Fire regimes and forest restoration in the Lake Tahoe Basin

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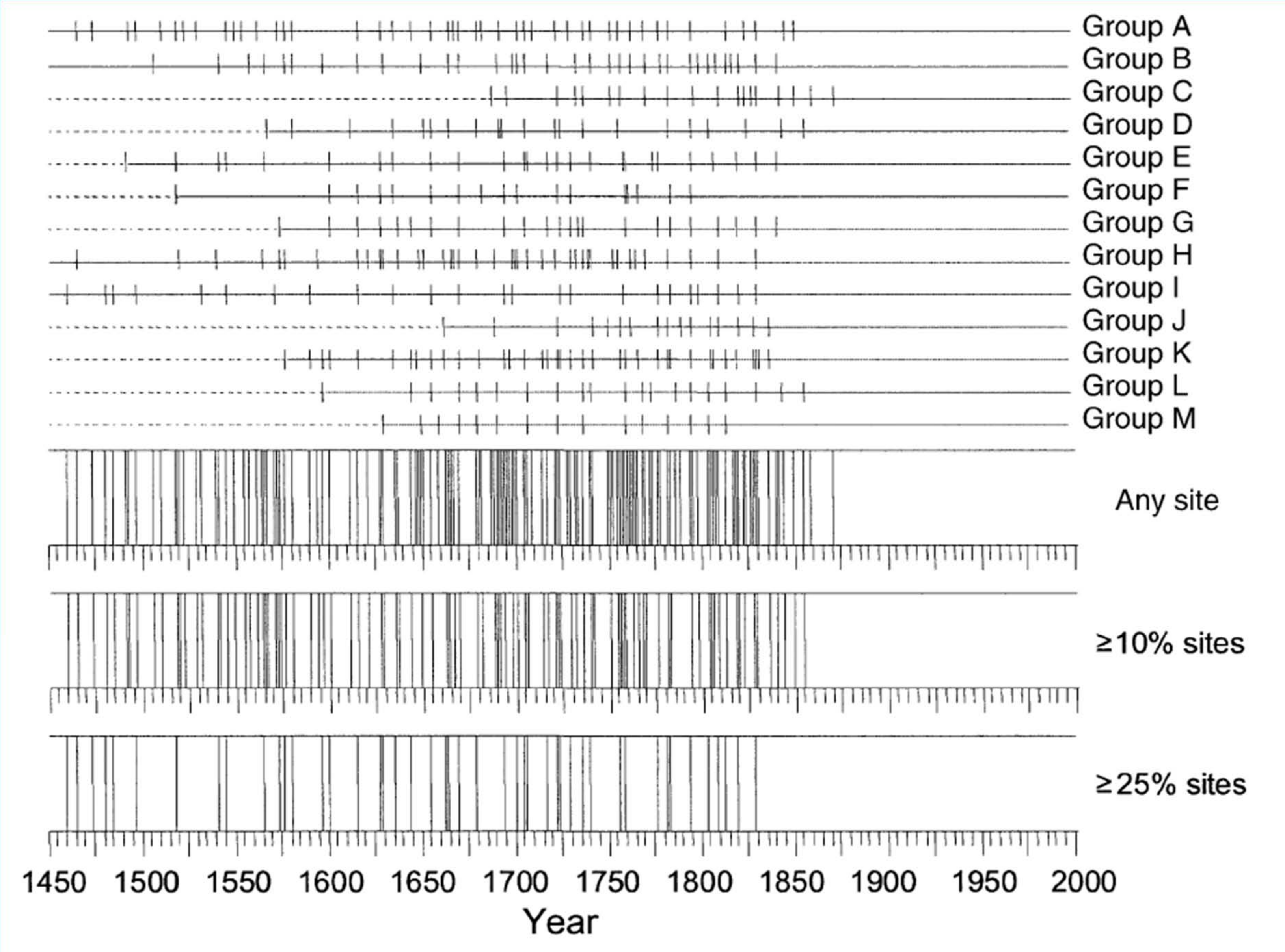
PAST AND CURRENT FIRE REGIMES

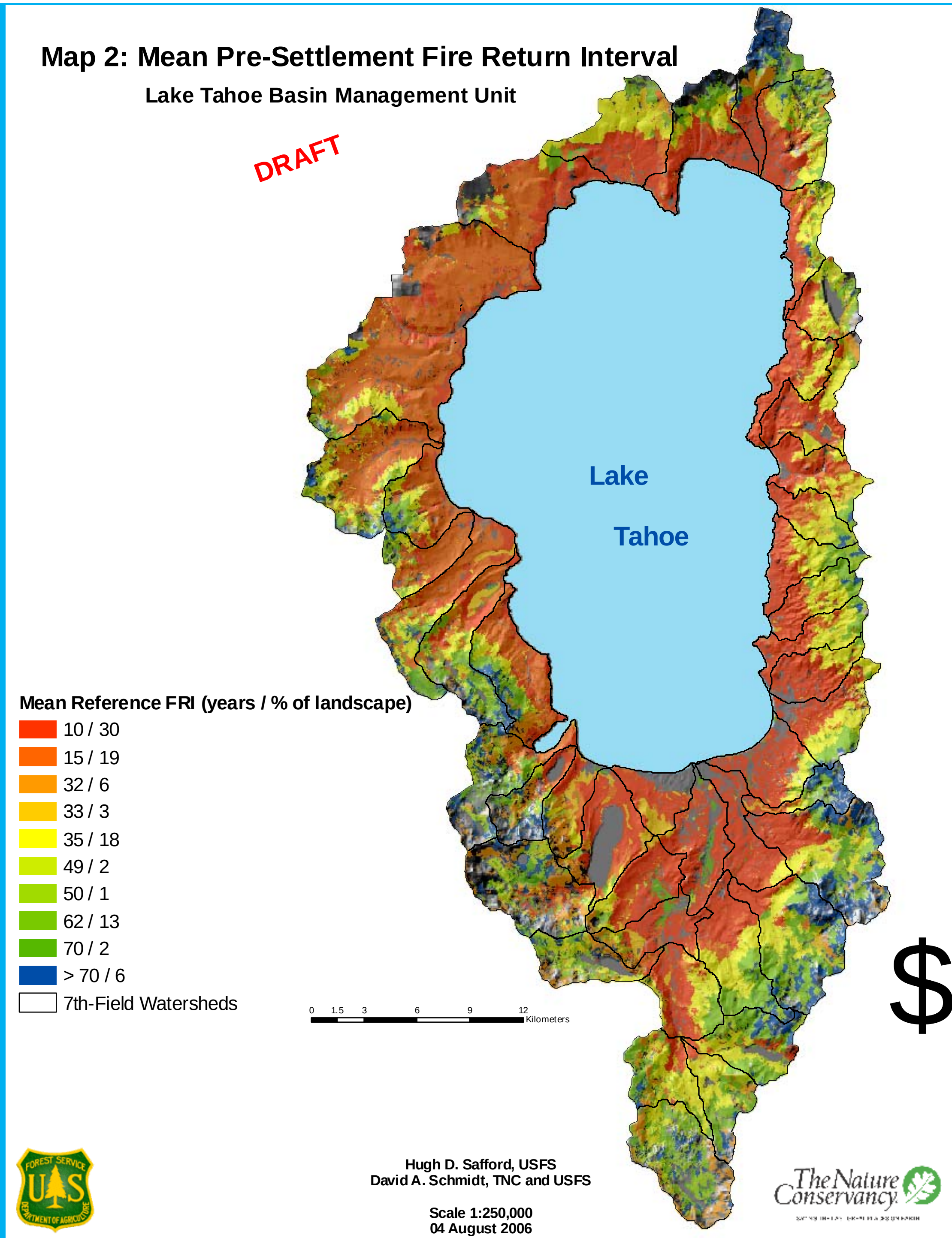
Past regime

Fire dendrochronology, east shore Lake Tahoe, Jeffrey pine and mixed conifer: Before 1850, fire return interval was 8-10 years. Last fire recorded was 1870.



A. Taylor 2004. *Ecological Applications*

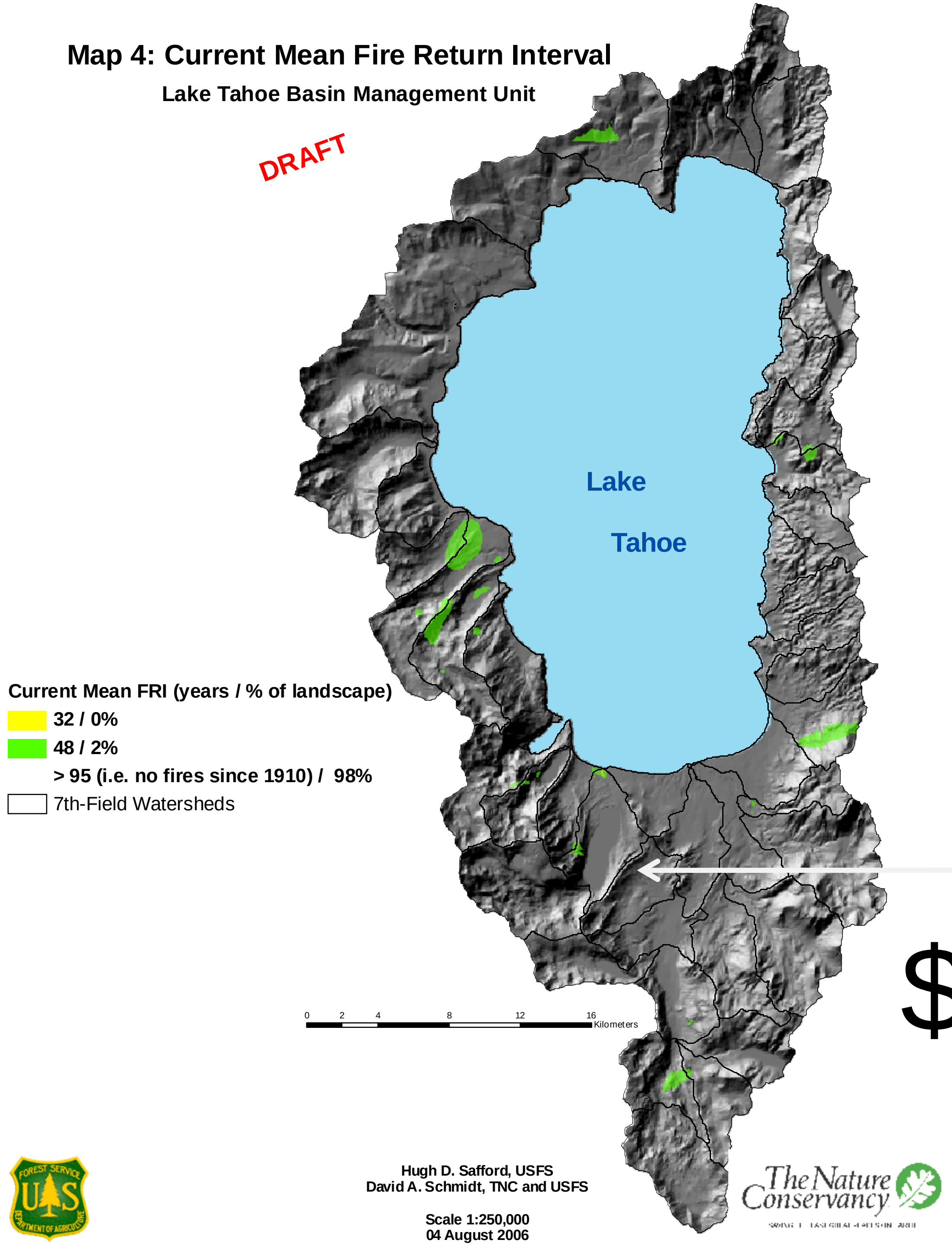
Past regime



Mean fire return intervals were ≤15 years on *c*. 50% of the landscape

In an average year, probably 3000-4000 acres of forest experienced fire

Current regime



Today: fire has almost disappeared as an ecological force in the LTB

Map is missing the Angora Fire

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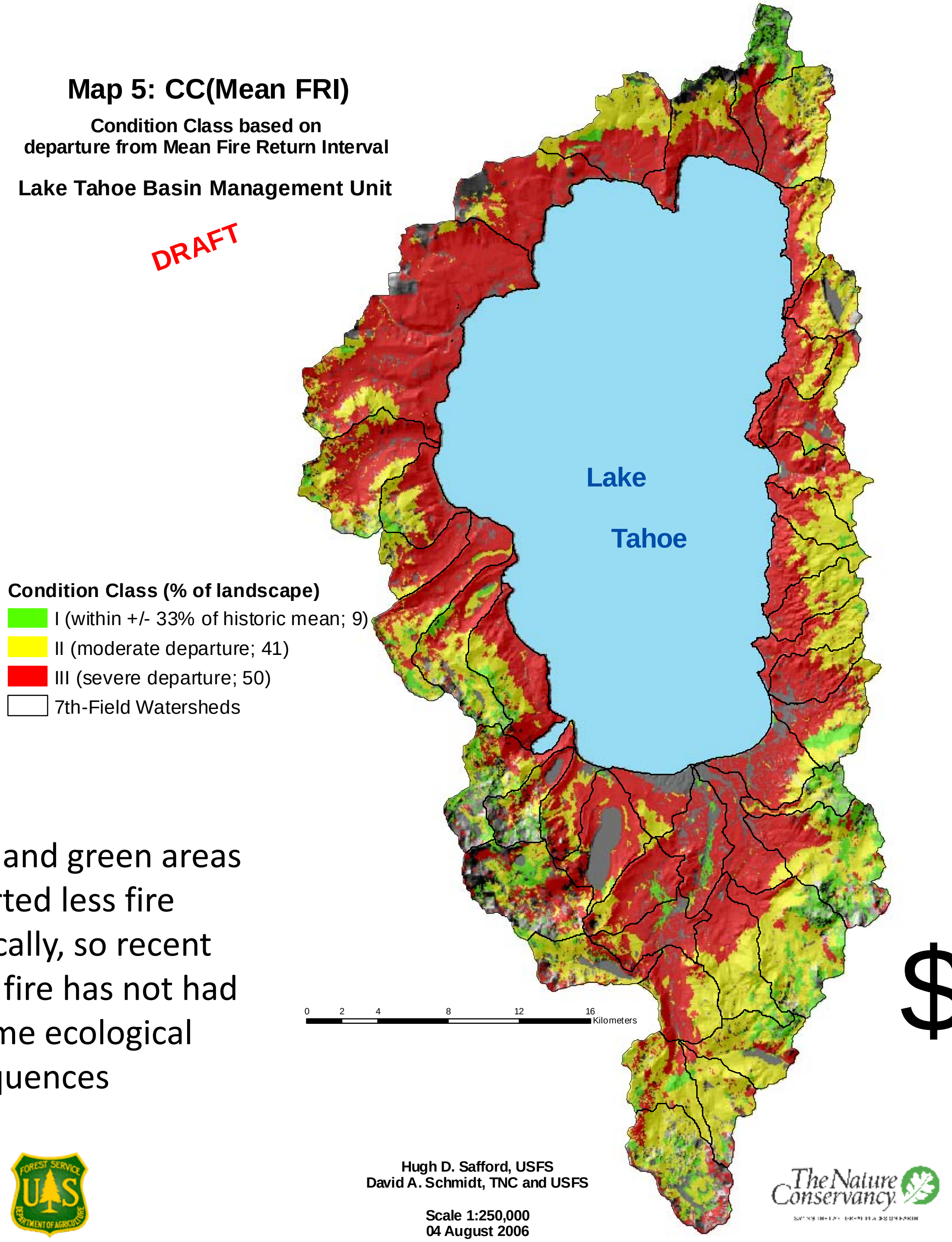
Current conditions

Fire as an ecological process



"Condition class" maps the extent to which the current landscape resembles the historical reference landscape. About ½ of the LTB (red) has "completely" lost the the disturbance regime that drove vegetation composition and structure

Yellow and green areas supported less fire historically, so recent lack of fire has not had the same ecological consequences

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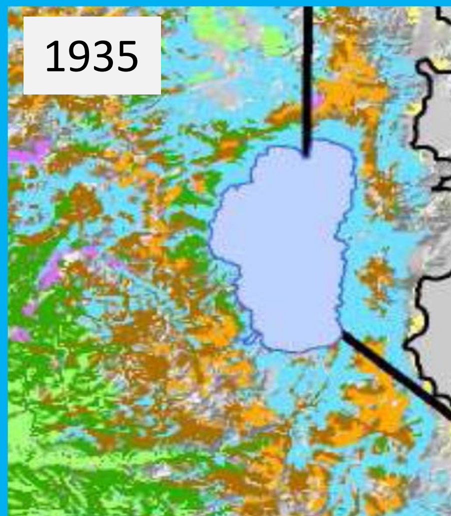
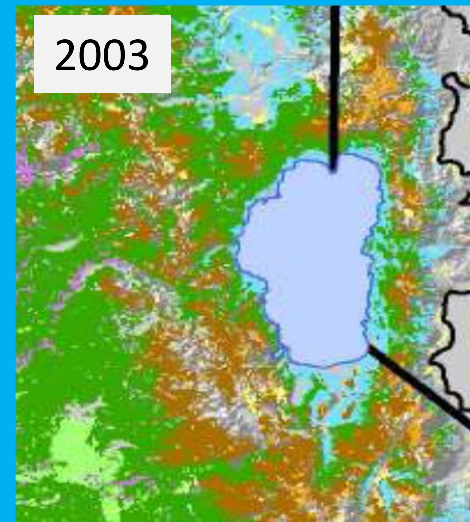
Changing forests

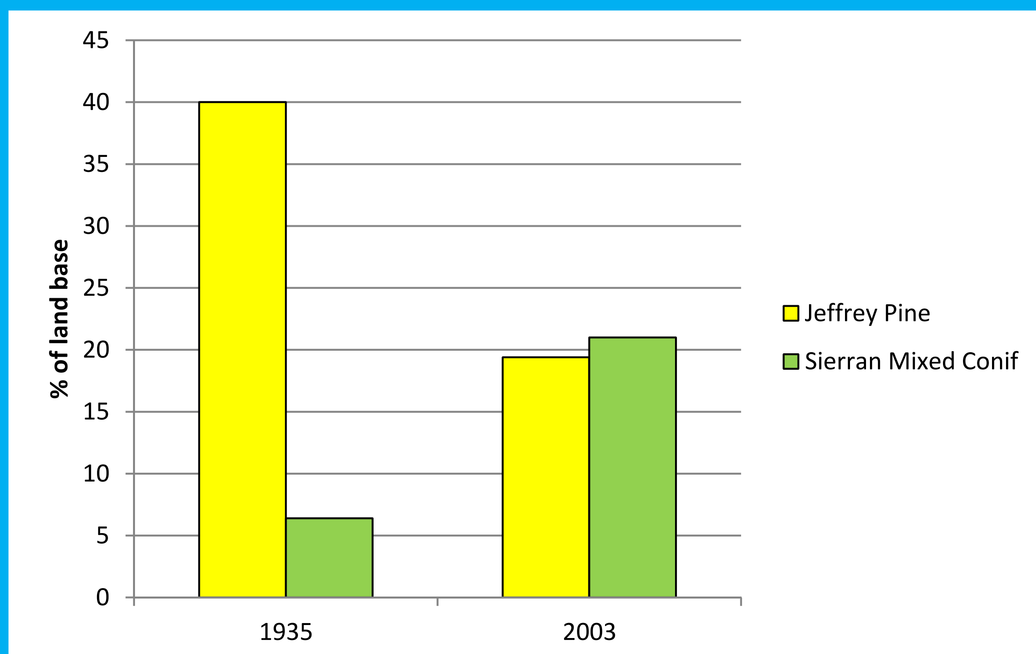
Frequent fire maintained a landscape dominated by fire tolerant species



Light blue = Jeffrey pine

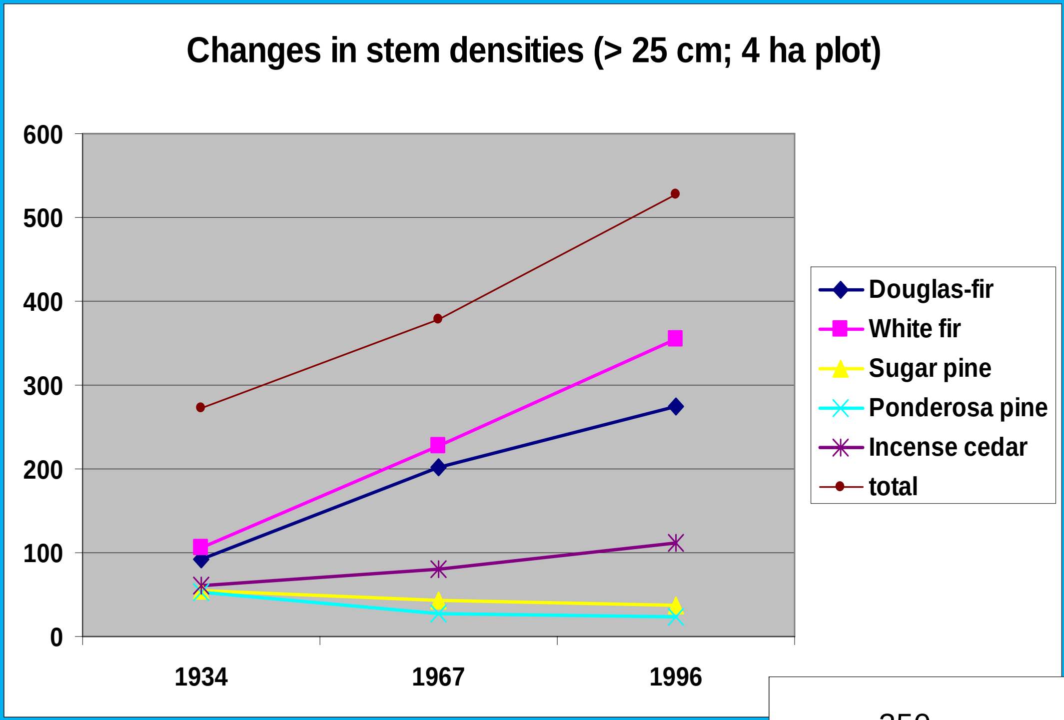
Dark green = fir dominated

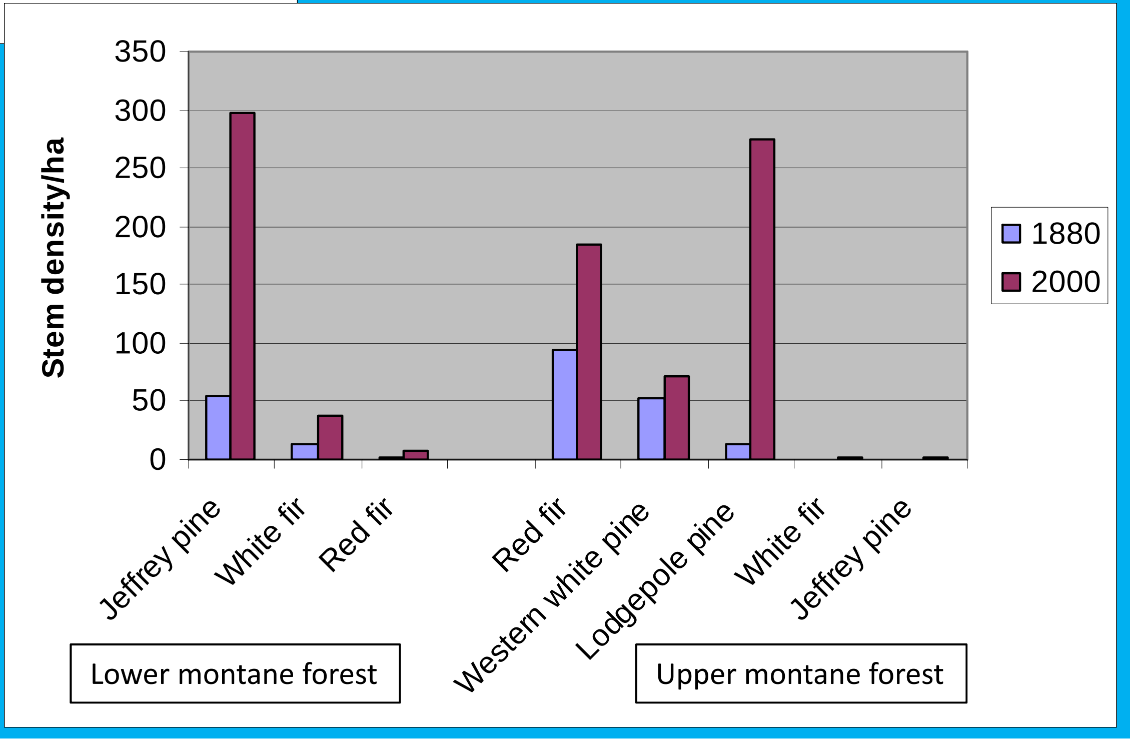




Ecological effects of fire suppression

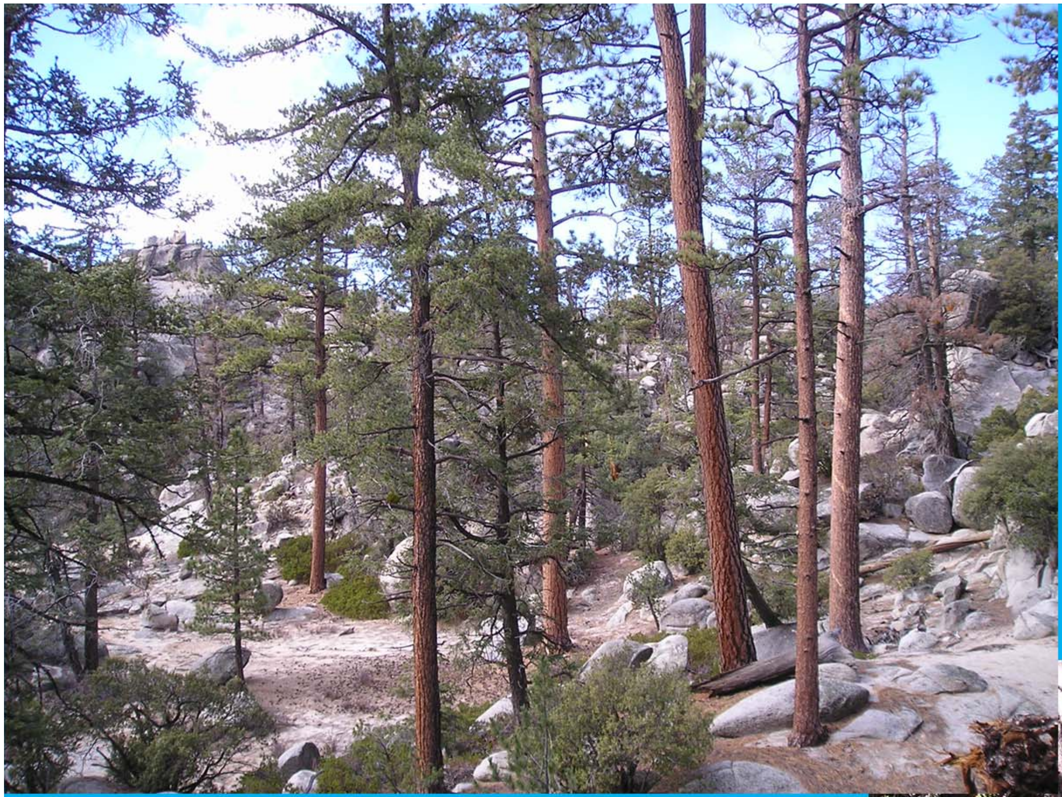
Tree composition in many Sierra Nevada forests is shifting to shade-tolerant, fire-intolerant spp, and stem densities are increasing





Greater biomass, stem density and cover = greater fuel loads and greater fuel continuity

(Taylor 2004)



Reference forest, northern Baja California, Mexico: pine dominated, large canopy trees, open canopy, low fuel loading (low litter levels, highly heterogeneous understory, fuel ladders rare), high diversity of understory species

Current forest, Lake Tahoe Basin, westshore: fir dominated, mostly small and mid-sized trees, closed canopy, high fuel loading (very deep litter, high fuel continuity, fuel ladders common), low diversity of understory species

Slaughterhouse Canyon: 1873

Area was completely cut by 1885

C. E. Watkins

Slaughterhouse Canyon: 1990

P. Goin

Emerald Point: 1880's vs. today

Emerald Point was part of a private estate and was not cut

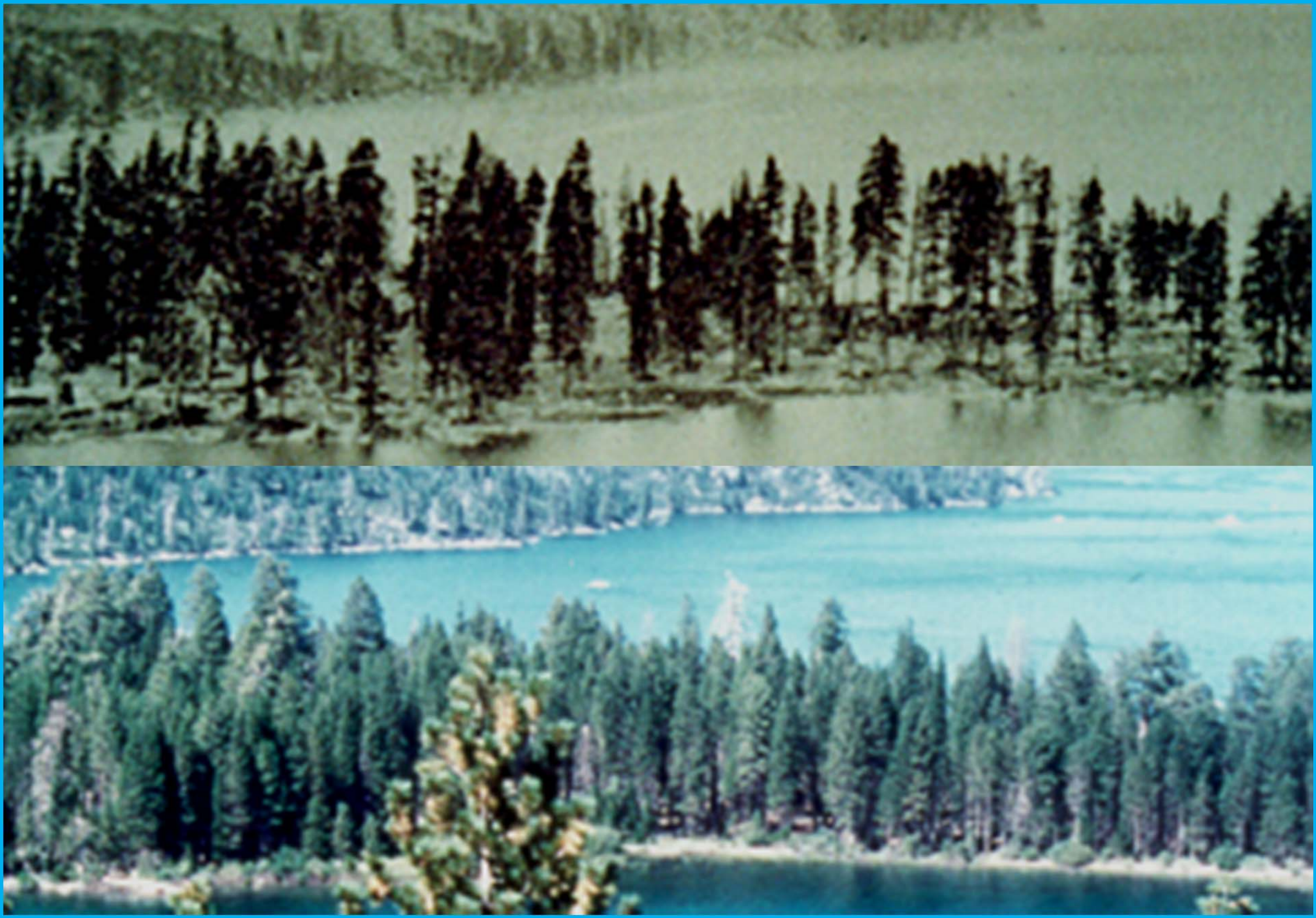
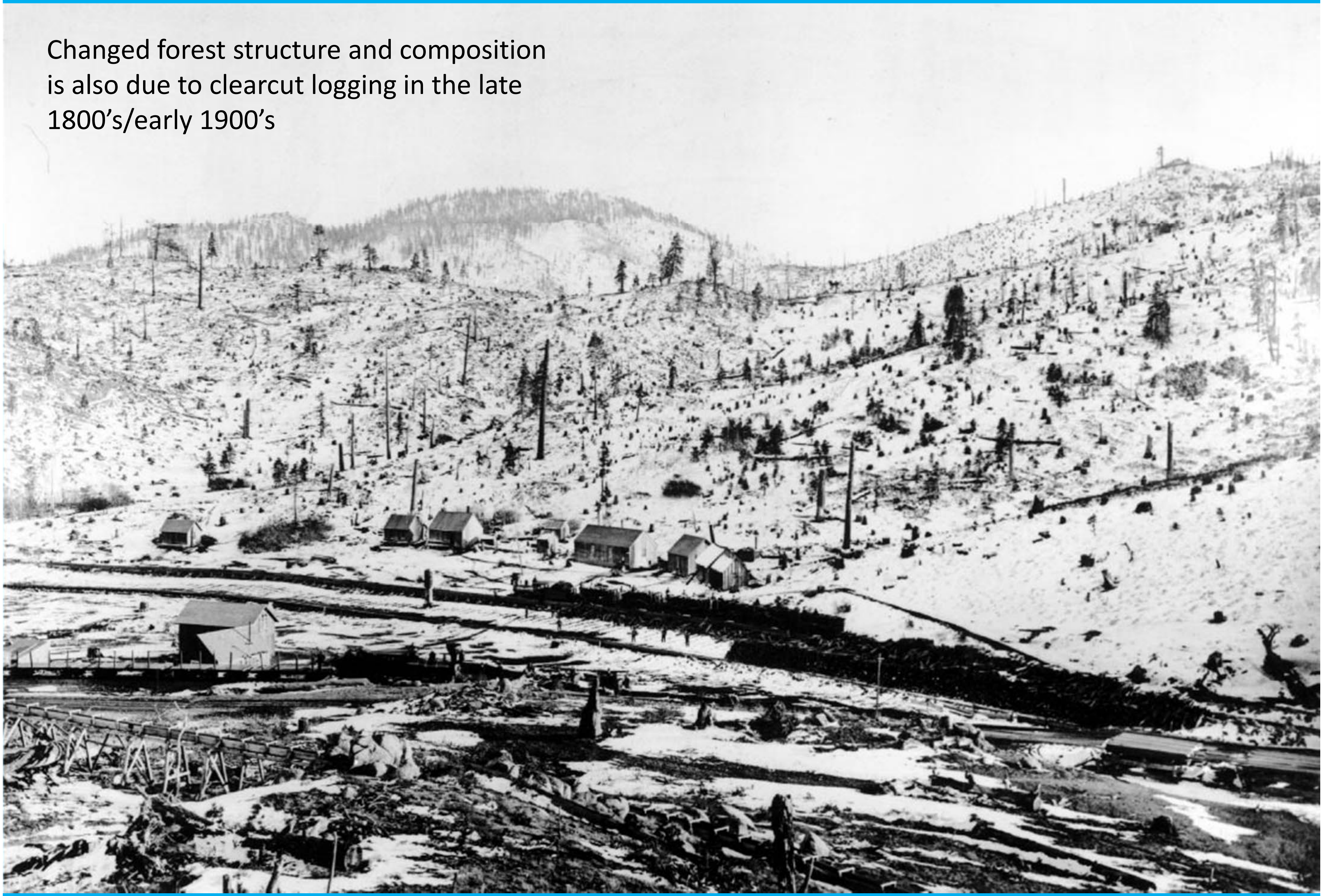


Photo courtesy of Rich Adams

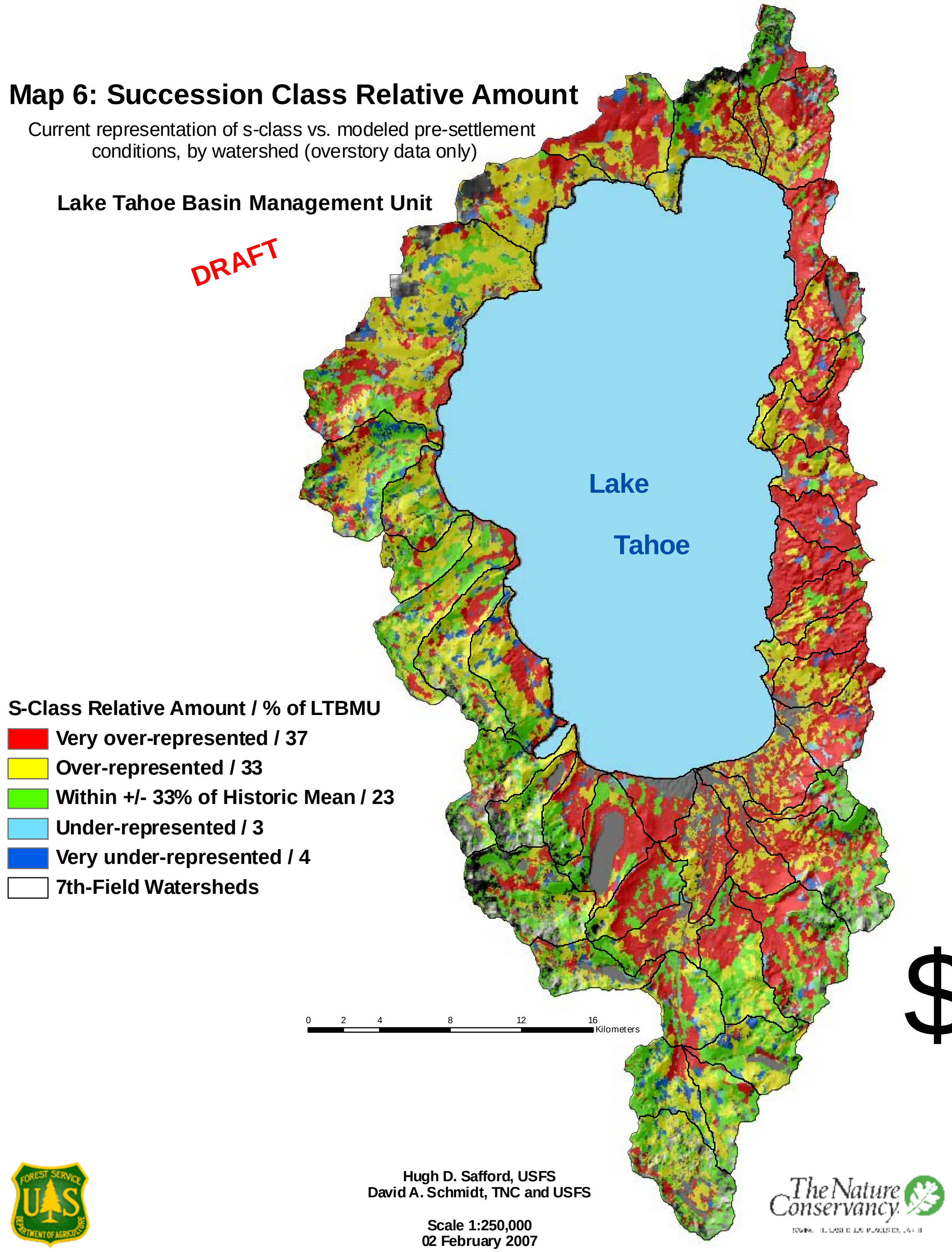
Spooner Summit: 1876

Changed forest structure and composition is also due to clearcut logging in the late 1800's/early 1900's



C. E. Watkins

Current conditions



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Forest structure

Red areas: landscapes where current forest structure is highly changed from the presumed structure before Euro-american settlement

Largest departures are in areas that were cut during the Comstock period

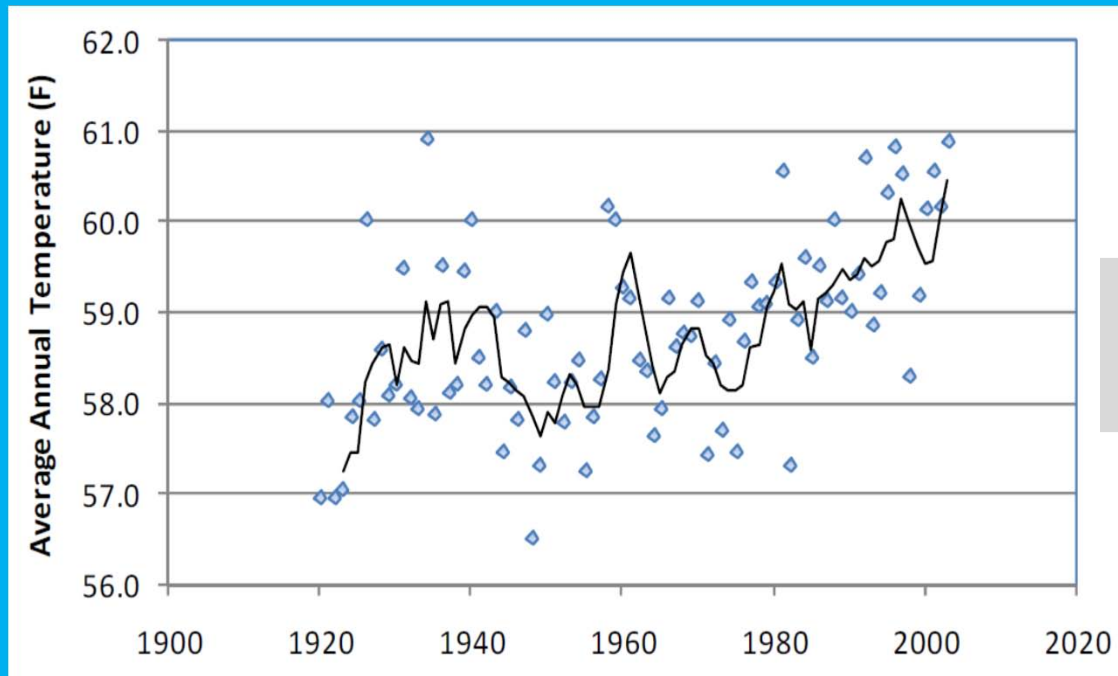
SUMMARY OF PAST AND CURRENT FIRE REGIMES

- Before 1850,fire was exceptionally common in the Lake Tahoe Basin
- Fires were largely low severity events, with minimal mortality of larger trees
- Such fires created the open stand conditions dominated by large trees that impressed early Euroamerican visitors to the Sierra Nevada
- Such fires favored the dominance of fire tolerant tree species, especially Jeffrey and sugar pine, which are not competitive with fir and incense cedar in the absence of disturbance
- A century of fire exclusion, combined with extensive early logging, has greatly changed LTB forests: species composition has changed, forest structure has changed, habitat conditions have changed, fire risk has increased

CURRENT TRENDS AND FUTURE FIRE REGIMES

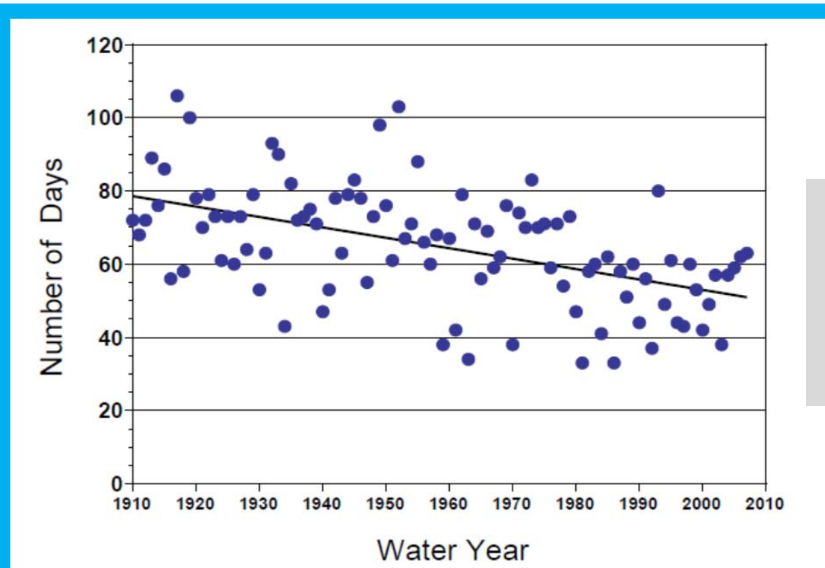
Current trends

Temperatures are climbing



California: mean annual temps, 1920-2005

Moser et al. 2009

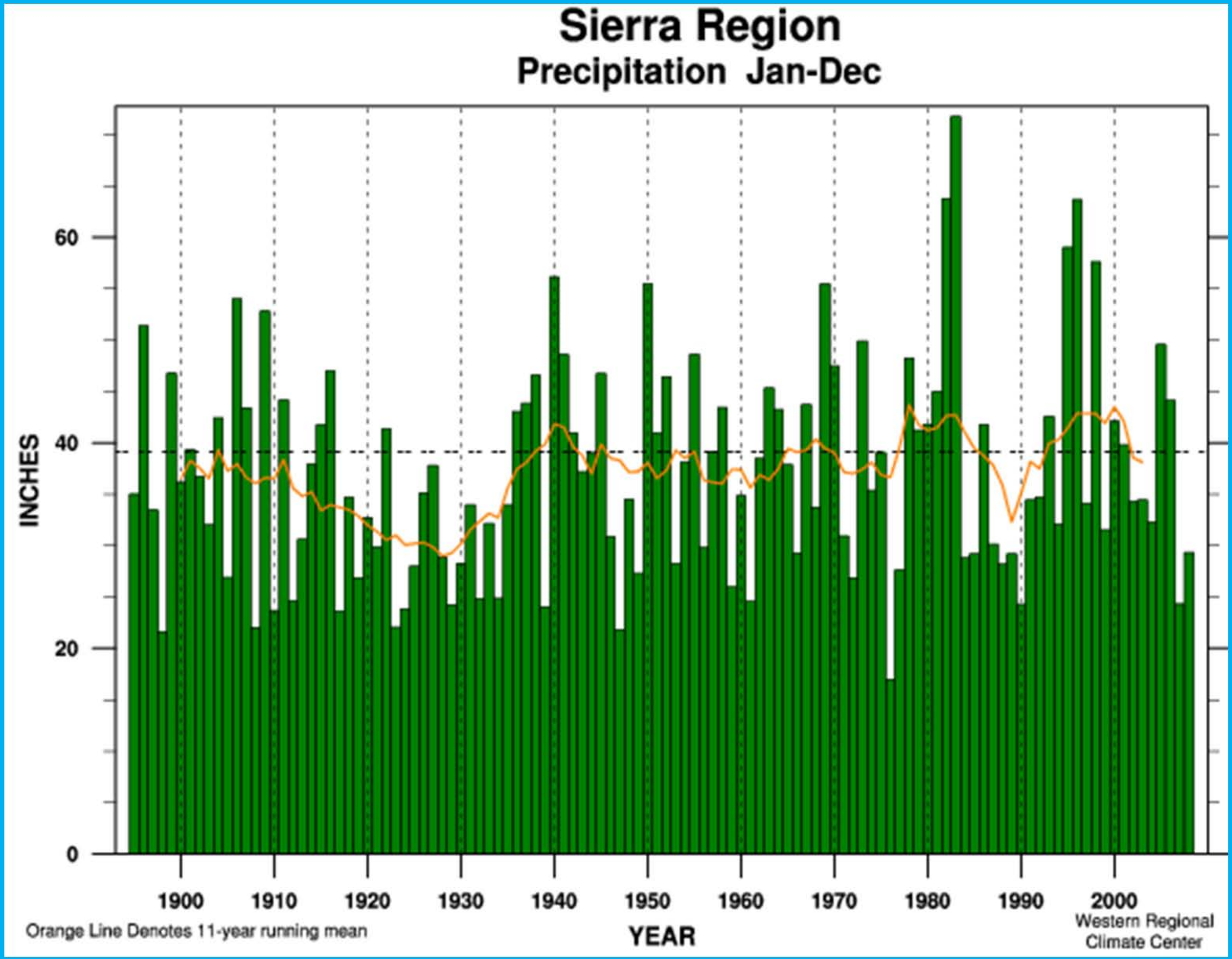


Tahoe City: number of days below freezing, 1910-2009

TERC 2009

Current trends

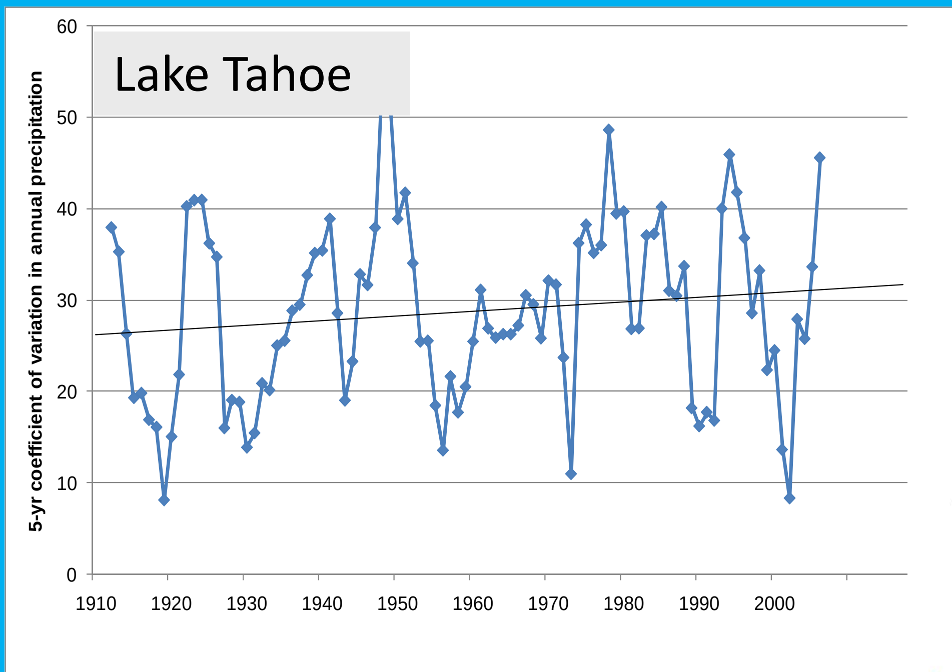
Precipitation is ~steady or rising



WRCC 2009

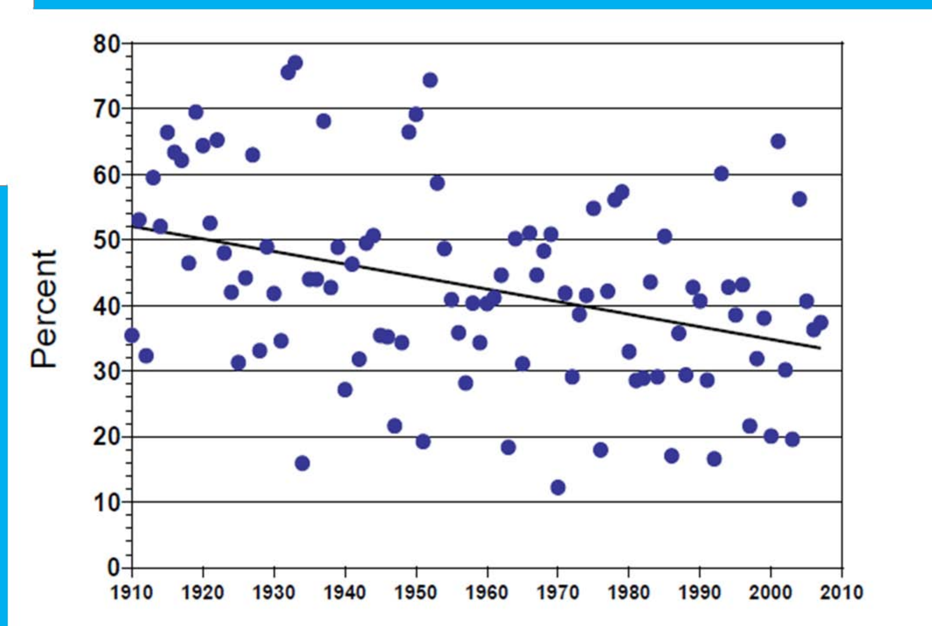
100+ year record shows modest increase in mean annual ppt in most N. California climate regions

Interannual variability in ppt. is up, and snow:rain proportion is down*



5-yr running coefficients of variation in mean annual precipitation

WRCC 2009



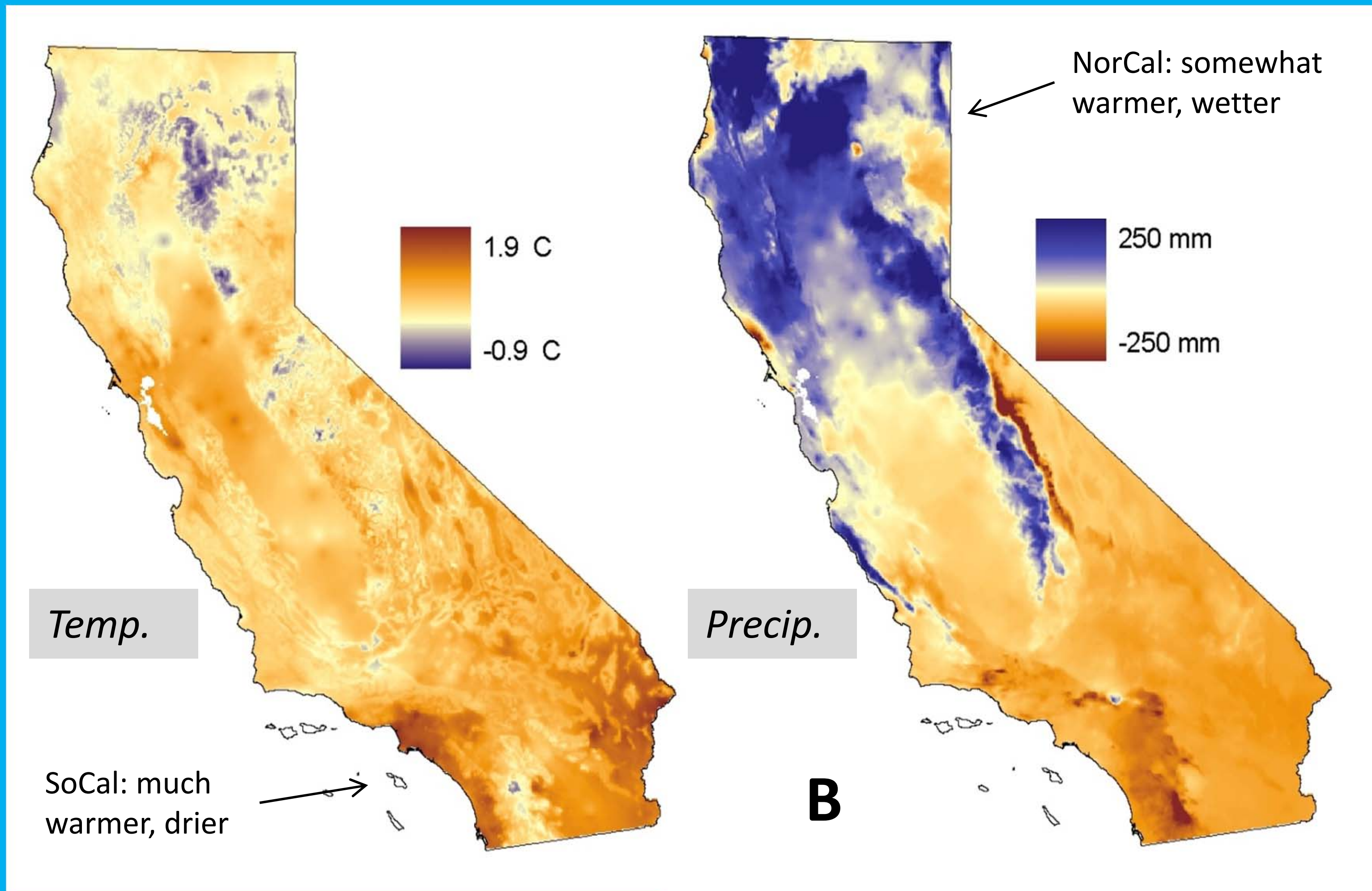
Tahoe City: snow as a fraction of total precipitation

TERC 2009

* but not at all stations

Spatial patterns in temperature and precipitation change

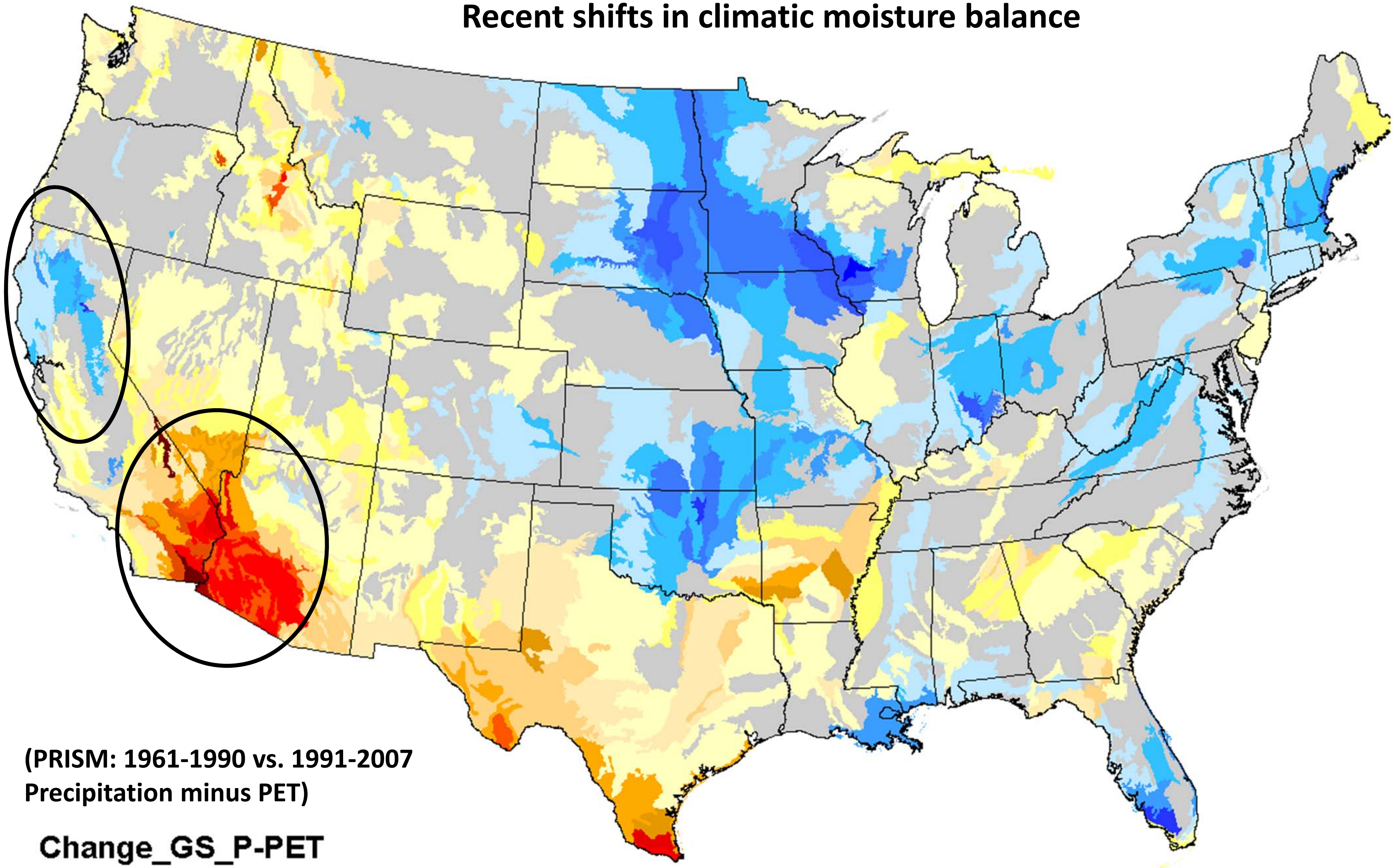
Current trends



early 20th century vs. early 21st century

Graphic courtesy of S. Dobrowski, Univ of MT

Recent shifts in climatic moisture balance



(PRISM: 1961-1990 vs. 1991-2007 Precipitation minus PET)

Change_GS_P-PET

Subsections

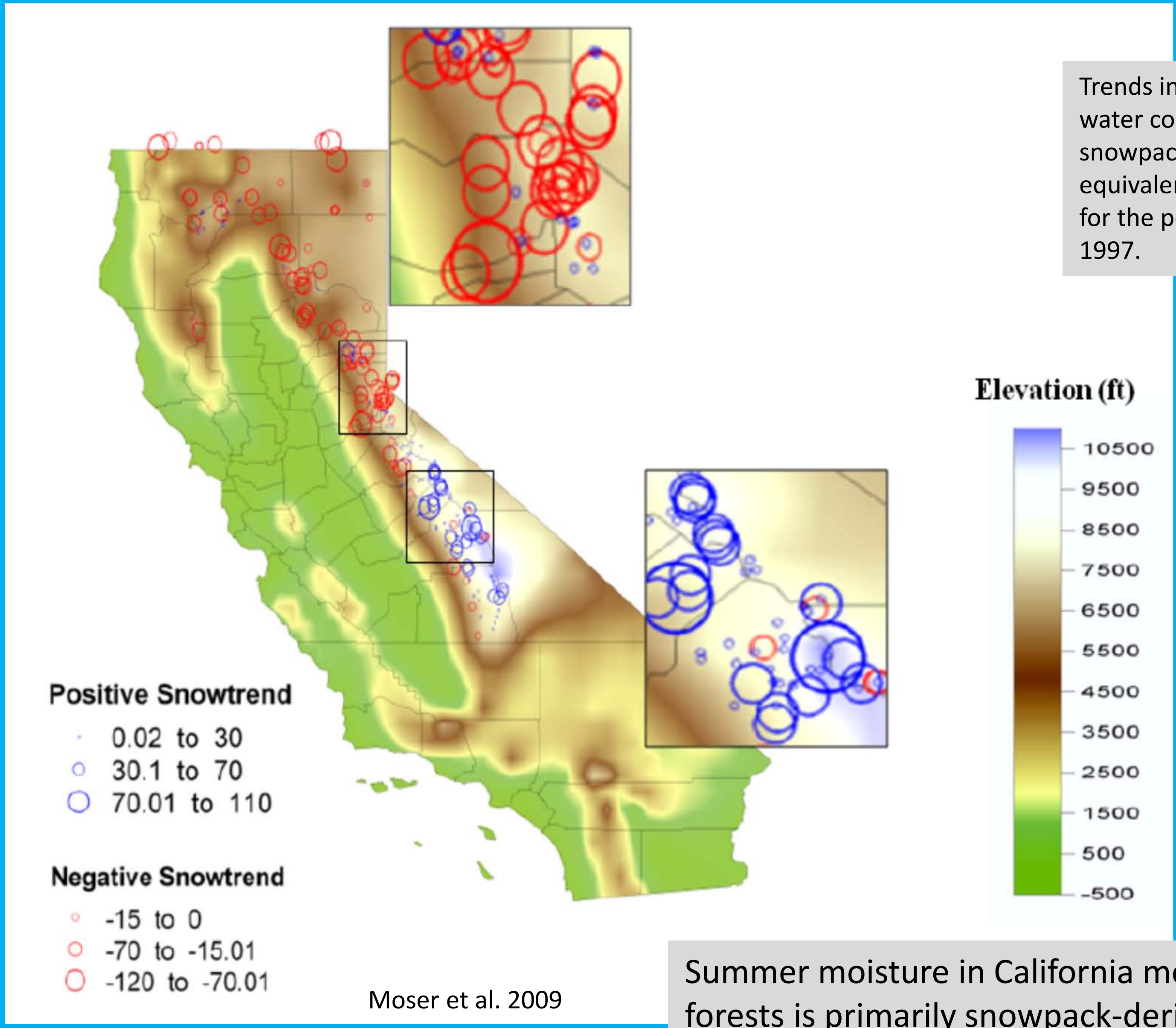
GS_CG_PPET

-6.4 - -6.0	-5.4 - -5.0	-3.4 - -3.0	-1.4 - -1.0	0.6 - 1.0	2.6 - 3.0
-5.9 - -5.5	-4.9 - -4.5	-2.9 - -2.5	-0.9 - -0.5	1.1 - 1.5	3.1 - 3.5
	-4.4 - -4.0	-2.4 - -2.0	-0.4 - 0.0	1.6 - 2.0	3.6 - 4.0
	-3.9 - -3.5	-1.9 - -1.5	0.1 - 0.5	2.1 - 2.5	

Graphic courtesy of D. Cleland, N. Research Station, USFS

Current trends

Winter snowpack is down across most of California

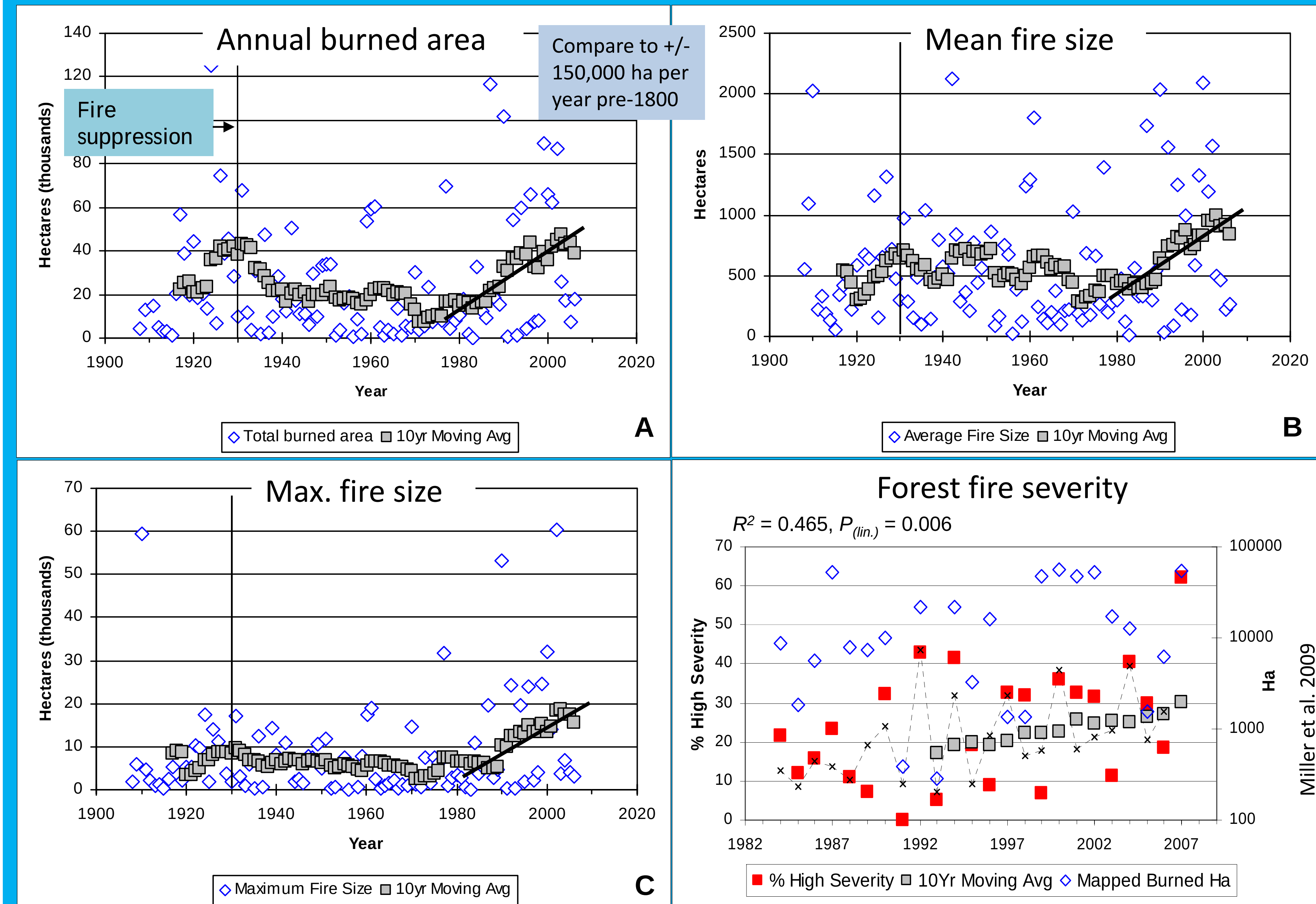


Moser et al. 2009

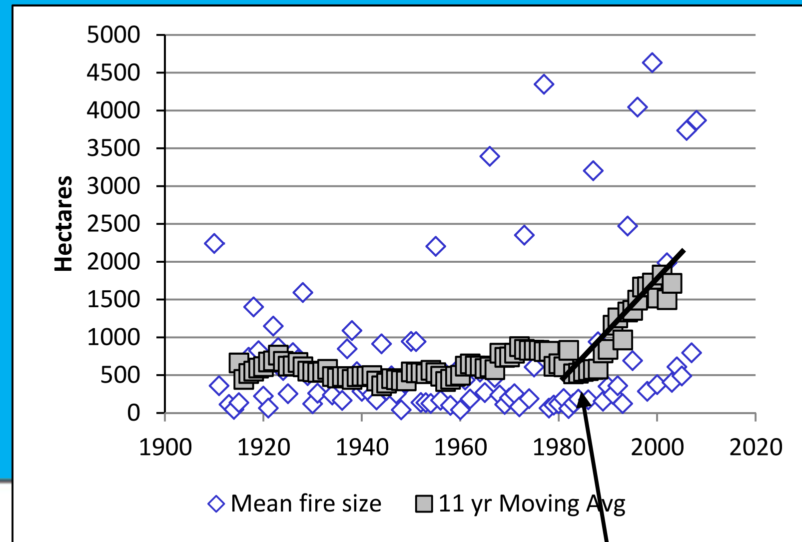
Trends in the amount of water contained in the snowpack ("snow water equivalent") on April 1, for the period 1950-1997.

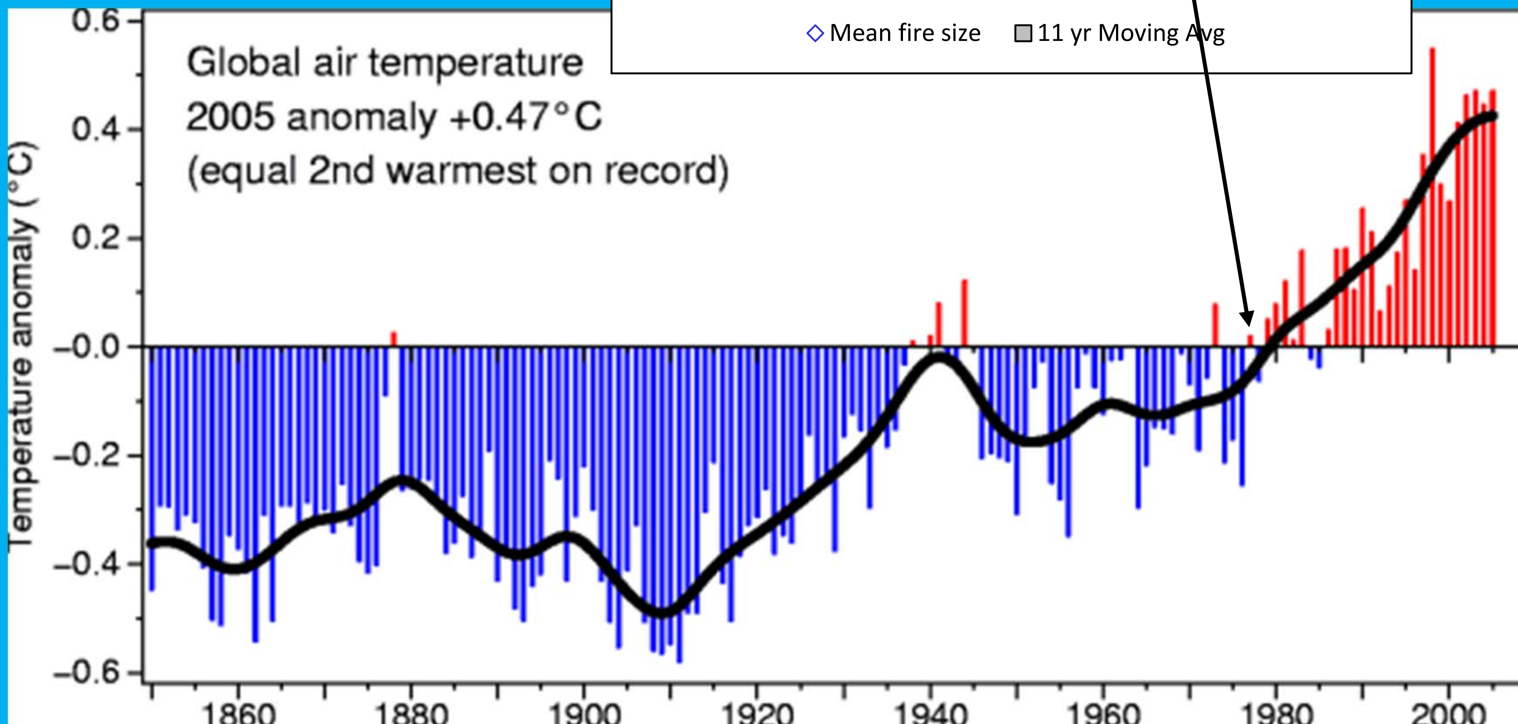
Summer moisture in California montane forests is primarily snowpack-derived

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

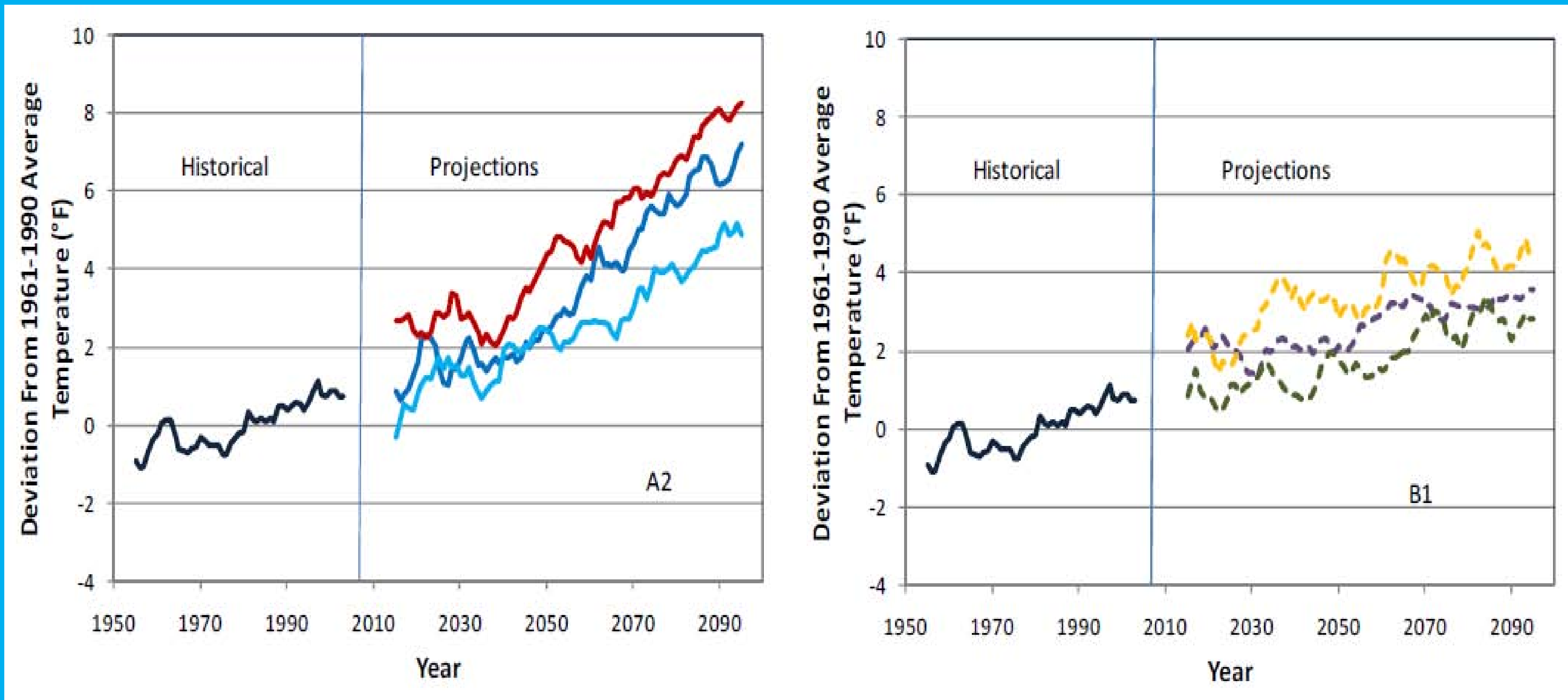




Miller and Safford 2008, Miller et al. 2009

Future climate: models project more of the same

California mean annual temperature

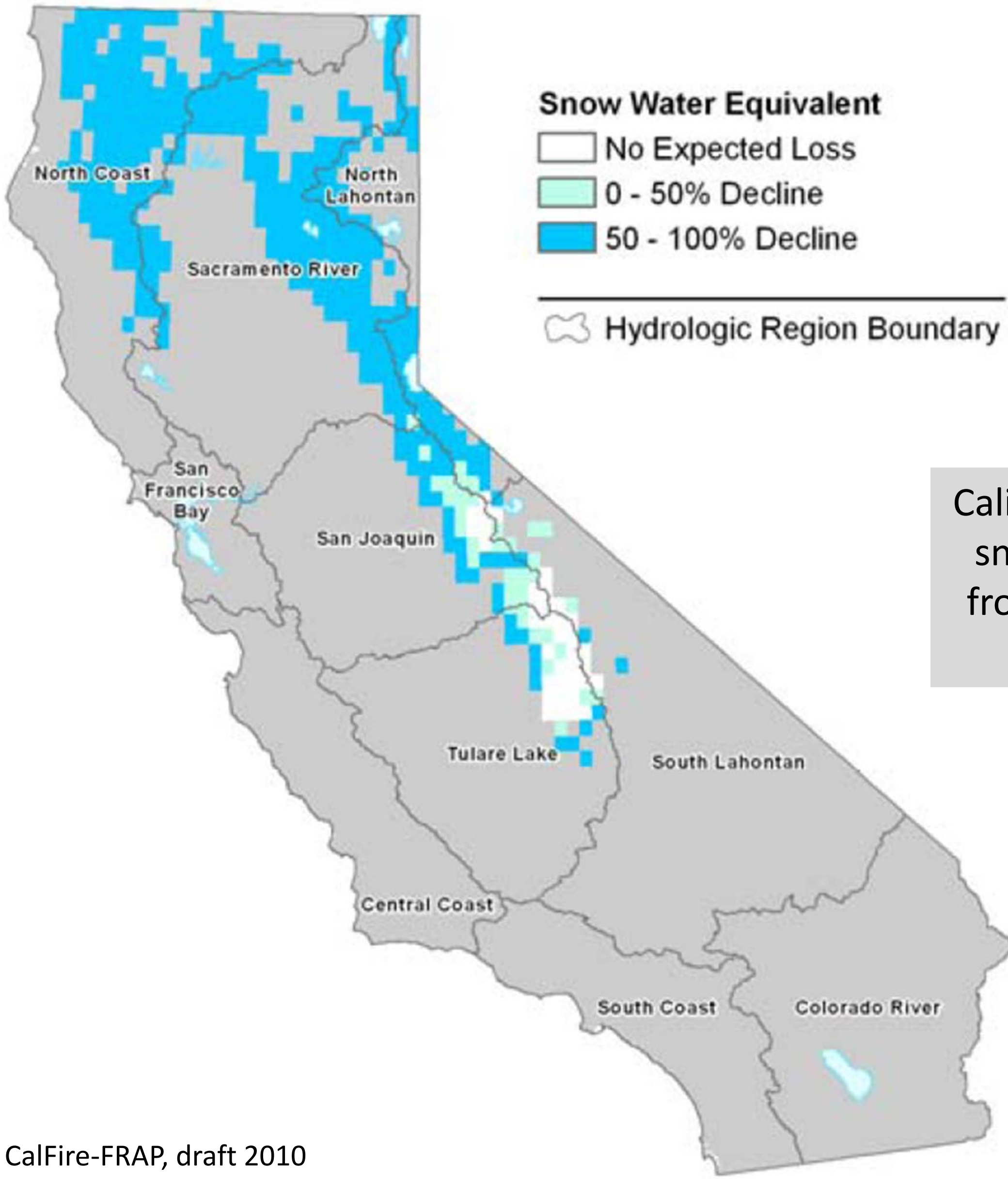


Moser et al. 2009

Historic and projected annual mean temperature for California, from three GCMs using the A2 and B1 IPCC emissions scenarios

Future climate

Future climate: snowpack



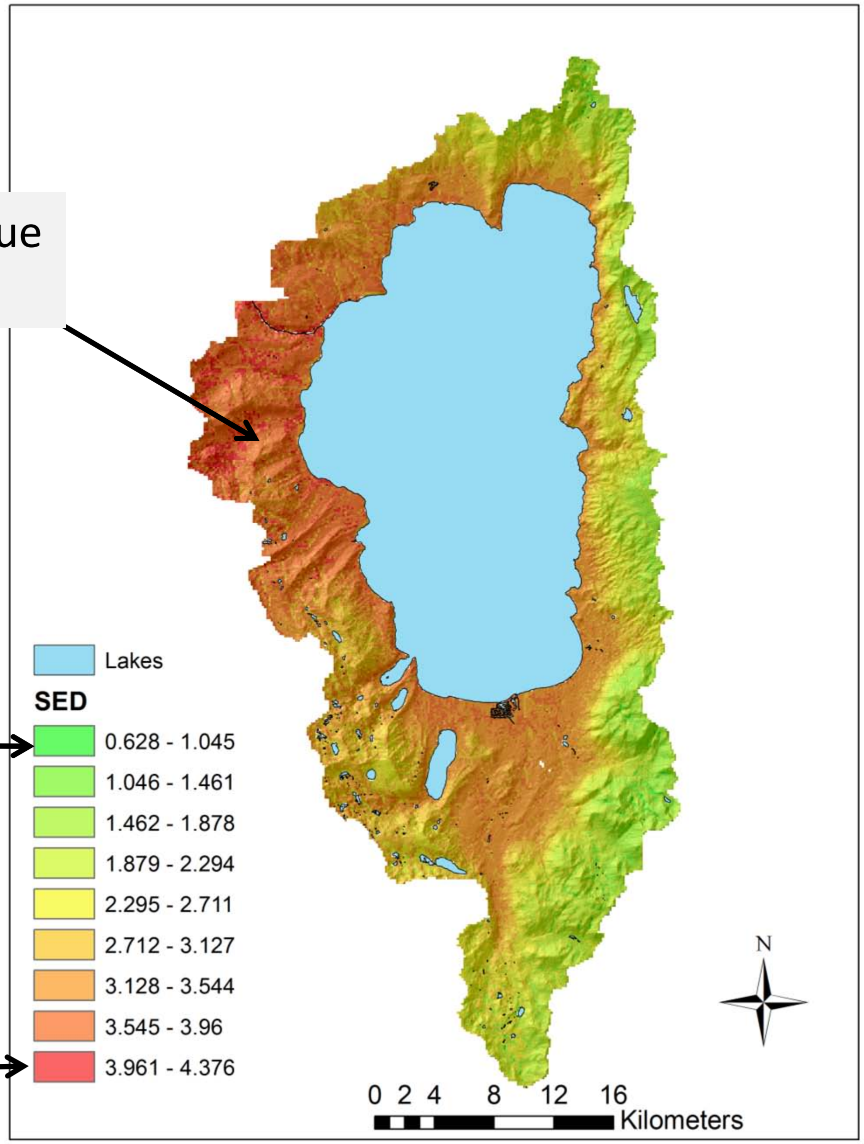
CalFire-FRAP, draft 2010

California: predicted snow-pack trends from 2010 to 2100

Climatic similarity: 20th vs. projected 21st century Lake Tahoe climate

Future climate

Non-analogue climate



High Similarity between current and projected climate

Low Similarity

Warmer? Yes, but much of the LTB is also likely to experience future climates that have no current analogue

Modeling based on all combinations of ranges of mid-21st century outputs from 16 Global Circulation Models for spring ppt, winter min temp, spring max temp; A2 scenario

Veloz et al., in prep

Future fire

Future fire trends: Models project increases in fire activity in most of the Sierra Nevada

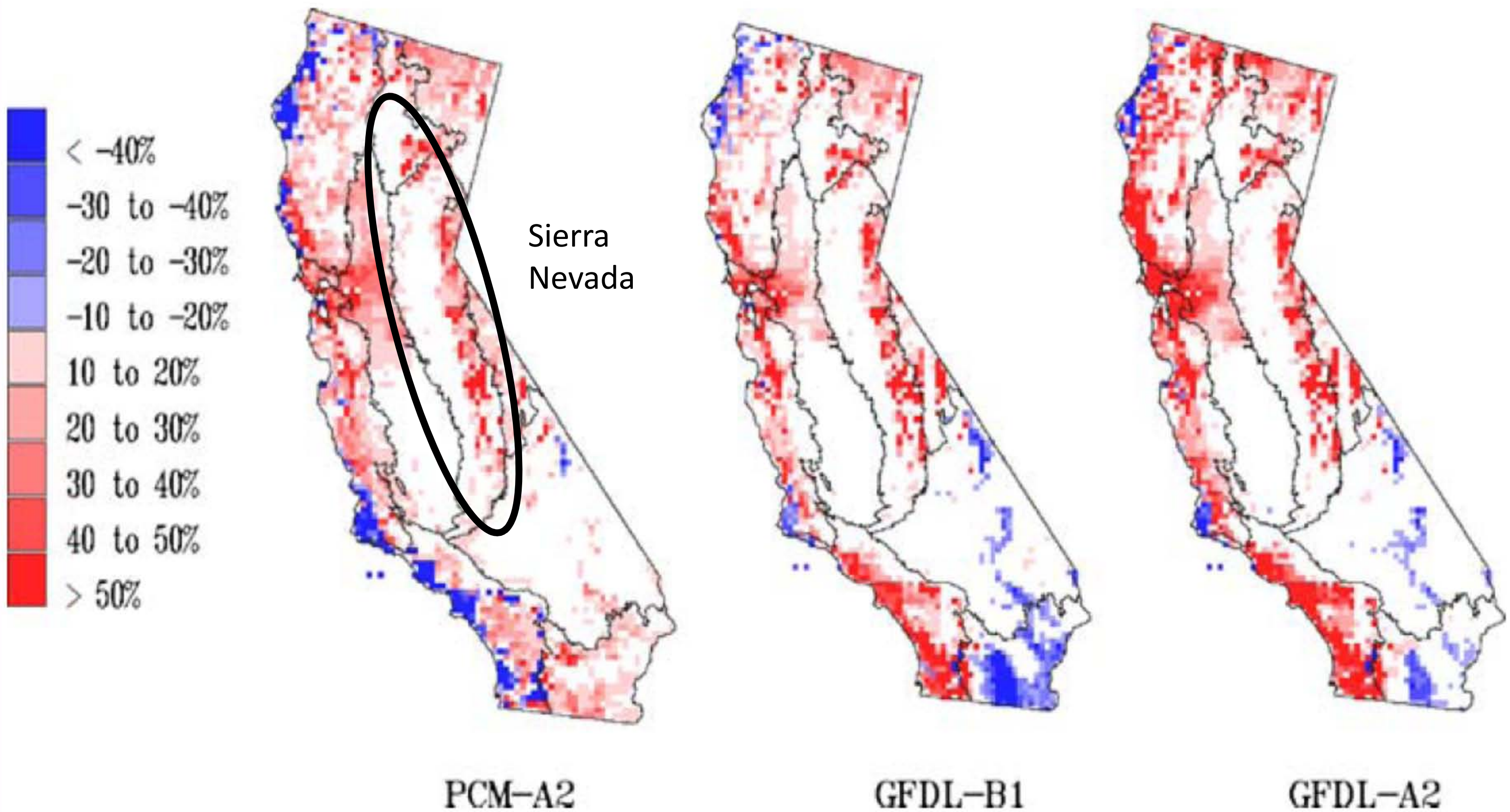


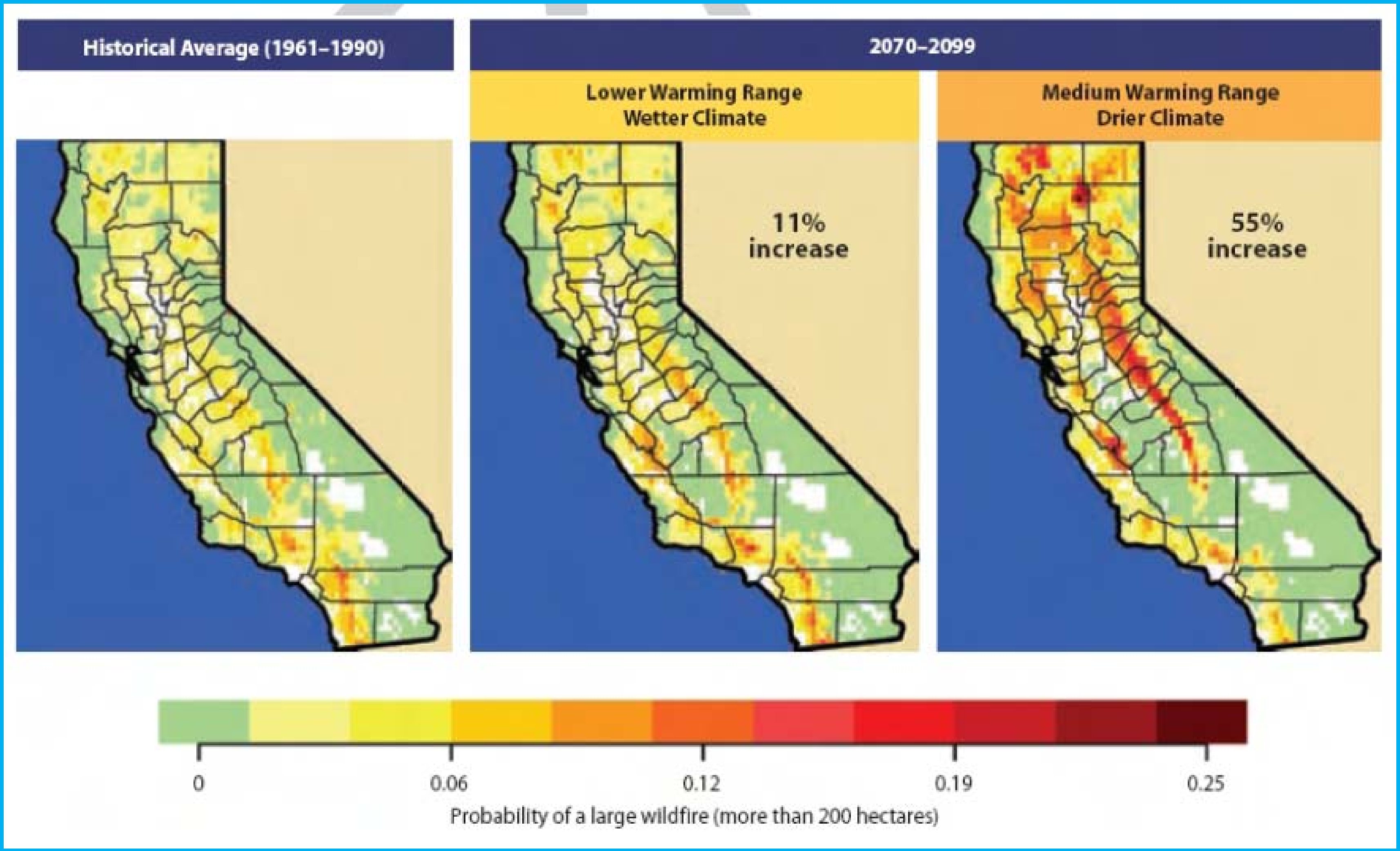
Fig. 8 Percent change in mean annual area burned for the 2050–2099 future period relative to the mean annual area burned for the historical period (1895–2003)

Lenihan et al. 2008

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

Future fire trends: Increasing probabilities of large wildfires

except in areas of climatic extremes (very wet, dry, or cold)



State of California 2009

SUMMARY OF CURRENT TRENDS AND FUTURE FIRE REGIMES

- Temperatures are rising rapidly – by 2100 LTB may experience mean summer temps that are 5-9 degrees (F) warmer than today

- Precipitation has remained steady or even increased, but it is falling more and more as rain; average snowpack in April is falling (some years will buck this trend!)

- Fire frequency, size, total area burned, and severity have all been rising rapidly in the Sierra Nevada; these trends are projected to continue into the future

- The problem is not more fire (the forests “need” more fire), it is that much of the fire we are dealing has negative ecological (and socioeconomic!) consequences

- These trends in fire activity, size, and severity are driven largely by climatic changes and increased forest fuels due to fire exclusion, but fire management practices also play a role

- Forest vulnerability to future climate change is very high in the LTB

CAN FOREST "RESTORATION" HELP LAKE TAHOE'S FORESTS PERSIST INTO THE FUTURE?

Important points:

1. Forests are dominated by large, long-living woody plants that can survive marked changes in climate once they are adults. These large adult plants dominate forest ecosystems, and they play a major role in influencing water availability, nutrients, sun and shade, habitat availability, etc.

2. In many forests, successional processes proceed very slowly in the absence of disturbance, because the adult trees "control" the site.

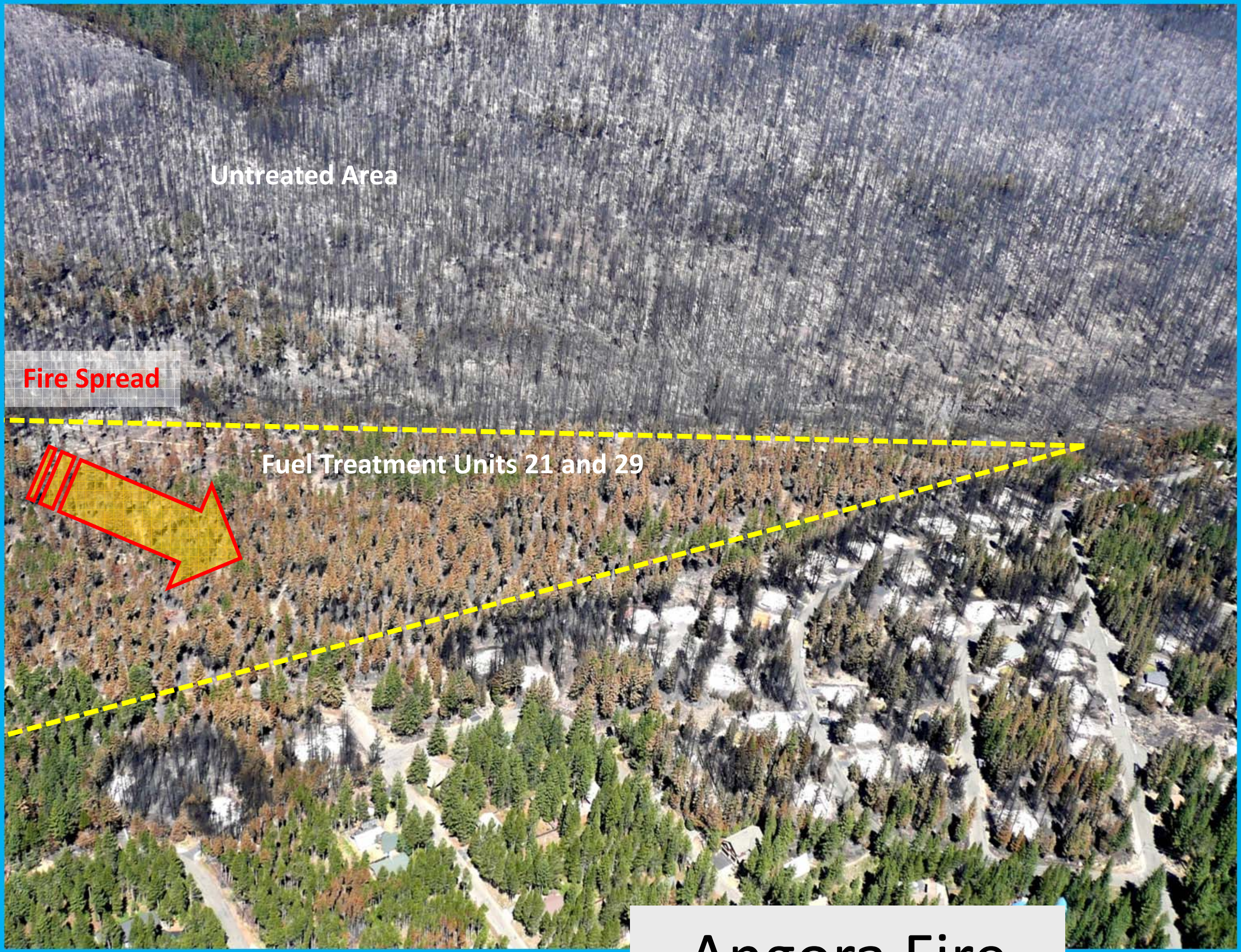
3. Major ecosystem change in forests is often dependent on severe disturbance events, because removal of the adult trees is necessary to free space and resources to the younger generation.

4. Climate change impacts on western forests will probably largely be realized through their influence on disturbance events, e.g., their influence on fire activity, and their influence on survival of young individuals.

5. Human influences on the occurrence and outcomes of disturbances like fire is probably key to the resilience of fire-prone forests as temperatures continue to warm

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

Properly accomplished forest management can significantly decrease forest loss (and home loss!) to fire

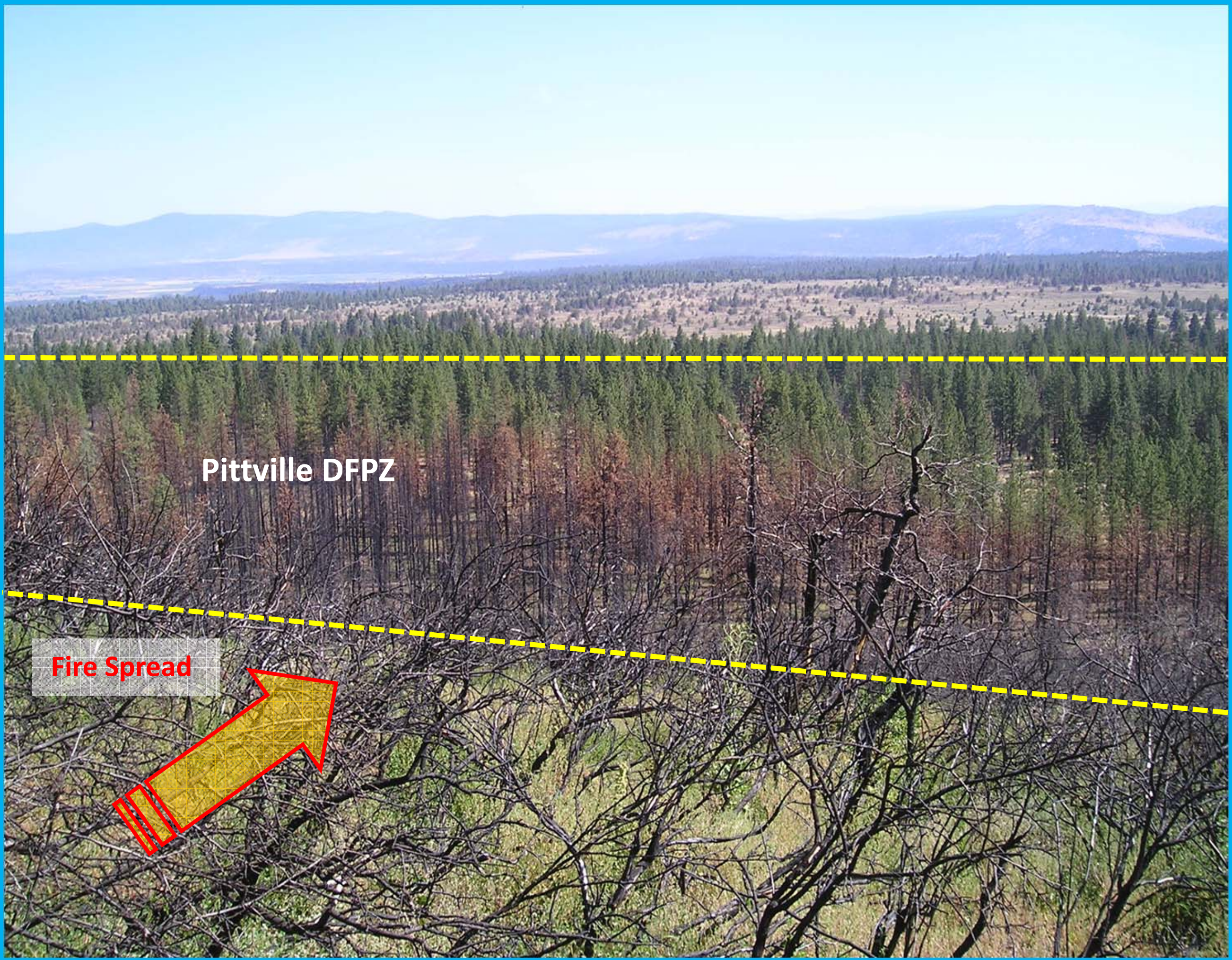


Angora Fire

UNTREATED

TREATED

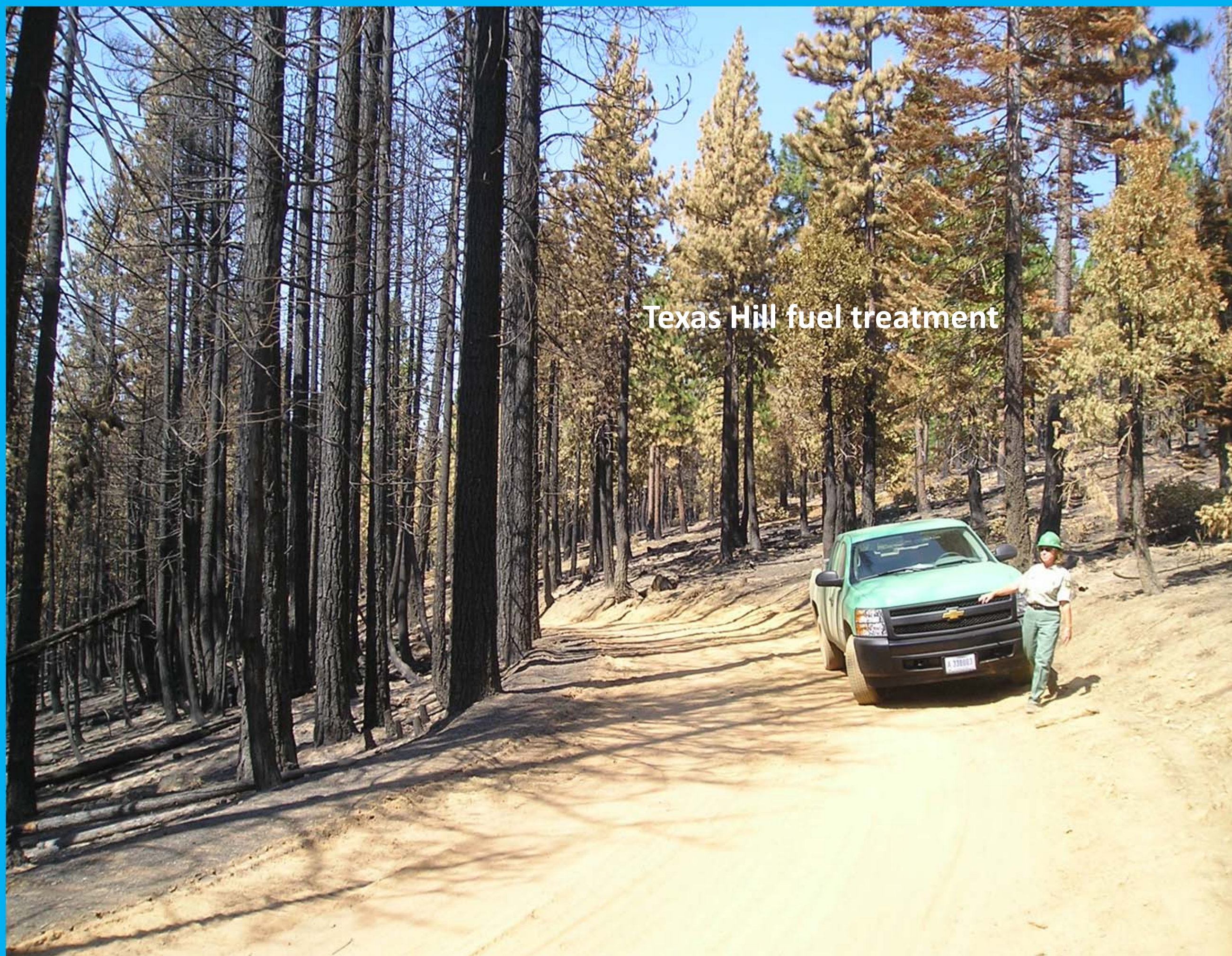
Peterson Fire, Lassen NF



TREATED

UNTREATED

American River Complex, Tahoe NF

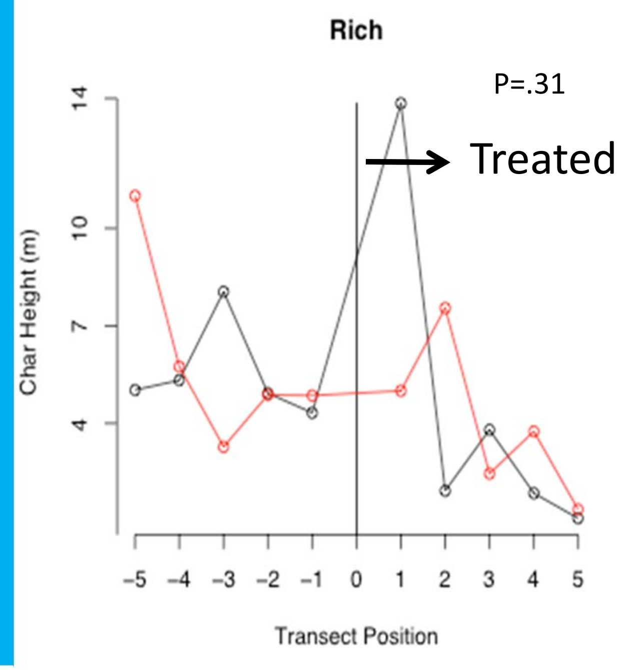


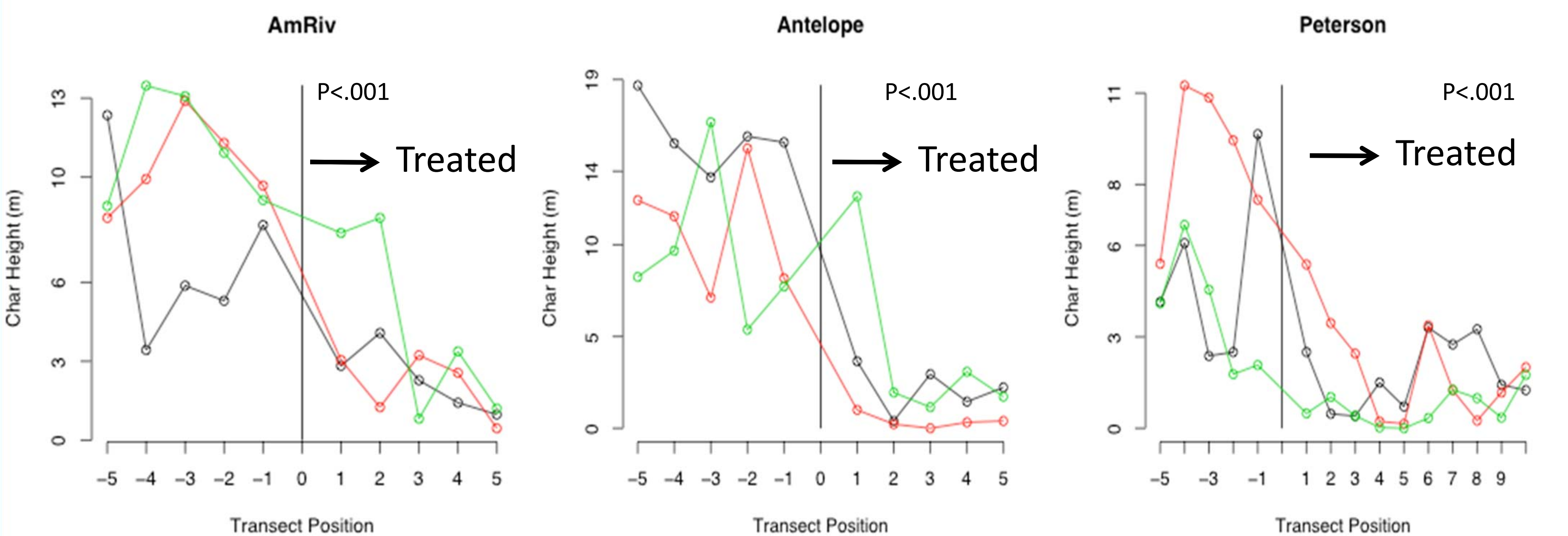
TREATED

UNTREATED

Fire severity is greatly decreased where forest structure has been restored

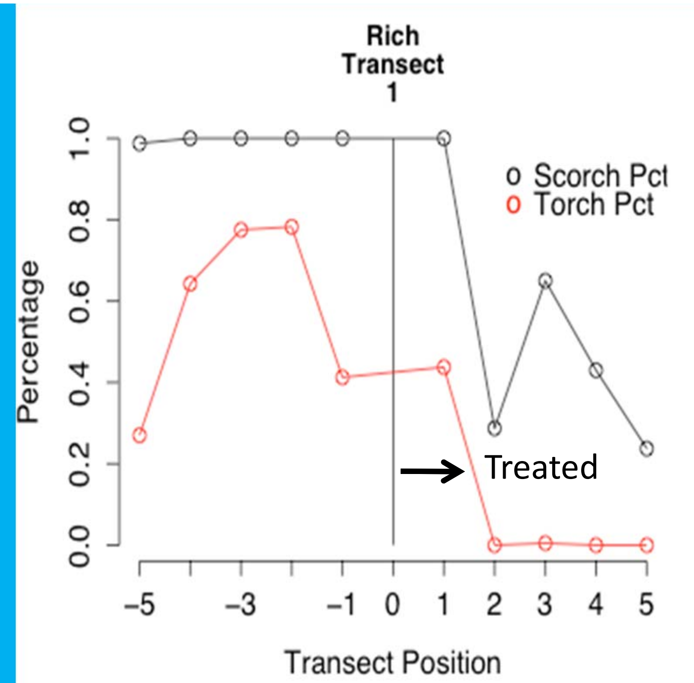
I. Bole char height in treated and neighboring untreated forest

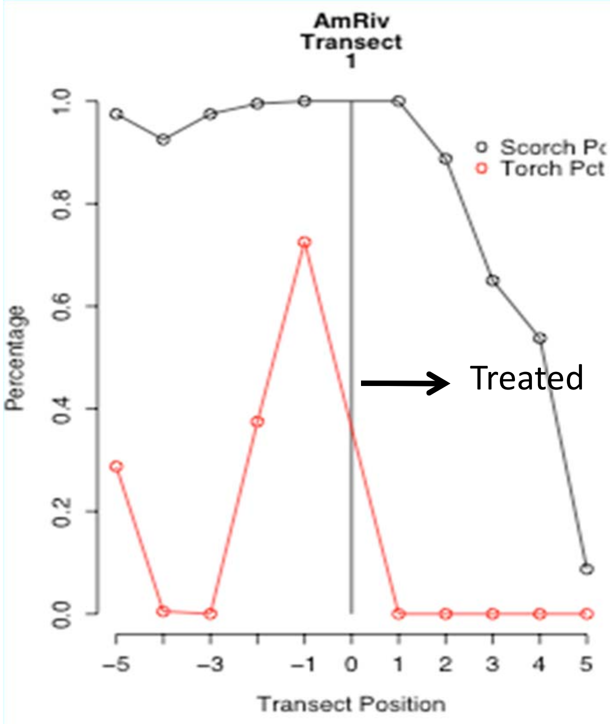


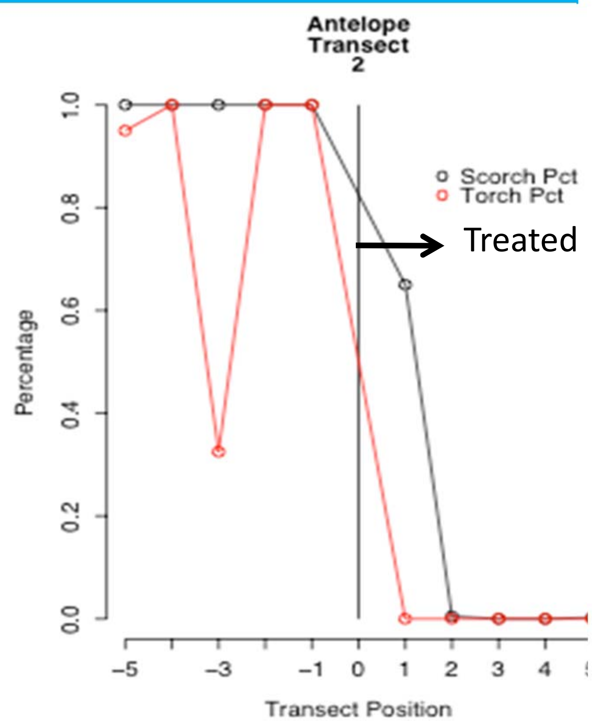


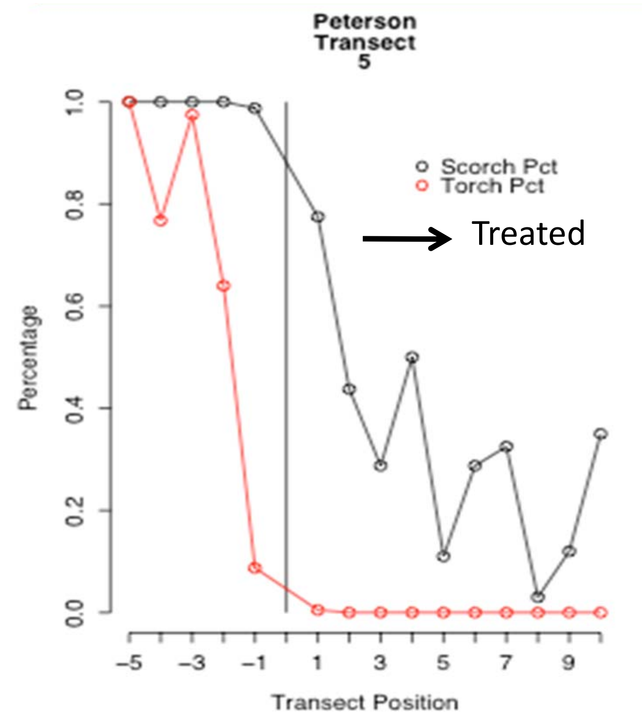
Fire severity is greatly decreased where forest structure has been restored

II. % of tree canopy scorched and burned (“torched”) in treated and neighboring untreated forest

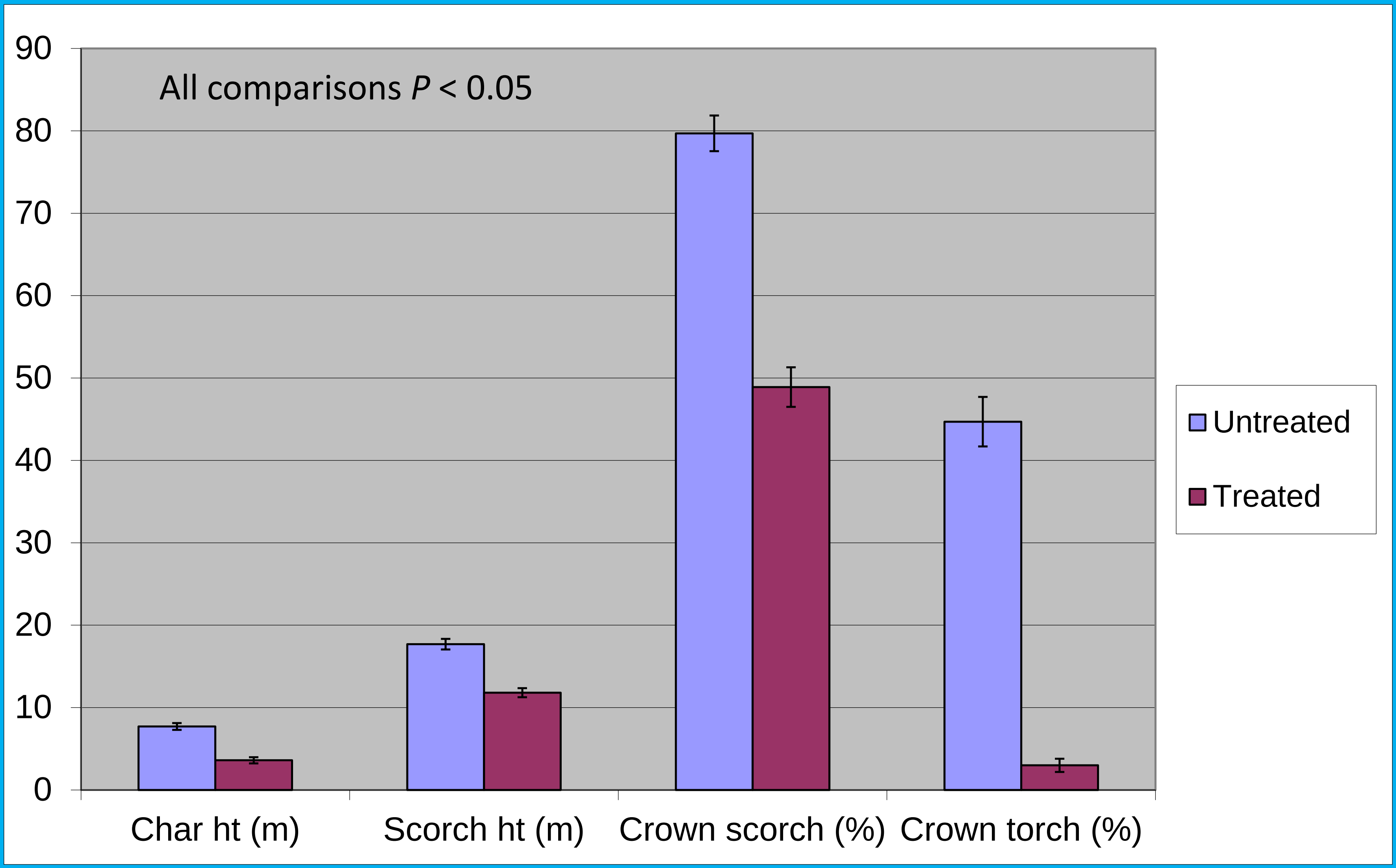




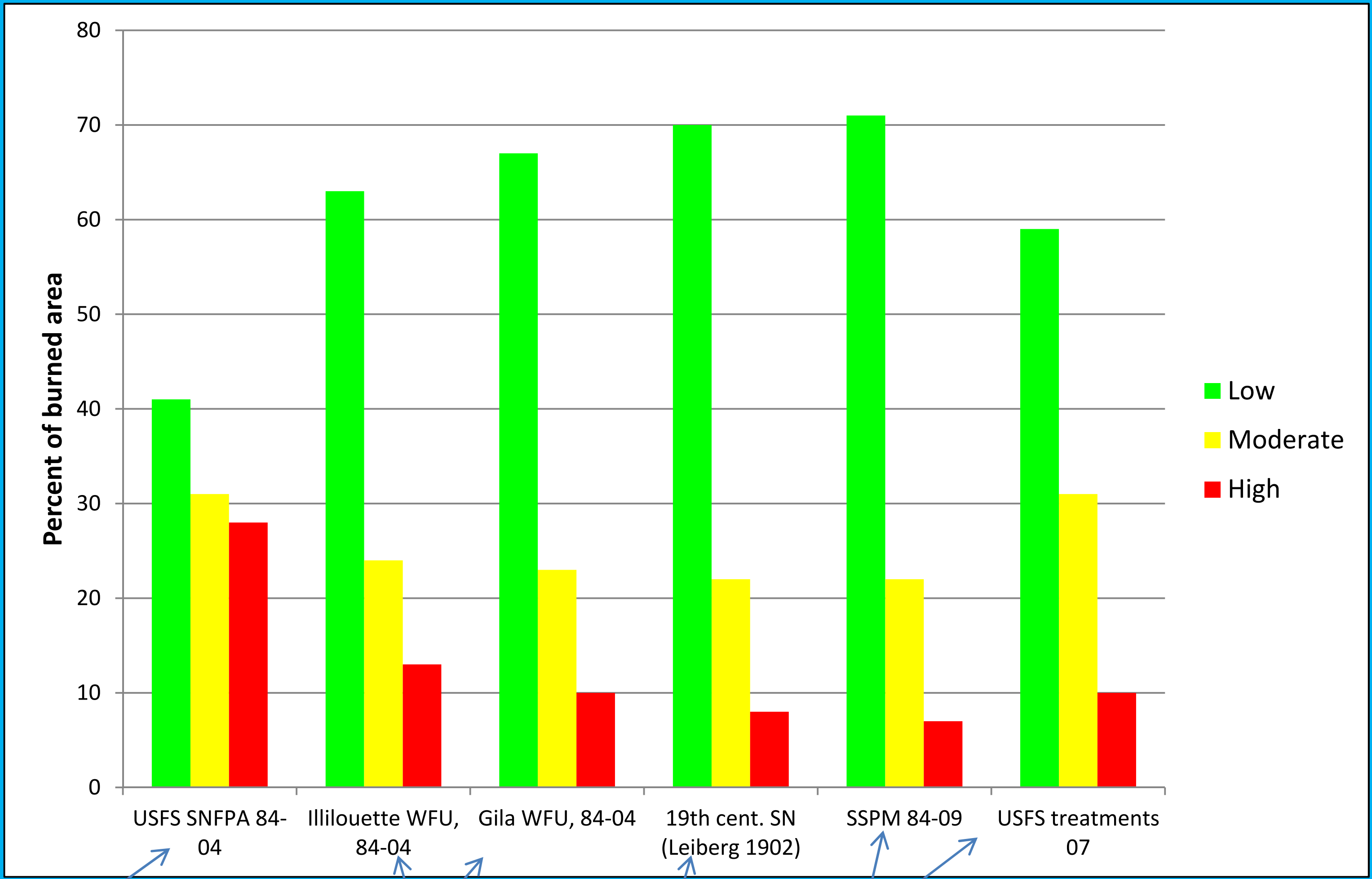




Angora Fire: fire severity



Fire severity



Current day, under fire suppression, all forests combined (minus blue oak & subalpine)

Current day, under Wildland Fire Use

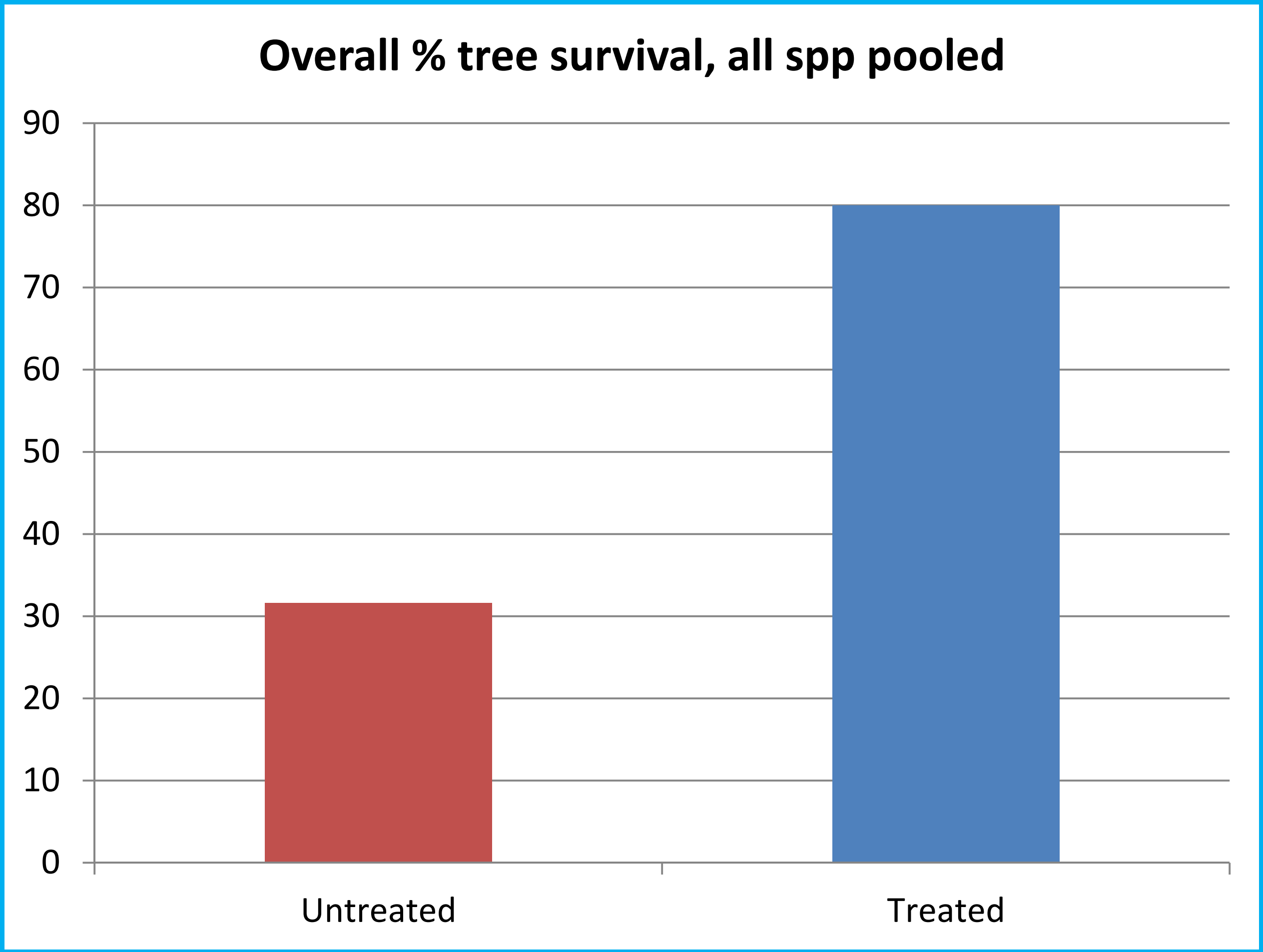
Past reference

Current references

On average, current fires in the SNFPA area burn at much higher severity than either historical or contemporary reference forests

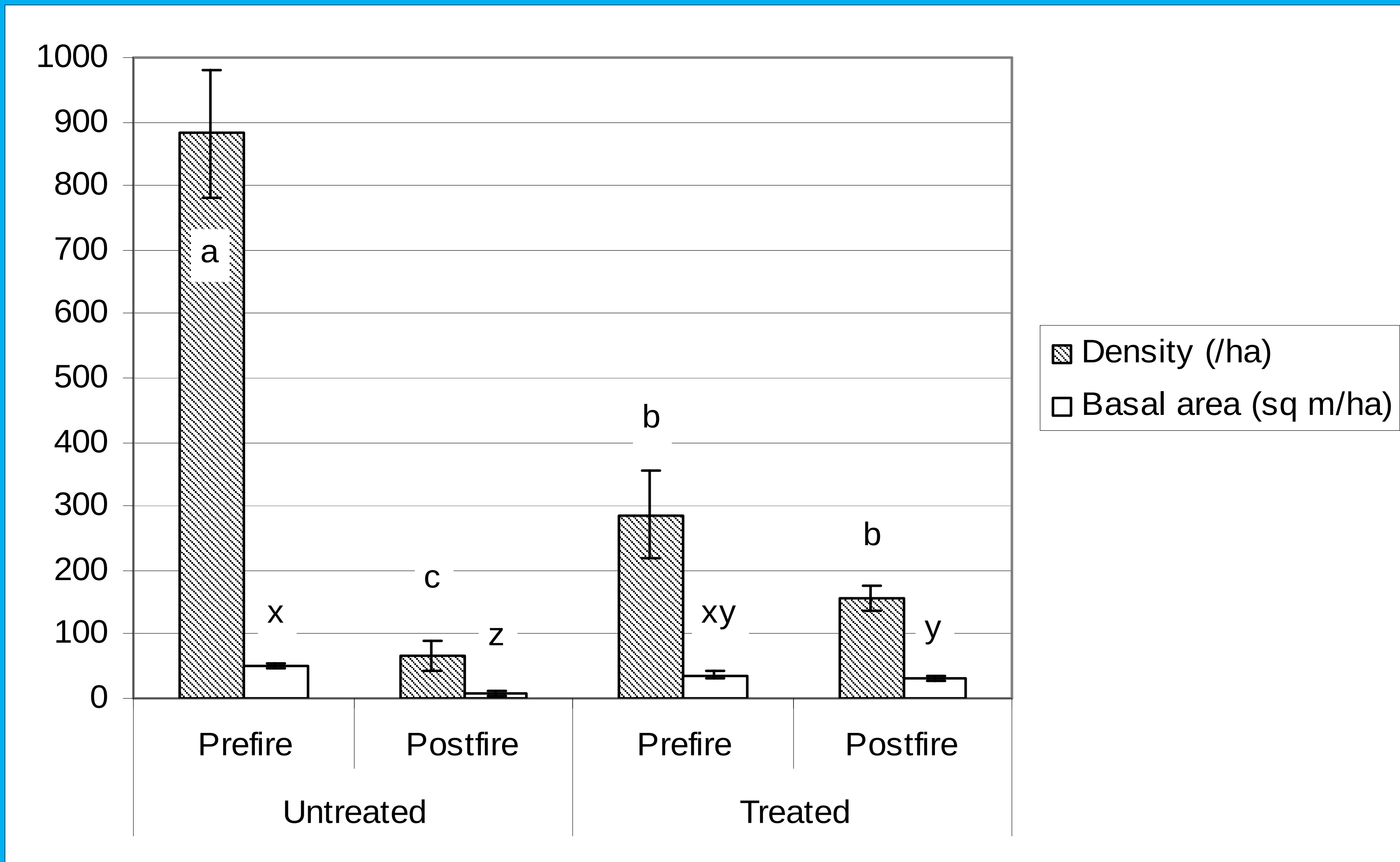
Tree mortality

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



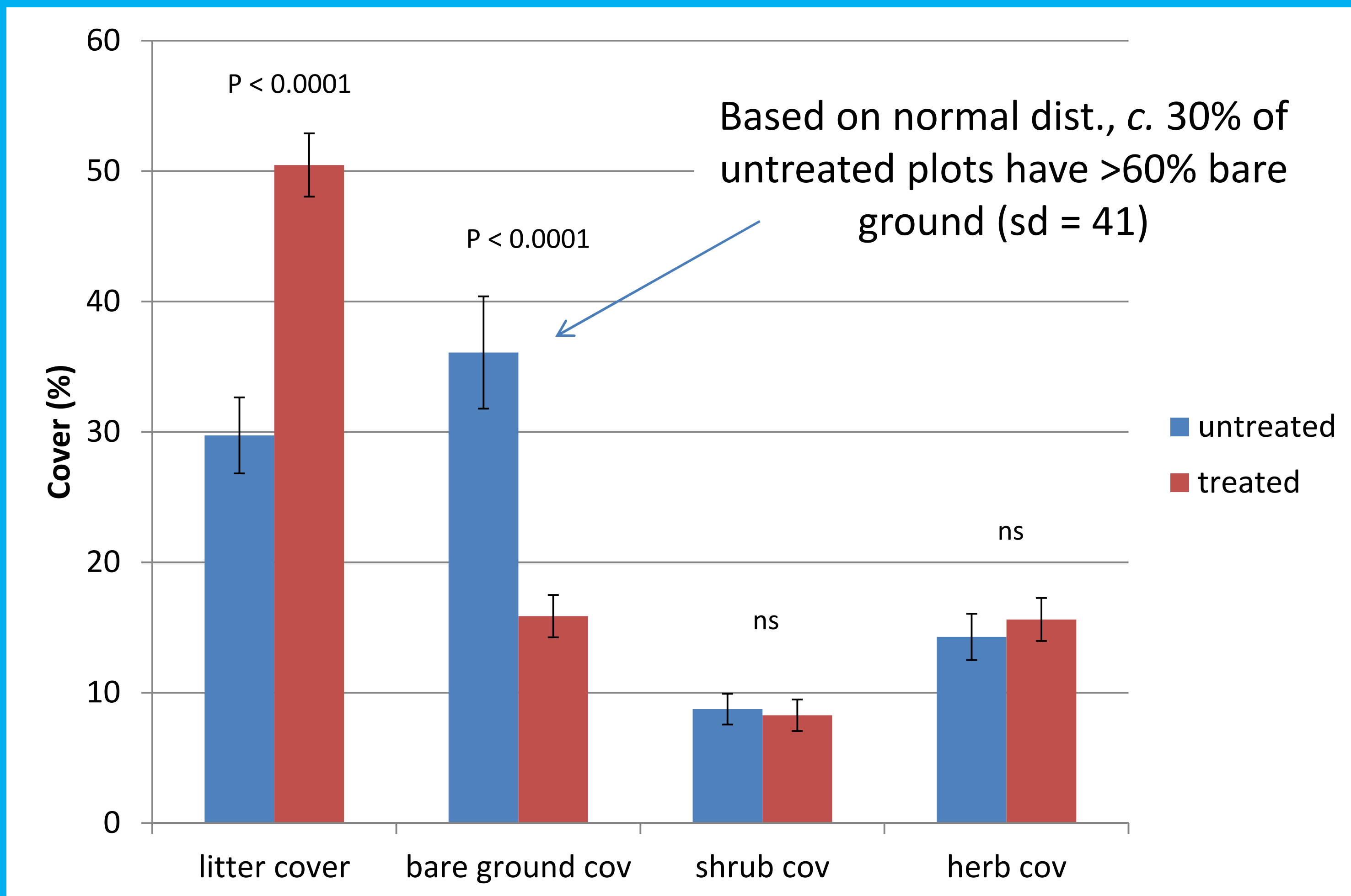
*data from six fires

Carbon loss



Angora Fire, untreated forest: 92% loss in density, 85% loss in basal area (treatments: 45% and 18% losses, not statistically significant)

Understory



60
50
40
30
20
10
0
Cover (%)
P < 0.0001
P < 0.0001
ns
ns
Based on normal dist., c. 30% of untreated plots have >60% bare ground (sd = 41)
untreated
treated
litter cover
bare ground cov
shrub cov
herb cov

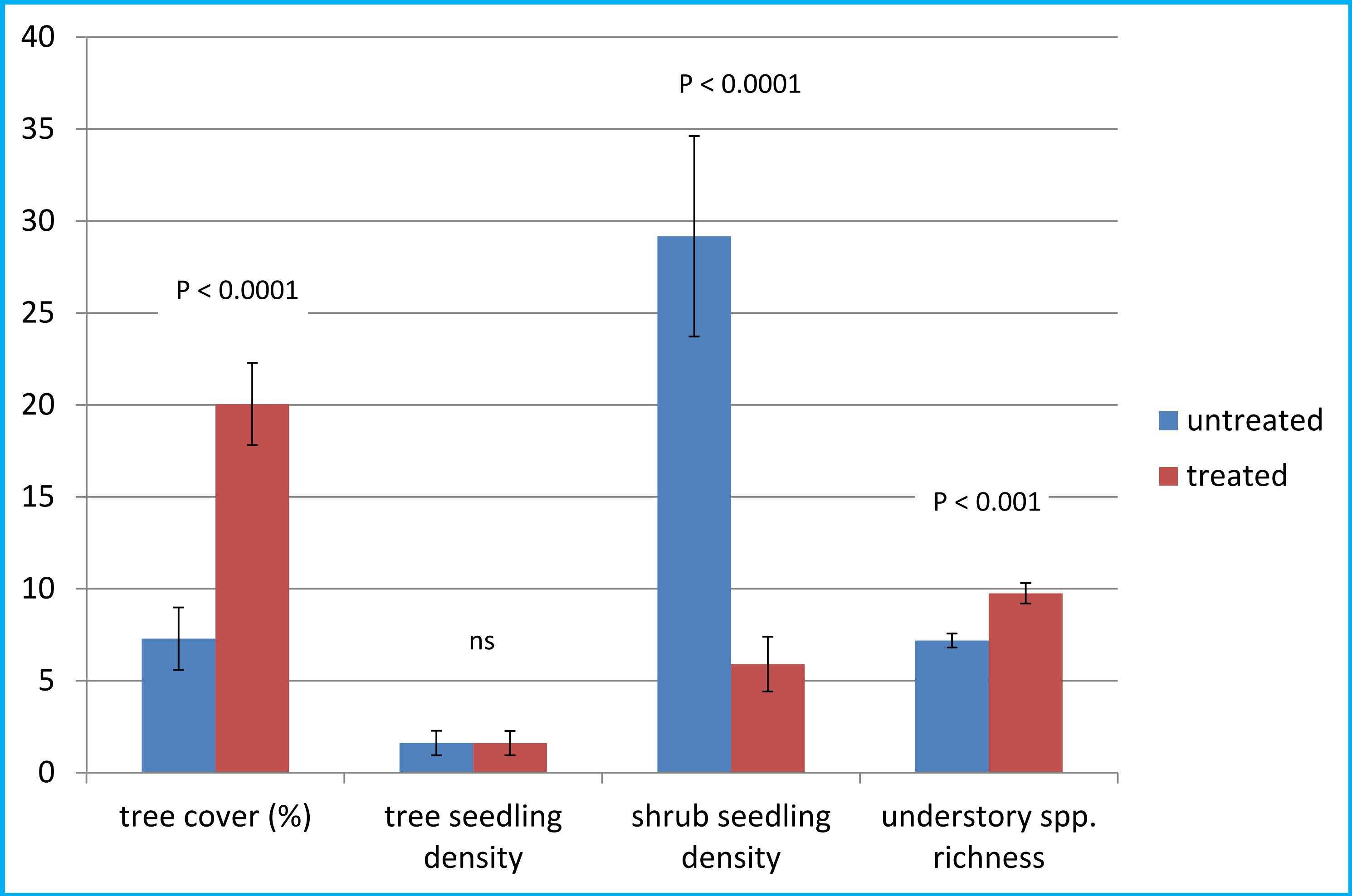
Bare ground and litter

Angora Fire, Transect 5

Treated ← 20 meters → Untreated

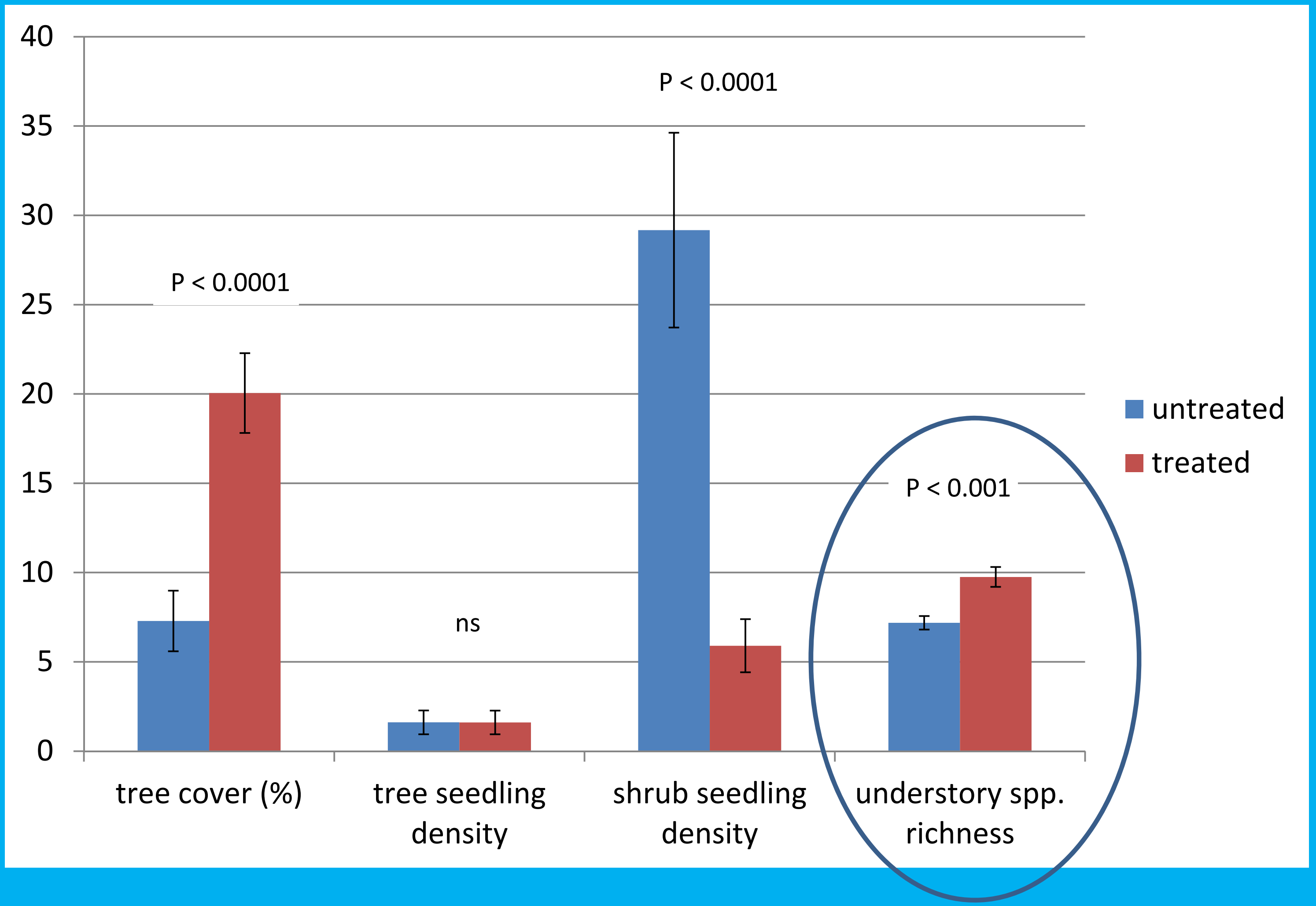
Yellow pine forests (Johansen et al. 2001): major erosion threshold reached at >60% bare ground

Tree cover, seedling density, species richness

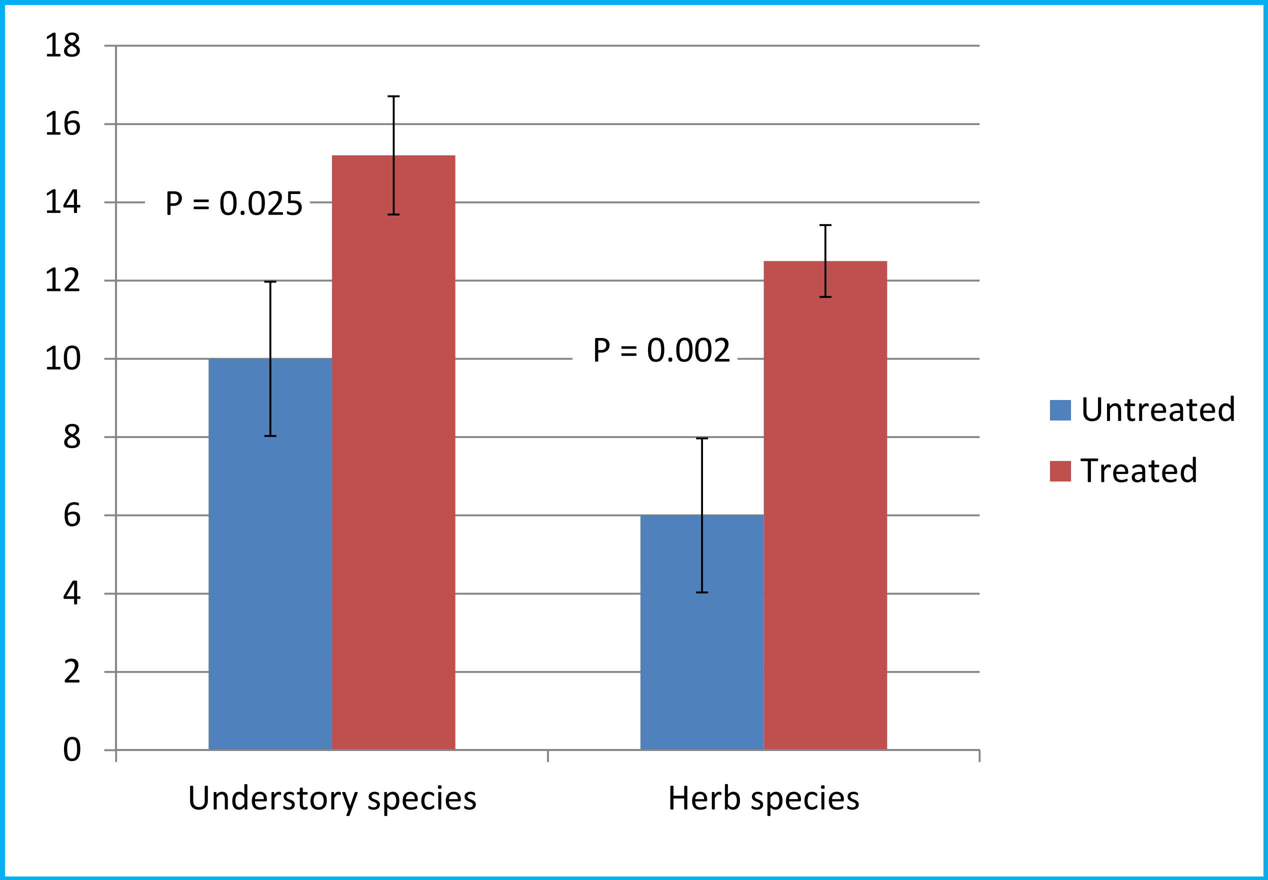


Includes all fires except Piute

Results 8 (cont.)



Large contiguous areas of high severity fire in yellow pine forests are uncharacteristic of the ecosystem: theory predicts they should be less biodiverse than areas of low and mixed severity



Angora Fire: species richness (alpha diversity) in 810 m^2 plots

Summary

- California trend is toward warmer temps, drier summers; and more frequent, bigger, and more severe fires in montane forests
- Completed and properly designed fuel treatments in yellow pine and mixed conifer forests:
  - Strongly reduce fire severity in almost all cases
  - Increase habitat heterogeneity in unburned forest
  - Promote resilience/retention of forest cover and biomass even in severe wildfires
  - Can increase understory species diversity at multiple scales
  - Can reduce soil loss in burned forest

Summary (cont.)

- Completed and properly designed fuel treatments:
  - Can increase heterogeneity of burn effects and provide similar or greater heterogeneity in postfire habitats as burned untreated forest
  - Provide safe environments for reintroduction of fire
  - Can play important role in restoration of ecological patterns and processes in these forest types