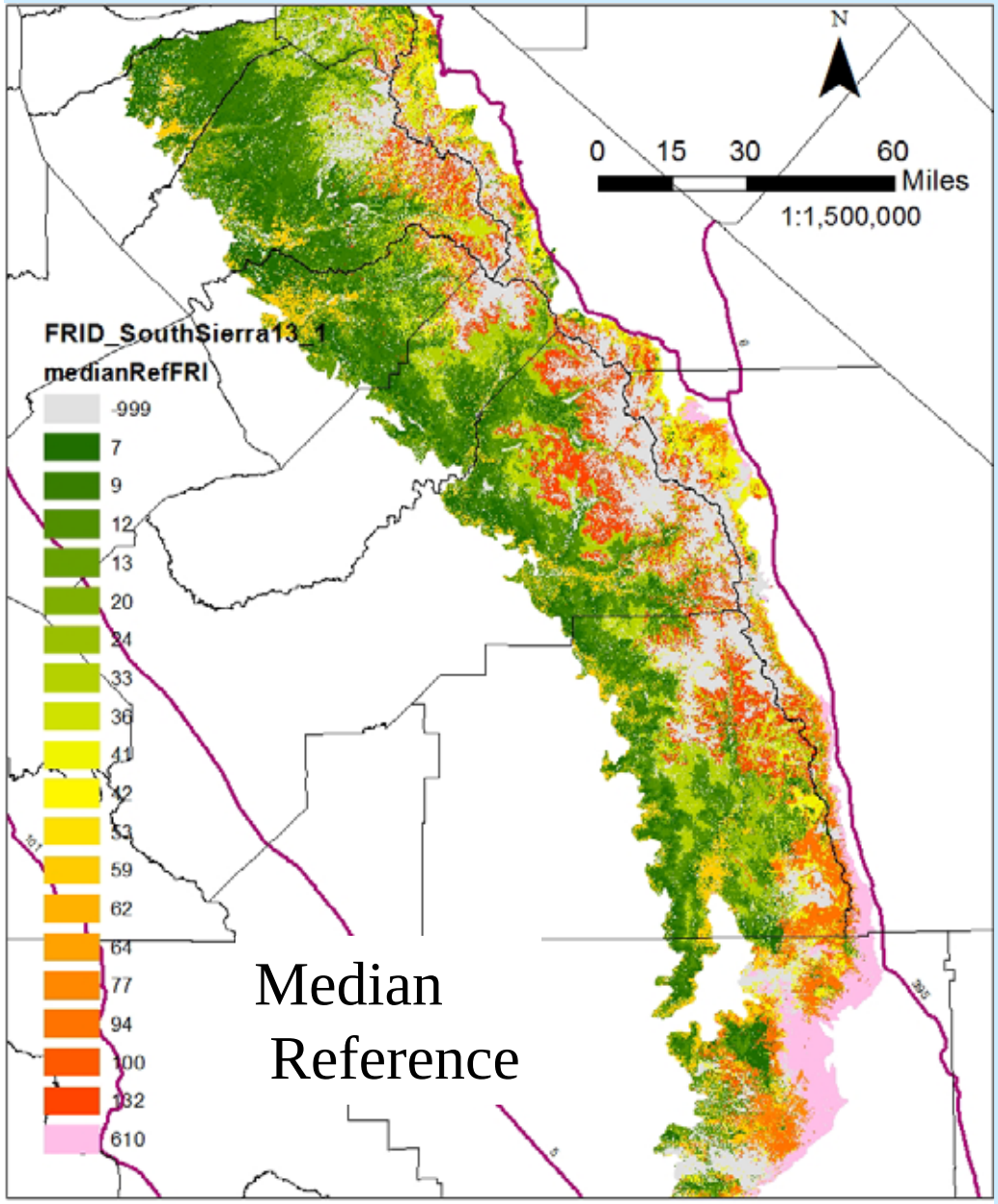
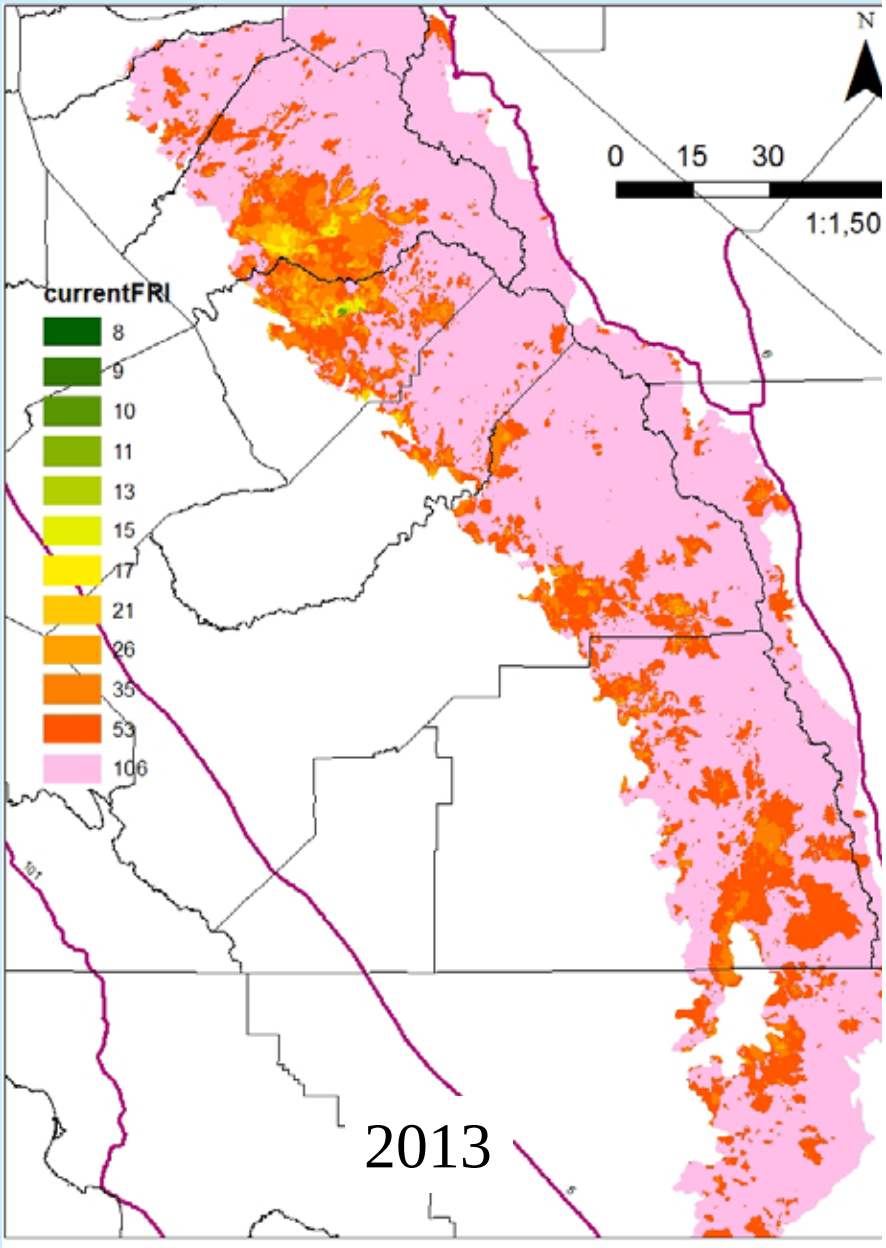
CA Fire Regime Intervals

Southern Sierra section, **Fire Regime Intervals**

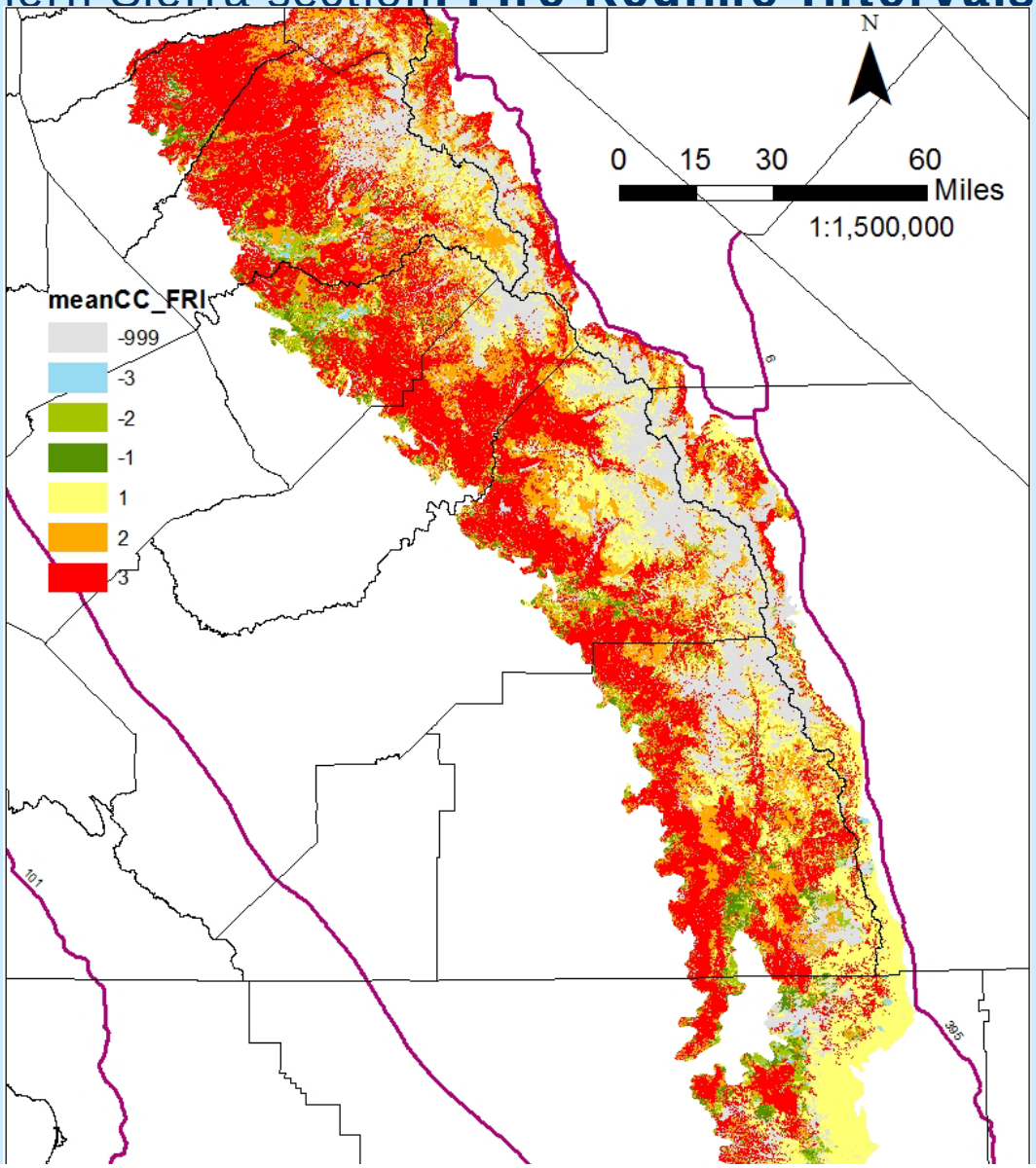




CA Fire Regime Intervals

Southern Sierra section. **Fire Regime Intervals**

Mean Condition Class



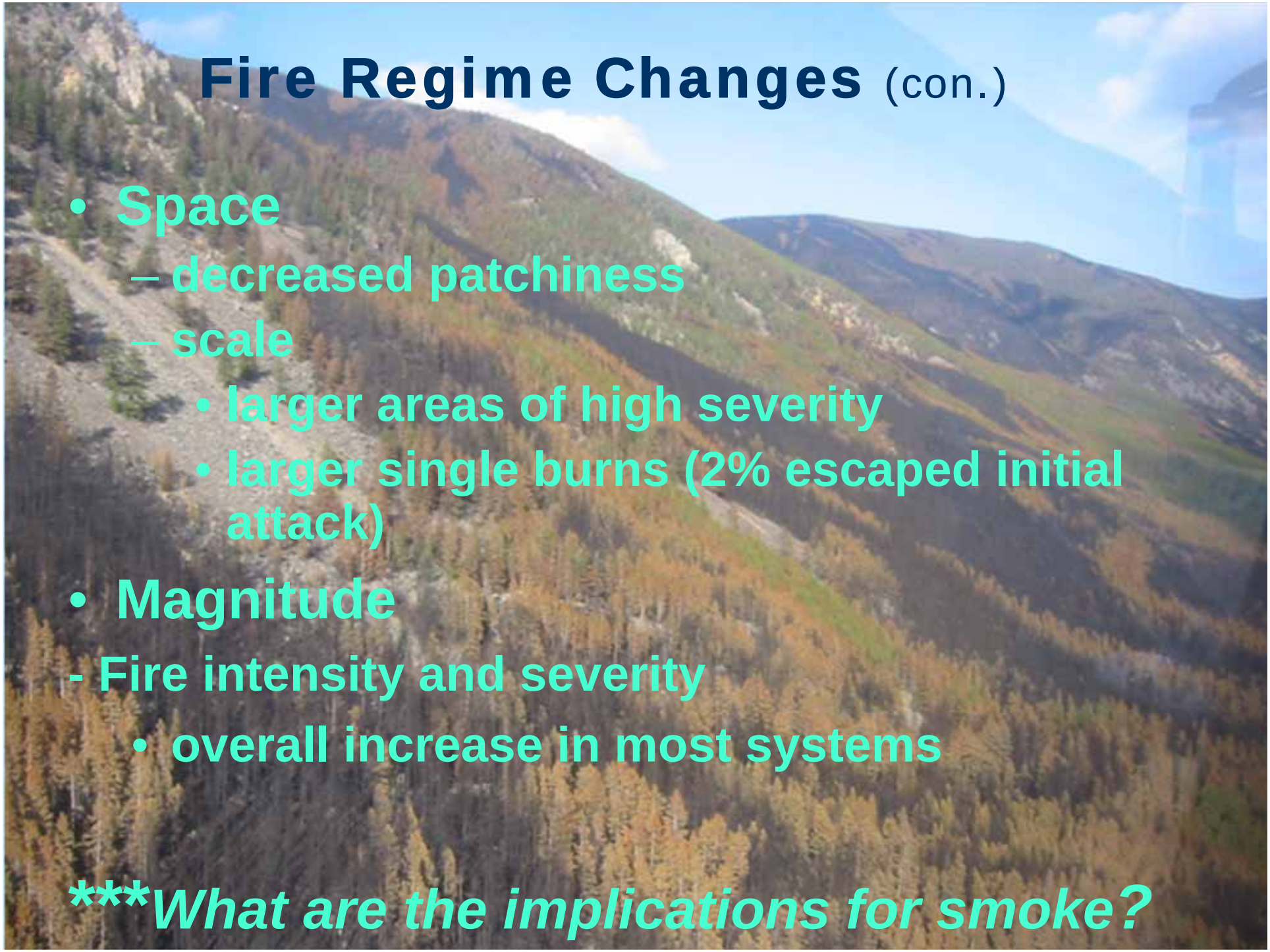
Index to show departed from reference conditions

Fire Regime Changes

- **Time/Seasonality**
  - **expanded seasonality**
    - Prescribed burning & climate cycles/change
  - **“extreme” conditions (temp, wind, fuel moisture)**
  - aggressive **fire suppression during natural season of burning**

Fire frequency/return interval

- **decreased in most systems**
- **increased in some systems**
  - **deserts, chaparral/WUI zone**



Fire Regime Changes (con.)

- **Space**
  - **decreased patchiness**
  - **scale**
    - **larger areas of high severity**
    - **larger single burns (2% escaped initial attack)**
- **Magnitude**

- Fire intensity and severity

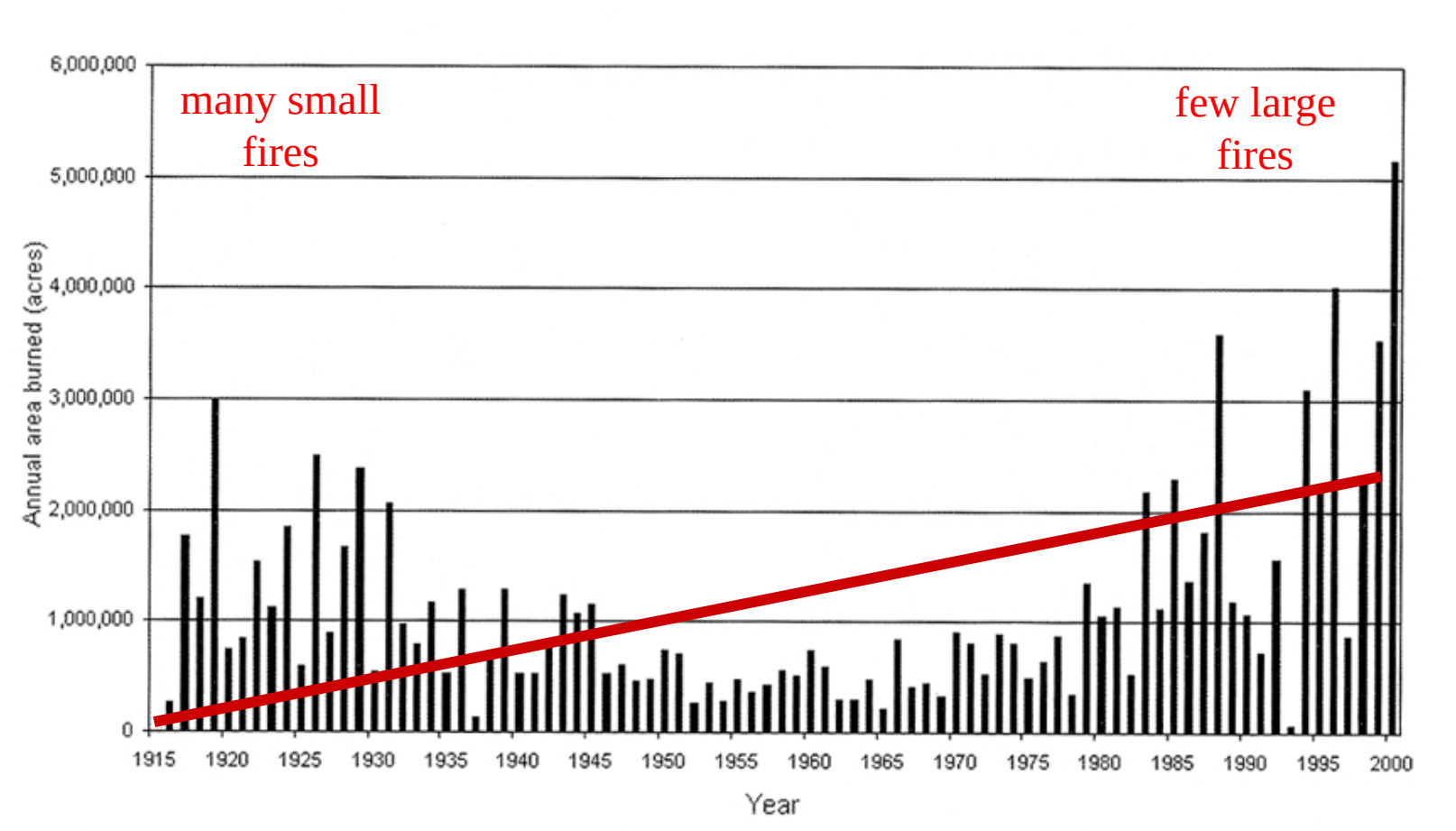
- **overall increase in most systems**

******What are the implications for smoke?***

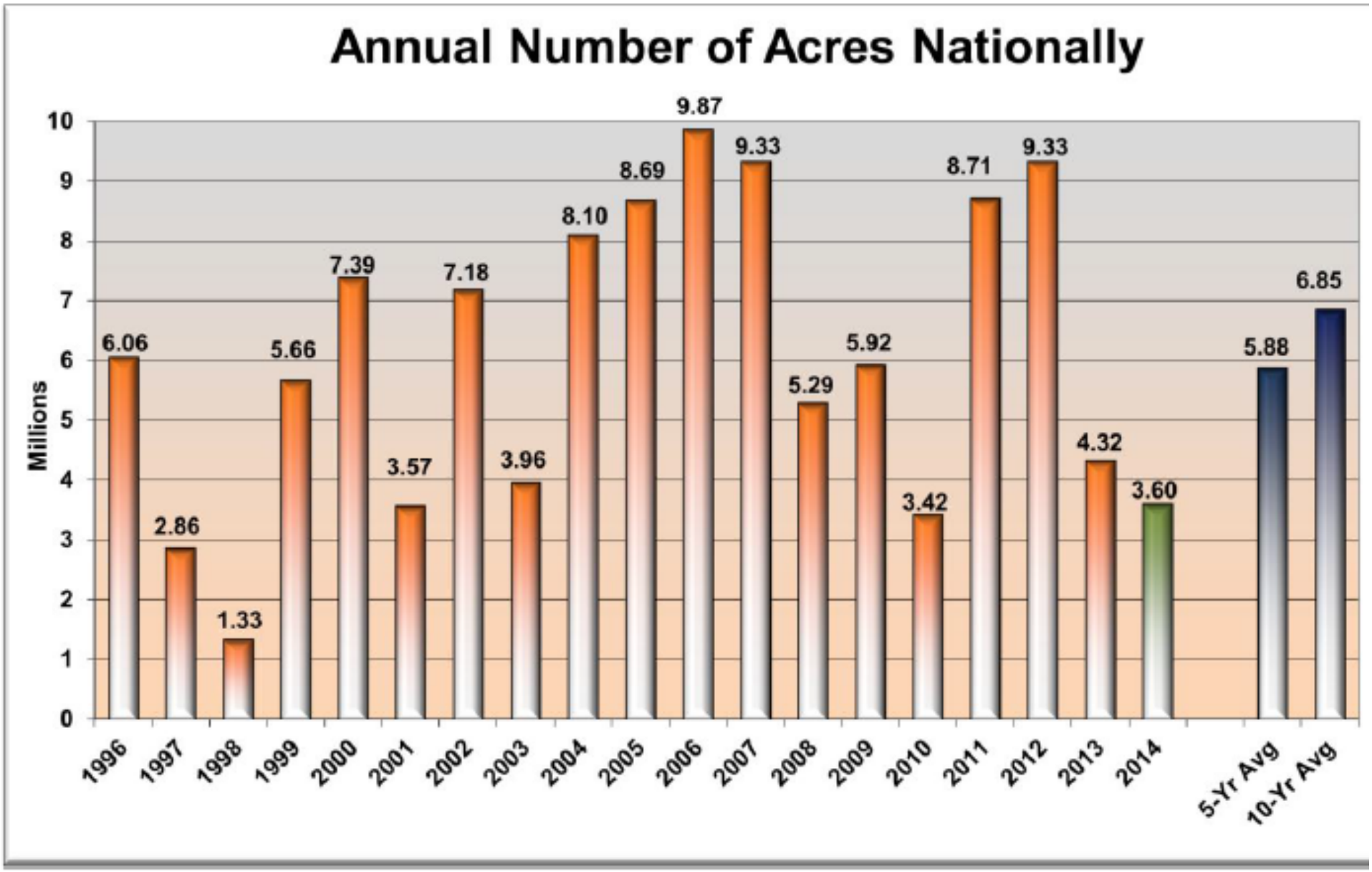
Fire Regime Changes

- Much more fire in the past on the landscape, compared to today
- Historically, fires were more frequent & occurred in the dry season
- Most fires are started by humans today
- Fires are becoming larger, more intense & severe

Humans Have Altered Fire Frequency and Severity



Consider: population density, policy, suppression, fuels, climate



wildfires reported to NIFC (2014)

Global Considerations

- **An increase in world wide land clearing**
  - Increased emissions & land type conversions contribute to global climate change
  - Slash & burn
- **Population increase**
- **Climate & drought cycles**
- **Increased CO_2 levels**

… may contribute to increased air quality regulations in the future

Malaysia

Mexico City

Lake in Sierra Nevada

Beijing

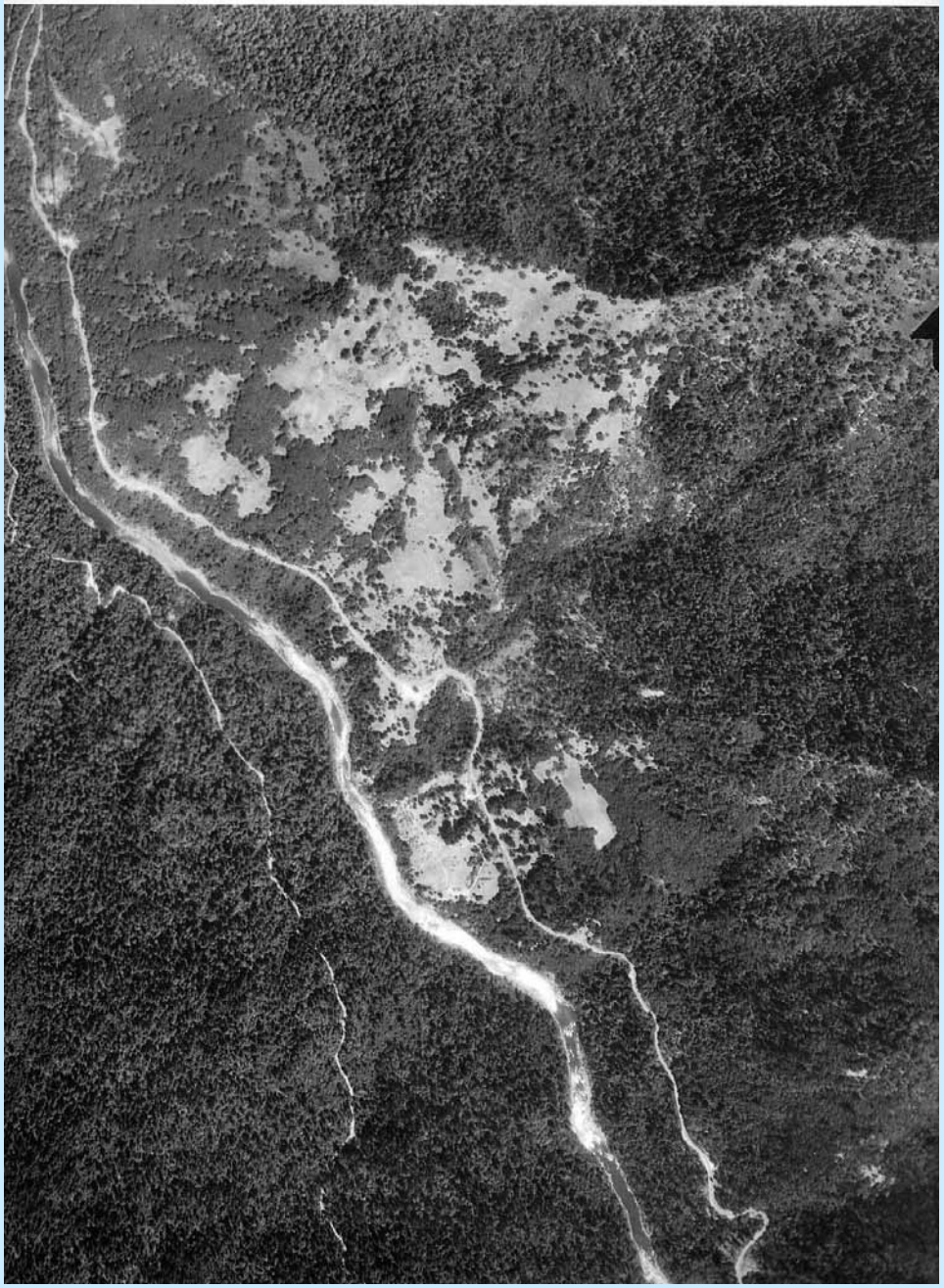
Does historical context matter?

It is important but…

- **Does it affect air quality regulations?**
- **Does it affect people's tolerance for smoke?**
- **EPA has recognized tradeoffs of restoring fire and air quality**
  - ***constant struggle to balance this***

Case Studies & DATA

Information not destined for comparison is probably not very useful…



Dearhorn Mountain-Lower Trinity River 1954 and 1990

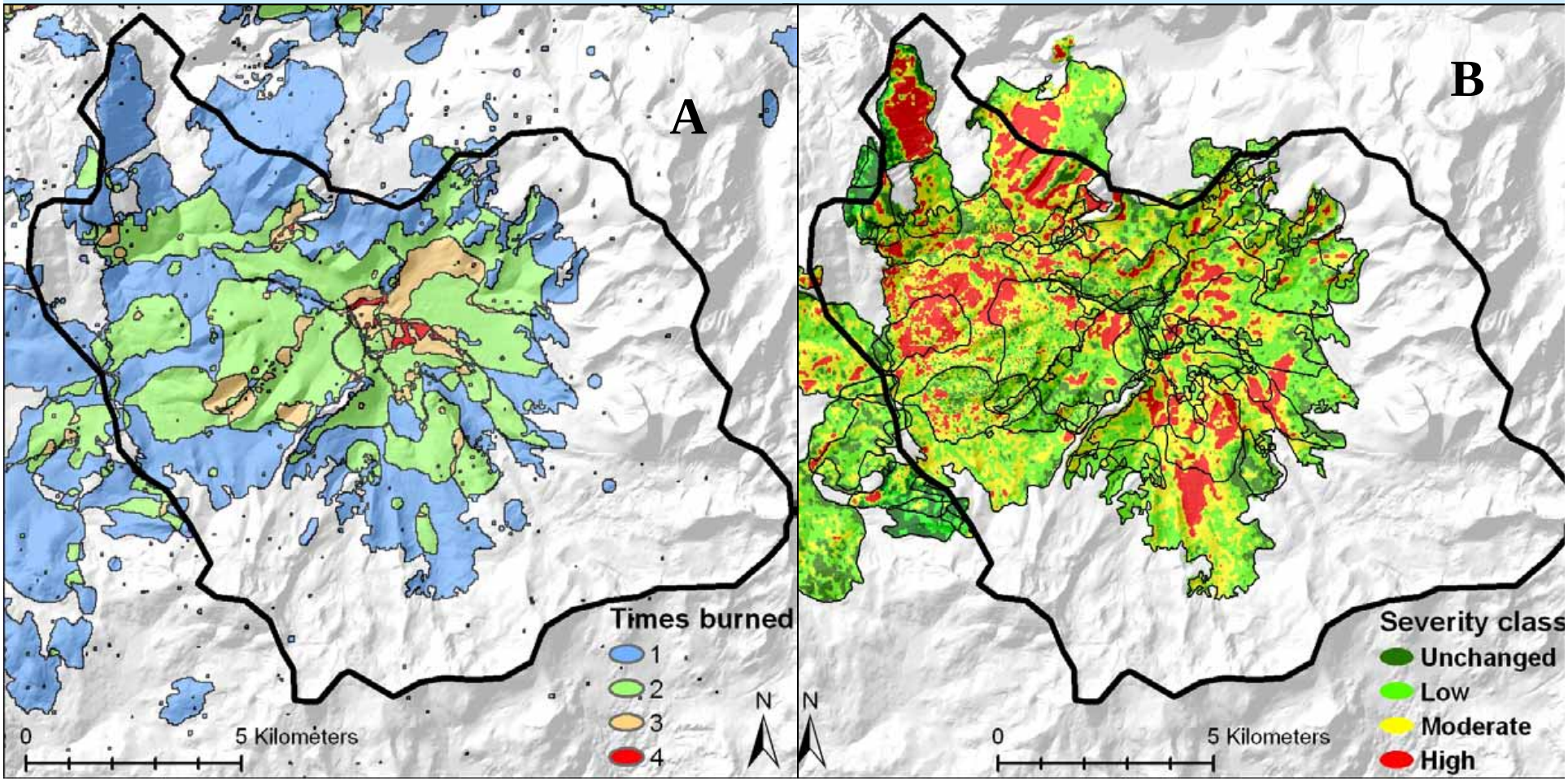
photos from California Indian Basketweavers Association, **supporter of prescribed burning**

2002 Cone Fire – Lassen NF Black's Mnt Exper. Forest
TREATED
low severity
UNTREATED
high severity
Which produced more smoke?
http://www.fs.fed.us/psw/topics/forest_mgmt/cone_fire/

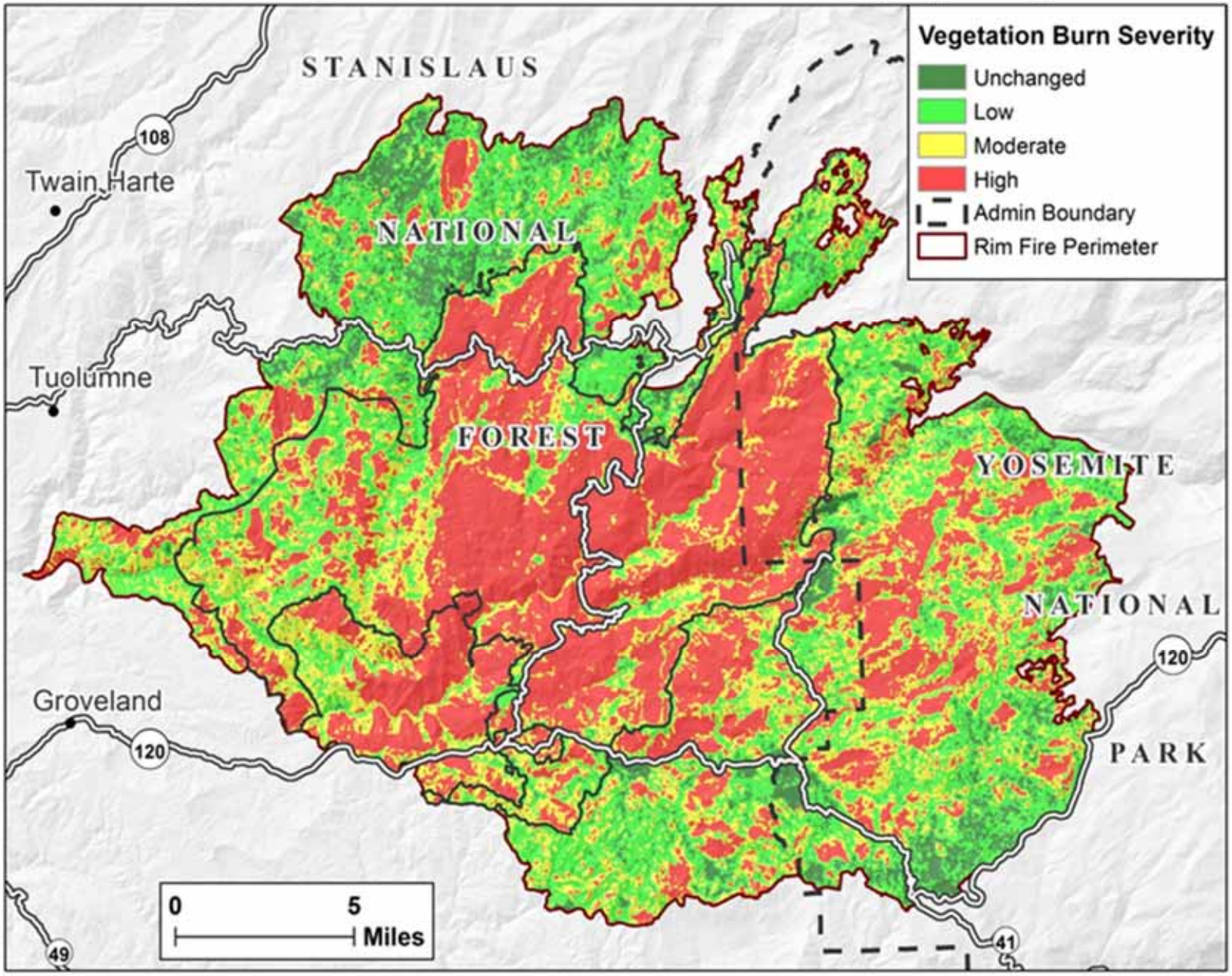
Yosemite NP, Illilouette Creek basin, Fire History (van Wagtendonk et al. 2012)

- 28 fires from 1973-2011
- Mixed severity across lands burned during this period
- Relatively low severity where fires burned 3 or 4 times

Land burned 0 to 4 times (A) **Composite fire severity** (B)



2013 Rim Fire, **Stanislaus NF & & Yosemite NP**
Preliminary Vegetation Burn Severity (CBI)



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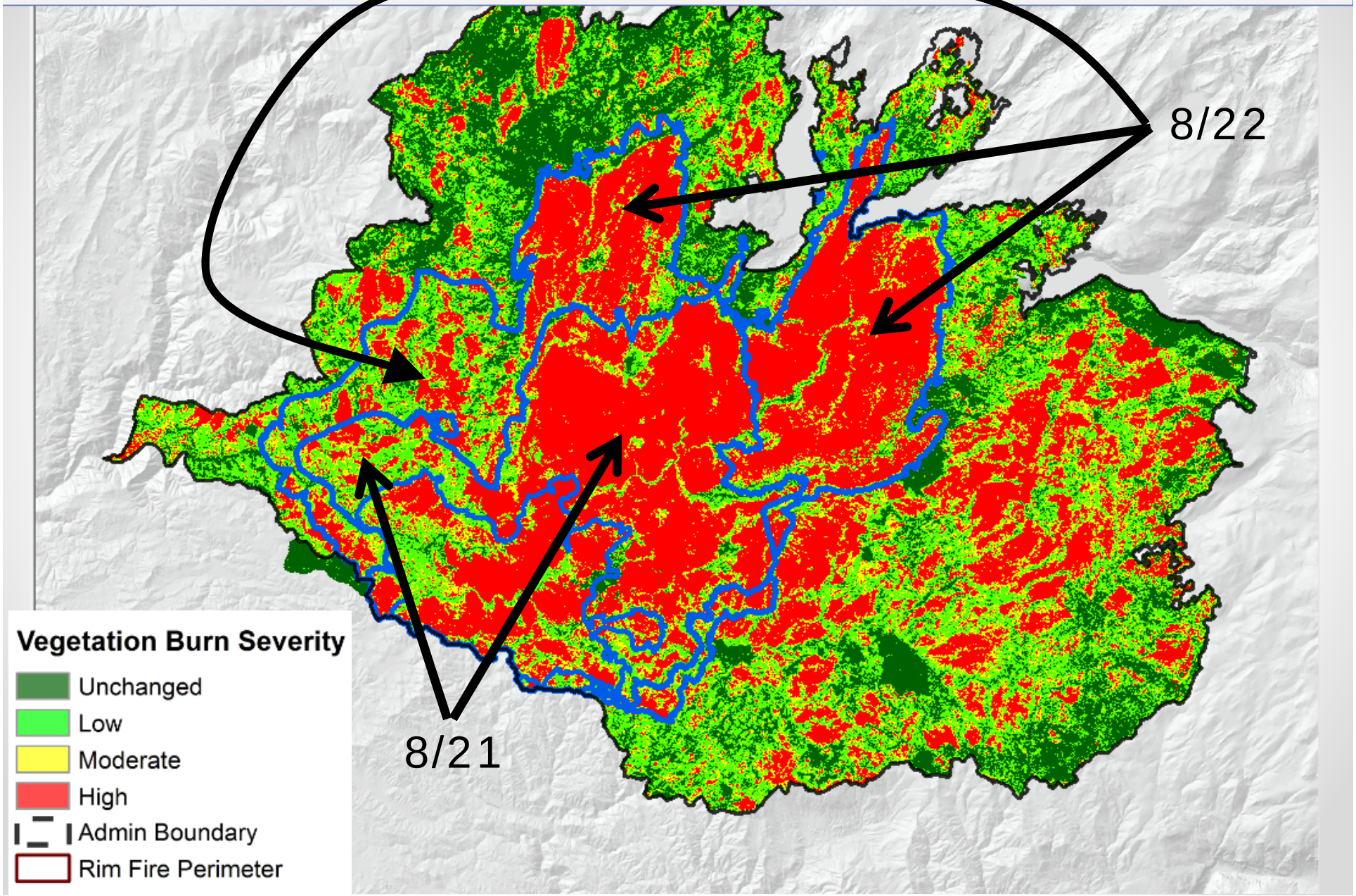
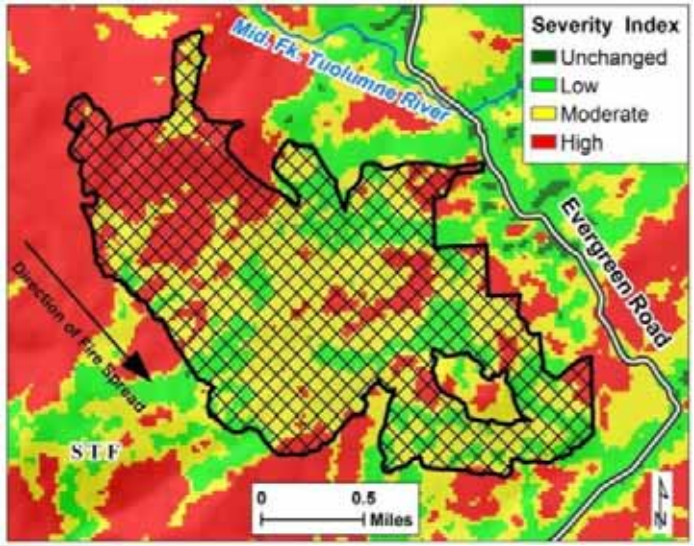
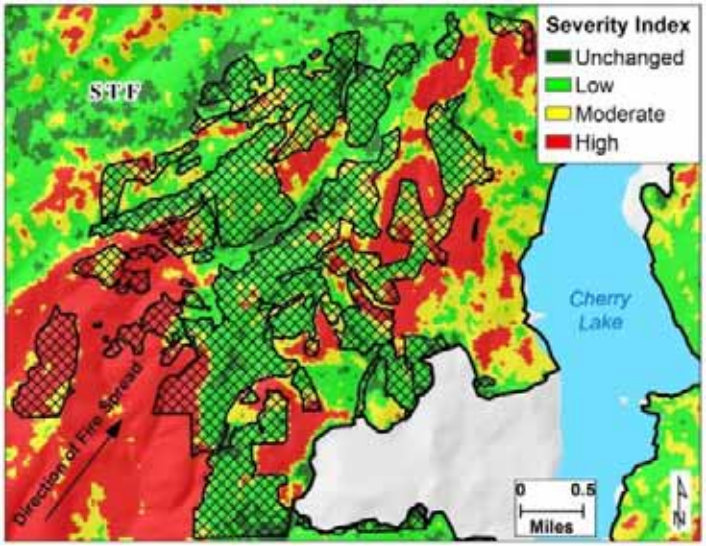


2013 Rim Fire - Fuel Treatment Effectiveness

Bear Mountain (1648 acres)
81% changed fire behavior

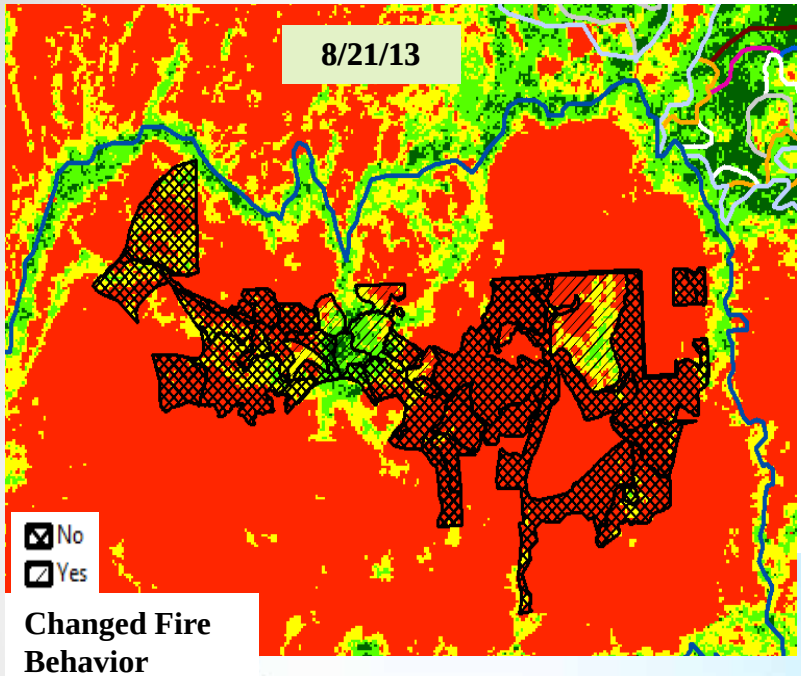


North Granite (3,300 ac)
75 % changed fire behavior

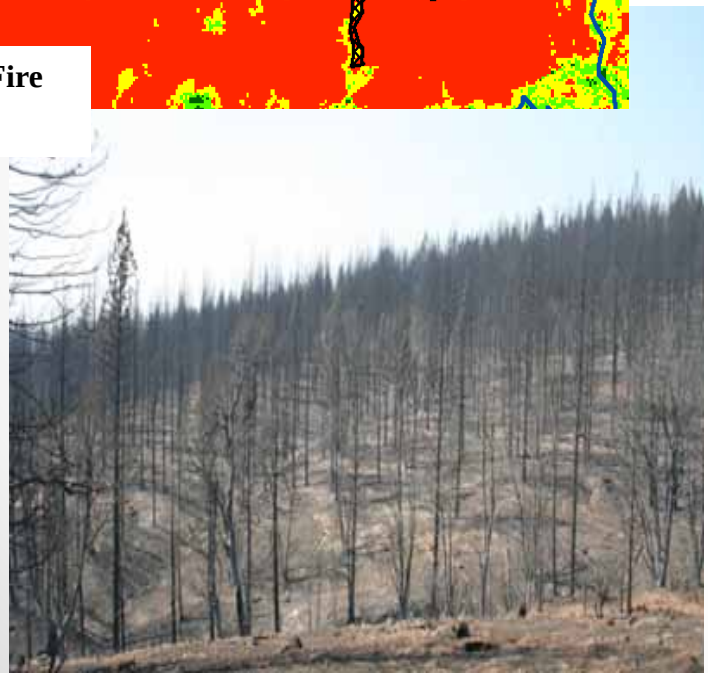


2013 Rim Fire - Fuel Treatment Effectiveness

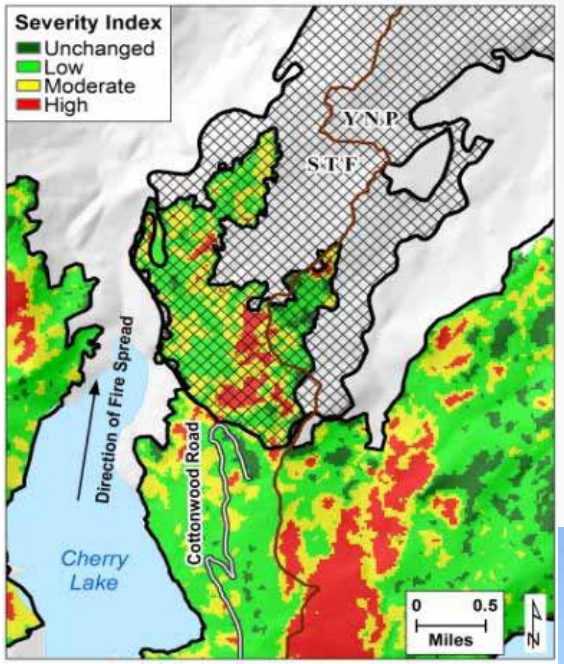
South Granite
13% changed fire behavior

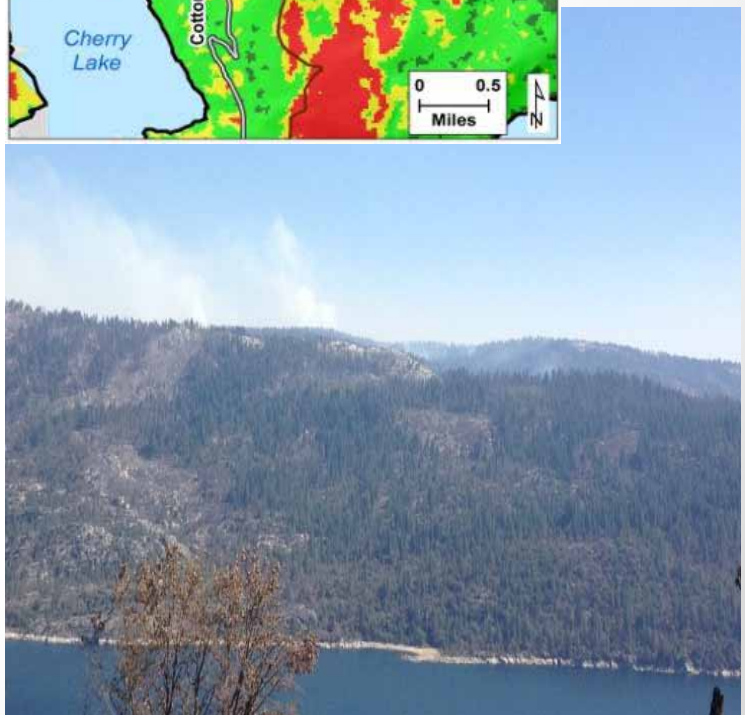


Changed Fire Behavior

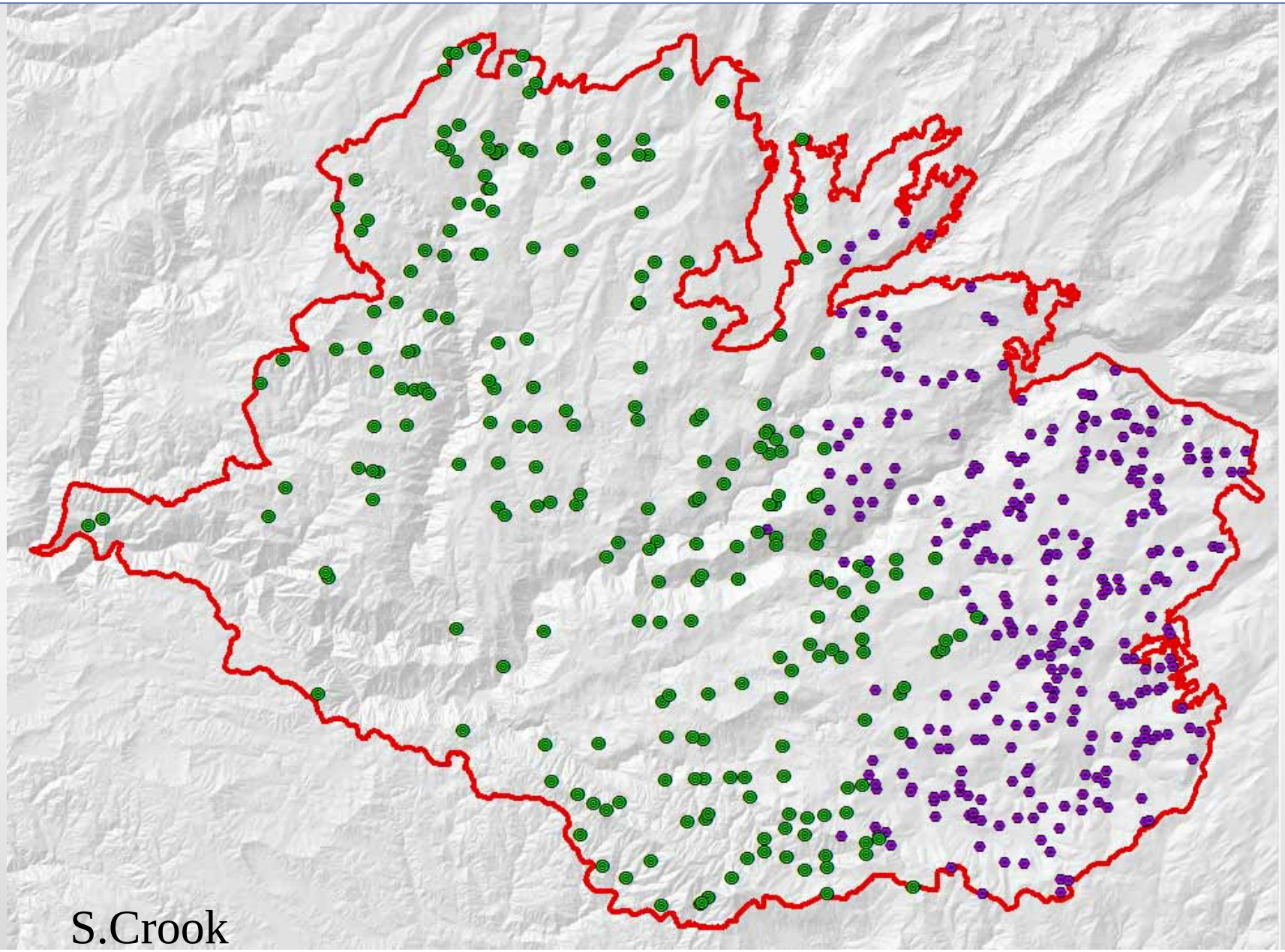


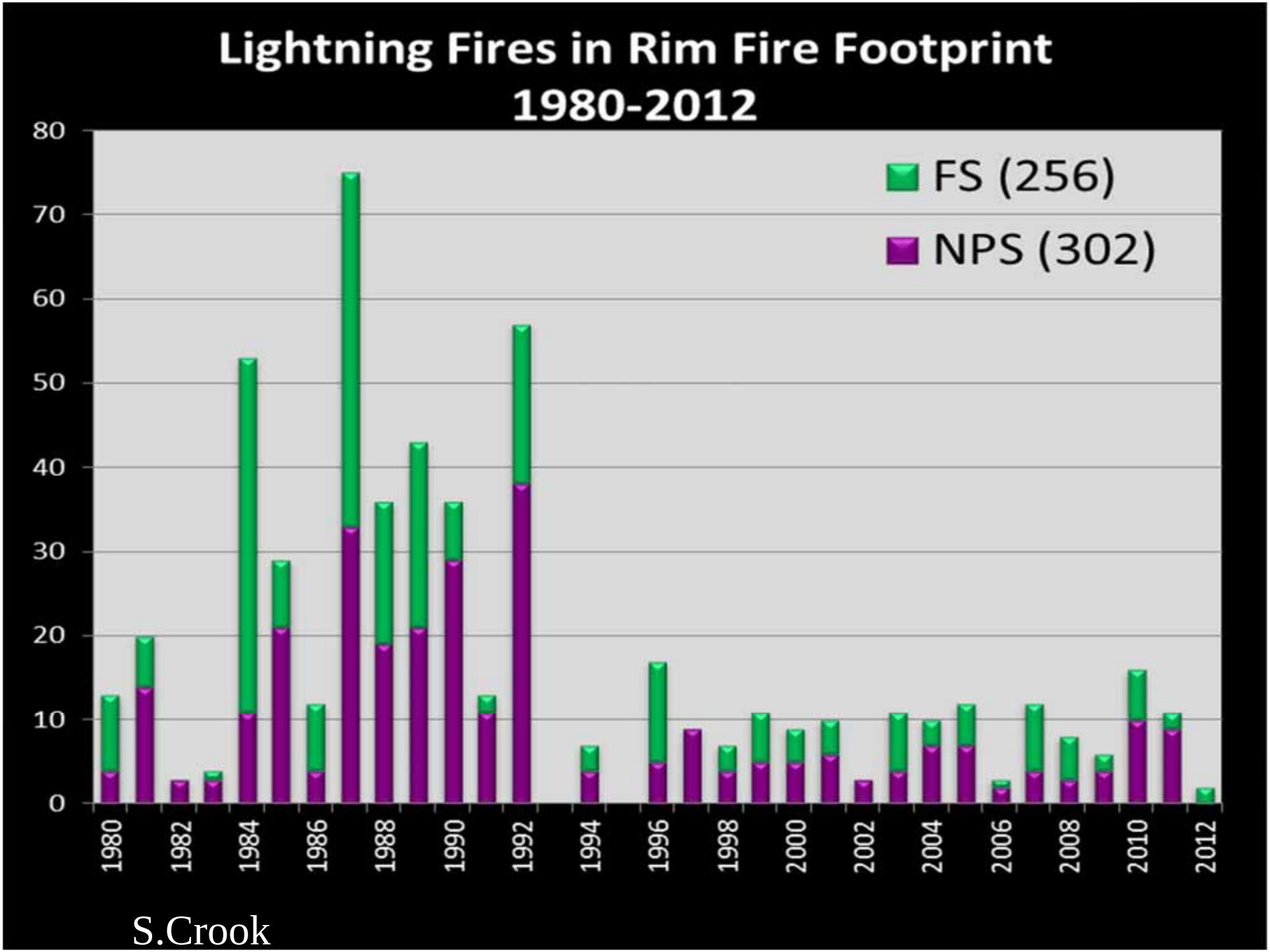
Kibbie Wildfire (1,400 ac)
73 % changed fire behavior





Lightning Fires inside the Rim Fire Footprint 1980-2012 (33 years, 558 fires)




Lightning Fires in Rim Fire Footprint
1980-2012
FS (256)
NPS (302)
80
70
60
50
40
30
20
10
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
S.Crook

Effects of Fire Exclusion to Ecosystems & Communities

- Larger wildfires
- Change in vegetative structure and composition
- Vegetation type conversion
- Invasive plants
- Increased risk to life, property & landscape function
- Increased risk to public health from emissions

Solutions

- **Prescribed burning**
- **Mechanical fuel treatments**
- **Unplanned wildfires: manage areas with resource benefit objectives**

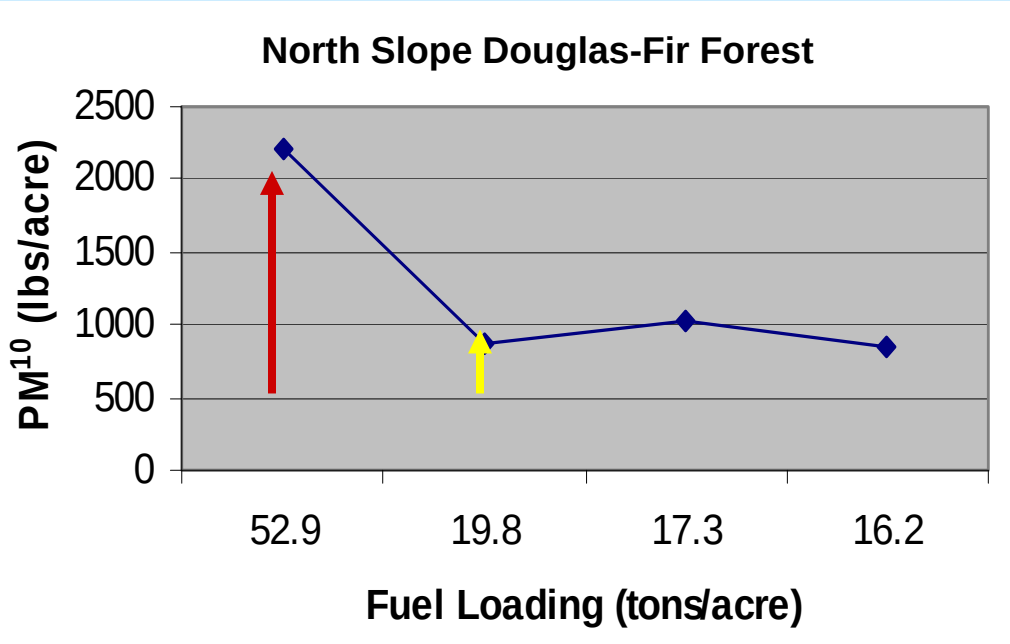
✓ **restore fire & smoke productions as an ecological process**

✓ **Consume/reduce small trees to conserve fewer large/old trees, reduce threat of built up fuels**

✓ **Increased forest restoration would result in increased streamflow (*Feather River study by Nature Conservancy)***

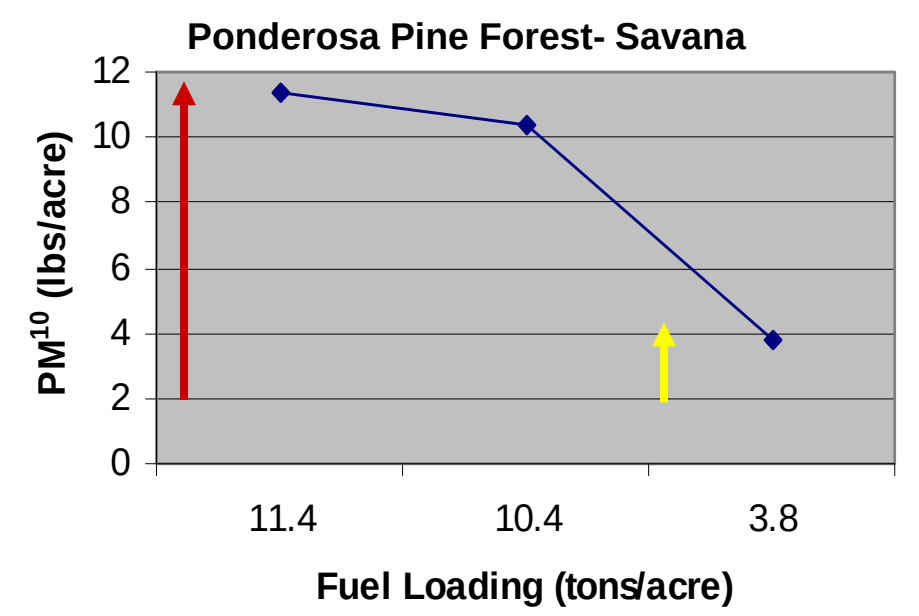
- **Bioenegry production process (use of biochar) & woody biomass utilization: net carbon savings**

Analysis of a wildfire with resource benefit objectives



Emissions & fuel loading before & after fire (used FOFEM and photo series)

How long will reduced conditions last?



(S. Beckman, AMSET, USFS)

USFS FBAT dataset used in FOFEM comparison

Emission Type (lbs/ac)	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6/7	Site 8	Site 9	Site 10
	Ponderosa pine		Mixed Conifer		Ponderosa pine			Mixed conifer	Ponderosa pine
PM-10	2,370	824	422	1,209	565	2,111	4,064	4,437	1,637
PM-2.5	2,009	699	357	1,024	479	1,789	3,444	3,761	1,387
CH4 – Methane	1,211	411	213	616	285	1,078	2,078	2,256	836
CO – Carbon Monoxide	26,445	8,833	4,601	13,429	6,169	23,541	45,373	49,061	18,251
C02 – Carbon Dioxide	127,670	65,657	28,925	68,277	38,307	114,314	216,749	264,678	88,515
NOX – Nitrous Oxide	37	54	19	25	24	34	59	119	26
SO2 – Sulfur Dioxide	98	46	21	52	28	89	168	199	68

Lion Fire, site 5

Fire Behavior Assessment Team

Lion Fire, site 9

Calibrating wildfire consumption/emissions with field data

- 6 conifer forest wildfires in CA measured by USFS Fire Behavior Assessment Team
- Inaccurate fuel load inputs
- FOFEM overestimated more in Klamath than Sierras - wide variability on plot level
- FOFEM fuel classifications overestimate duff & underestimate litter
- Showed importance of fuel load inputs to improved consumption/emissions

(Lyderson et al. 2014, Journal of Geophysical Research: Biogeosciences)

Prescribed fire effects on field-derived and simulated forest carbon stocks over time

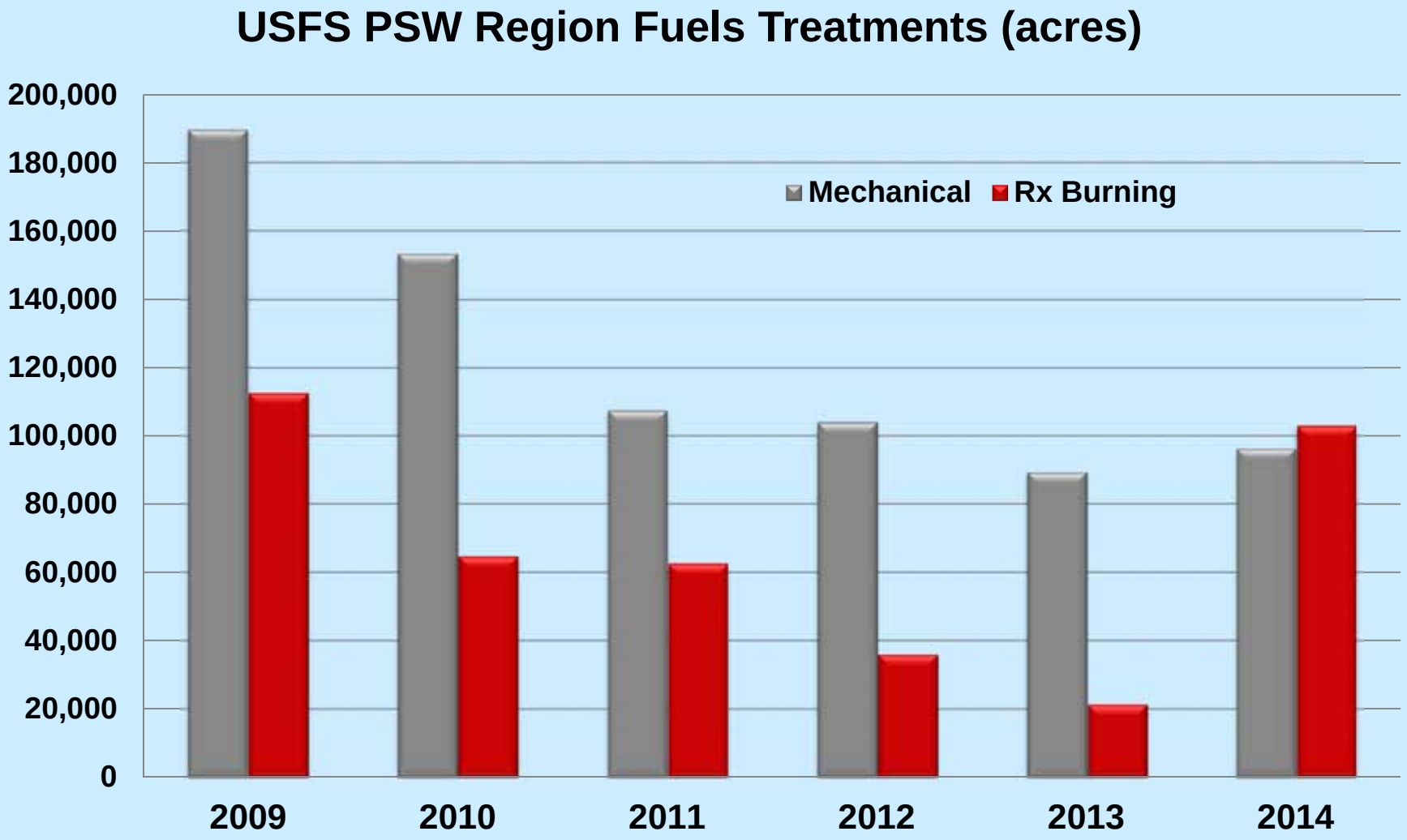
(Vaillant et al. 2013, used FVS-FFE and CA field data)

Carbon pool (tons/ac)	Pre-fire	1 yr after fire	2 yrs after fire	8 yrs after fire
trees	67	66	65	69
Surface fuel (woody debris)	12	7	8	8
Forest floor (litter and duff)	11	5	5	7
Simulated Wildfire emissions	15	8	9	10
Net (total biomass* - wildfire)	76	71	72	78

* Snag, herb and shrub pools not listed above

Prescribed fire reduced predicted wildfire emissions by 45% the 1st year after treatment and remained reduced through 8 year post-treatment (34%).

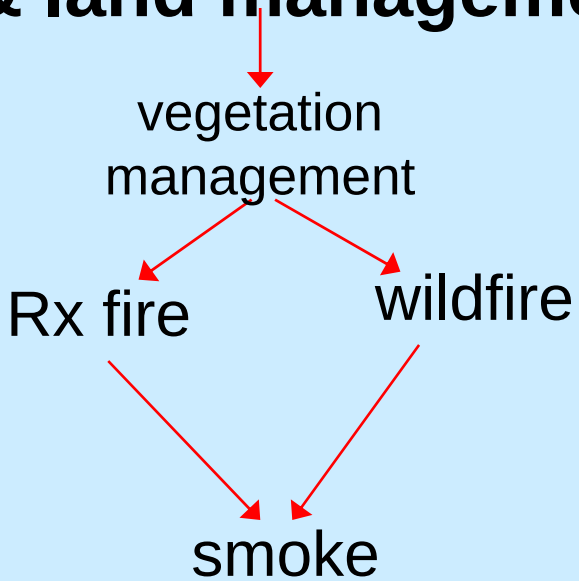
USFS in CA: snapshot of treatments



S.Crook, FACTS, approximate

Choices & Opportunities

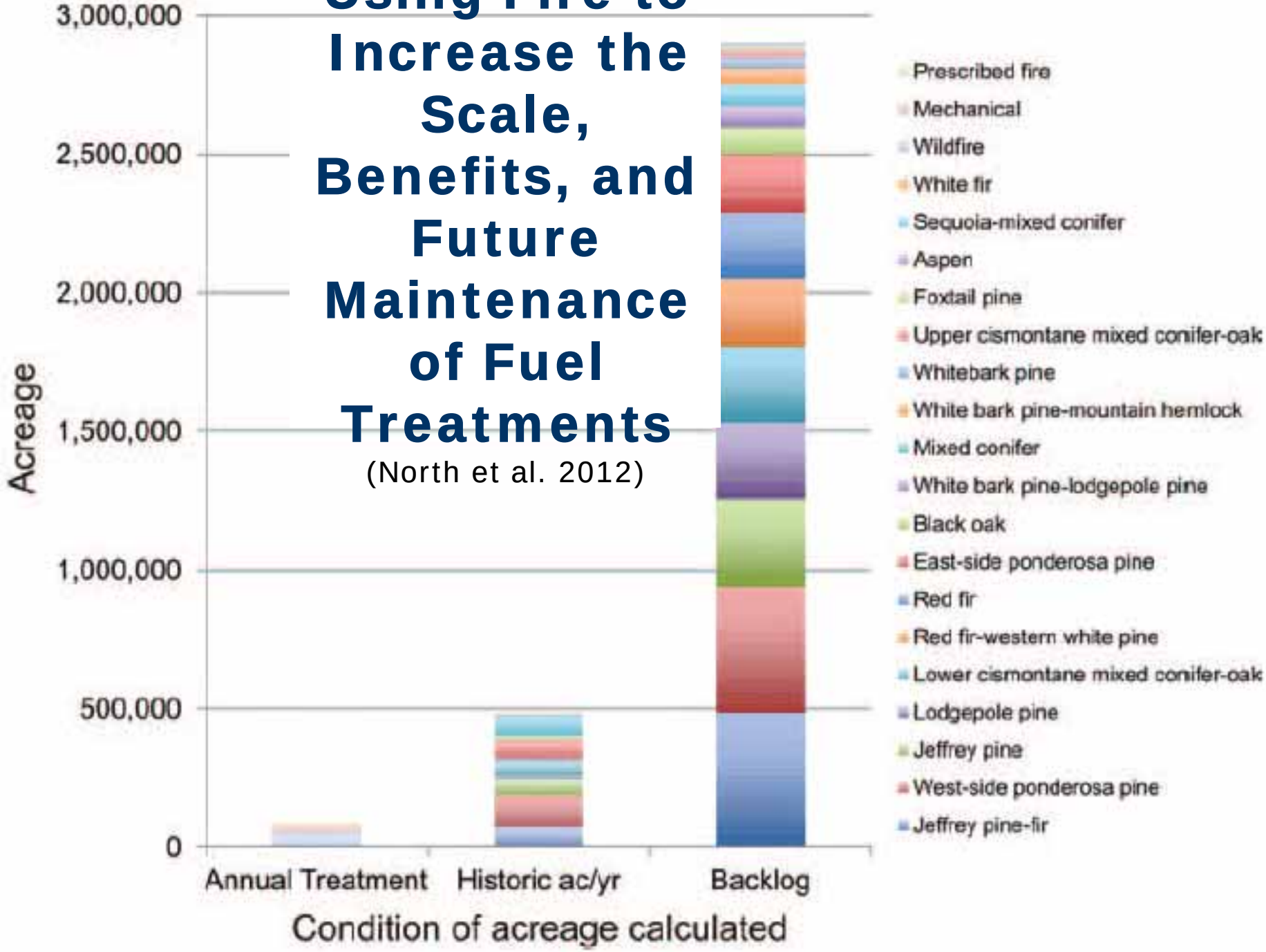
wildfire & land management policy



Knowledge of fire history, fire regimes, fire effects & landscape conditions *facilitates* land managers to develop **informed management strategies**

Using Fire to Increase the Scale, Benefits, and Future Maintenance of Fuel Treatments

(North et al. 2012)



Using Fire to Increase the Scale, Benefits, and Future Maintenance of Fuel Treatments (North et al. 2012)

Management Implications

- **Problem: frequent fire regime forests- the pace & scale of current fuels reduction treatments is too limited to mitigate increasing fire severity trends (<20% of SN are treated)**
- **Solution: concentrate large-scale fuels reduction efforts & *transition areas of fire suppression to fire maintenance***
- ***Fundamental change – restore ecosystem processes & emphasize treating entire firesheds (large, contiguous & outside WUI)***

What happens when large landscapes have great fuel accumulations?

…difficult to suppress, multi-state smoke impacts, exceed natural range of effects, contribute to negative feedback

Antelope & Moonlight (PNF), Zaca (LPF), American River Complex (TNF/ENF), Rim (STF)

Prescribed Fire or Wildfire Focus?

Under the same conditions, if it is a wildfire:

- no control of consumption/production rate or transport of emissions
- smoke produced from wildfire is 2 to 4 times that of prescribed fire *(Ottmar et al. 2000, Wiedinmyer & Hurteau 2010)*
- *less* planning or operational strategies to minimize smoke production and impacts (WFDSS, FOFEM, IFDSS)

Wildfire or Prescribed Fire

- **increasing management of wildland fires for resource benefit**
  - **"A wildland fire may be concurrently managed for one or more objectives *[based on Land/Resource Management Plan direction]* and objectives can change as the fire spreads..."** (Guidance for Implementation of Federal Wildland Fire Management Policy 2009)
  - **"Wildfires could be more extensively used to achieve ecological & management objectives"** (Miller et al. 2012)
- **Potential to reduce hazard fuels & restore fire across many more acres**
- **Smoke:**
  - **Short term: more smoke this week**
  - **Long-term: reduction of future smoke potential; less large wildfires, less contiguous fuels, less consumption**

Public Information

- At wildfires & prescribed fires
- On the web
- *Example* USFS Video Series

Minimizing Smoke Impacts of Prescribed Fire

https://www.youtube.com/watch?v=8RSHhFgqIxc

- ✓ Agency addresses air quality impacts of smoke
- ✓ Why the USFS uses fire as a land management tool
- ✓ Ways the USFS leads in smoke management
- ✓ How prescribed fire helps reduce smoke impacts

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U.S. Forest Service

Summary:

Years of fire exclusion

+

different land use patterns

+

generations of policy/rules to control the historical role of fire

+

current resource management practices

= today's URGENT situation

Thank you!

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ENTERPRISE TEAM
U.S. Forest Service

Questions/Comments

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Fire Behavior Assessment Team (FBAT)

http://www.fs.fed.us/adaptivemanagement/projects/FBAT/FBAT.shtml

Fire Behavior Assessment Team

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Thank you!

When one tugs at a single thing in nature,
he finds it attached to the rest of the world."
John Muir

We do not accept unnecessary risk
or transfer it to our partners or future generations.
Tom Tidwell, USFS Chief

Be sure you're right, then go ahead.
Davey Crockett, King of the Wild Frontier

There's no crying in restoration.
Dean, San Bernardino NF, Restoration Staff

Never miss a burn window.
Jon Payne, STF Summit RD FMO, retired