Fire Ecology of Southern Sierra Nevada Ecosystems

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Fire Ecology of Sierra Nevada Ecosystems

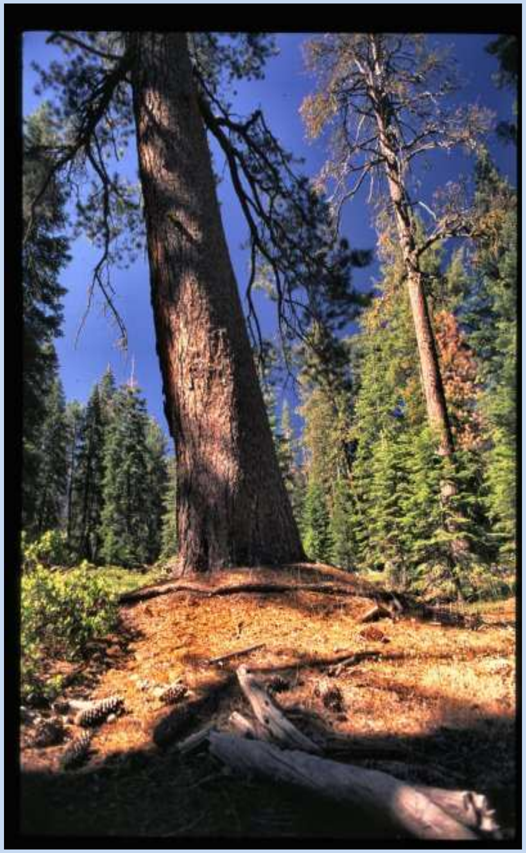
1. Fire regimes of Sierra Nevada ecosystems
2. Wildfire emissions of California: pre-settlement vs. current
3. Changing climates and wildfire
4. Fuel treatment effectiveness and wildfire
5. Forest carbon sequestration

Fire Regimes of Sierra Nevada Ecosystems

Sierra Nevada Forest Fire Regimes

Vegetation Type	Fire Return Interval	Historic Fire Severity
Ponderosa pine forest	high frequency (5–12 years)	Low
Mixed-conifer forest	high frequency (8–20 years)	Low
Red fir forest	mixed frequency (11–69 years)	Low/Moderate
Lodgepole pine forest	low frequency (25–80 years)	Mixed



Sierra Nevada Forest Fire Regimes

Vegetation Type	Fire Return Interval	Historic Fire Severity (type)	Pre-settlement Fire Size*
Ponderosa pine forest	high frequency (5–12 years)	Low (surface)	Large (>100 ha)
Mixed-conifer forest	high frequency (8–20 years)	Low (surface)	Large (>100 ha)
Red fir forest	mixed frequency (11–69 years)	Low/Moderate	Medium (10-100 ha)
Lodgepole pine forest	low frequency (25–80 years)	Mixed	Small (<1 ha)

*Based on pre-settlement period in California (before 1850)

Sierra Nevada Forest Fire Regimes

Vegetation Type	Fire Return Interval	Historic Fire Severity (type)	Area (km^2) burned per year in CA*
Ponderosa pine forest	high frequency (5–12 years)	Low (surface)	136
Mixed-conifer forest	high frequency (8–20 years)	Low (surface)	690
Red fir forest	mixed frequency (11–69 years)	Low/Moderate	51
Lodgepole pine forest	low frequency (25–80 years)	Mixed	34

*Based on pre-settlement period in California (before 1850; Stephens et al. 2007)

Sierra Nevada Forest Fire Regimes

Vegetation Type	Fire Return Interval	Historic Fire Severity	Area (km^2) burned per year in CA*	Fire Return Interval Departure
Ponderosa pine forest	high frequency (5–12 years)	Low	136	High
Mixed-conifer forest	high frequency (8–20 years)	Low	690	High/Moderate
Red fir forest	mixed freq. (11–69 years)	Low/Moderate	51	Low/Moderate
Lodgepole pine forest	low frequency (25–80 years)	Mixed	34	Low

*Based on pre-settlement period in California (before 1850; Stephens et al. 2007)

Sierra Nevada Hardwood/Shrub/Herb Fire Regimes

Vegetation Type	Fire Return Interval	Historic Fire Severity	Area (km^2) burned per year in CA*
Montane hardwood	high frequency (13–15 years)	Low	135
Montane chaparral	mixed frequency (16-45 years)	High	8
Foothill hardwood	high frequency (7–17 years)	Low	128
Foothill chaparral	mixed frequency (8–70 years)	Low	113
Montane meadow	low frequency (40–100 years)	Low	6
California grasslands	high frequency (3 to 8 years)	High	176

*Based on pre-settlement period in California (before 1850)

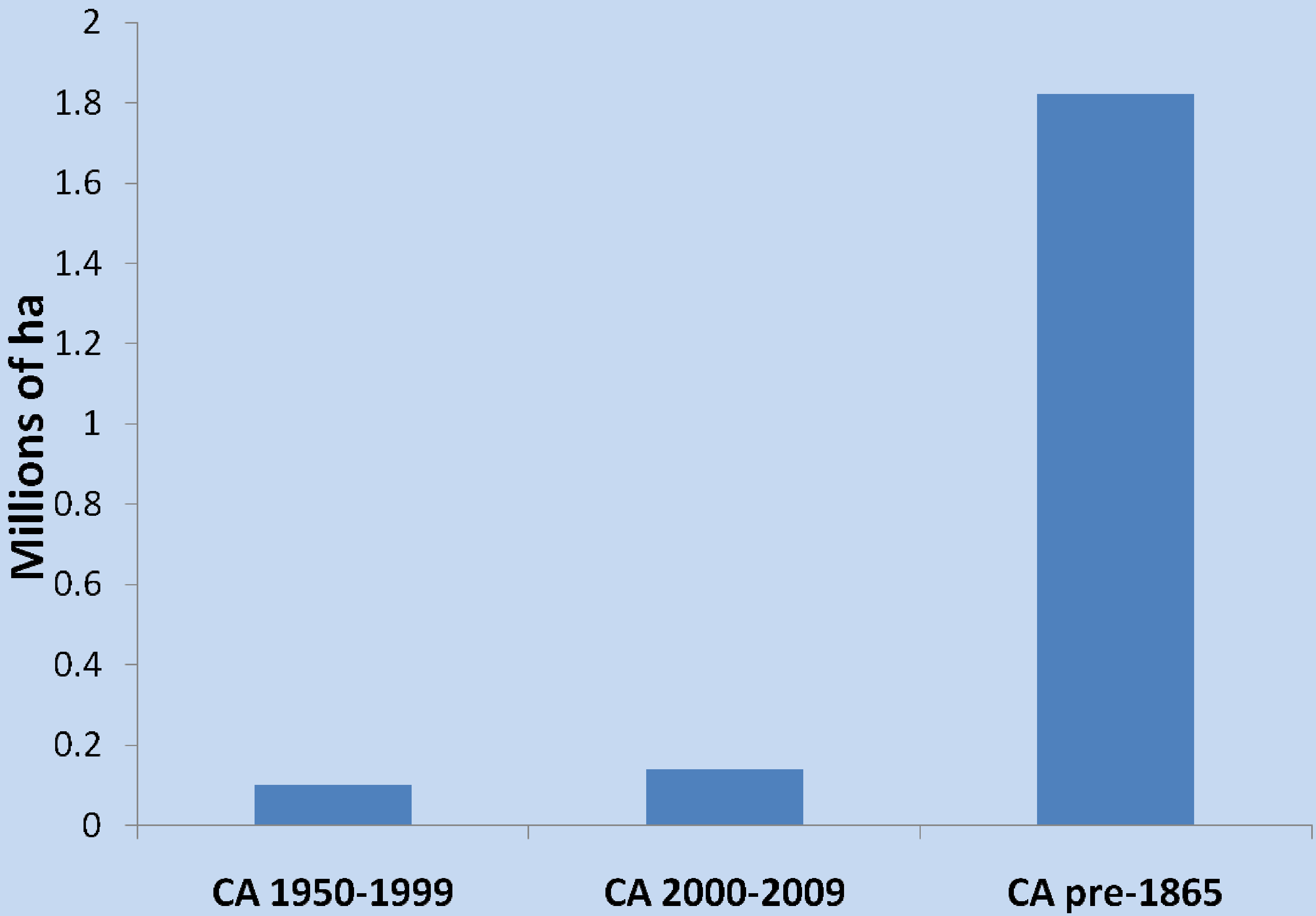
Sierra Nevada Hardwood/Shrub/Herb Fire Regimes

Vegetation Type	Fire Return Interval	Historic Fire Severity	Area (km^2) burned per year in CA*	Fire Return Interval Departure
Montane hardwood	high frequency (13–15 years)	Low	135	High/Moderate
Montane chaparral	mixed frequency (16-45 years)	High	8	Moderate
Foothill hardwood	high frequency (7–17 years)	Low	128	Low/Moderate
Foothill chaparral	mixed frequency (8–70 years)	Low	113	Variable
Montane meadow	low frequency (40–100 years)	Low	6	Variable
California grasslands	high frequency (3 to 8 years)	High	176	Low

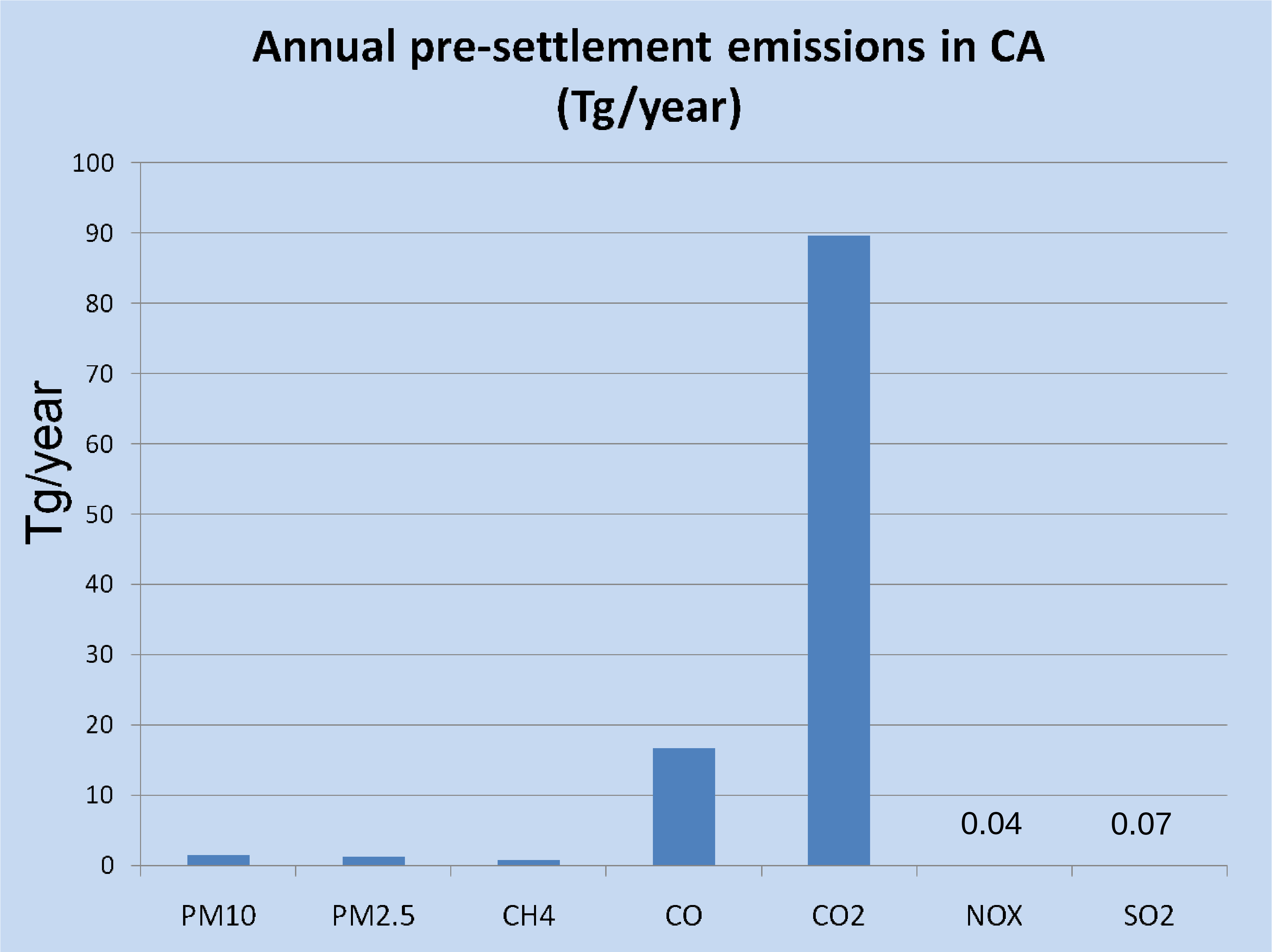
*Based on pre-settlement period in California (before 1850)

Wildfire Area and Emissions of Pre-settlement California

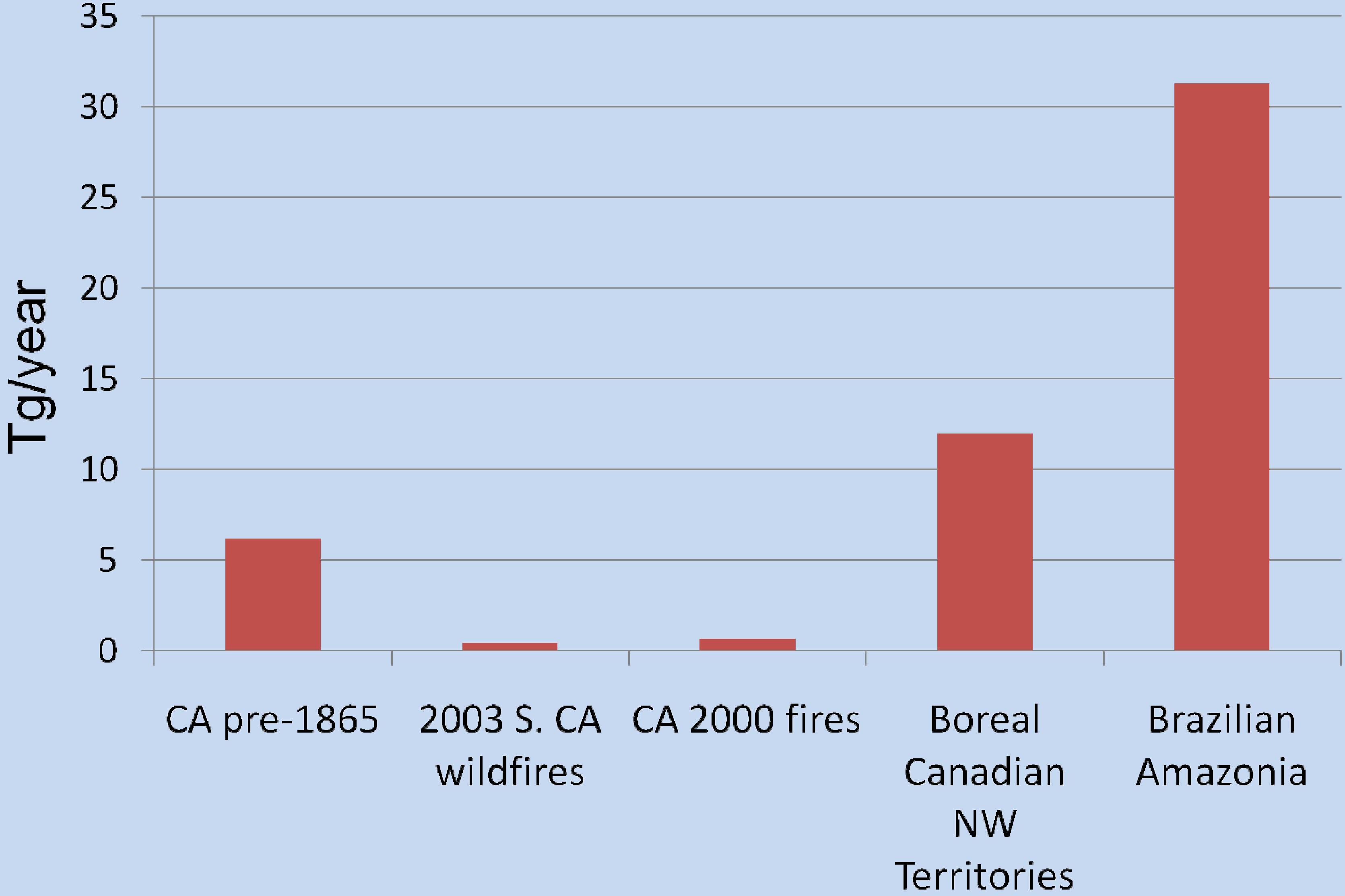
Annual hectares burned by wildfire



Source: Stephens et al. 2007

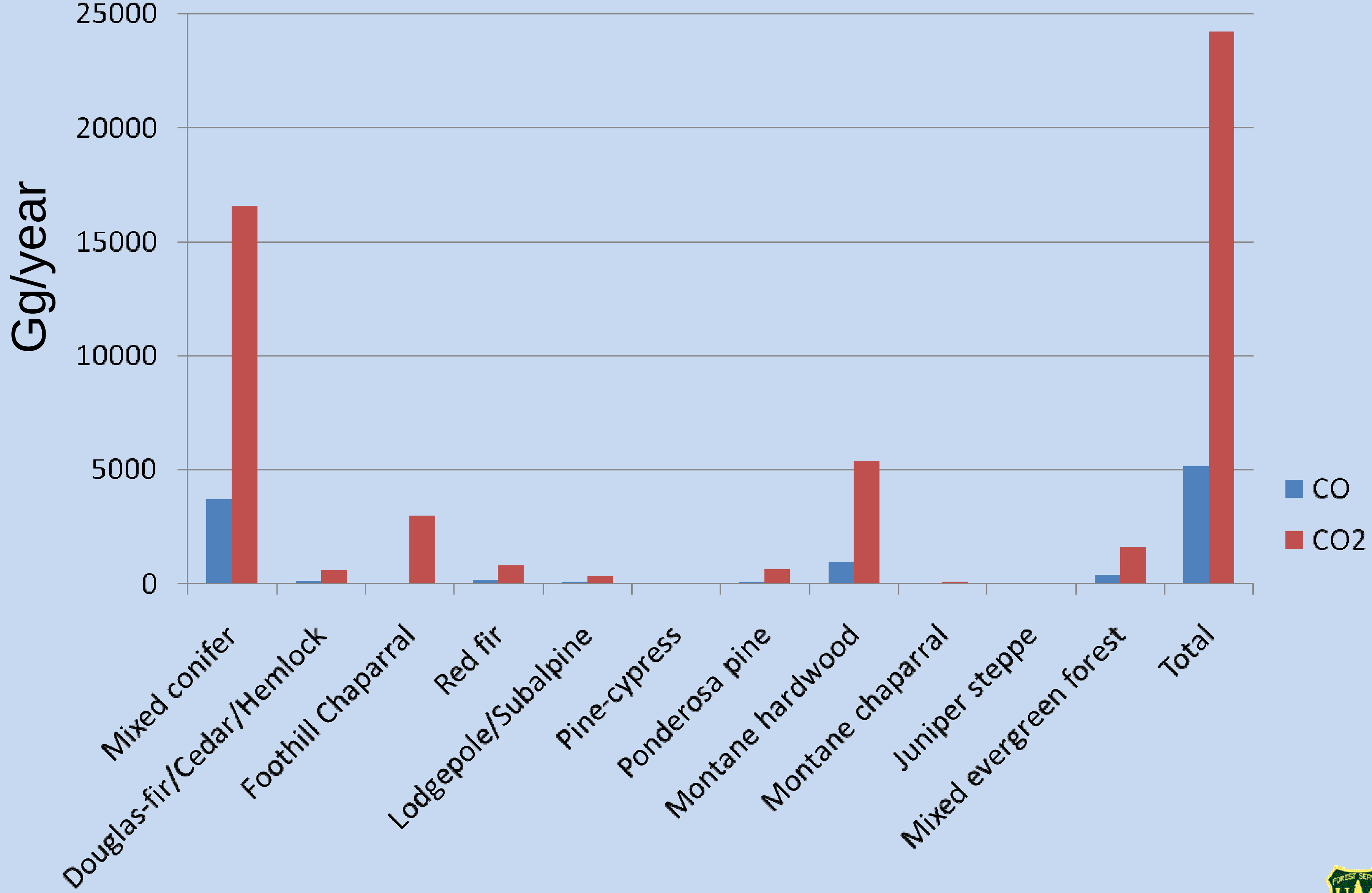

Annual pre-settlement emissions in CA
(Tg/year)
Tg/year
100
90
80
70
60
50
40
30
20
10
0
0.04
0.07
PM10
PM2.5
CH4
CO
CO2
NOX
SO2

Annual emissions of CO



Stephens et al. 2007

CO and CO_2 Emissions for Pre-settlement California



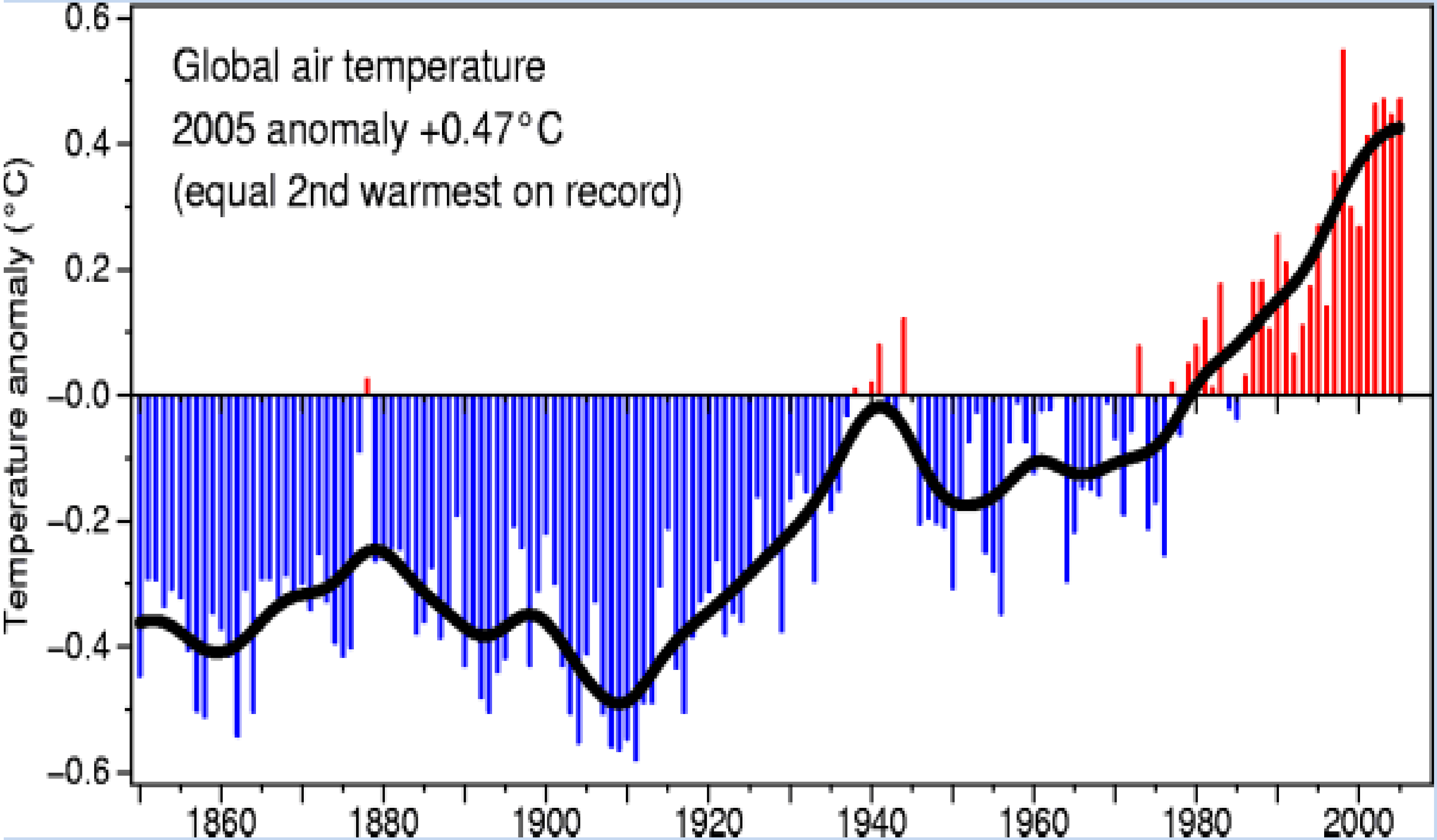
Stephens et al. 2007

“Of the hundreds of persons who visit the Pacific slope in California every summer to see the mountains, few see more than the immediate foreground and a haze of smoke which even the strongest glass is unable to penetrate.”

C.H. Merriam (1898)
Chief, Division of the U.S. Biological Survey

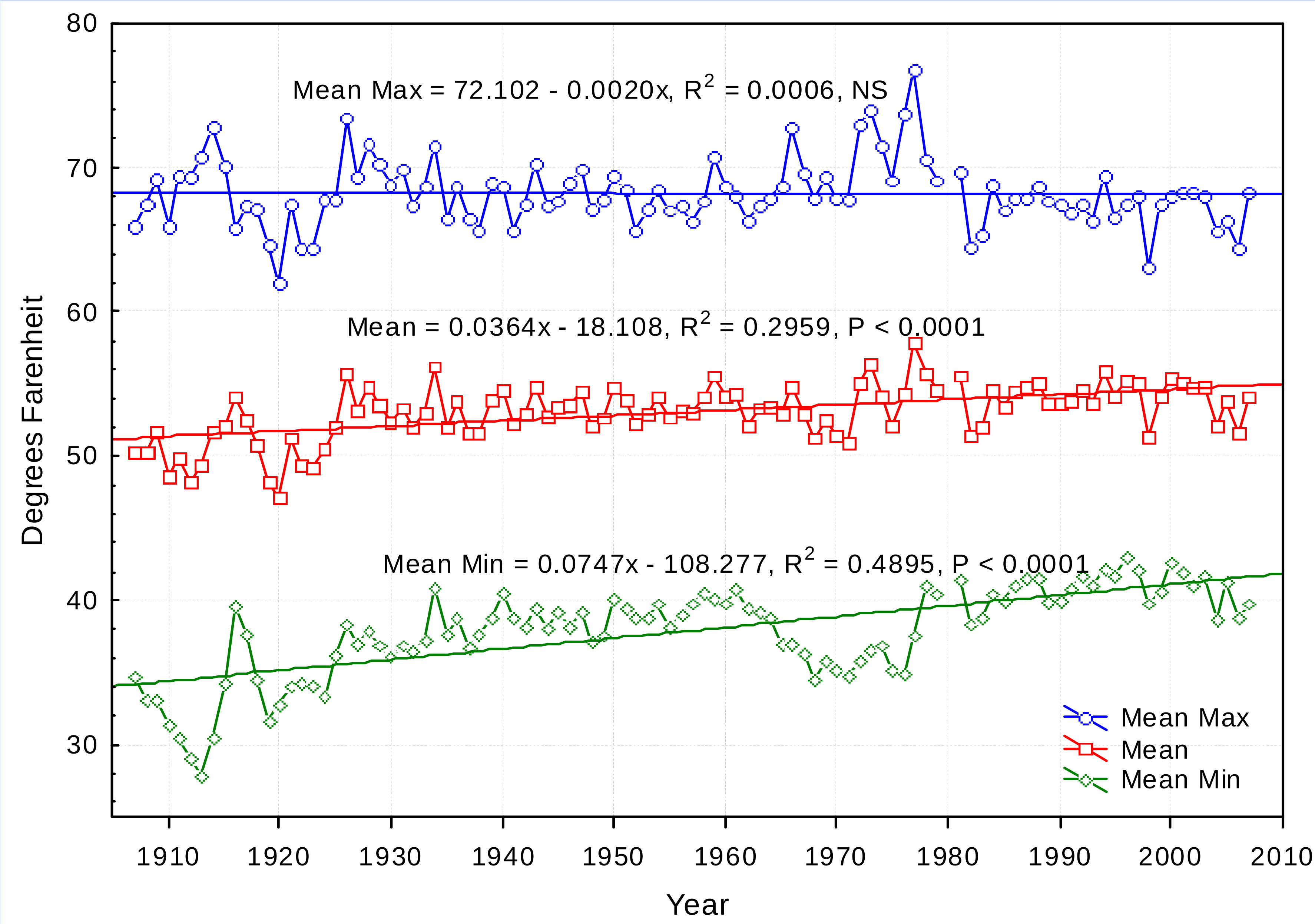
Changing Climates and Wildfire in the Sierra Nevada

Global air temperature trends

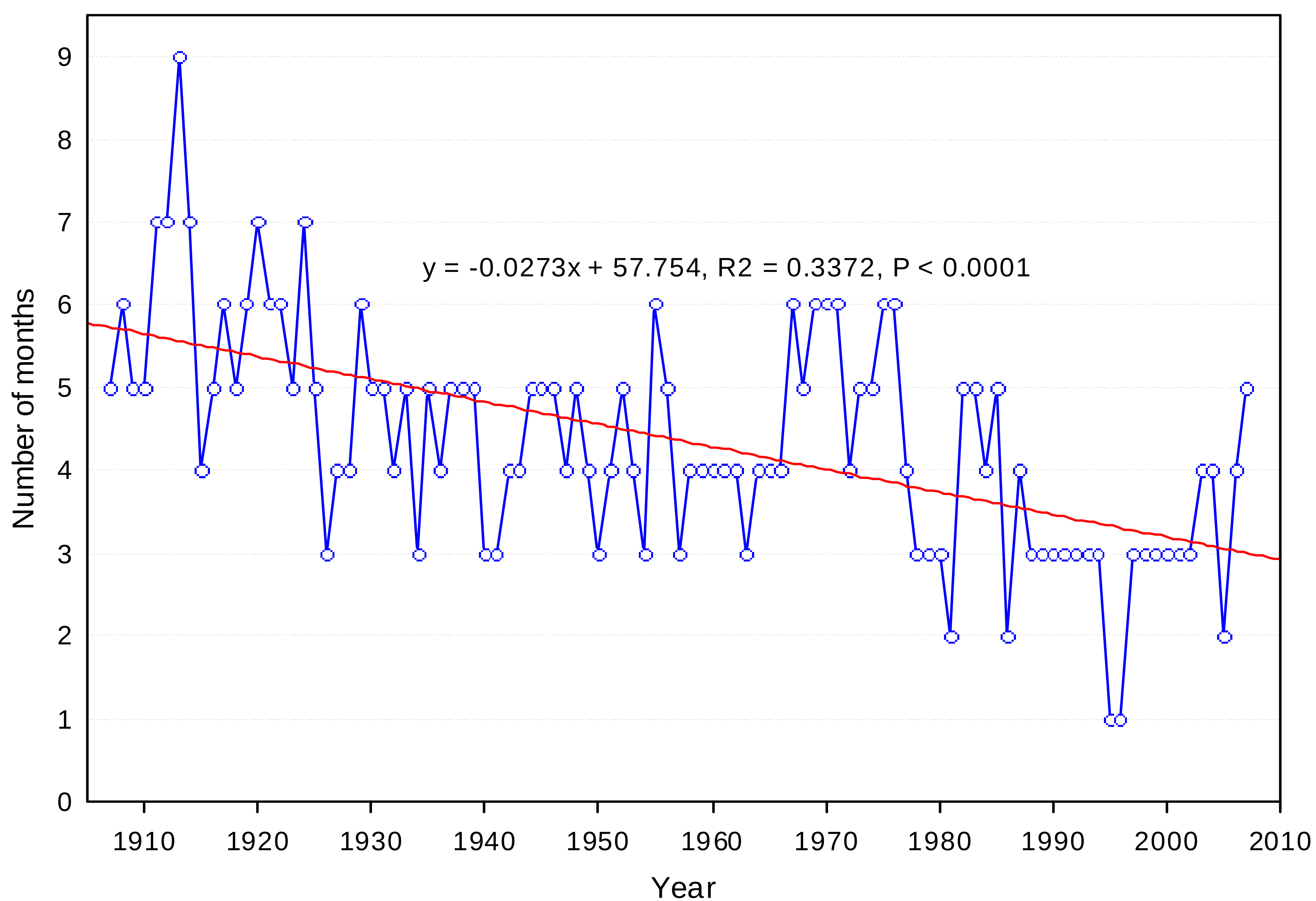


NOAA 2007

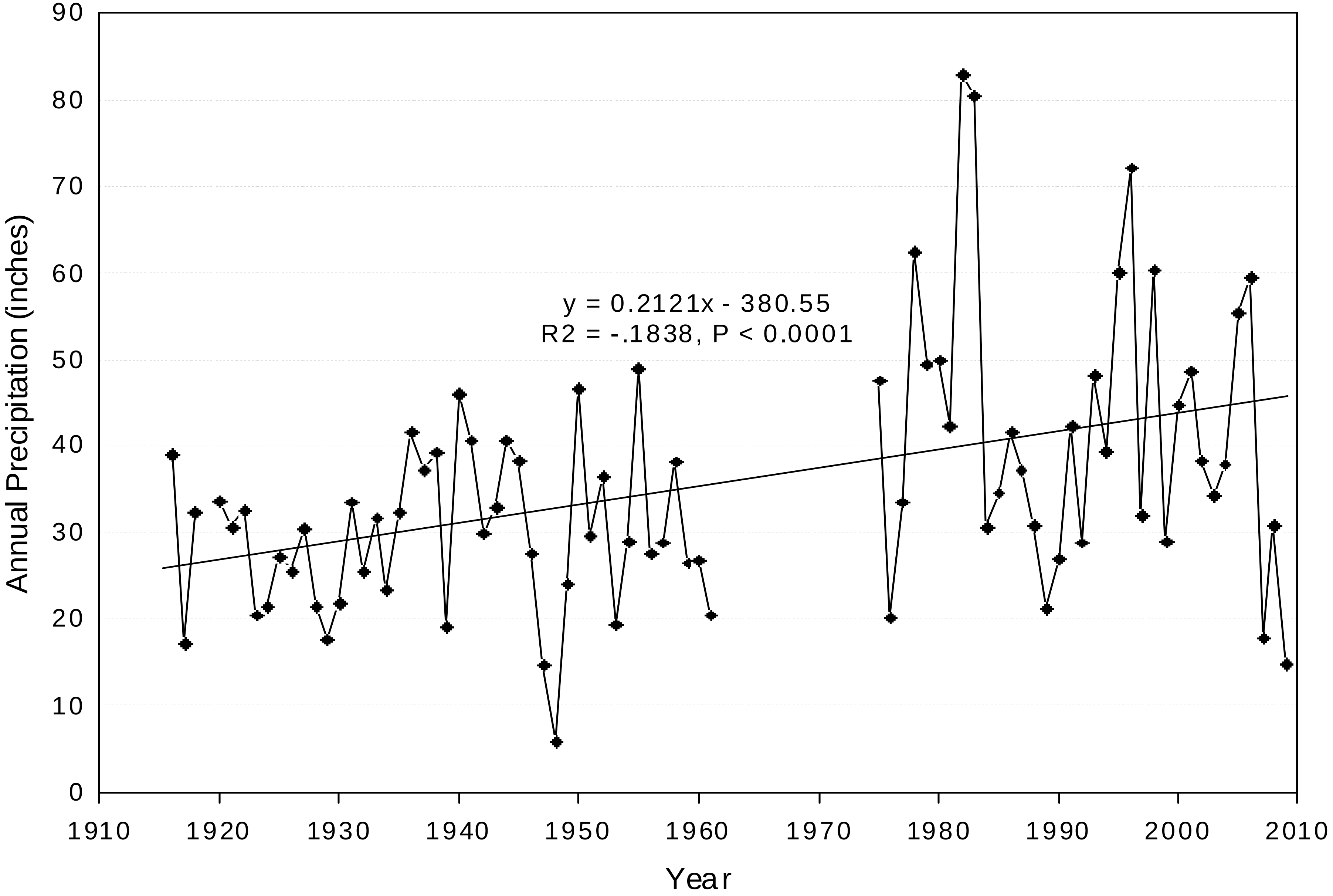
Temperature in Yosemite Valley



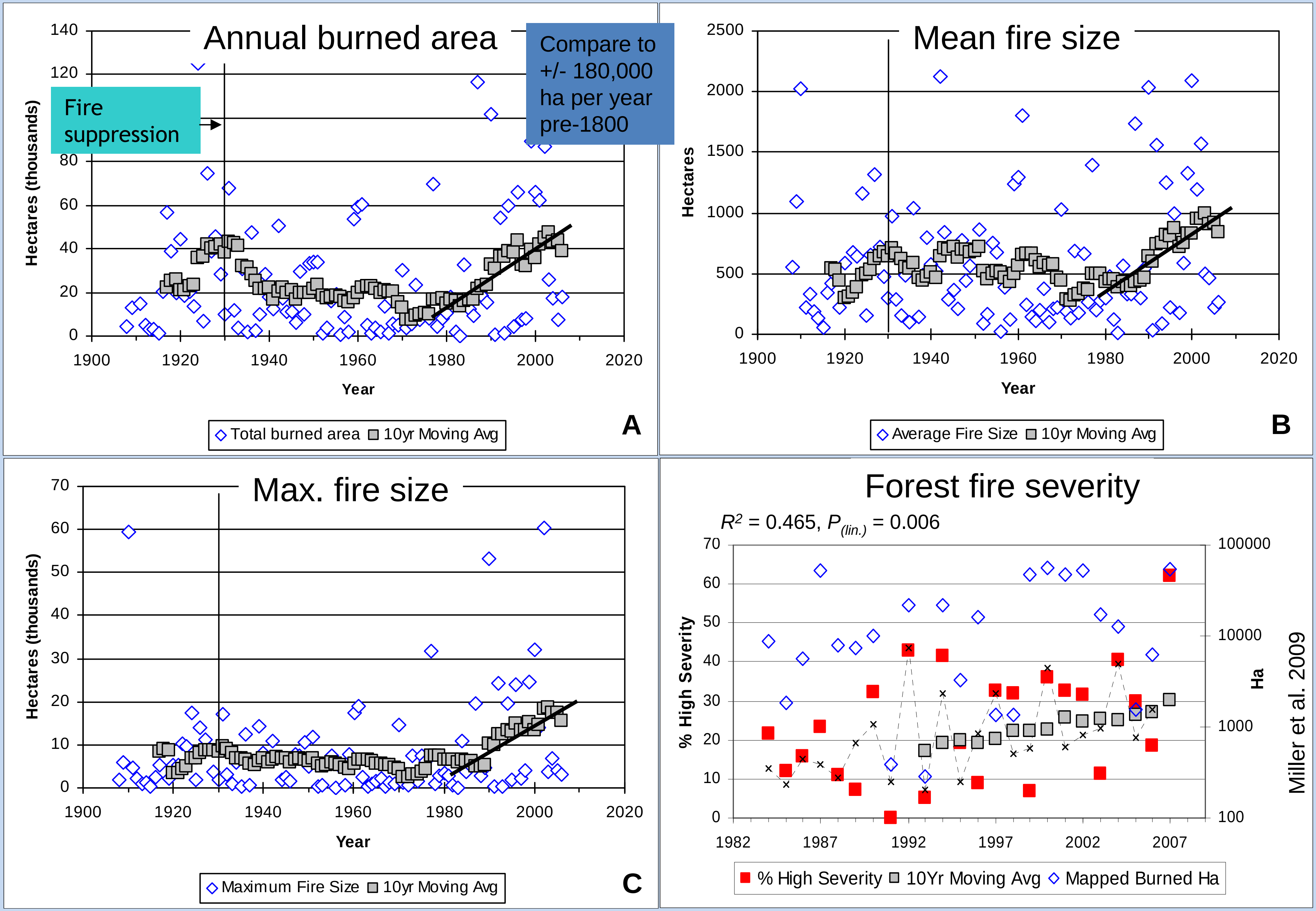
No. of months with monthly mean temperature below freezing



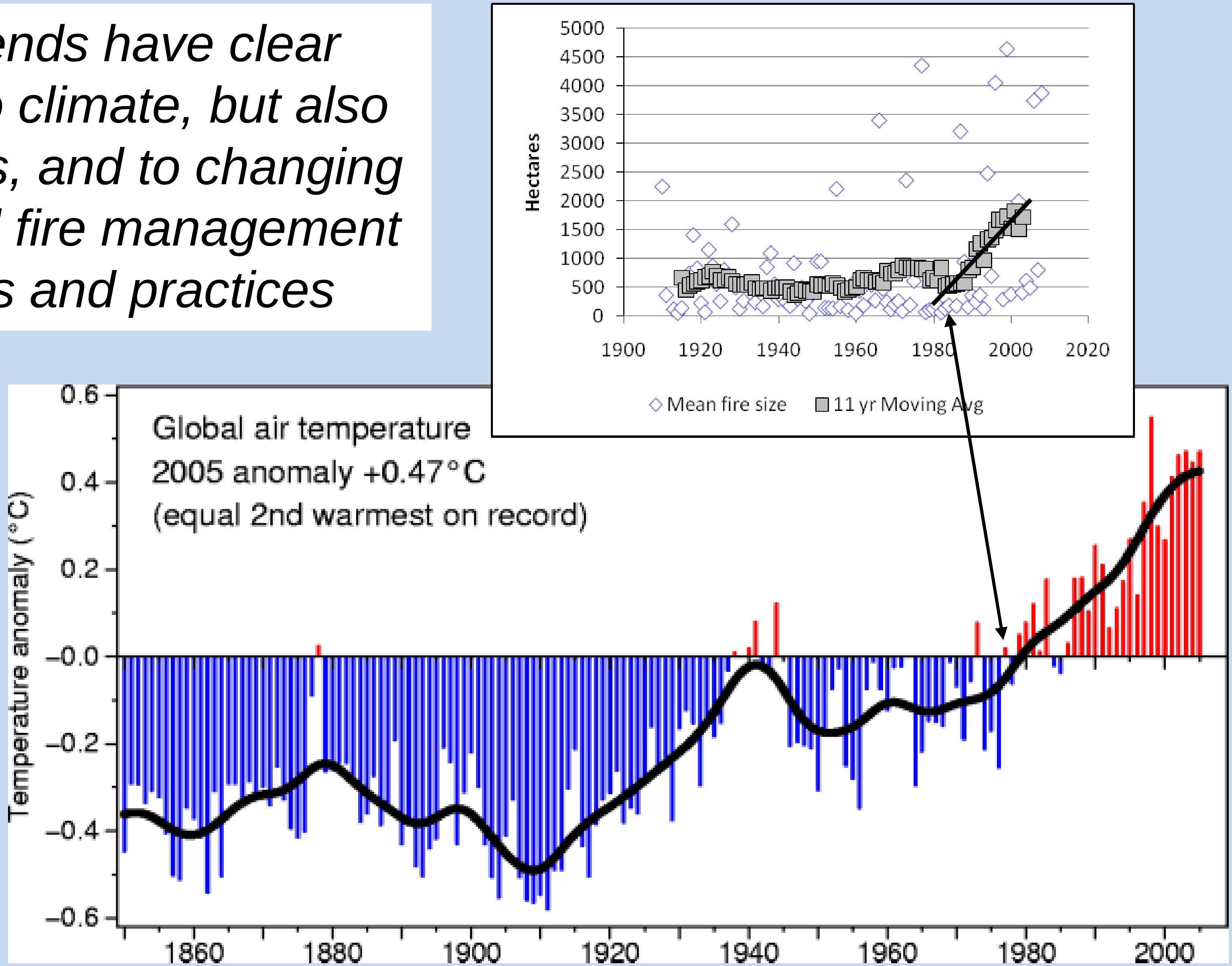
Precipitation at Huntington Lake



Sierra Nevada: trends in fire area and severity

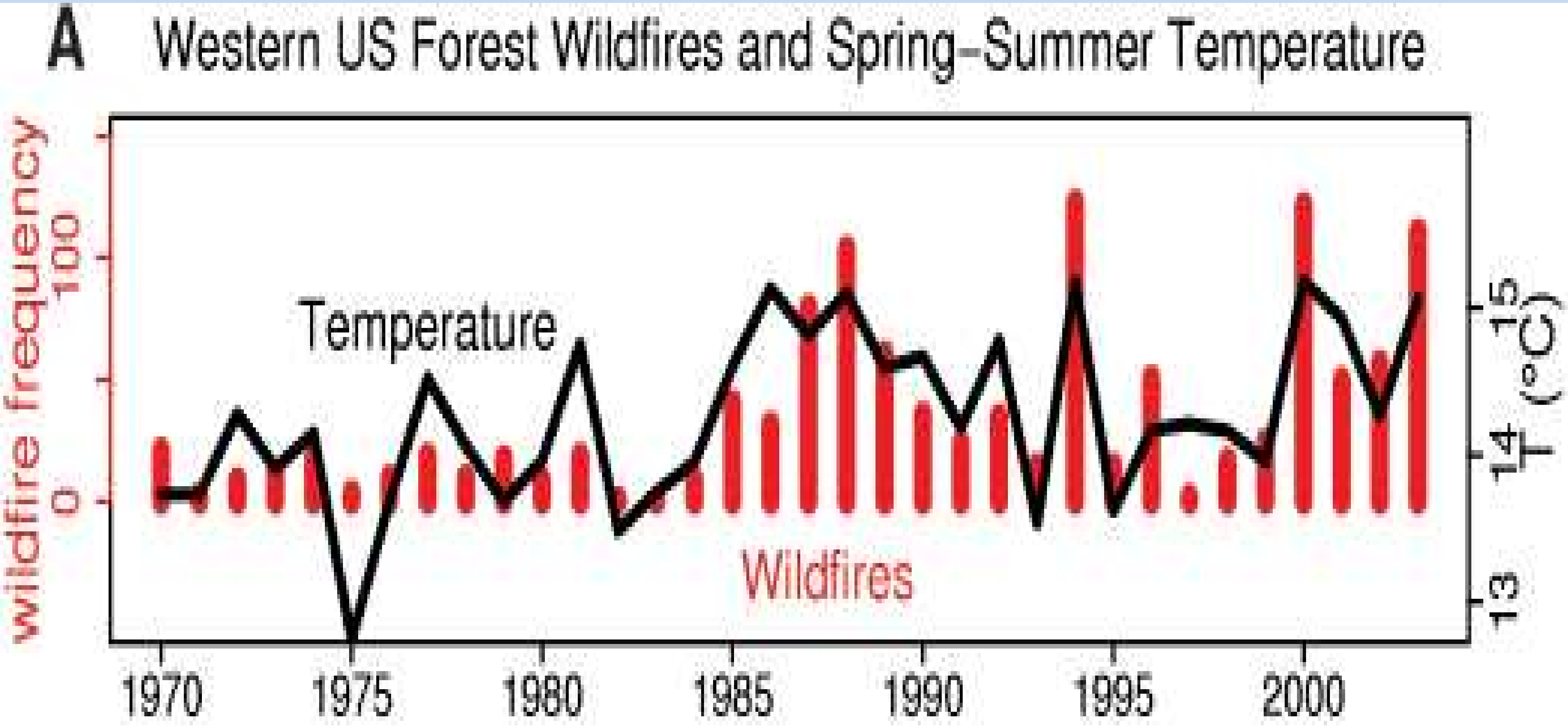


Fire trends have clear links to climate, but also to fuels, and to changing federal fire management policies and practices



Miller and Safford 2008, Miller et al. 2009; Miller, Ramirez & Safford, in prep

Wildfire Frequency in Western U.S. Forests



Westerling et al. 2006

Future fire trends: *Models project increases in fire activity in many parts of the Sierra Nevada*

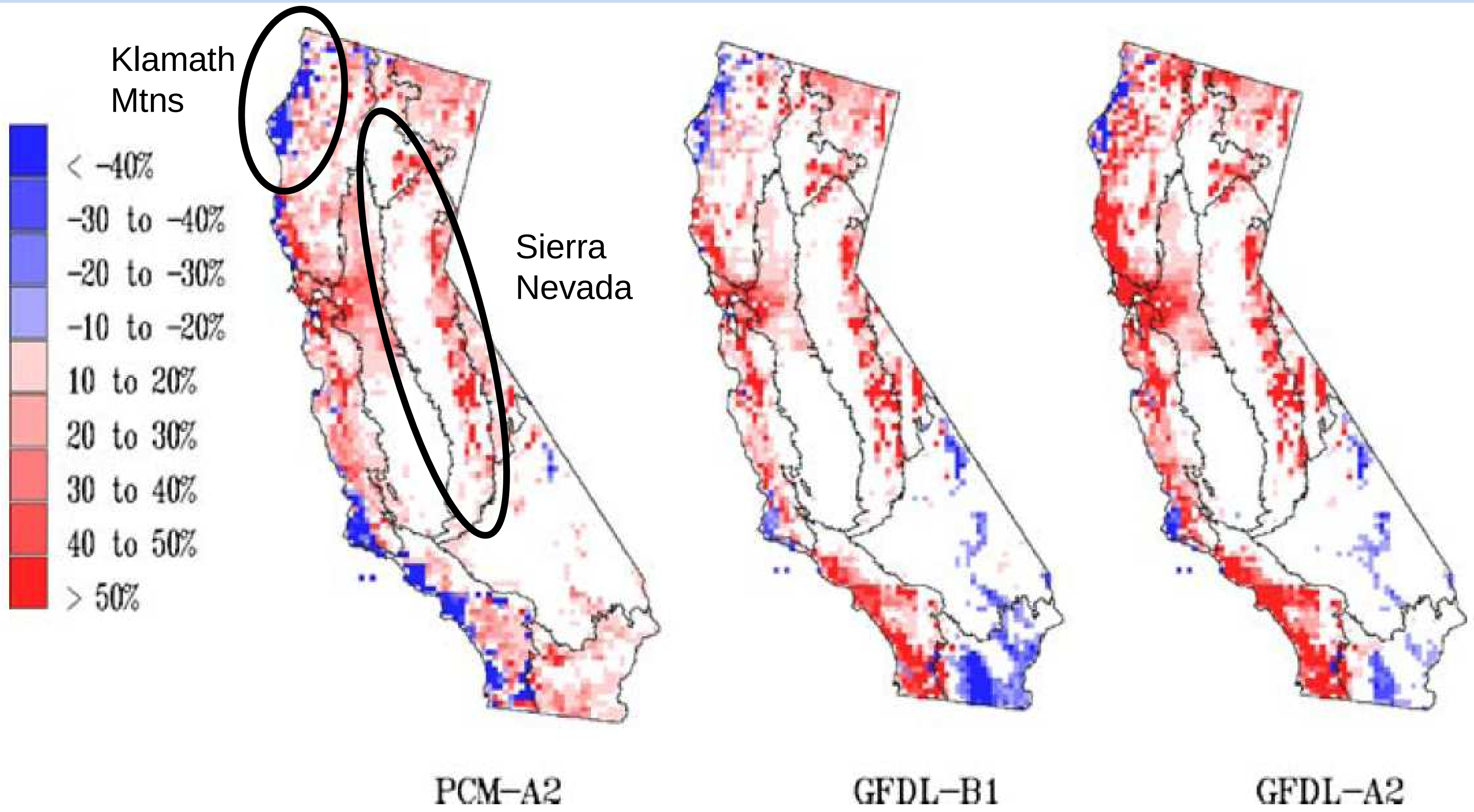
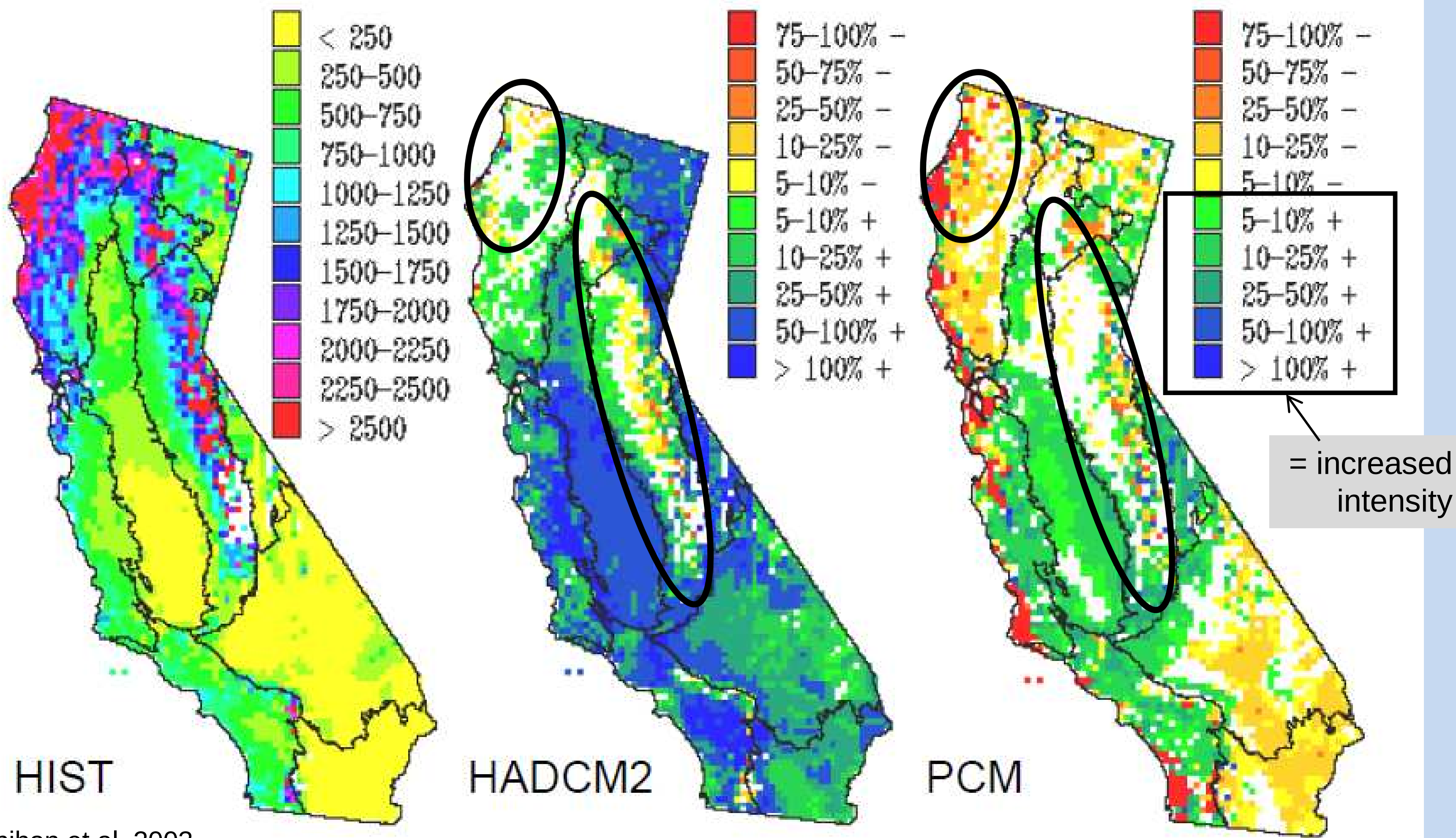


Fig. 8 Percent change in mean annual area burned for the 2050–2099 future period relative to the mean annual area burned for the historical period (1895–2003)

Lenihan et al. 2008

PCM-A2: no change in ppt., +2.5 to 3°C; GFDL-B1 sce nario: slightly drier, +2.5 to 3°C; GFDL-A2: much drier, +4 to 5°C

Future fire trends: increasing fire intensity,
except in Klamaths under drier future scenario



Lenihan et al. 2003

HADCM2: much wetter than today, +3.5 to 4°C; PCM: slightly drier, +1.5 to 2.5°C

Assessing the ecological effects of forest fuel treatments in the Sierra Nevada

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Basic questions

How effective are fuel treatments for mitigating wildfire effects on:

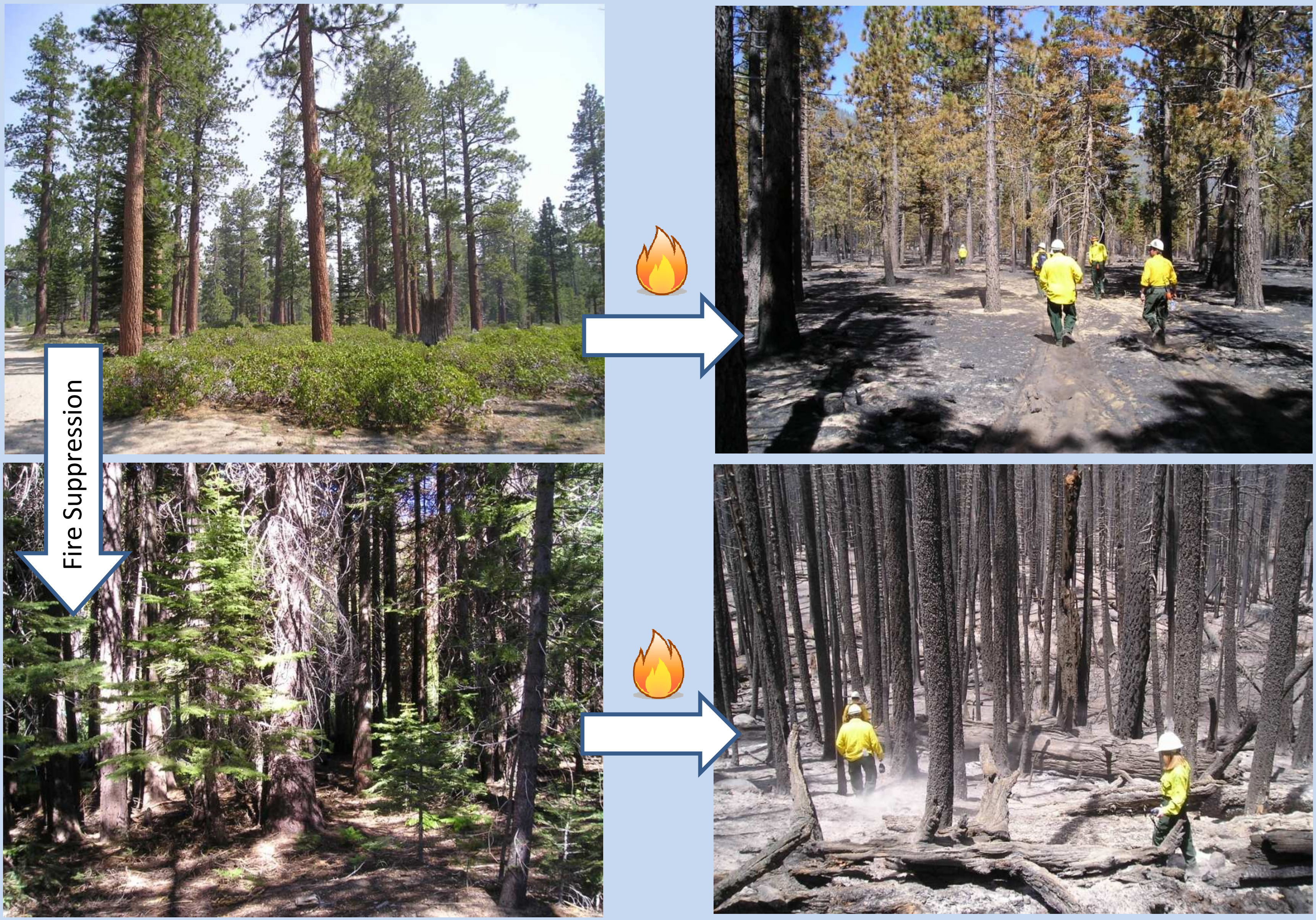
1. Fire severity and behavior
2. Tree mortality
3. Understory vegetation and fuels
4. Forest landscape

Fuel treatments

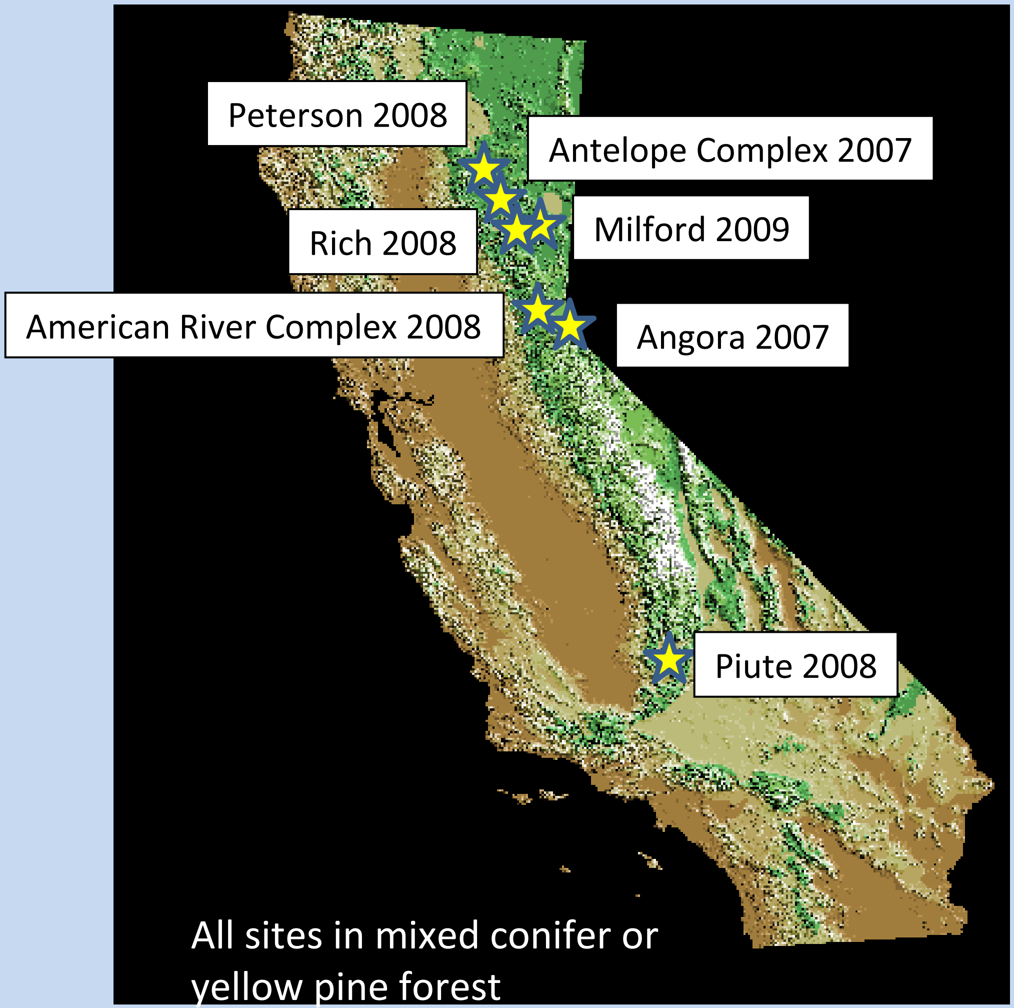
Fuel treatments included these two steps:

1. Thinning from below (understory thinning)
2. Follow-up treatment of surface fuels
   - Prescribed burning
   - Pile burning

California yellow pine and mixed conifer forests are adapted to frequent fires of predominantly low to moderate severity



Sampled Locations

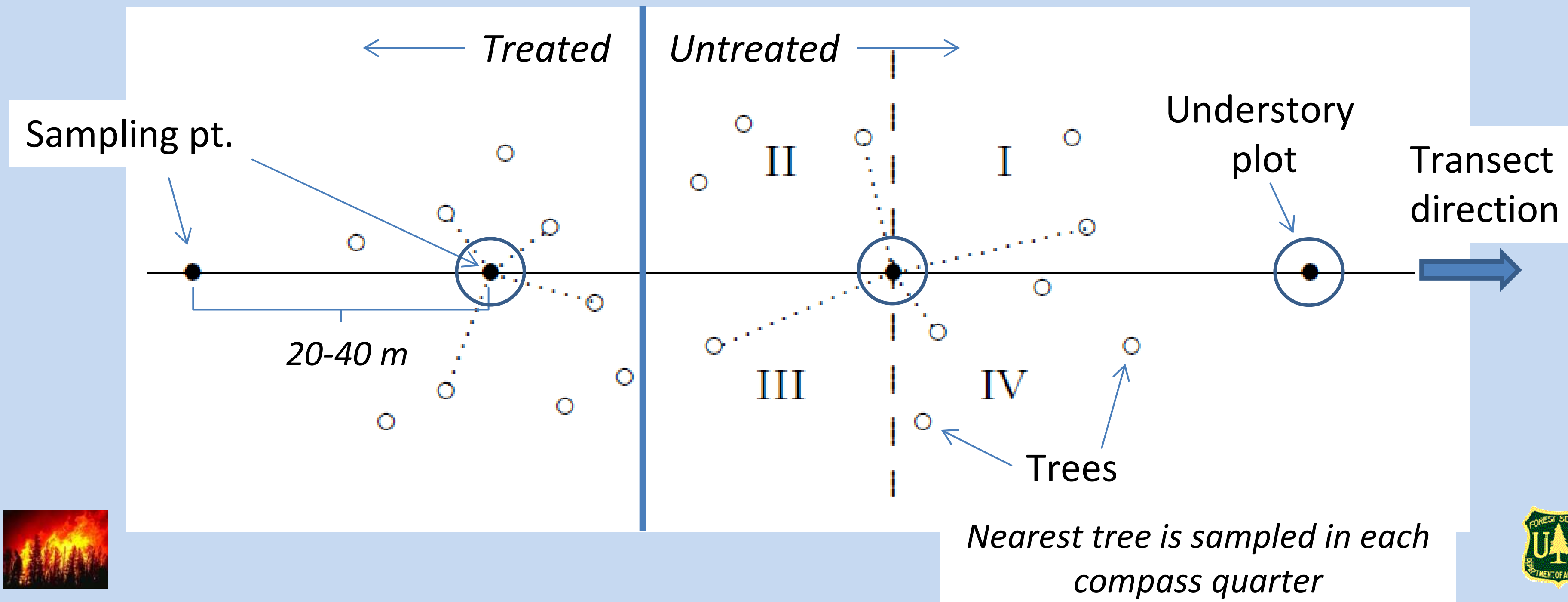


All sites in mixed conifer or yellow pine forest

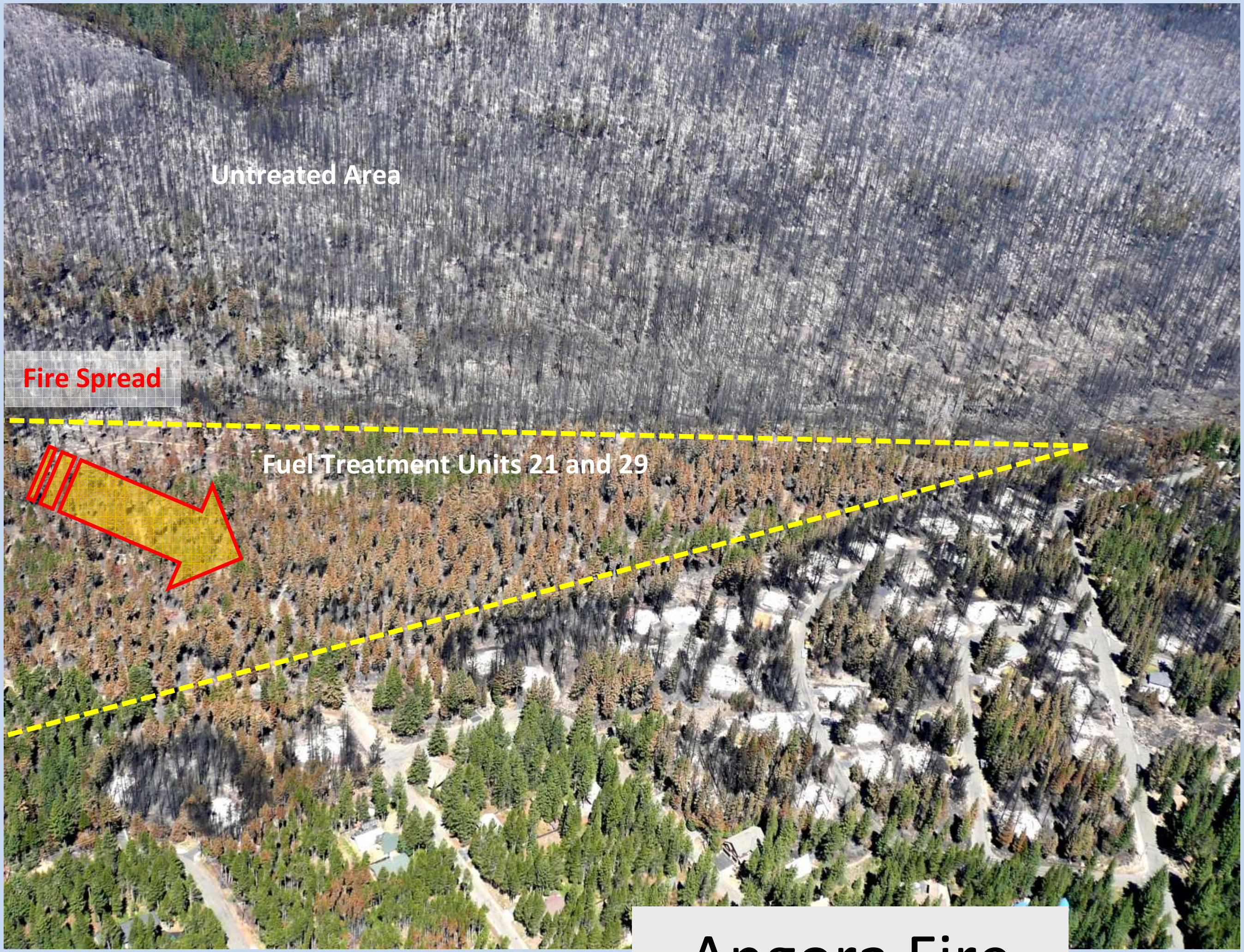
- Sample completed fuel treatments that have been burned by wildfire
- Compare to neighboring burned, untreated forest
- Resample sites for 3 yrs
- Add unburned controls where possible

Field Methods

- Transects, installed perpendicularly to fuel treatment boundary
- Point center quarter
  - –distance, species, mortality, dbh, ht, scorch ht, torch ht, bole char ht, % crown scorch, % crown torch, beetle attack rate
- Plot sampling (12 m^2) at each point
  - – understory veg diversity and cover, litter cover and depth, seedling density



Results I: Fire severity - typical scenes, untreated vs. treated, $\leq$ one year postfire

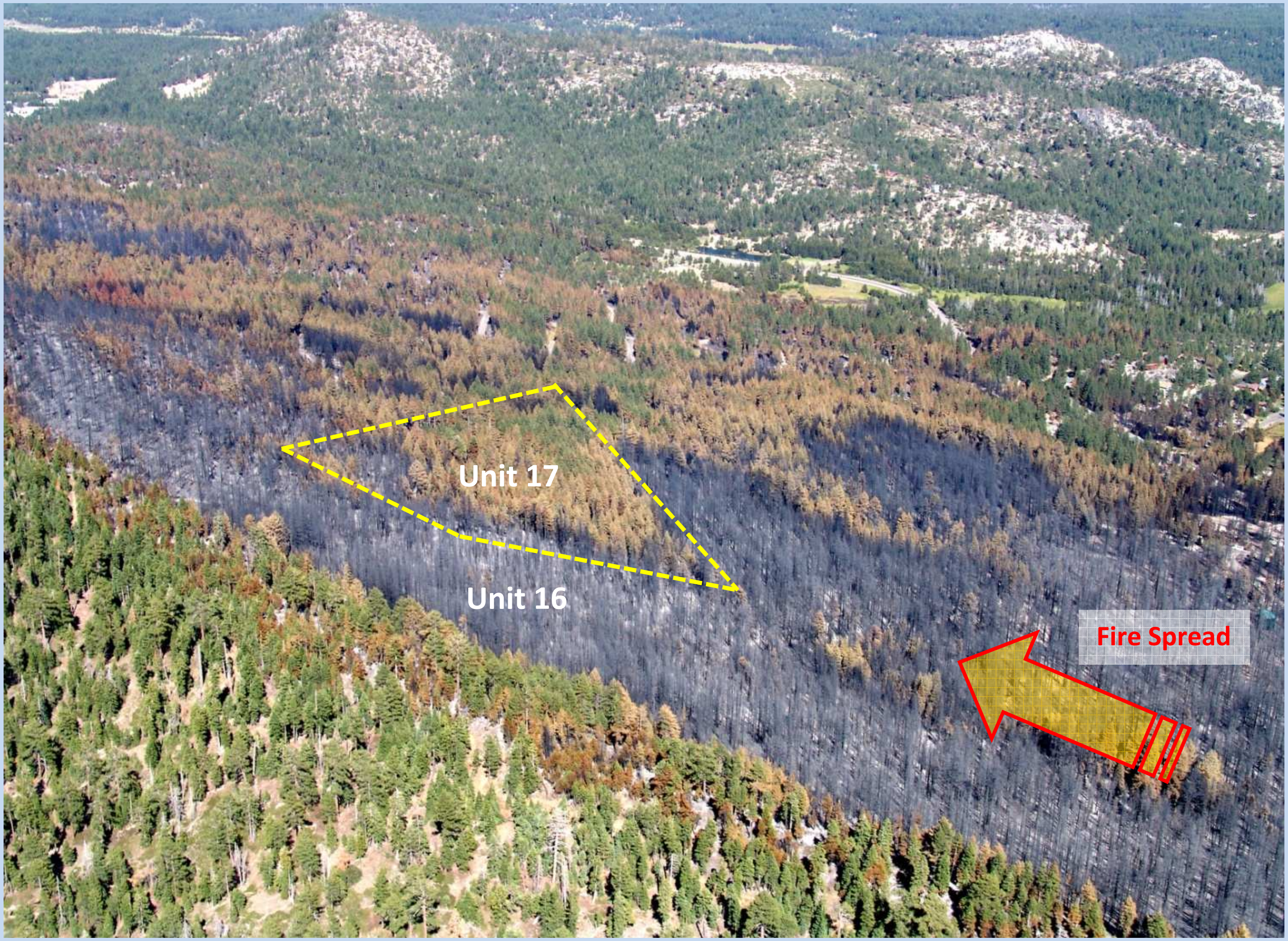


Angora Fire

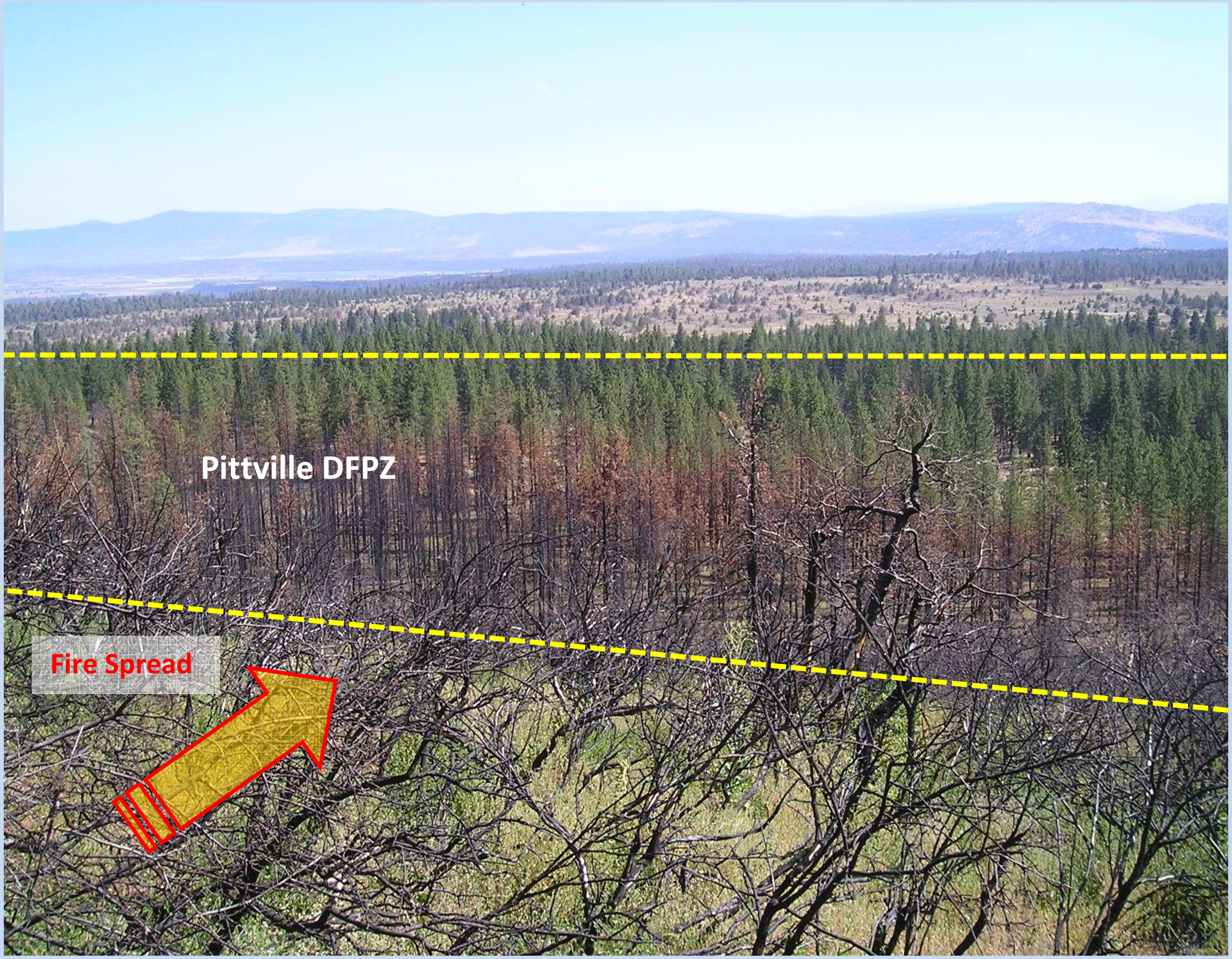
UNTREATED

TREATED

Angora Fire, LTBMU



Peterson Fire, Lassen NF



TREATED

UNTREATED

American River Complex, Tahoe NF

TREATED

UNTREATED

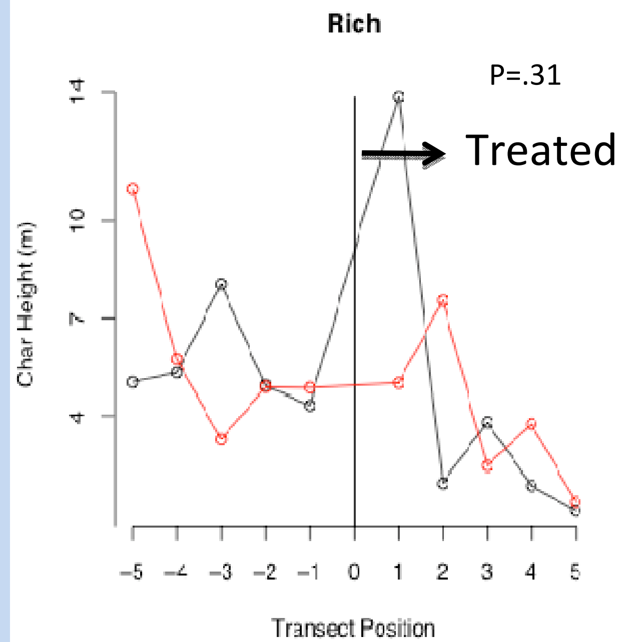
Piute Fire, Sequoia NF

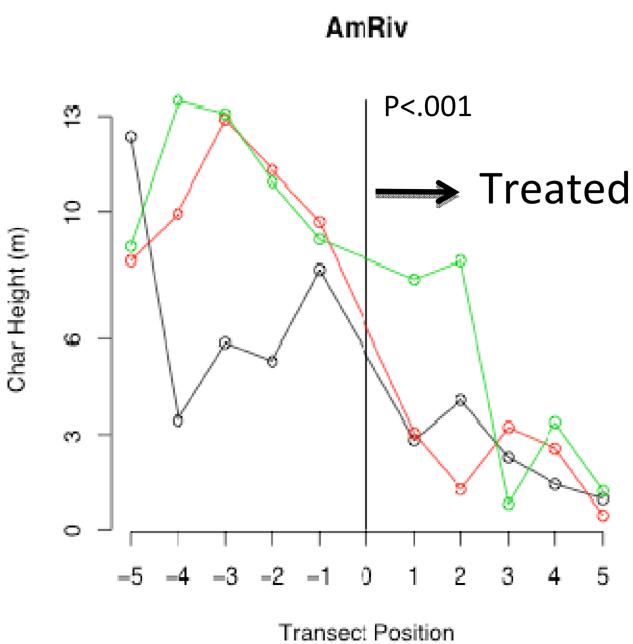
TREATED

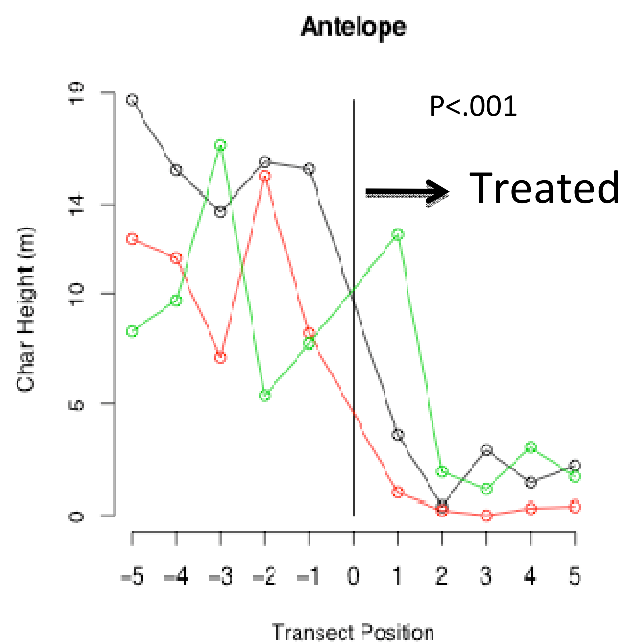
UNTREATED

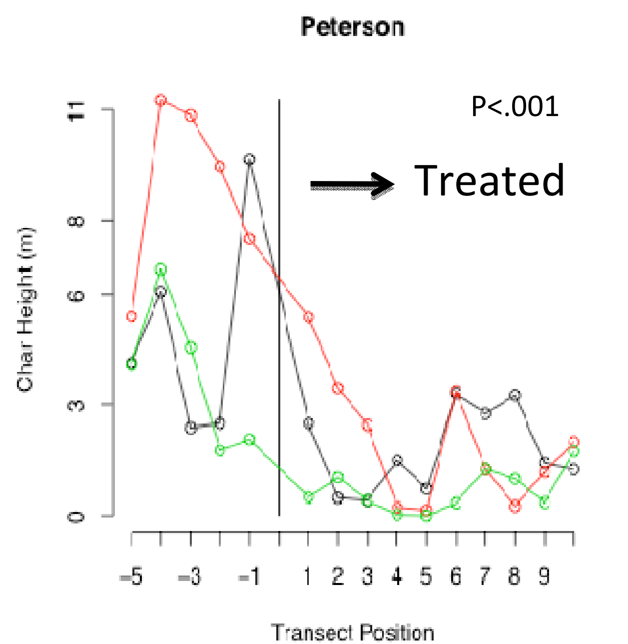
Results II: Ground-based fire severity measures

Bole char height



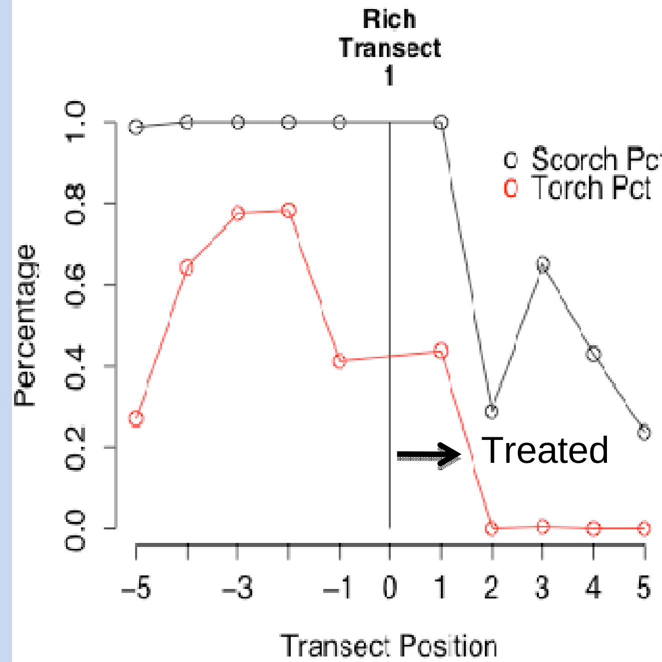


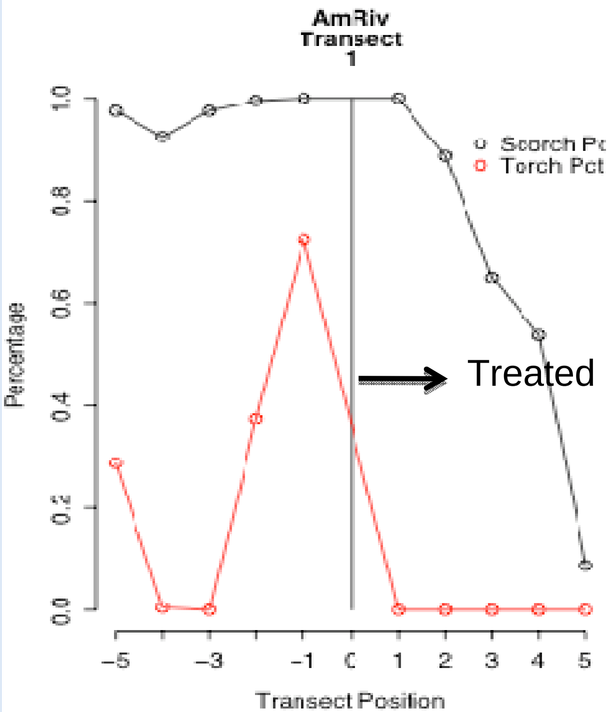


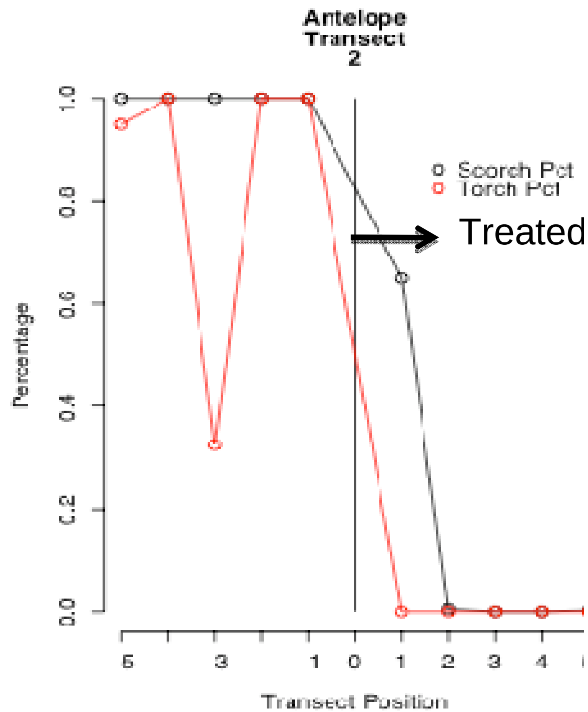


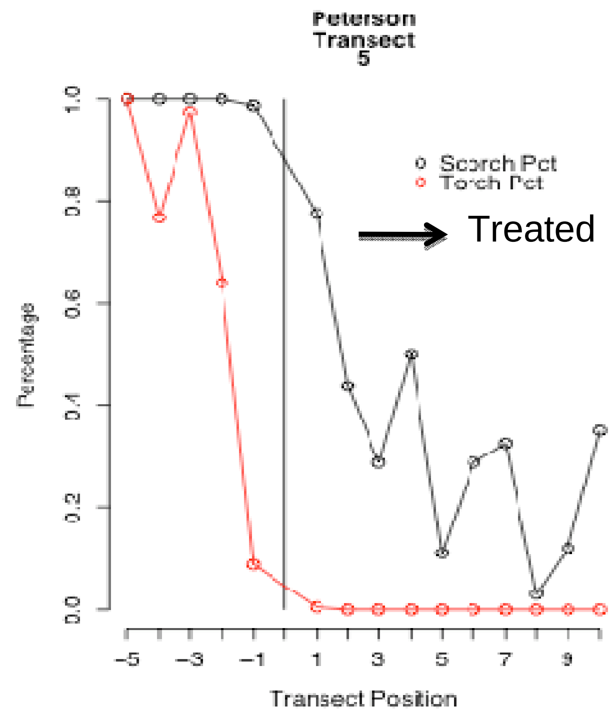
Results II: Ground-based fire severity measures

Scorch & torch percent

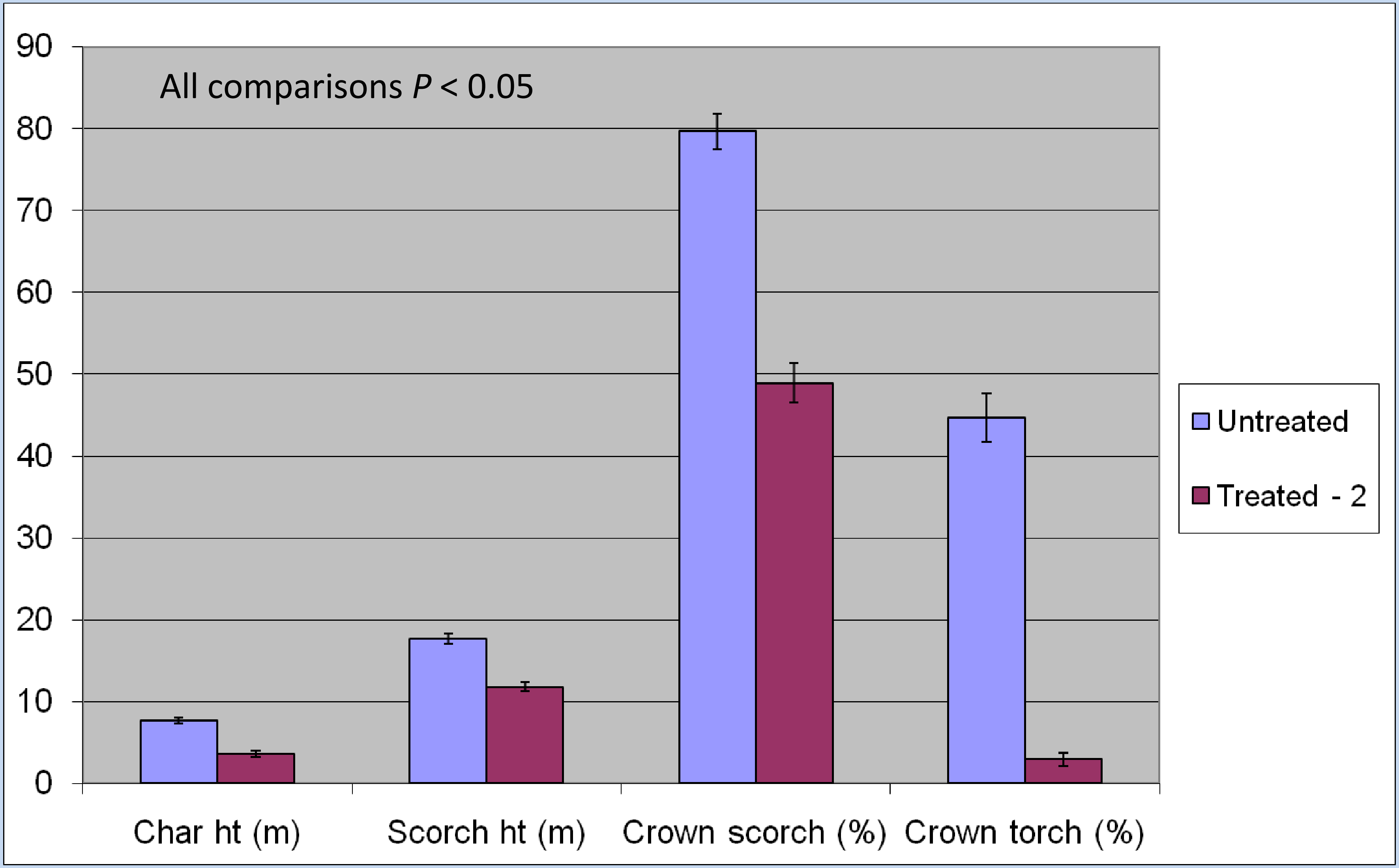




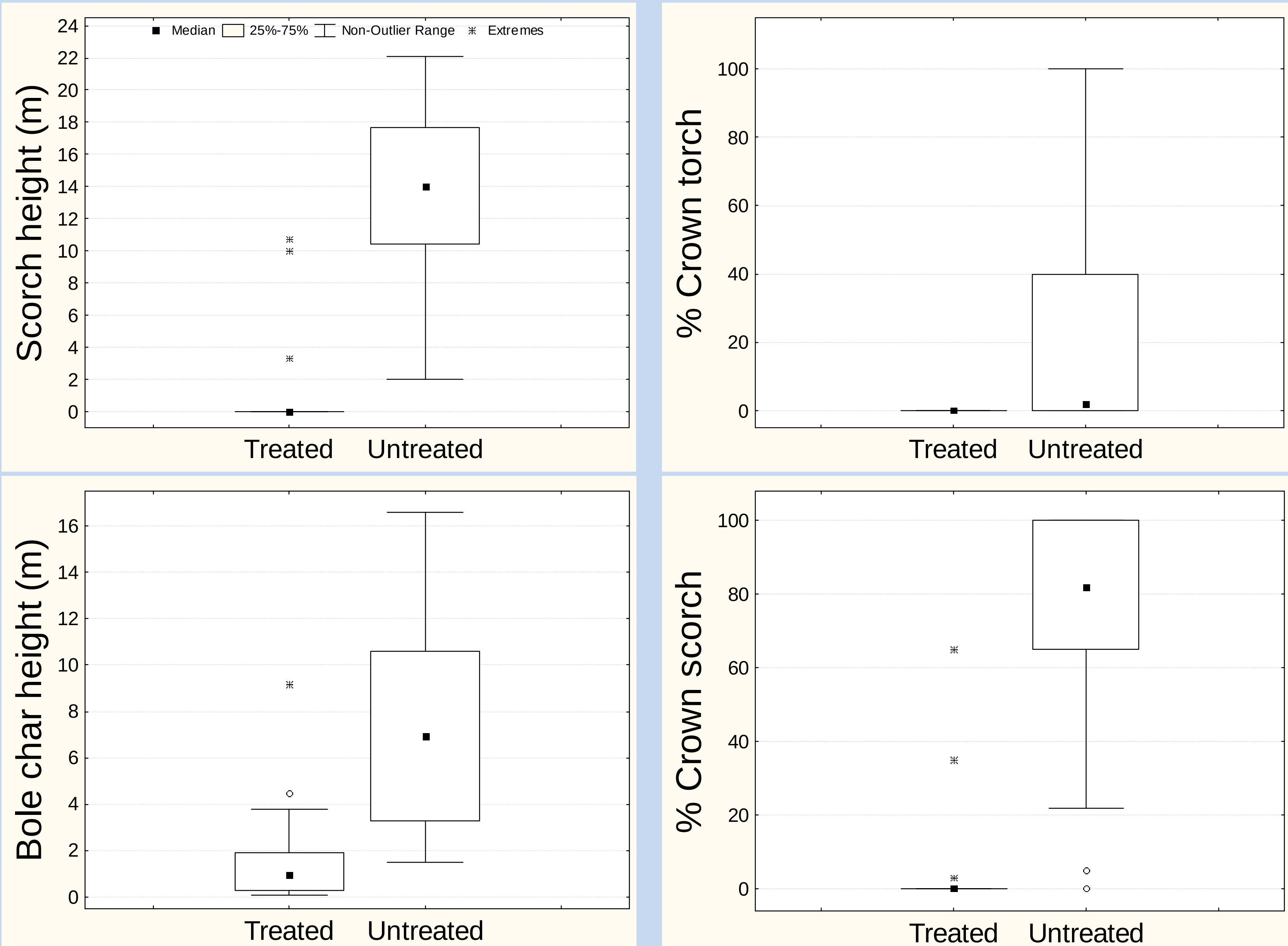




Angora Fire: fire severity

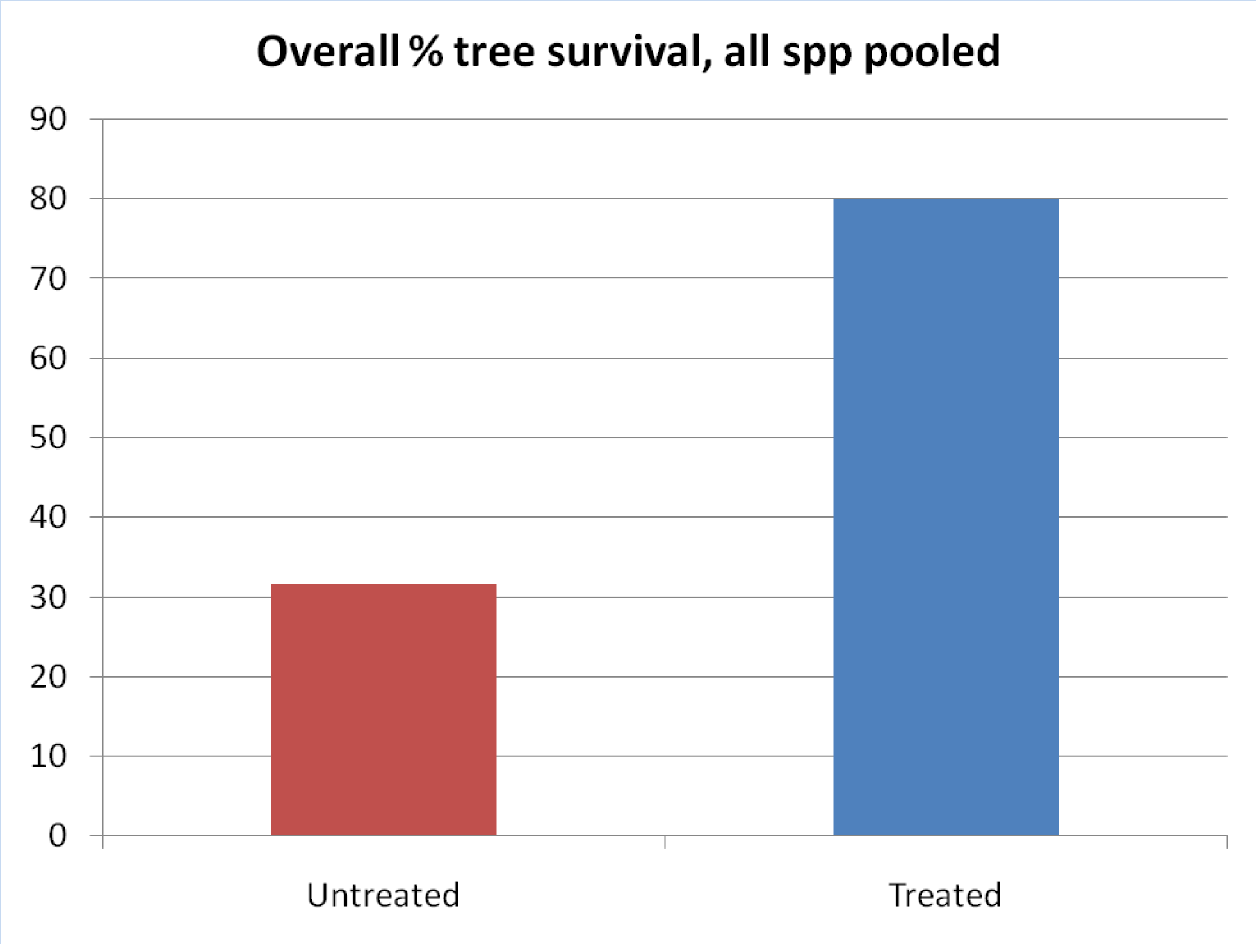


Piute Fire: fire severity



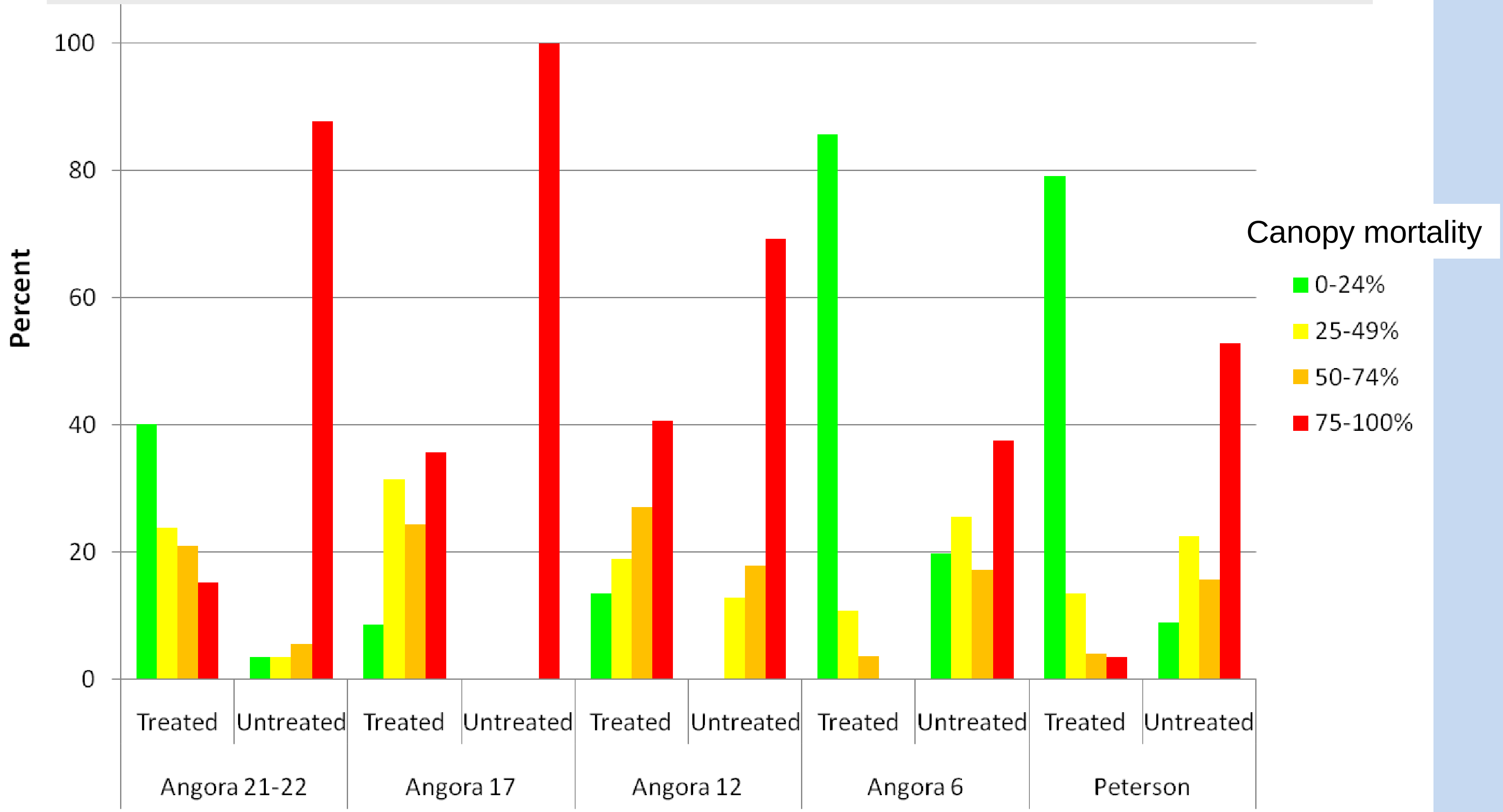
Results V: Tree mortality

On average, 8/10 trees are alive one year post fire in treatments, vs. 3/10 in neighboring untreated forest

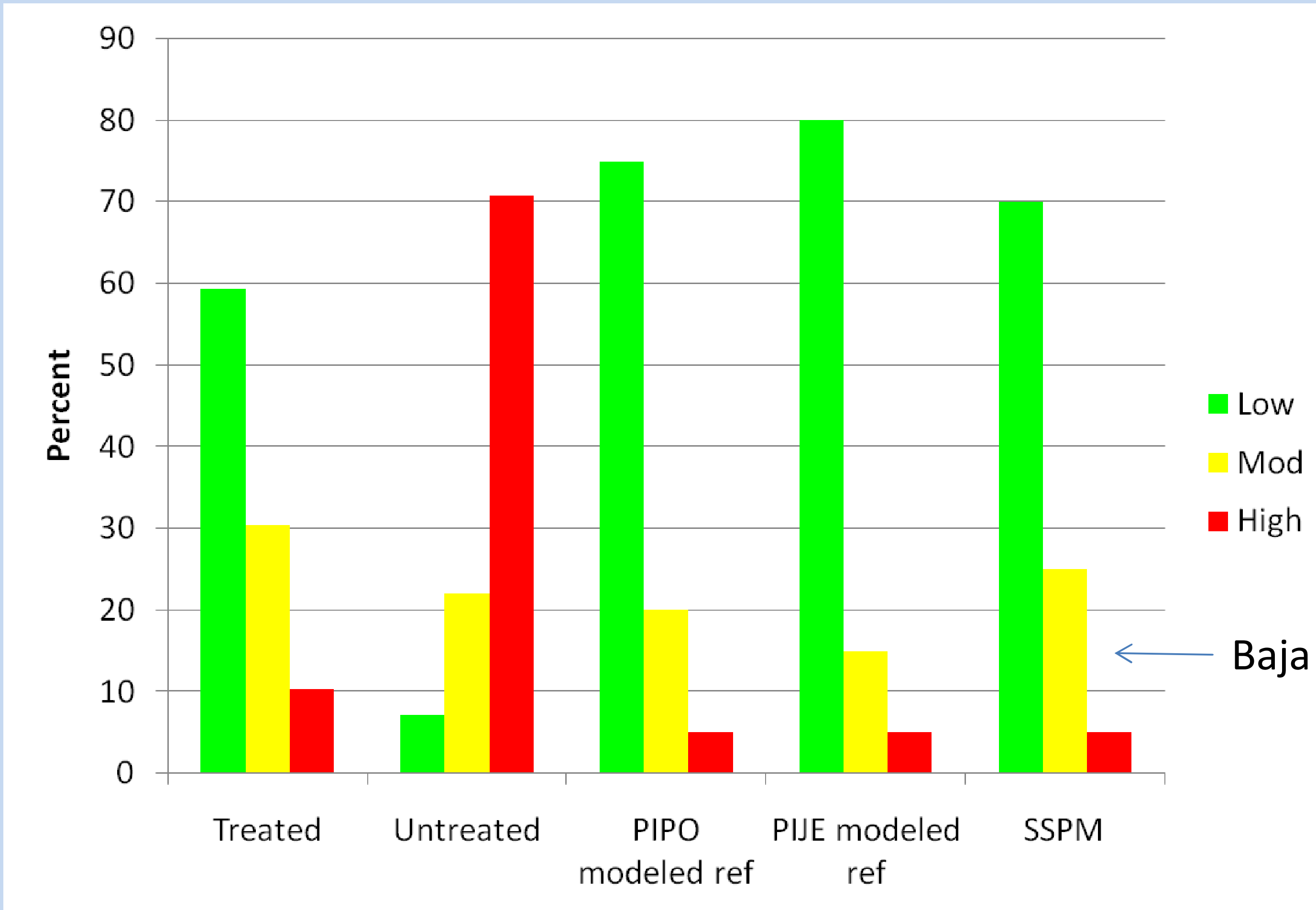


Results III: Heterogeneity in fire severity - canopy mortality classes

Data from field calibrated remote sensing: treatments often show higher spatial heterogeneity in fire effects than untreated forest



Results IV: Fire severity in treatments approximates “natural” condition

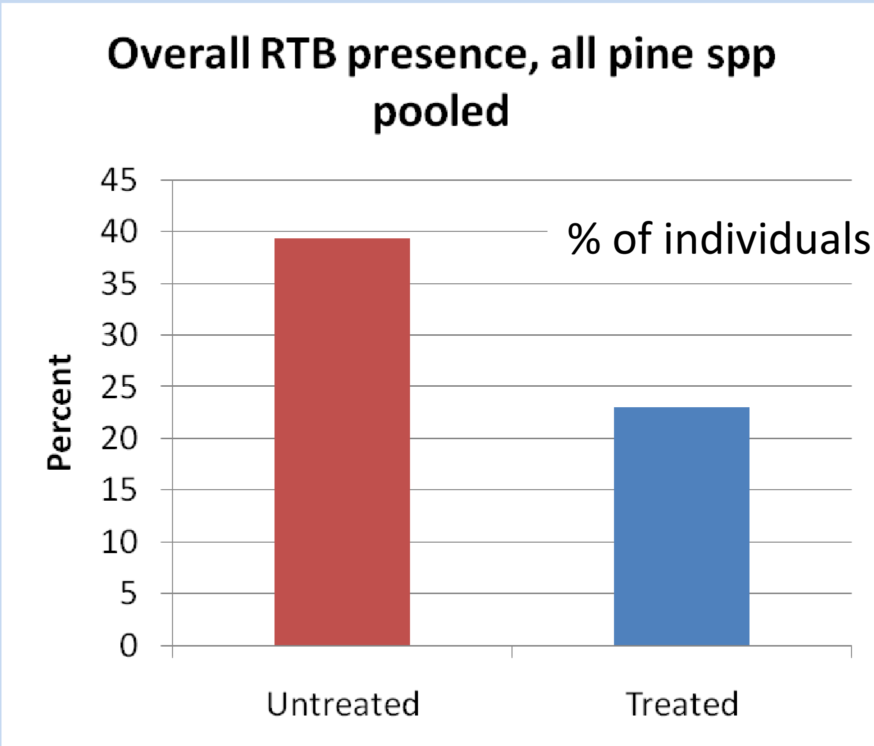


Baja California

Safford, in prep.

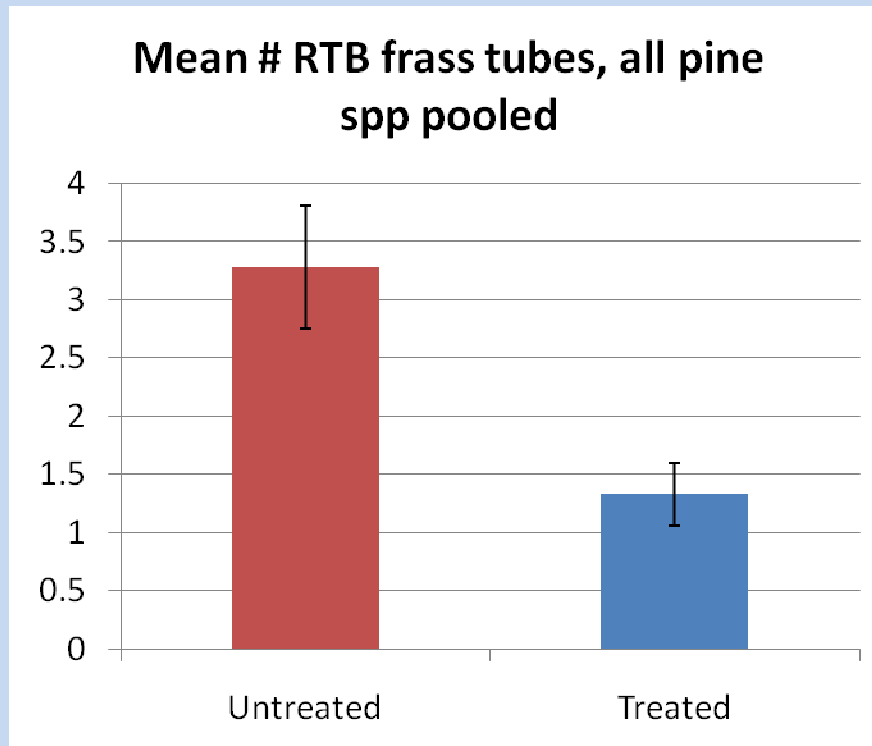
Stephens et al. 2007

Results VI: Red turpentine beetle attack



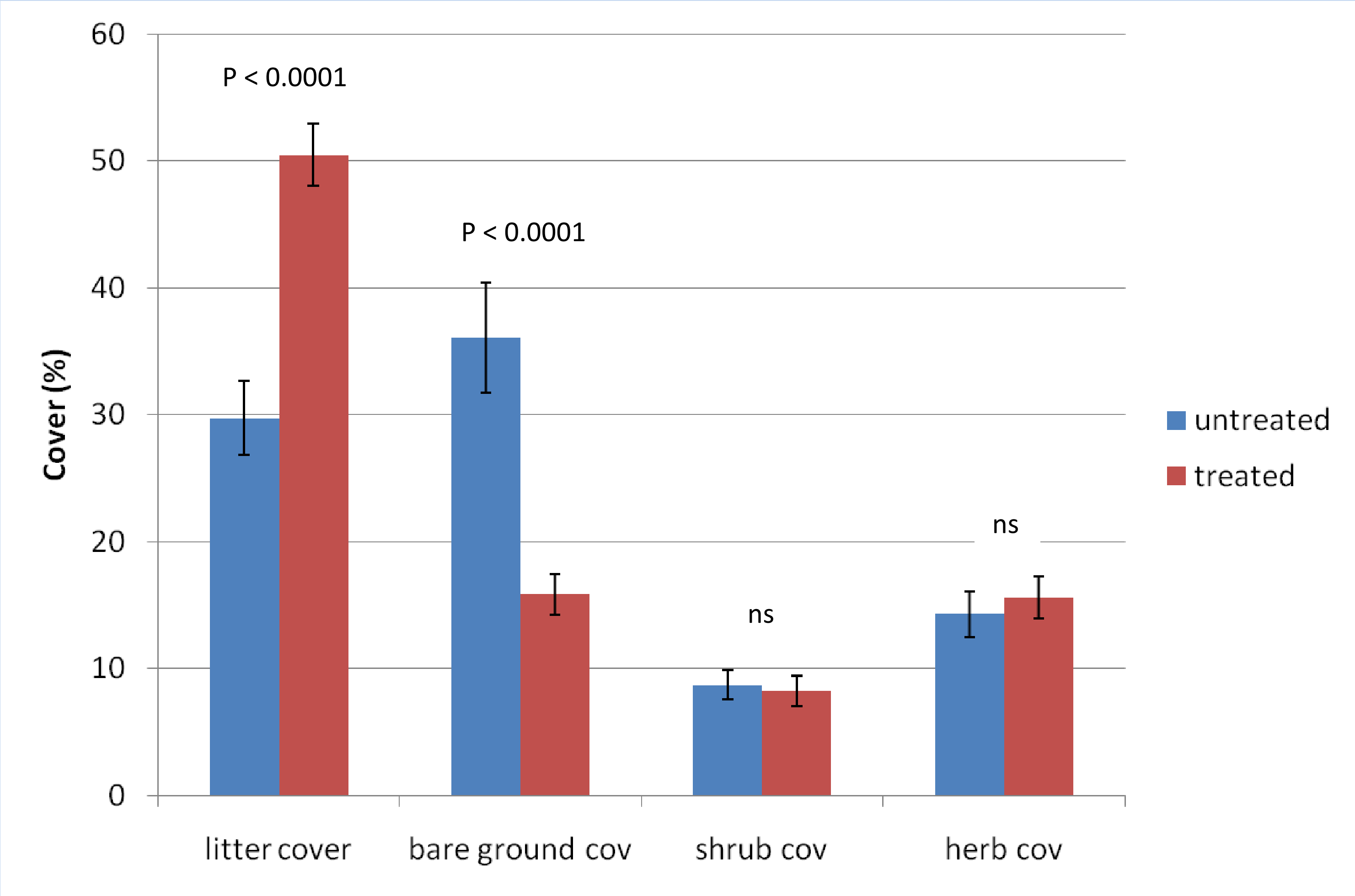
% of individuals attacked

Dendroctonus valens

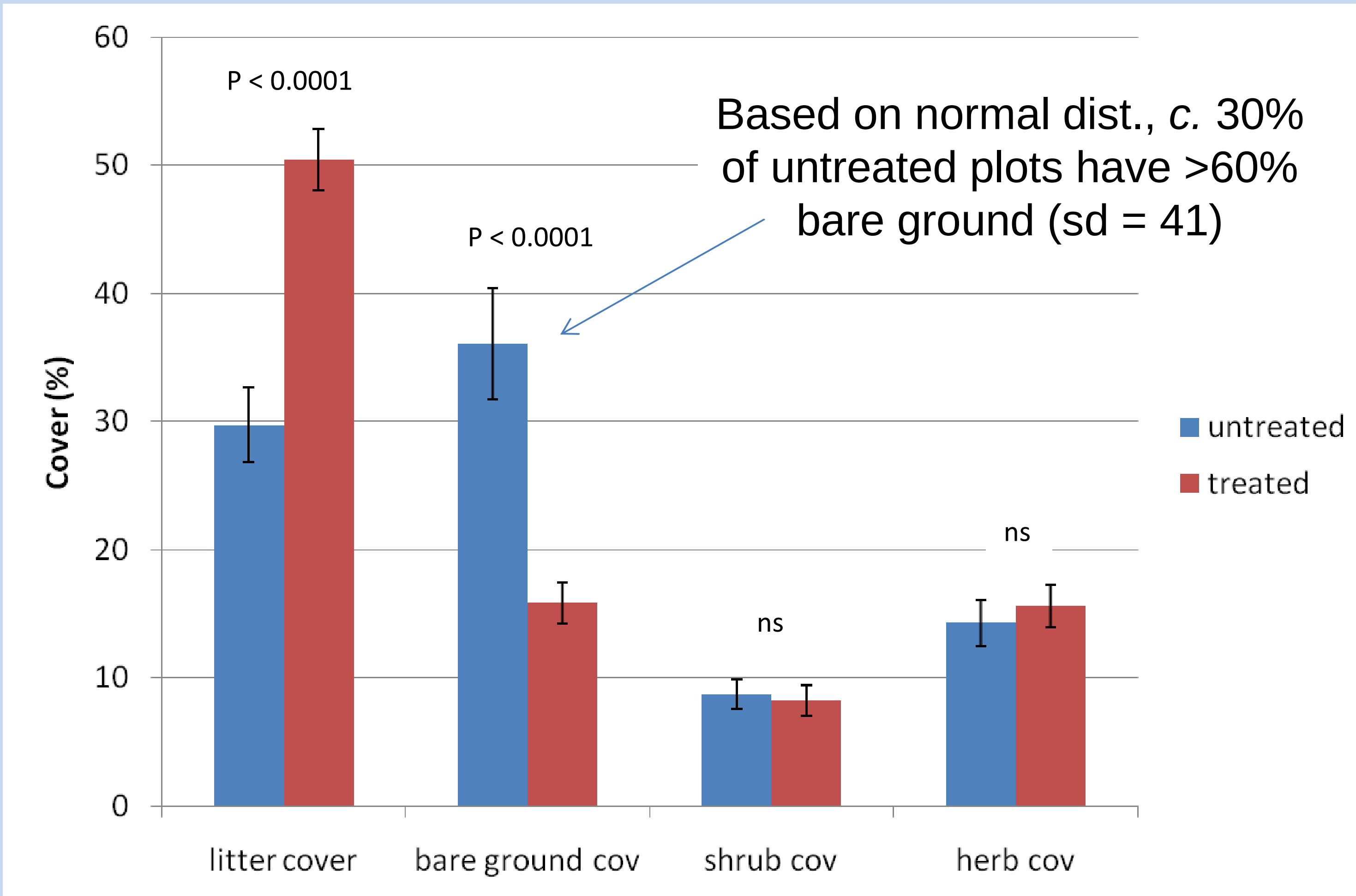


Results VII: Understory

Includes all fires except Piute



Understory (cont.)



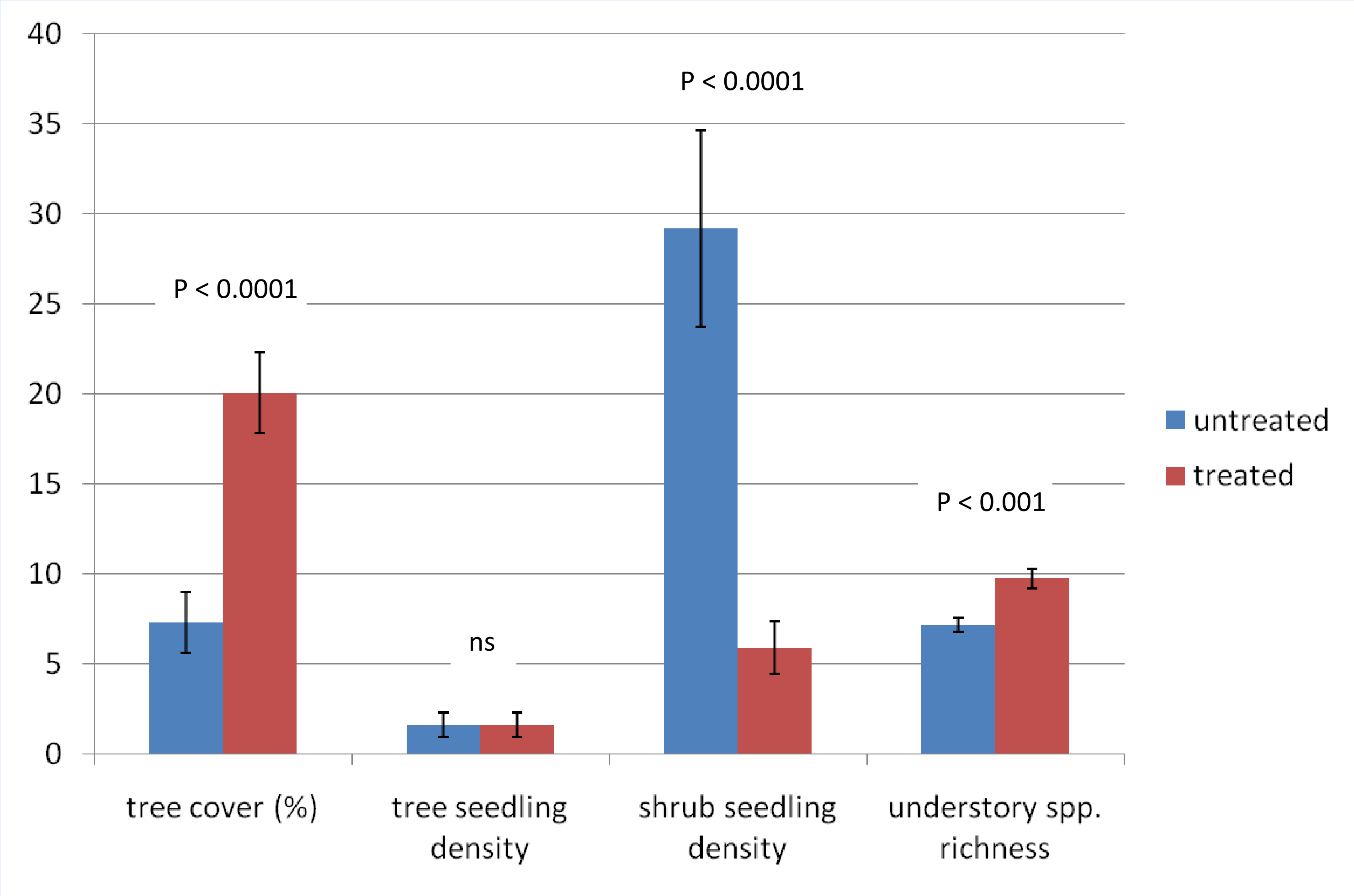
Bare ground and litter

Angora Fire, Transect 5

Treated ← 20 meters → Untreated

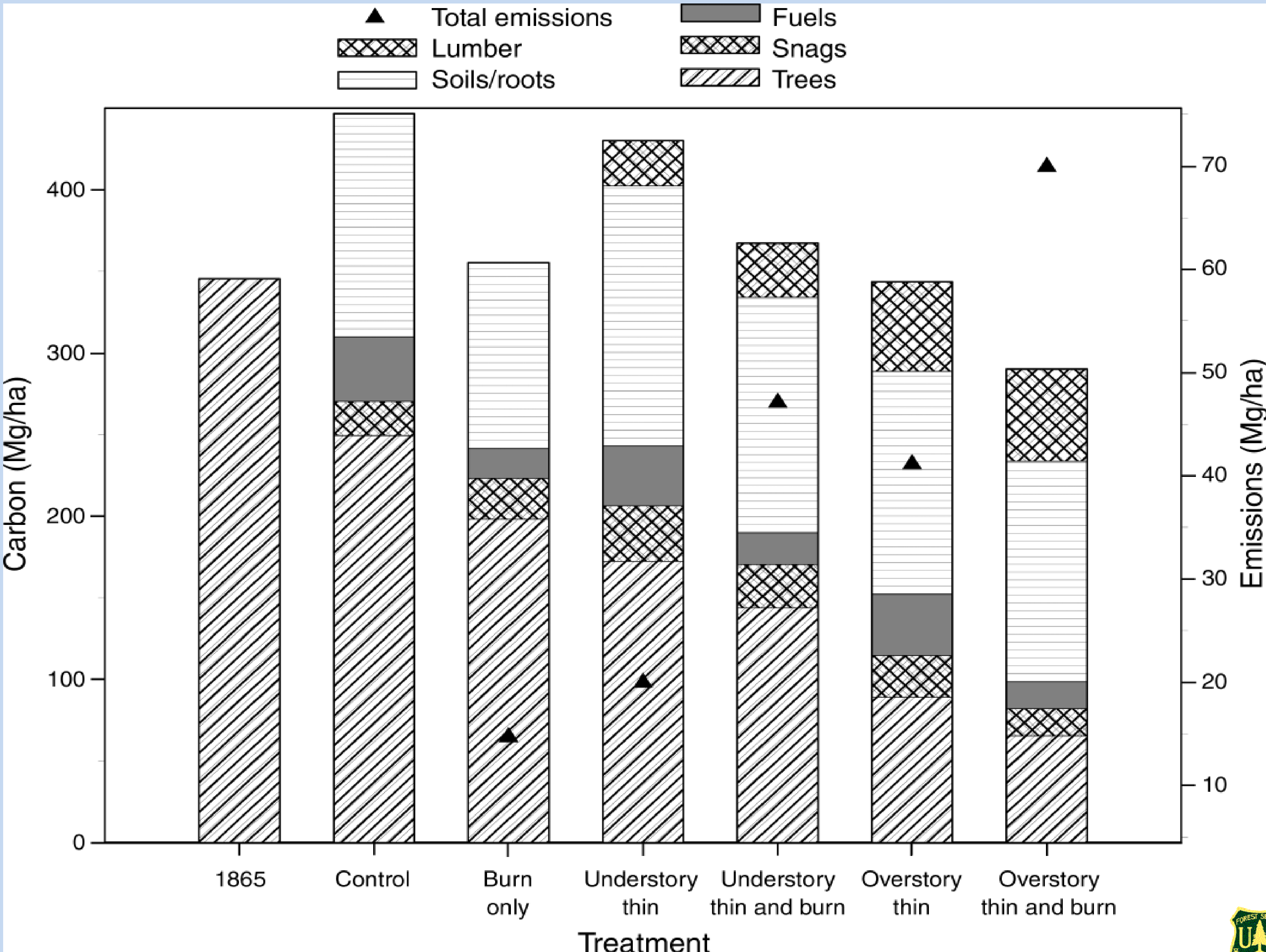
Yellow pine forests (Johansen et al. 2001): major erosion threshold reached at >60% bare ground

Results VIII: Tree cover, seedling density, species richness

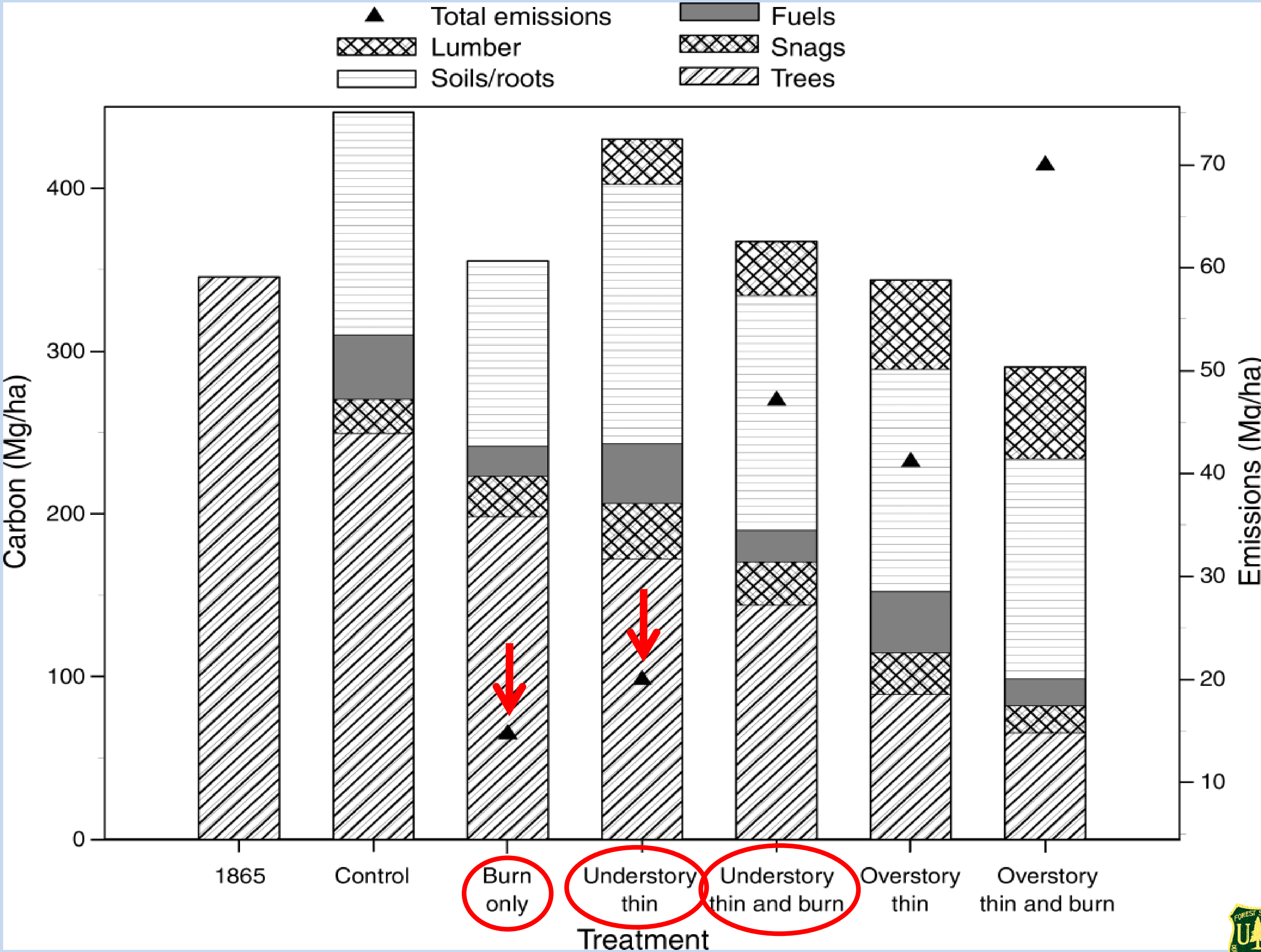


Includes all fires except Piute

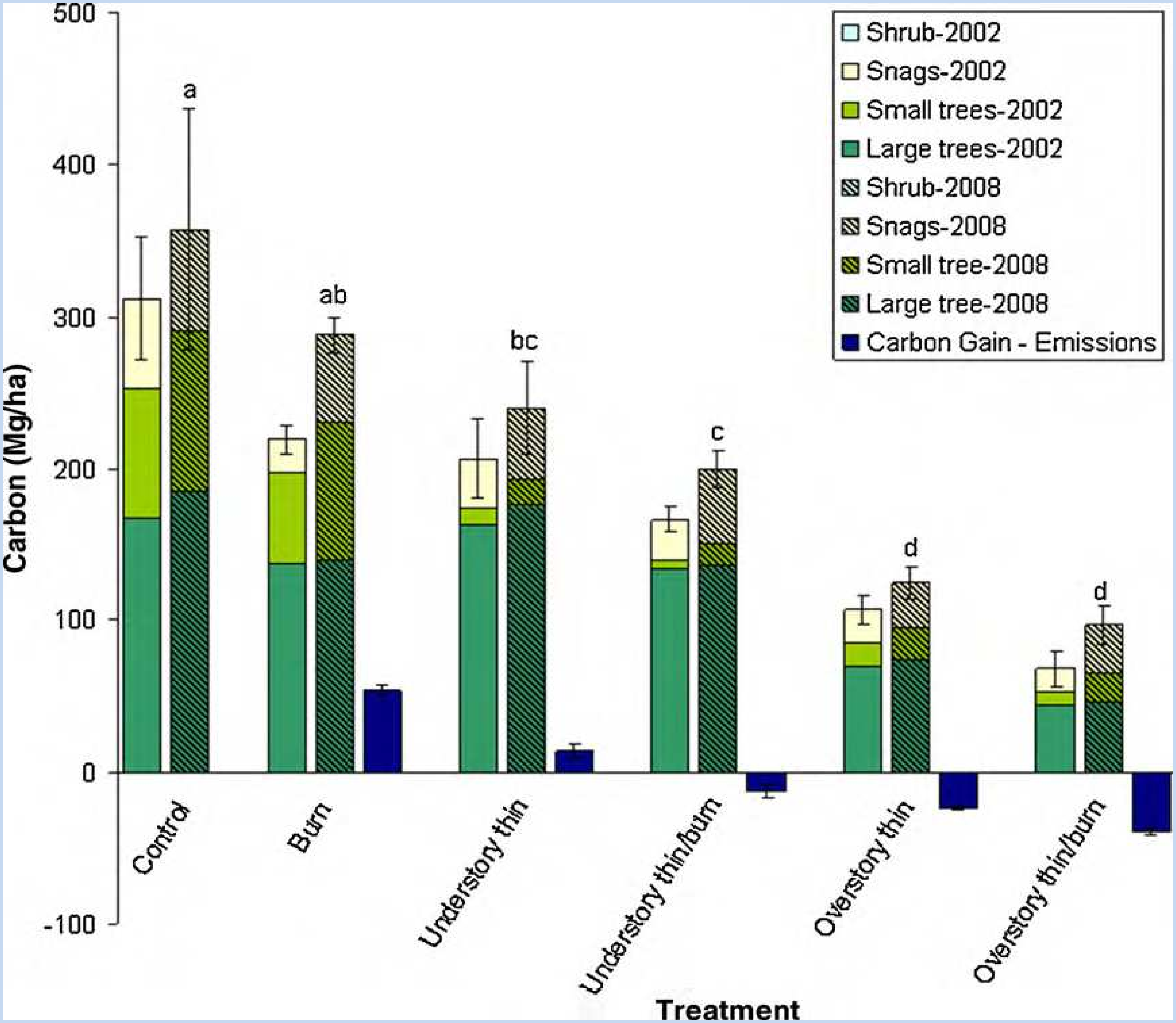
Forest Carbon Sequestration



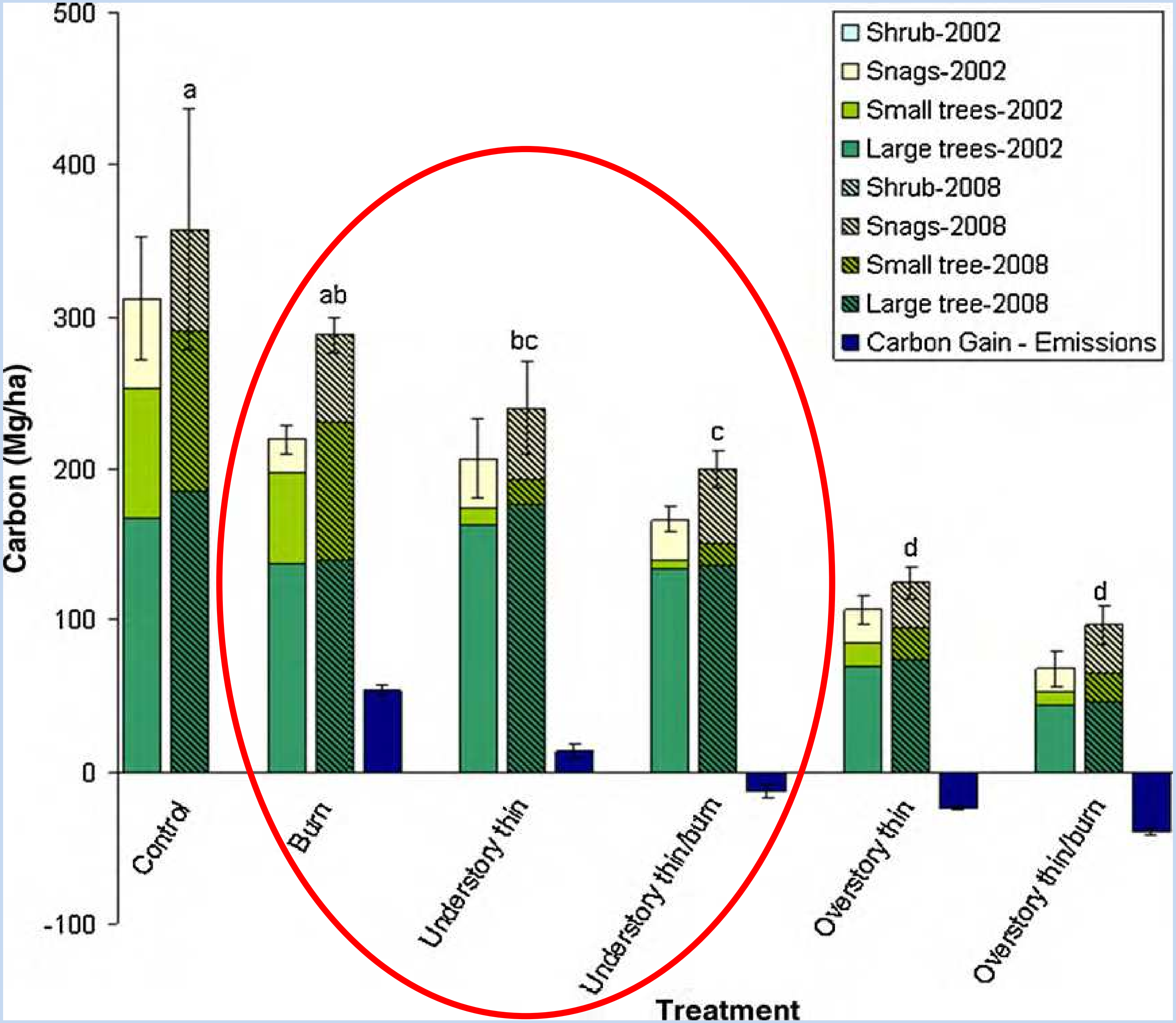
North et al. 2009



North et al. 2009



Hurteau and North 2010



Hurteau and North 2010

Summary I

- Sierra Nevada fire regimes are typified by frequent, low-severity fire in mid-elevation forests and woodlands
- In California, pre-settlement fires were frequent and covered large areas of all ecosystem types, especially mid-elevation forests
- Current (post-1950) annual wildfire emissions during ‘extreme’ wildfire years are only a fraction of pre-settlement California wildfire emissions

Summary II

- In the Southern Sierra Nevada, temperatures are increasing, especially low temps and freezing days; moisture has increased at some stations
- In Sierra Nevada forests, fires are becoming larger, more frequent, and higher severity
- Recent fire patterns linked to warming temperatures; also seen throughout western U.S.
- Models project increases in wildfire activity and intensity in the Sierra Nevada

Summary III

- Completed and properly designed fuel treat-ments in yellow pine and mixed-conifer forests:
  - Reduces fire severity in almost all cases
  - Promotes resilience/retention of forest cover even in severe wildfires
  - Reduces beetle attacks on live trees
  - Reduces soil loss in burned forest

Summary III

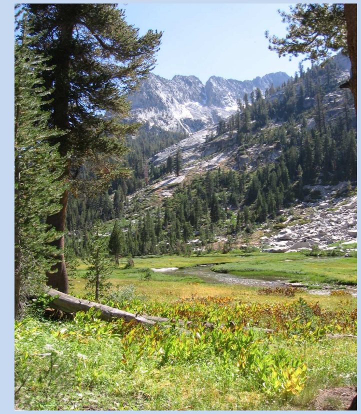
- Completed and properly designed fuel treatments can:
  - Increase heterogeneity of burn effects
    - Heterogeneity enhances habitat diversity with benefits to plant and wildlife species
  - Provide relatively safe environments for reintroduction of fire
  - Restore key ecological patterns and processes in these forest types
  - Maximize carbon sequestration and minimize carbon emissions

Informal Guidelines that Assist in Forest Restoration

- **Must include explicit treatment of surface and ladder fuels**
  - It is best to remove the material from the site
- **Should include some fire component**
  - Preferably Rx underburning, but pile burning OK (the sloppier the better); 10-15% tree mortality is OK!
- Should create highly heterogeneous habitat conditions, not evenly-spaced stands
- Mature tree densities (>12” dbh) = 12-40 trees/acre
- Basal Area = 80-130 ft^2/acre
  - Use physical habitat template to guide prescription
- See ***An Ecosystem Management Strategy for Sierran Mixed Conifier Forests*** (North et al. 2010) Gen. Tech. Report for more info.








12/11/2008