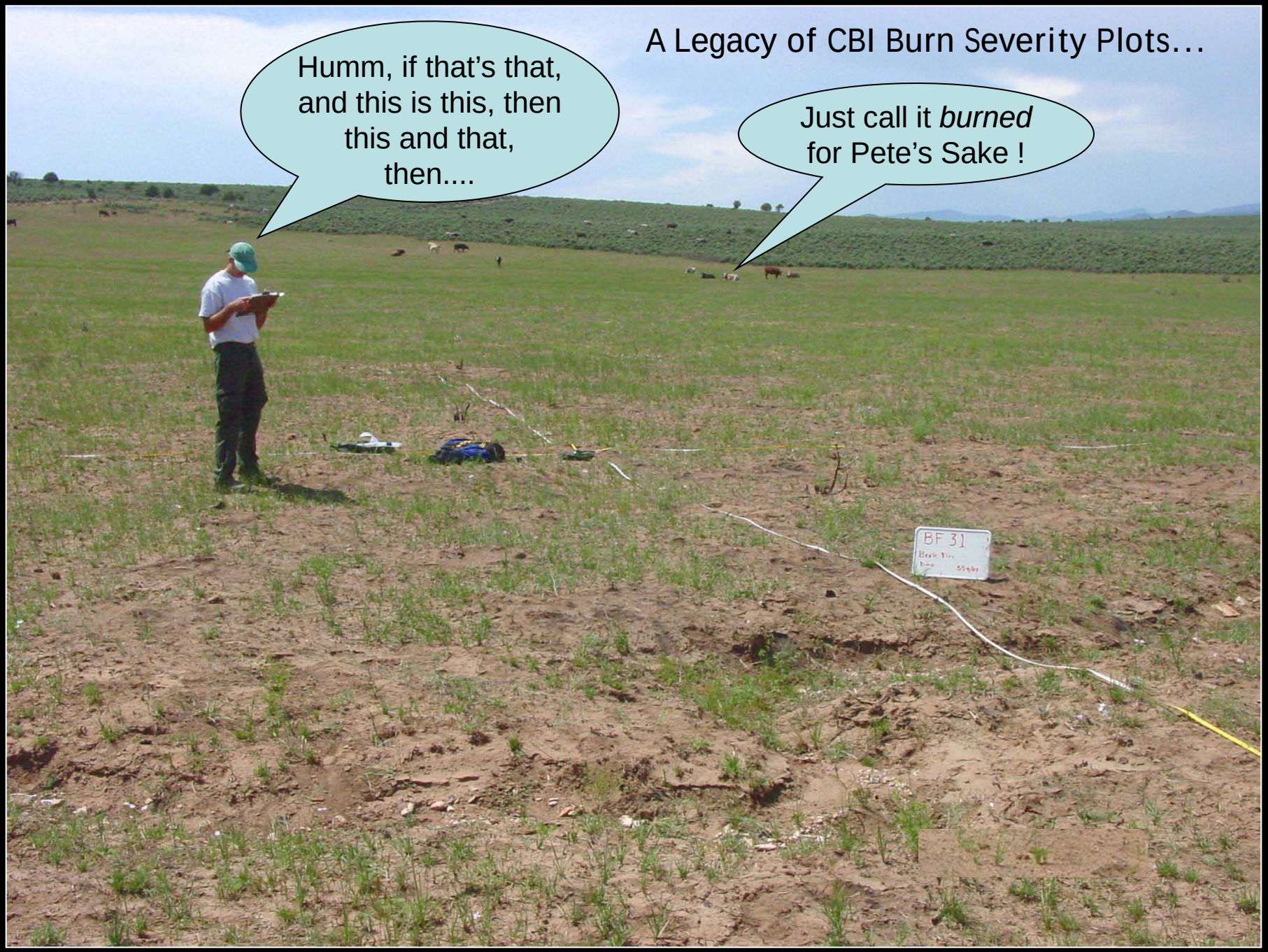
Fire Science Activities 2009

Carl Key, USGS NOROCK

- CBI Photo Series and Active Fire Gallery
- Monitoring Trends in Burn Severity Program
- Climate Impacts on Burn Severity


A Legacy of CBI Burn Severity Plots…
Humm, if that's that, and this is this, then this and that, then....
Just call it *burned* for Pete's Sake !
BF 31

http://nrmsc.usgs.gov/science/fire/CBI

Composite Burn Index (CBI) Photo Series

The Composite Burn Index (CBI) Photo Series uses plot data and photos to illustrate the range of burn severity encountered in different ecosystems of the U.S. We selected examples from over 2,500 plots and 85 fires, spanning very low to very high degrees of ecological change from fire. The series offers managers and scientists a way to calibrate their field interpretations, providing a sense of what the CBI represents visually on the ground. It offers insight into the variety and combinations of fire effects that make up the overall fire condition on a site.

- Important Information About This Site.
- Brief Description of the CBI.
- Summary Description of Low, Moderate, and High Burn Severity Categories.

Regions

Pages are best viewed with full browser window open or at least 1280/1024 pixel

Alaska (Yukon Charley Rivers N.P. & Noatak N.P.)
California Yosemite N.P.
California Other (Southern Sierras & Sequoia & Kings Canyon N.P.)
Central U.S. (Black Hills, SD; Voyageurs N.P.)
Eastern U.S. (Shenandoah N.P.)
Northern U.S. Rockies-Glacier National Park
Northern U.S. Rockies-Tetons (Grand Teton N.P., Bridger Teton N.F.)
Northern U.S. Rockies-Yellowstone N.P. (Coming Soon)
Southwest Grand Canyon N.P.
Southwest Other (New Mexico & Utah)

With support from NPS Fire Management Program Center

And much assistance from:
Suzanna Carrithers, NoRock
Scott Lange, NPS
Nate Benson, NPS

POST-FIRE Conditions

Ten "Regions"
Alaska
California Yosemite
California Other
Central U.S.
Eastern U.S.
North Rockies U.S. – Glacier
North Rockies U.S. – Tetons
North Rockies U.S. – Yellowstone
Southwest Grand Canyon
Southwest Other

Southwest Region - Grand Canyon; Severity Series 2 - Low to High

Poplar Fire CBI=0.47

PLOT P86

A. Substrates	0.82
B. Vegetation <1 m.	0.67
C. Vegetation 1-5 m.	0.75
D. Intermediate Trees	0.03
E. Big Trees	0.03
Understory CBI	0.76
Overstory CBI	0.03
Total Plot	0.47

Poplar Fire CBI=1.10

PLOT P42

A. Substrates	1.44
B. Vegetation <1 m.	0.87
C. Vegetation 1-5 m.	1.30
D. Intermediate Trees	0.80
E. Big Trees	0.95
Understory CBI	1.25
Overstory CBI	0.88
Total Plot	1.10

Poplar Fire CBI=1.53

PLOT P93

A. Substrates	2.32
B. Vegetation <1 m.	1.43
C. Vegetation 1-5 m.	1.18
D. Intermediate Trees	1.55
E. Big Trees	0.93
Understory CBI	1.72
Overstory CBI	1.24
Total Plot	1.53

Poplar Fire CBI=2.14

PLOT P98

A. Substrates	2.72
B. Vegetation <1 m.	1.33
C. Vegetation 1-5 m.	2.50
D. Intermediate Trees	1.95
E. Big Trees	1.93
Understory CBI	2.28
Overstory CBI	1.94
Total Plot	2.14

Poplar Fire CBI=2.87

PLOT P58

A. Substrates	3.00
B. Vegetation <1 m.	2.80
C. Vegetation 1-5 m.	2.65
D. Intermediate Trees	2.93
E. Big Trees	2.93
Understory CBI	2.83
Overstory CBI	2.93
Total Plot	2.87

Severity Similarity CBI 0-1, Rockies-GNP Region

Wedge Canyon CBI=0.36

PLOT 1042

A. Substrates	0.56
B. Vegetation <1 m.	0.40
C. Vegetation 1-5 m.	0.45
D. Intermediate Trees	0.32
E. Big Trees	0.08
Understory CBI	0.48
Overstory CBI	0.18
Total Plot	0.36

Robert Fire CBI=0.56

PLOT S2235

A. Substrates	0.94
B. Vegetation <1 m.	0.93
C. Vegetation 1-5 m.	0.13
D. Intermediate Trees	0.40
E. Big Trees	0.40
Understory CBI	0.68
Overstory CBI	0.40
Total Plot	0.56

Sharon Fire CBI=0.71

PLOT Bob1a

A. Substrates	1.15
B. Vegetation <1 m.	1.13
C. Vegetation 1-5 m.	0.75
D. Intermediate Trees	0.33
E. Big Trees	0.30
Understory CBI	1.04
Overstory CBI	0.32
Total Plot	0.71

Trapper Fire CBI=0.88

PLOT 1135

A. Substrates	0.76
B. Vegetation <1 m.	0.88
C. Vegetation 1-5 m.	1.15
D. Intermediate Trees	0.78
E. Big Trees	N/A
Understory CBI	0.92
Overstory CBI	0.78
Total Plot	0.88

Robert Fire CBI=0.95

PLOT 9009

A. Substrates	1.00
B. Vegetation <1 m.	0.53
C. Vegetation 1-5 m.	2.10
D. Intermediate Trees	0.60
E. Big Trees	0.66
Understory CBI	1.23
Overstory CBI	0.63
Total Plot	0.95

Reconnaissance, Landscape, & Training Photos

Active Fire Gallery

http://nrmsc.usgs.gov/image/tid/9

1999 Anaconda Fire

With much assistance from: Suzanna Carrithers, NoRock; Scott Lange, NPS

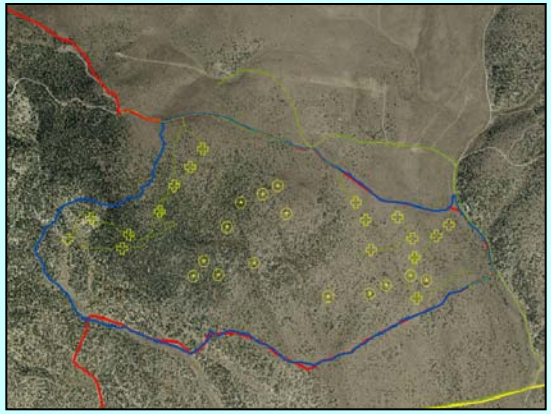
MTBS - Monitoring Trends in Burn Severity - http://www.mtbs.gov

- Develop new concepts of potential severity and non-biased thresholding
- Provide guidance for operations at RSAC (USFS) and EROS (USGS)
- Plan and develop materials for 1-day workshop, ‘09 Fire Congress in Savanna
- Glacier National Park Fire Management
  - Post-fire vegetation response / update 1999 Veg. Map for recent fires
  - Fire, Critical Resources and Climate Change, identify “vulnerabilities and adaptations” to wildfires as influenced by climate change
  - Improve stand age database, data organization and information transfer
- Training and field studies
  - BLM Gleason prescribed burn Ely, NV
  - USFS, AREBA project, Cold Springs burn, Mt Adams, WA

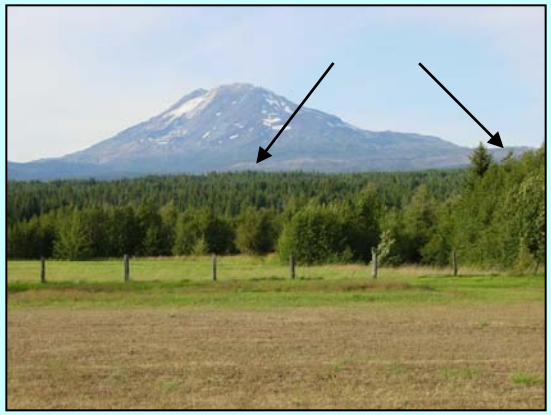
    Accelerated Remeasurement and Evaluation of Burned Areas

MTBS - Monitoring Trends in Burn Severity - http://www.mtbs.gov

ELY NEVADA – Gleason Rx, BLM



MOUNT ADAMS, WA – Cold Springs, USFS



Climate Impacts on Burn Severity in Three Forest Ecoregions of the U.S.

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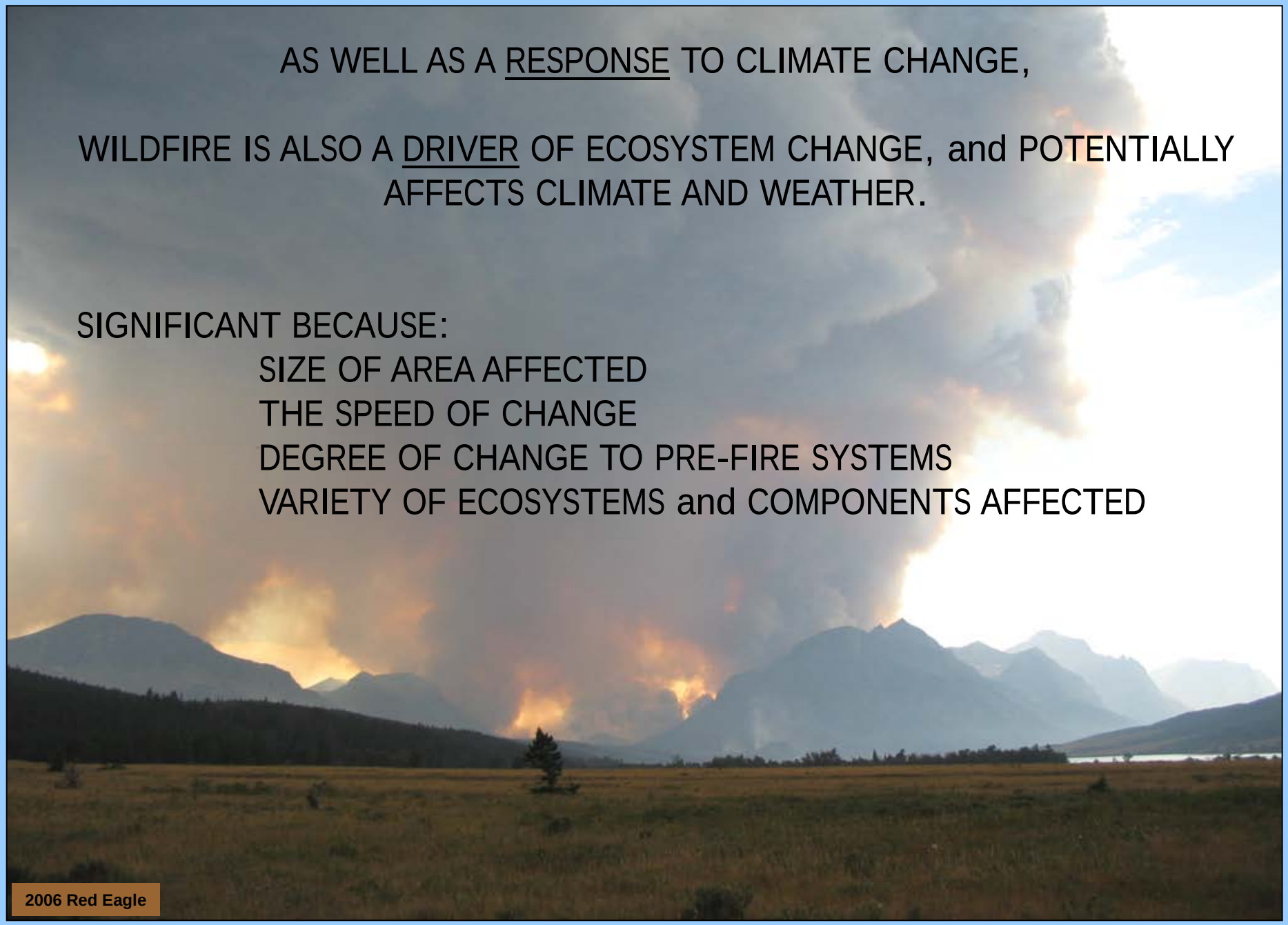
Selected September 30, 2008
Funding Allocated May 22, 2009
Contracts and Agreements by August...

AS WELL AS A RESPONSE TO CLIMATE CHANGE,

WILDFIRE IS ALSO A DRIVER OF ECOSYSTEM CHANGE, and POTENTIALLY AFFECTS CLIMATE AND WEATHER.

SIGNIFICANT BECAUSE:

- SIZE OF AREA AFFECTED
- THE SPEED OF CHANGE
- DEGREE OF CHANGE TO PRE-FIRE SYSTEMS
- VARIETY OF ECOSYSTEMS and COMPONENTS AFFECTED



2006 Red Eagle

Fire Frequency, Extent, Pattern, Severity, and Recovery
All link to climate and weather…. But, relationships are complex

What do fires need to burn?

1) Fuel *(Past climate)*
   a) Quantity
   b) Distribution
   c) Structure
   d) Moisture Content

2) Ignition *(Present)*

3) Fire Weather *(Present)*
   a) Oxygen – Wind
   b) Relative Humidity
   c) Temperature

What governs post-fire responses?

1) Burn Severity
   a) Survivorship
   b) Biomass consumption
   c) Changes to soil

2) Patchiness and pattern
   a) Available seed sources
   b) Refugia, biodiversity

3) Future Weather/Climate
   a) Species selection
   b) Productivity, growth
   c) Erosion, infestation, etc.

Prior work predicts increase in burned area across forests (Balshi et al. 2009; Spracklen et al. 2009, etc.).

But climatic influence on other fire regime characteristics remains less well known, i.e. burn severity, distribution, and seasonality.

Assess the role of climate and weather as contributors to wildfire burn severity across the western U.S. – *Never before possible*….

Compare and contrast the three distinct ecoregions, surrounding Yukon-Charlie, Glacier, and Yosemite National Parks

1. How is climate/weather variability spatiotemporally manifested in large area patterns of burn severity?

2. To what extent can we generalize *impacts from* and *trends in* burn severity across the three ecoregions? How are they similar, how do they differ?

Key Fire Variables:

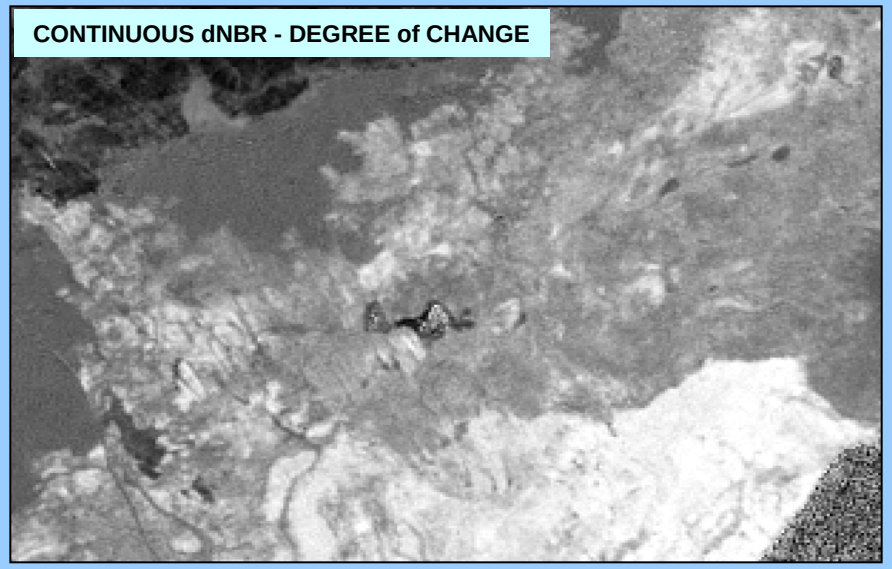
Ignition Frequency & Periodicity

Burn Area & Duration – *dNBR & records*

Severity Frequency – *dNBR*

Burn pattern, heterogeneity, and patch dimensions – *dNBR*

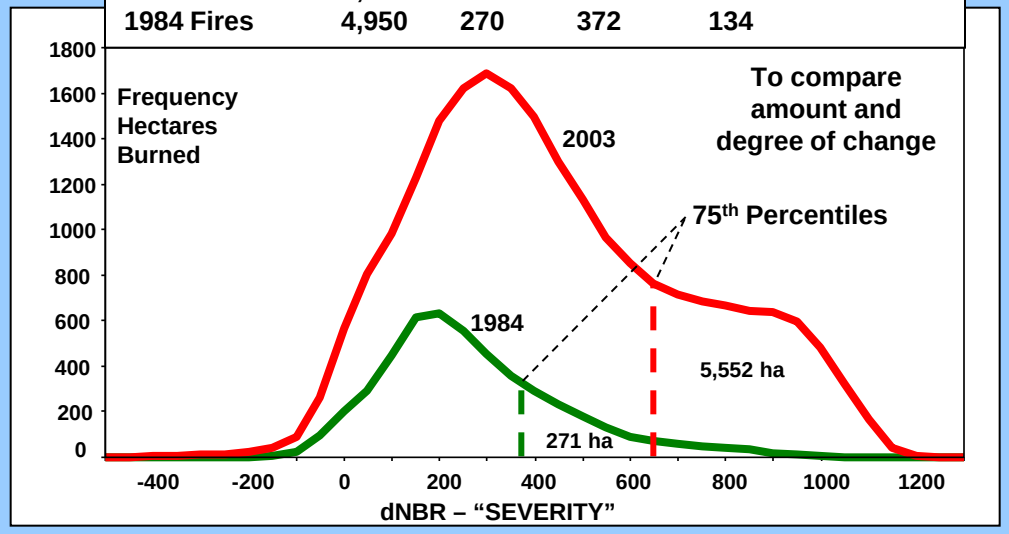
Summarized annually, monthly and by burn

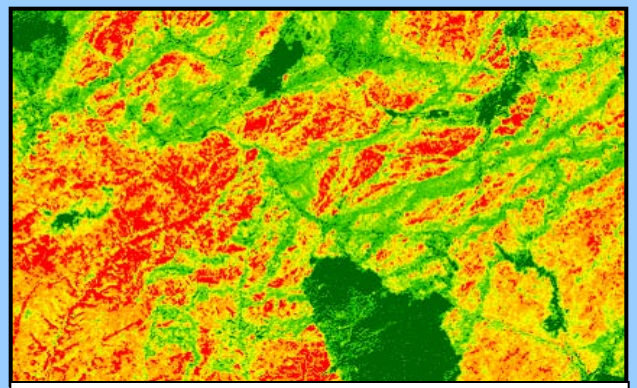


Using Continuous and Categorical dNBR.....

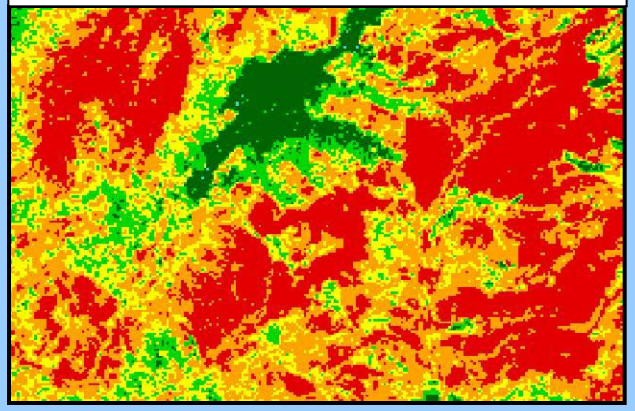
Burn Response Curves >>> Severity "Population" Statistics

	HA	dNBR Mean	dNBR 75th Pct.	μ dNBR * 100km^2
2003 Fires	22,160	439	640	974
1984 Fires	4,950	270	372	134





PATCH VARIATIONS – CATEGORICAL dNBR



Key Climate Variables:

Annual and monthly temperature and precipitation summaries

mean, max and min, growing degree days, and potential evapotranspiration

4-km climatology and anomalies

Seasonality – Phenology & Drought Indices and Trends

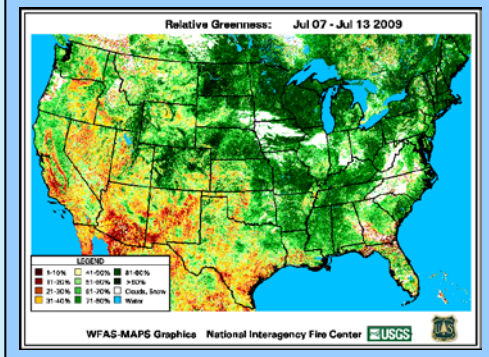
NDVI Composite Index, Palmer Drought Severity Index, Palmer Z Index, Standardized Precipitation Index,

Snow Water Equivalent, Runoff/Stream-flow data

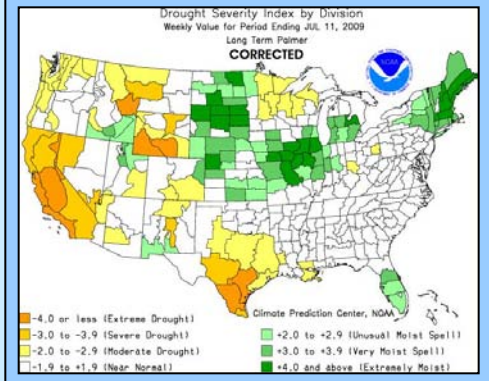
National Fire Danger Rating System (NFDRS), and Wildland Fire Assessment System -- Haines Index & Fuel Moisture

National and North American Lightning Detection Network data

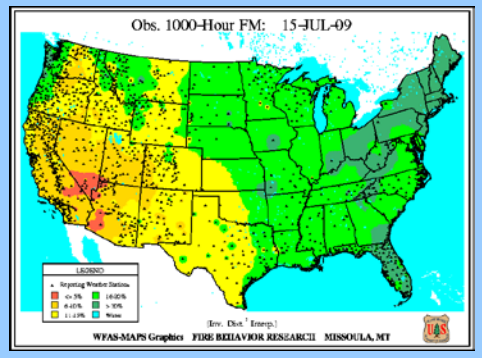
NDVI Composite Index



Palmer Drought Severity



Fuel Moisture



Possible Teleconnection Linkages:

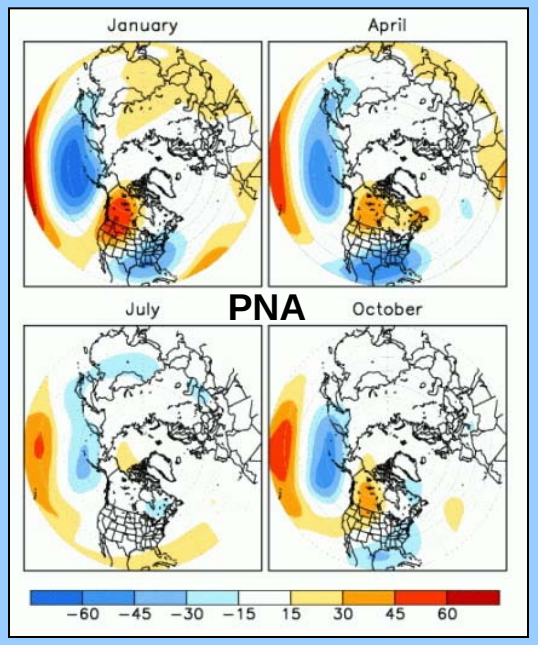
	NPI	PNA	PDO	ENSO
Yukon-Charlie	X	XX	X	
Glacier	x	X	X	x
Yosemite		X	X	XX

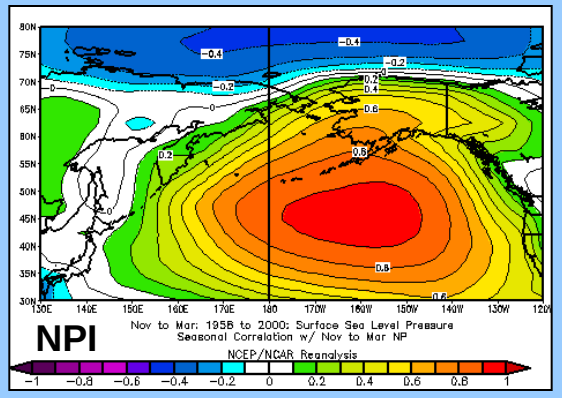
NPI – North Pacific Index, correlated to Aleutian Low Pressure Index (ALPI)

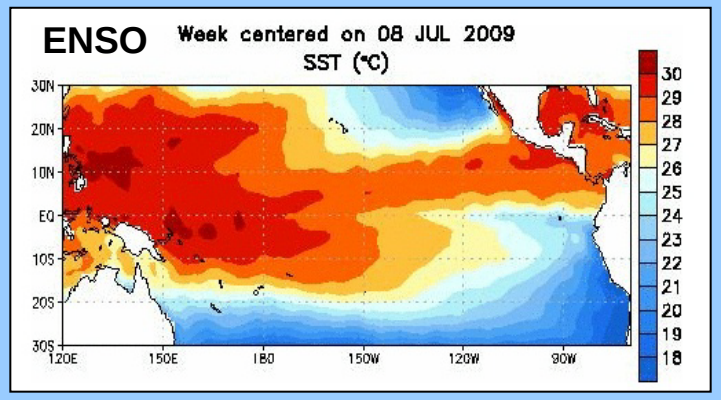
PNA – Pacific / North American teleconnection pattern

PDO – Pacific Decadal Oscillation

ENSO – El Niño-Southern Oscillation







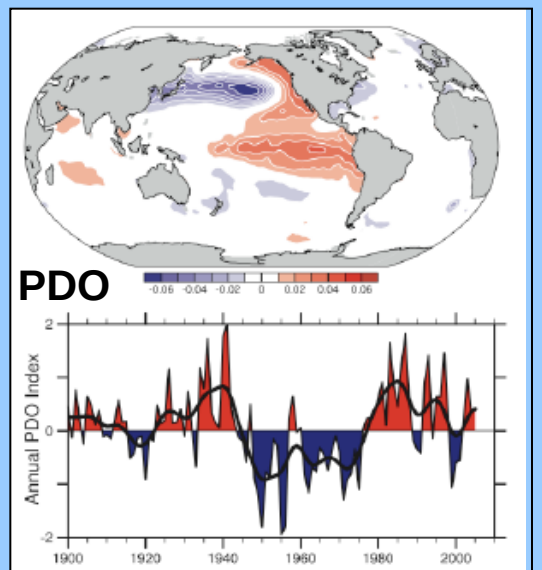


Figure 3.28. *Pacific Decadal Oscillation: (top) SST based on the leading EOF SST pattern for the Pacific basin north of 20°N for 1901 to 2004 (updated; see Mantua et al., 1997; Power et al., 1999b) and projected for the global ocean (units are nondimensional); and (bottom) annual time series (updated from Mantua et al., 1997). The smooth black curve shows decadal variations (see Appendix 3.A).*

Key Analyses:

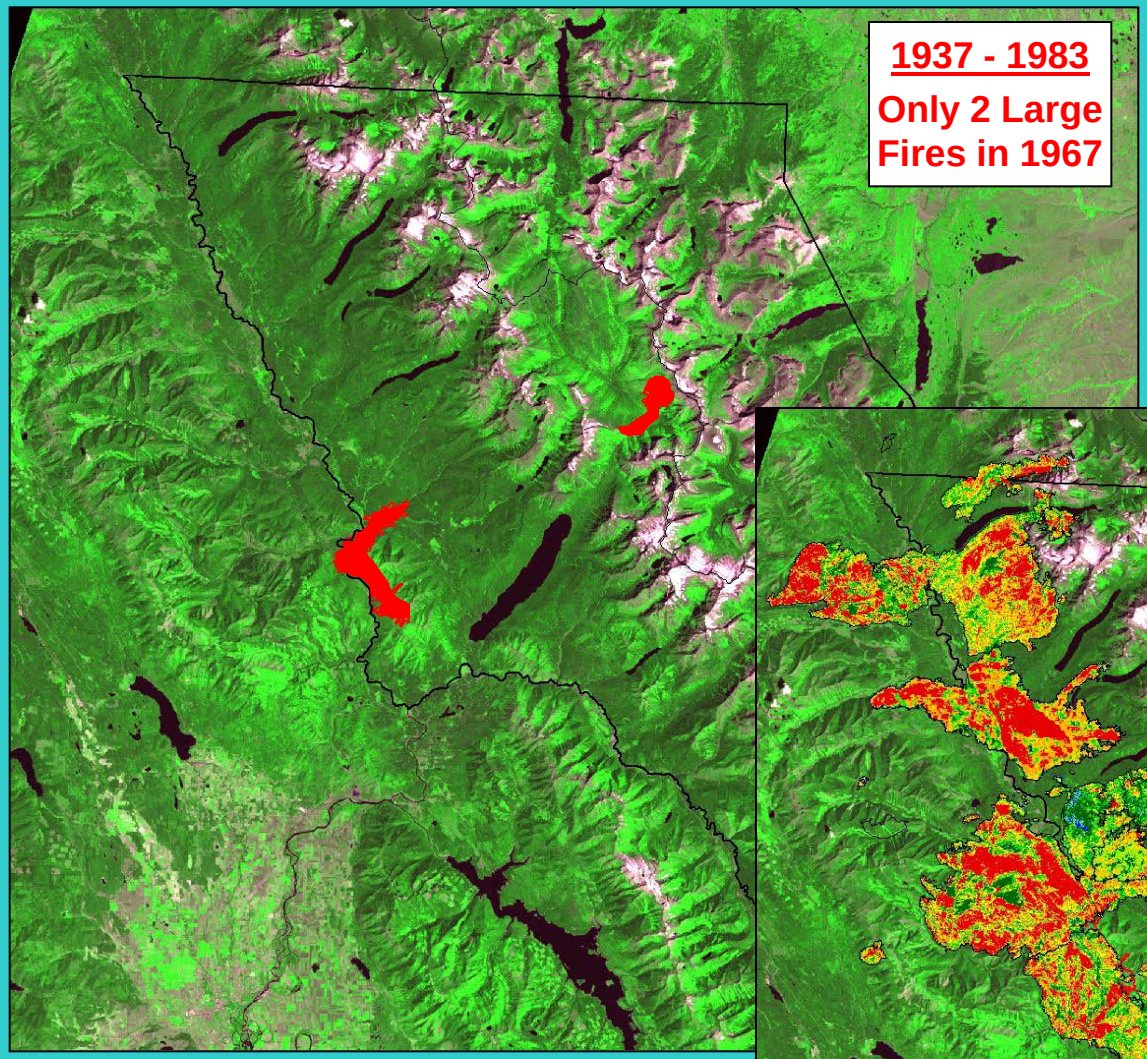
- Relate climate variables to burn summaries over monthly and annual time series, using correlation and trend analysis

- Include characteristics and trends in landscape metrics of burn severity (e.g. heterogeneity, patch size, and complexity)

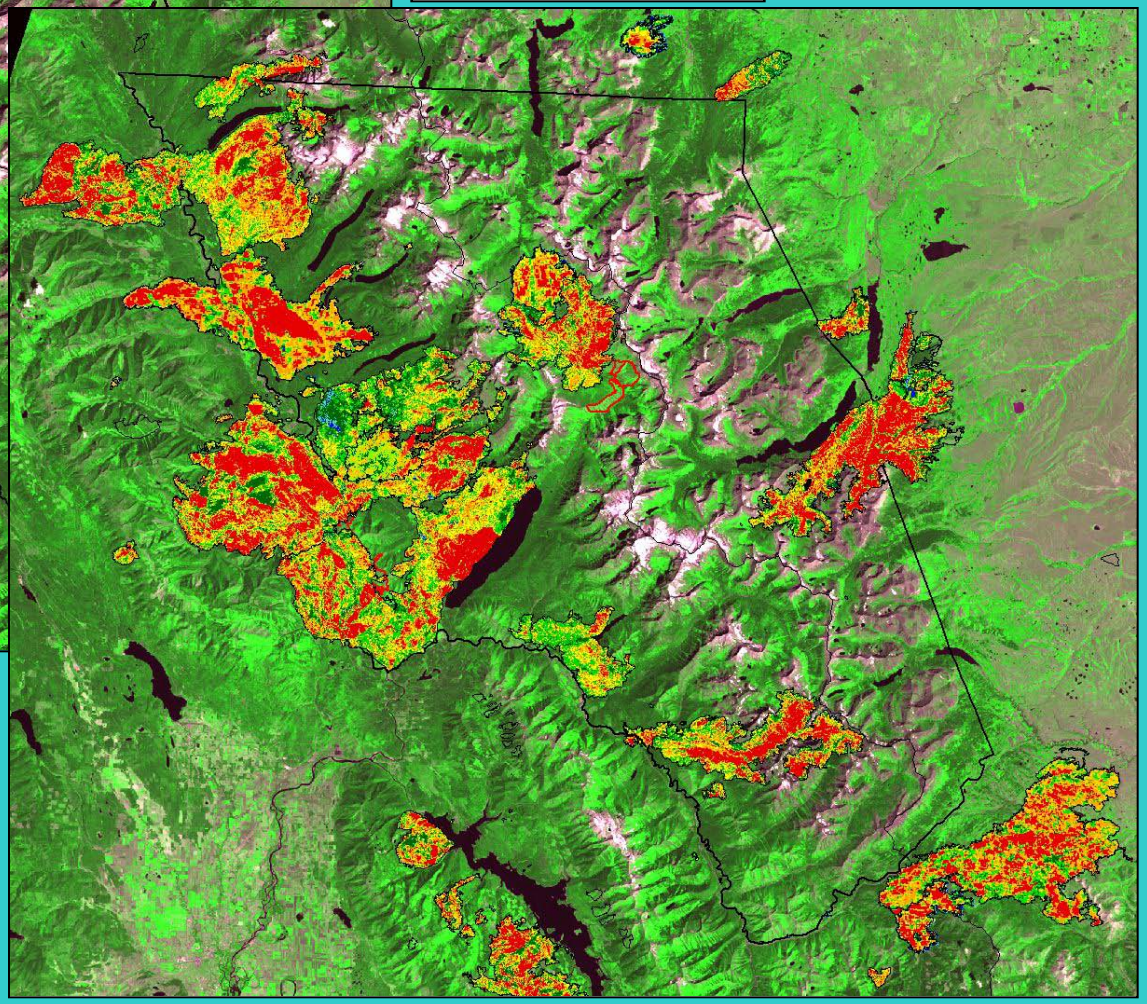
- Test for temporal trends in burn size, periodicity, composition, and pattern within and across regions and time intervals

- Compare climate and fire associations to understand climatic influences, and look for regional synchrony, asynchrony, or lack of trend.

GLACIER REGION



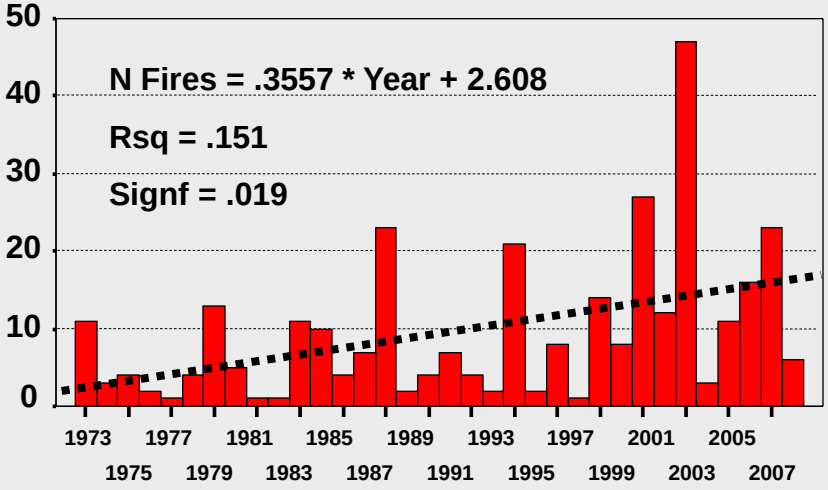
1973 Landsat Image



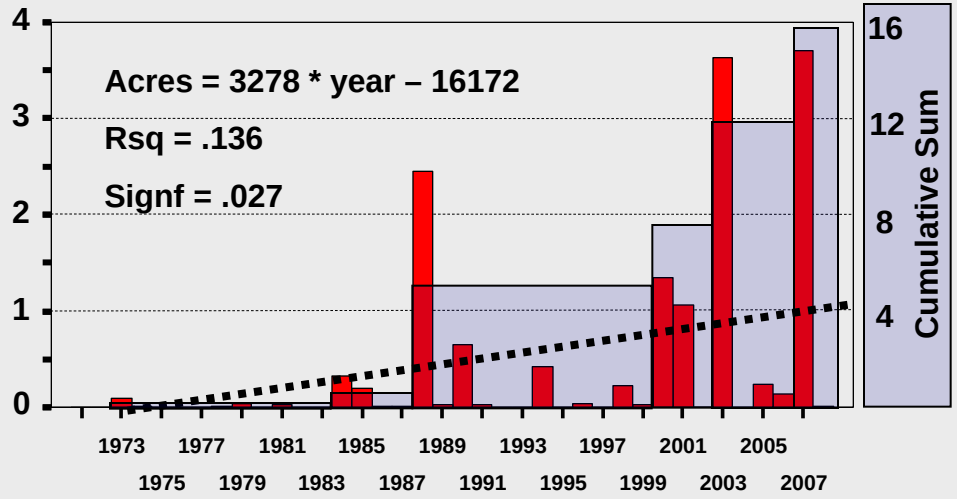
Key et al

Northwest MT and ID, 4 National Forests.

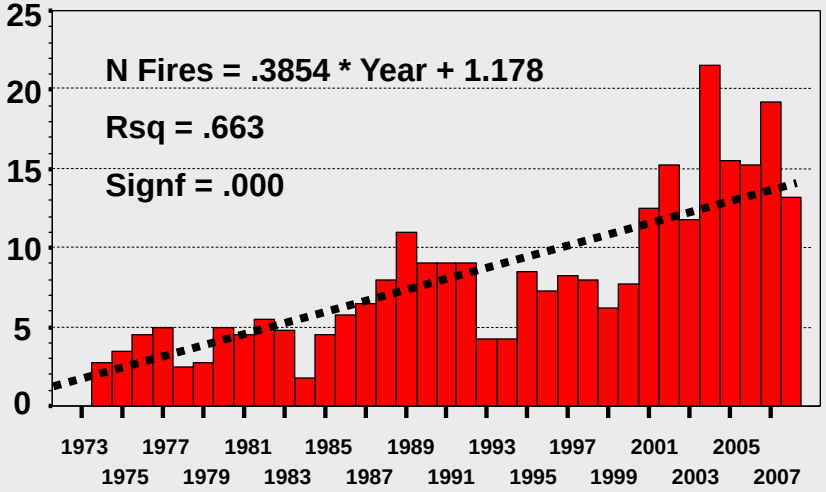
N Fires > 50 Acres by Year 1973-2008



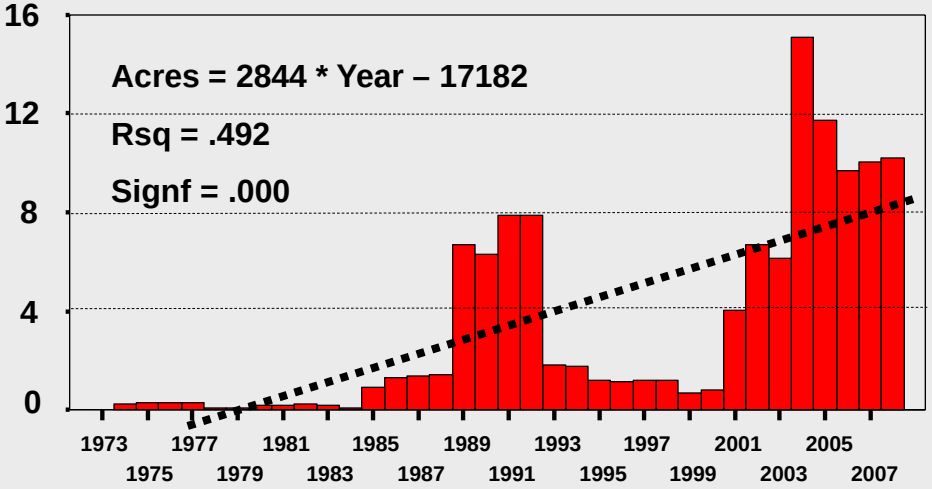
Perimeter Acres x 100K, All Fires 1973-2008



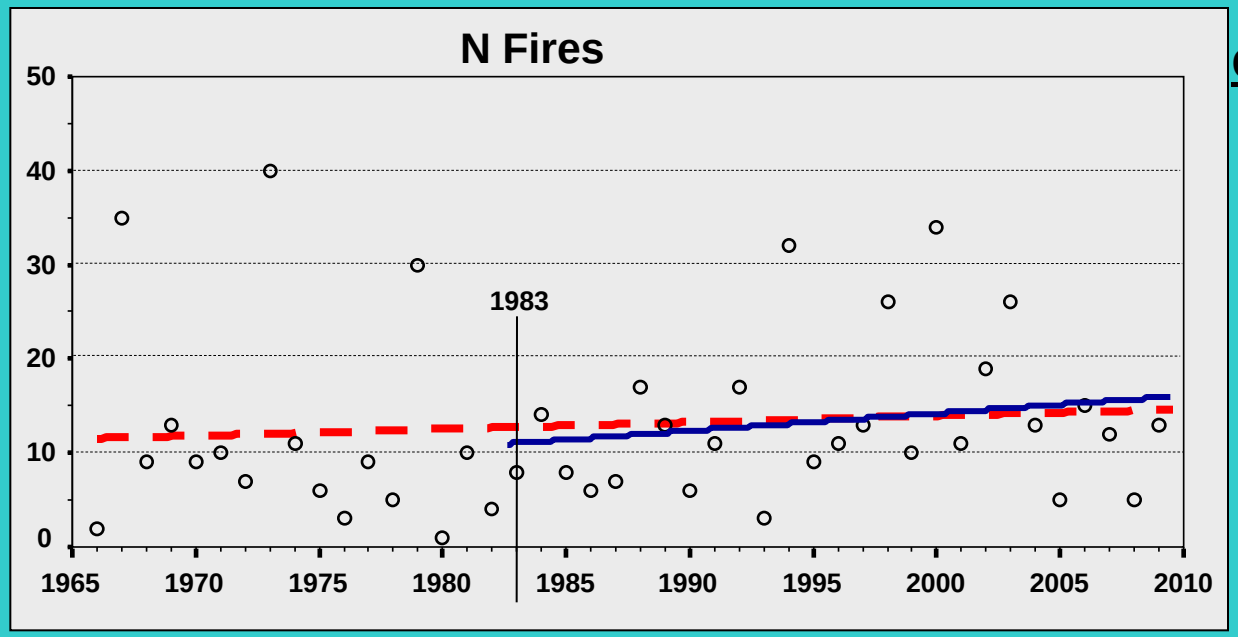
N fires > 50 Acres, Prior 4-year moving average



Perimeter Acres x 10K, Prior 4-year moving average



Key et al



GLACIER REGION 1966 - 2009

N66 = *0.063* * YEAR + 11.6

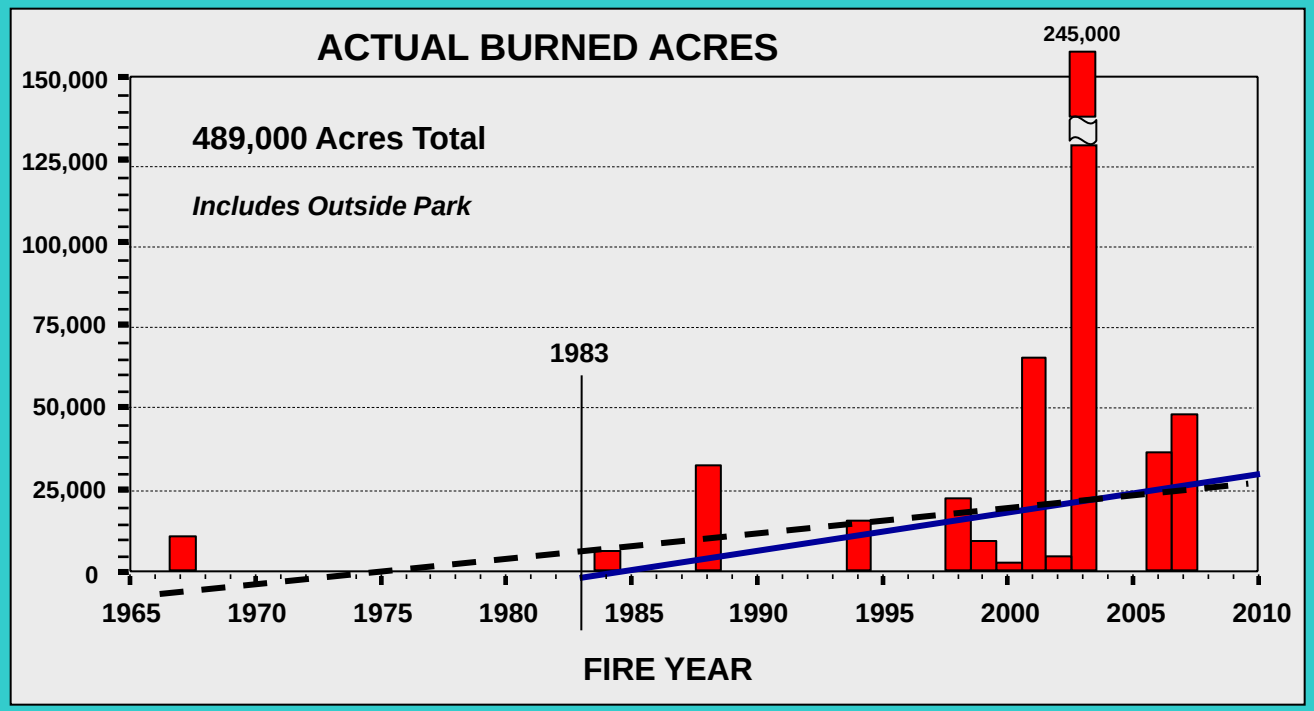
Rsq = .007

Signf = .579

N83 = *0.178* * YEAR + 11.2

Rsq = .031

Signf = .378



A66 = *813* * YEAR – 7581

Rsq = .004

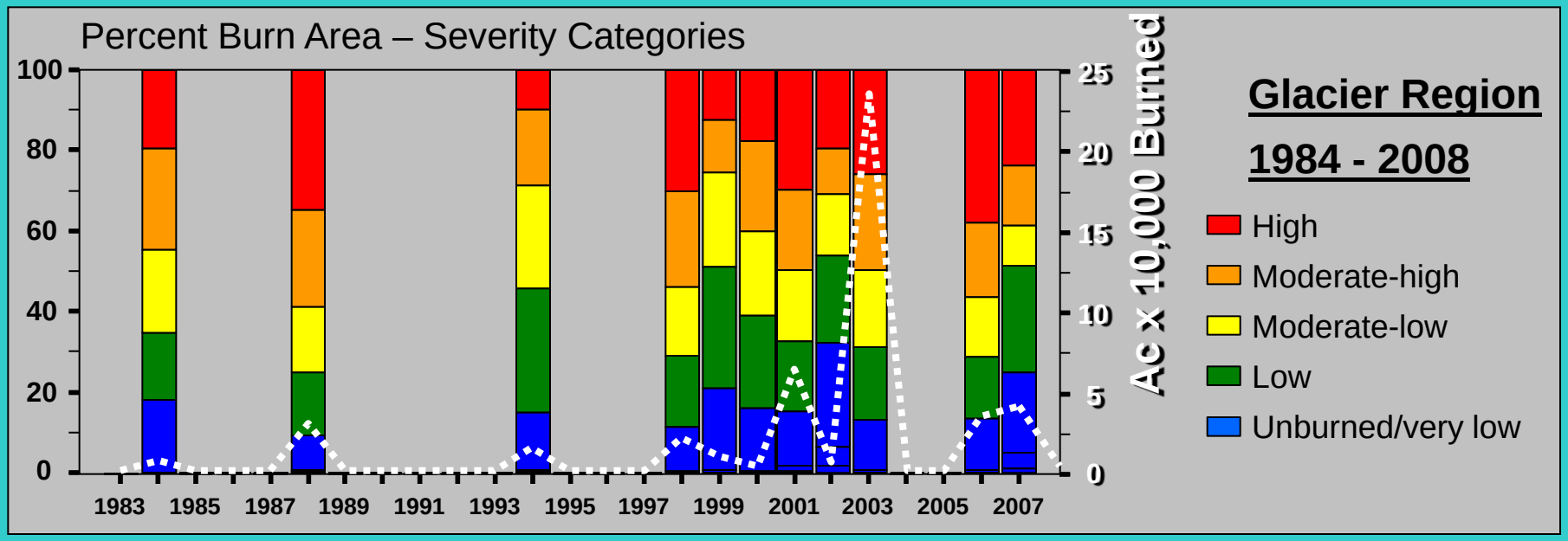
Signf = .527

A83 = *1353* * YEAR – 1663

Rsq = .071

Signf = .180

Key et al



Pct Higher = *-0.149* * YEAR + 45.7

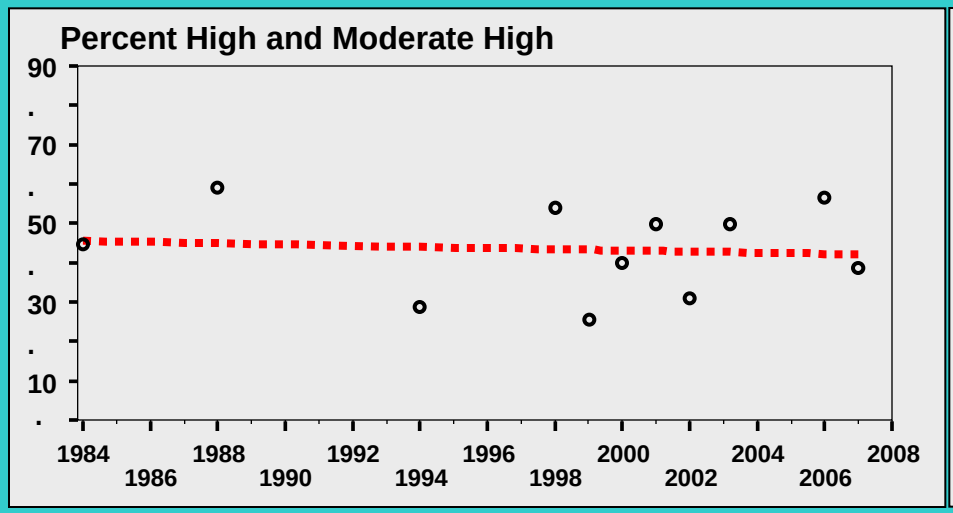
Rsq = .009

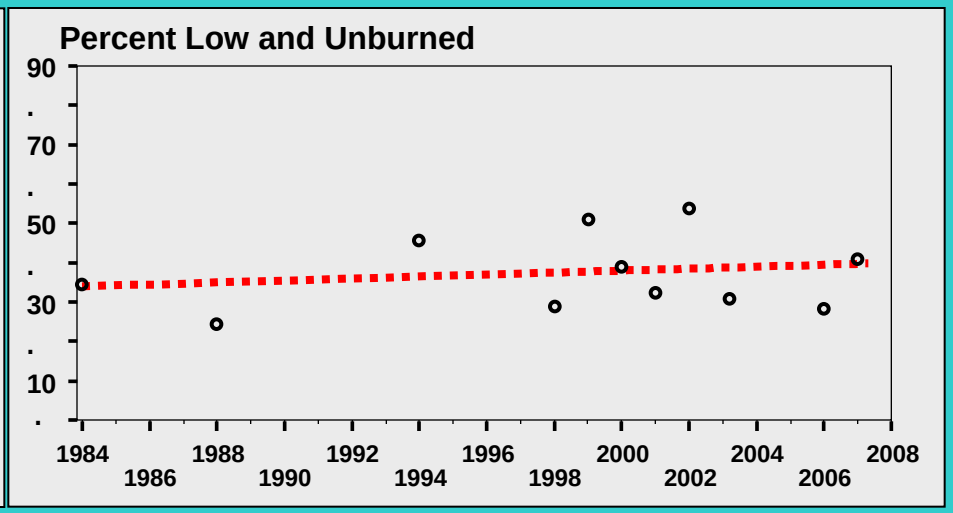
Signf = .787

Pct Lower = *0.250* * YEAR + 33.6

Rsq = .035

Signf = .582

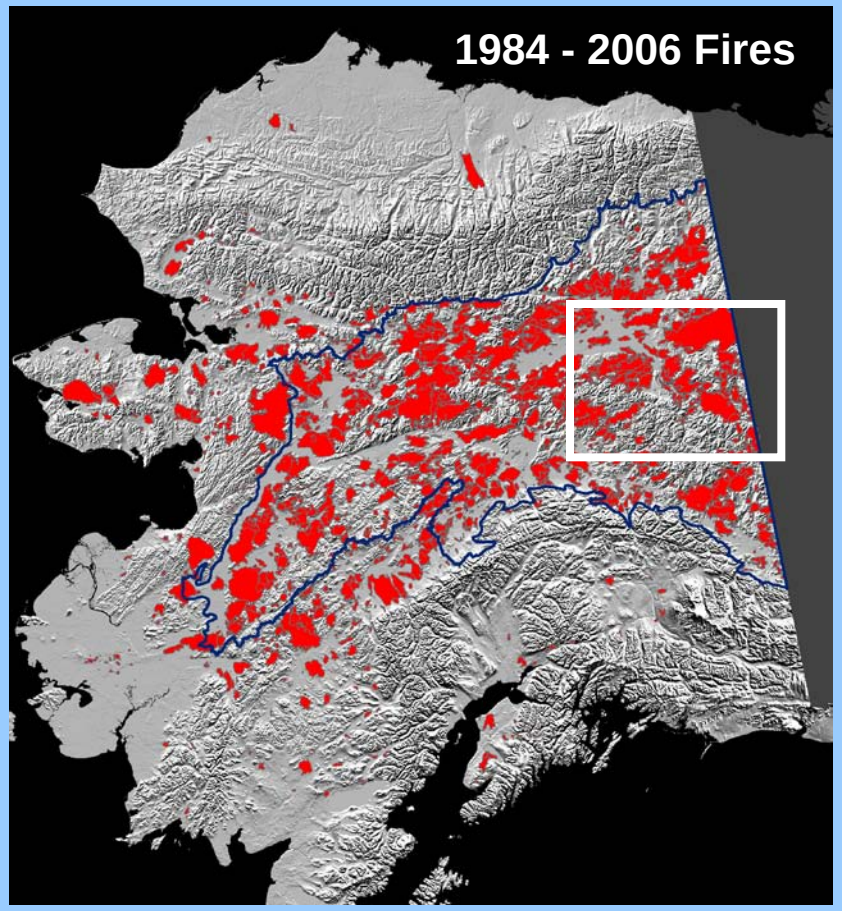


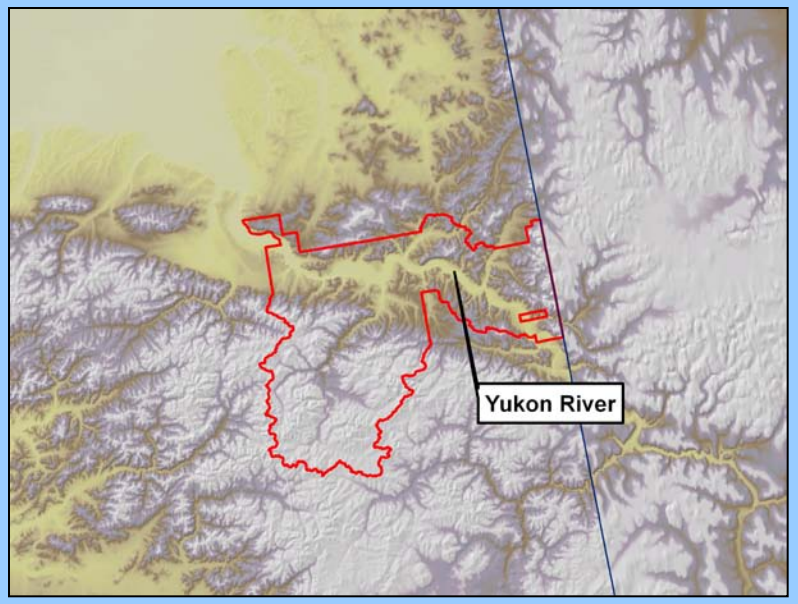


Key et al

Yukon Charlie Rivers National Preserve

- 1 million Hectare park in heart of Alaska interior
- Bisected by the Upper Yukon River,
- Represents boreal ecotypes and fire regimes throughout Yukon Basin





- Fire primary disturbance
- Not well understood
- Most research done on black spruce/soil carbon
- Missing data; Data-poor region
- Absent fire-scarred trees

<u>Yukon Charlie</u>
Variety of Vegetation and Fuel Types.

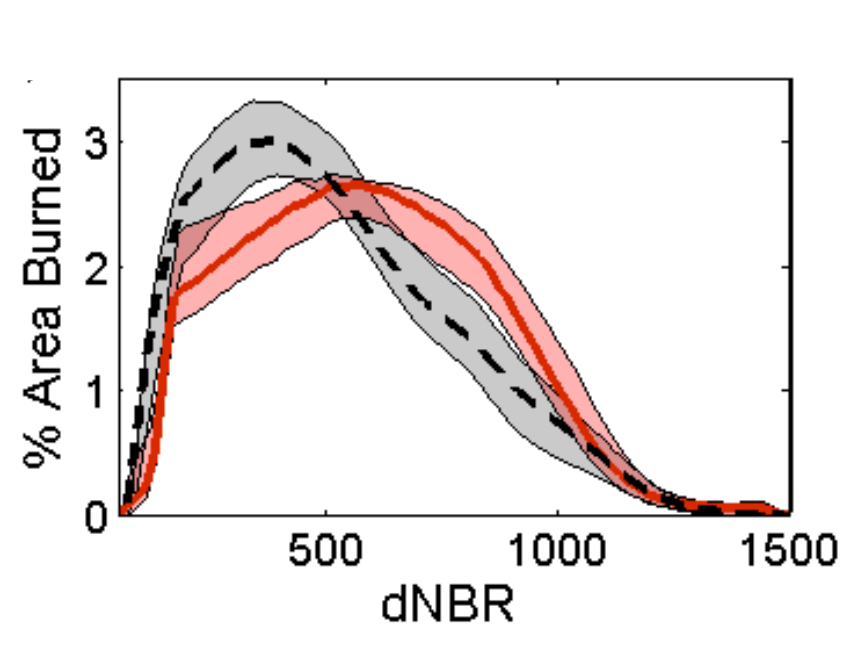
Low to High Elevation Gradient.

NPS Fire Monitors Sampling Burn Severity with the Composite Burn Index (CBI) since 1999.

YUCH Trends in Burn Severity- Continuous dNBR

H1: Burn severity has increased over time...

***Mean, with 95% confidence levels**



Earlier Fires

Later Fires

- Bootstrap random selection of 60 / 100 burns over all years
- Divide samples in half, “earlier” and later” (do not use arbitrary year)
- Test if later fires burned with higher severity

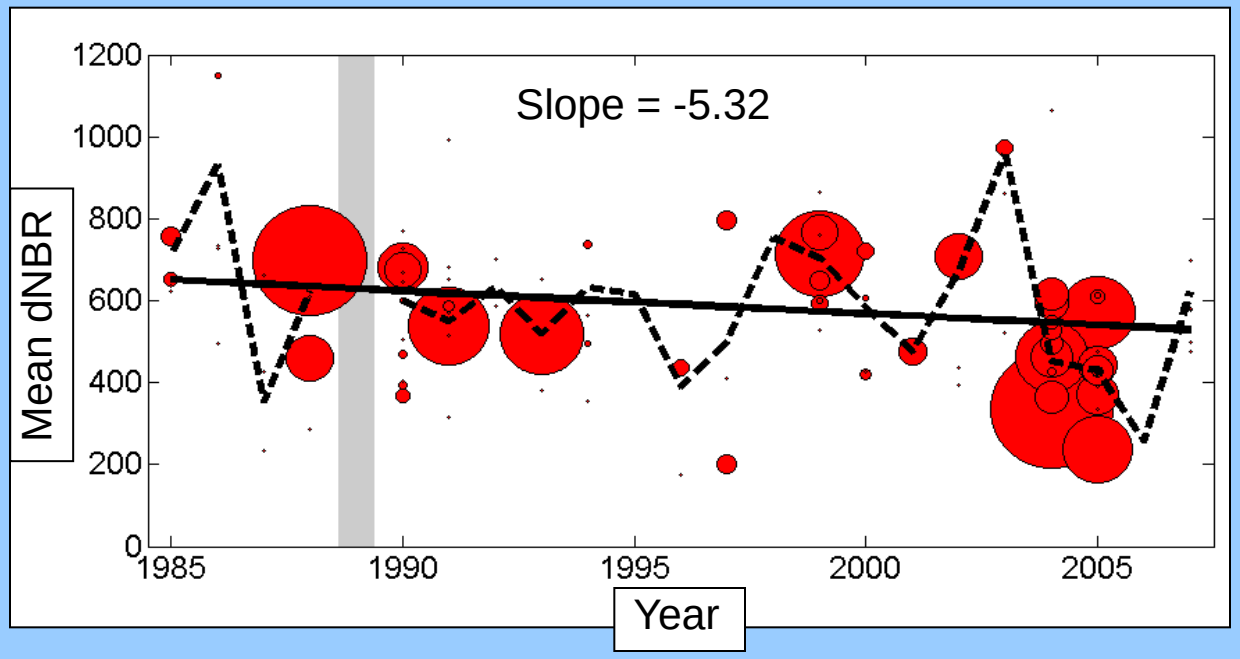
Decrease in severity as a fraction of burn.

Earlier fires burned at significantly higher severity

Later fires had significantly larger percent of the burn at lower severity

Kolden et al

YUCH Trends in Burn Severity- Mean dNBR

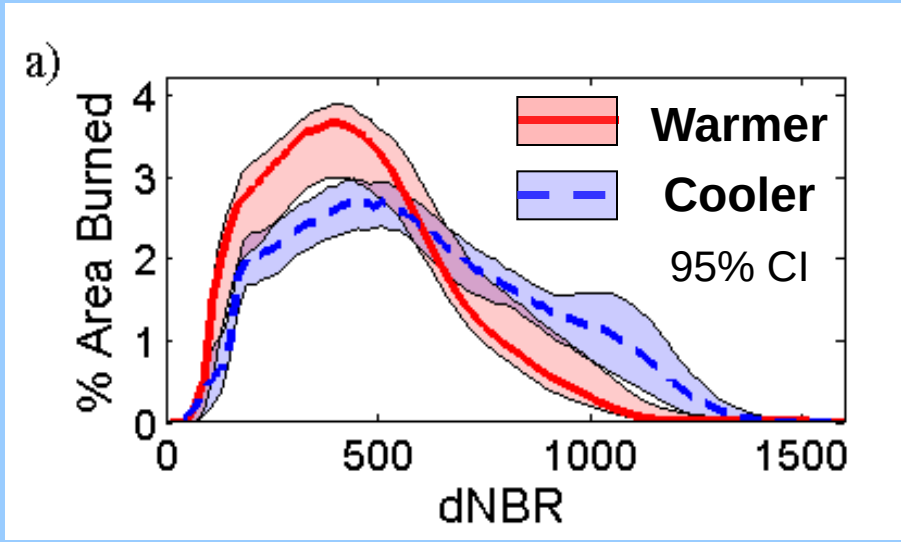


1) Burn severity decreasing (mean dNBR/fire), but trend not significant
2) Large fires in 2004/2005 burned at relatively lower severity

Kolden et al

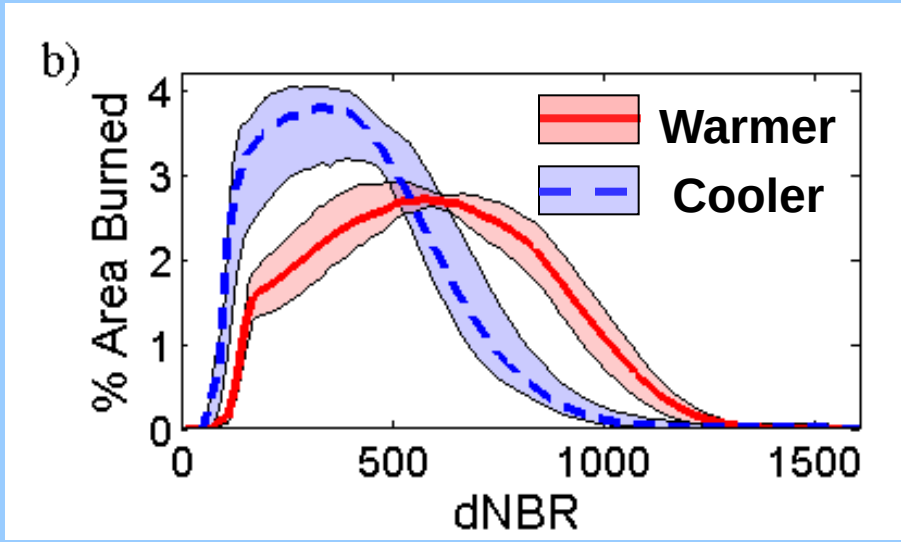
YUCH Trends in Burn Severity- Climate

a) Cooler JJA ***anomaly*** enables significantly more severe fire than warmer JJA anomaly



b) Warmer JJA ***climatology*** enables significantly more severe fire than cooler JJA climatology

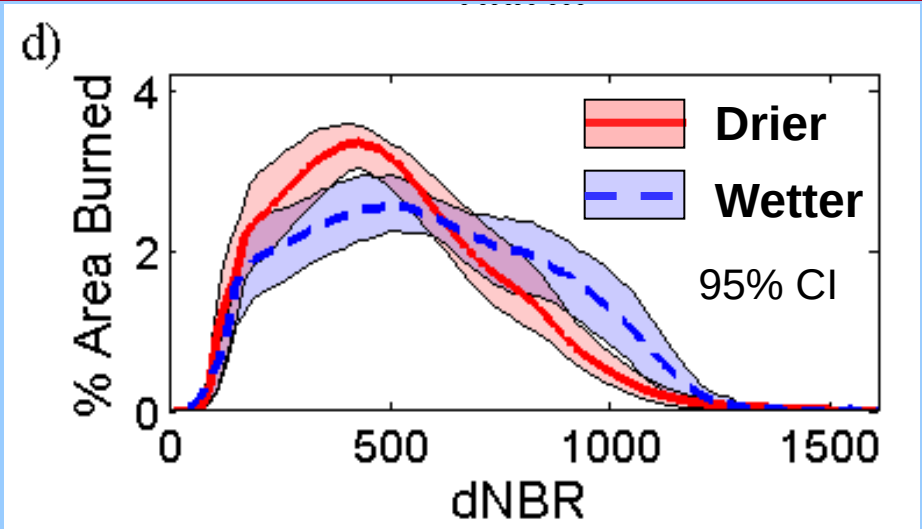
- Climatologically warmer sites burn more severely – why?
- Elevation? Vegetation? Aspect?



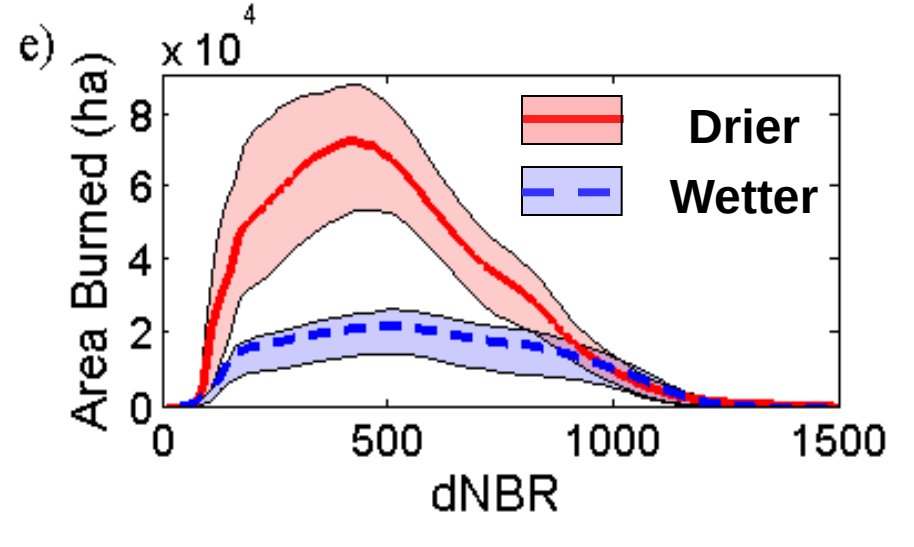
Kolden et al.

YUCH Trends in Burn Severity- Climate

d) Fires burn significantly more severely given a wetter August than a drier one



e) From total area burned (not just % of area), significantly larger fires burn during drier Augusts

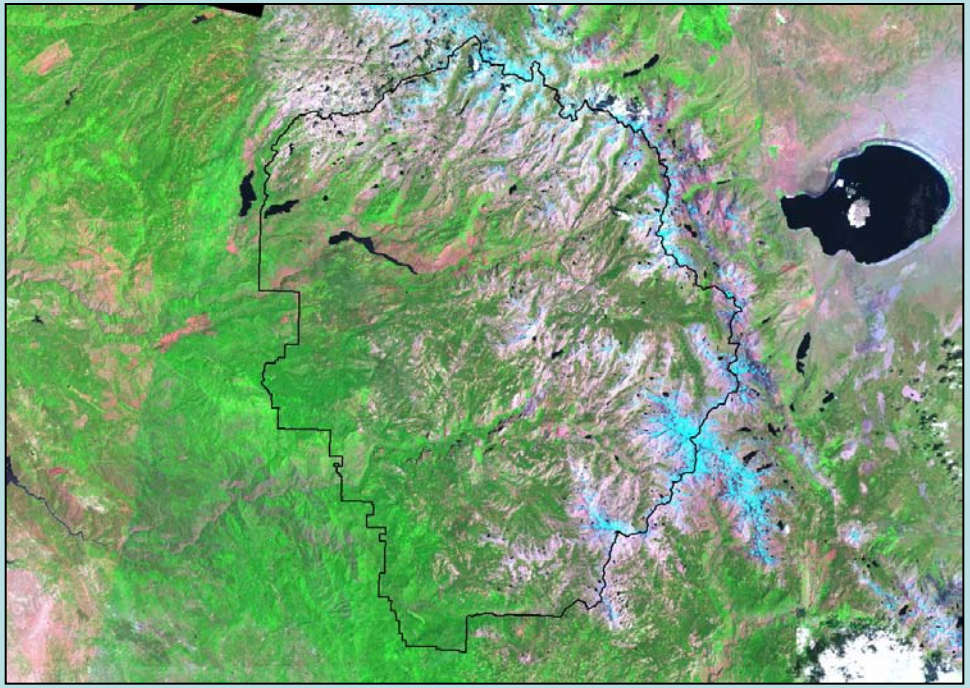


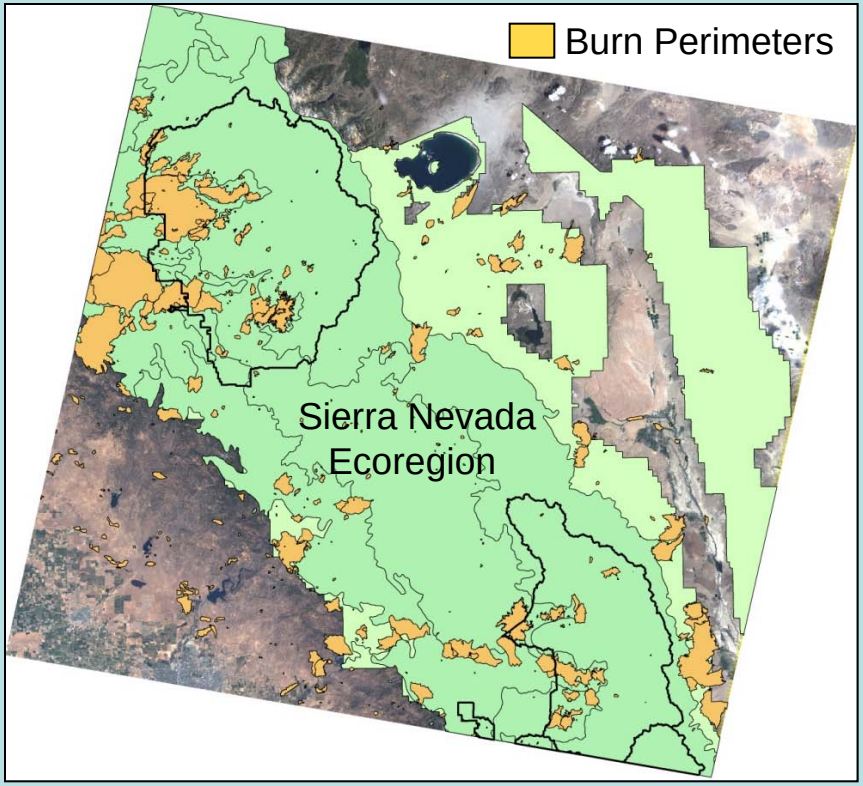
Consistent with findings of August drought leading to large fire years

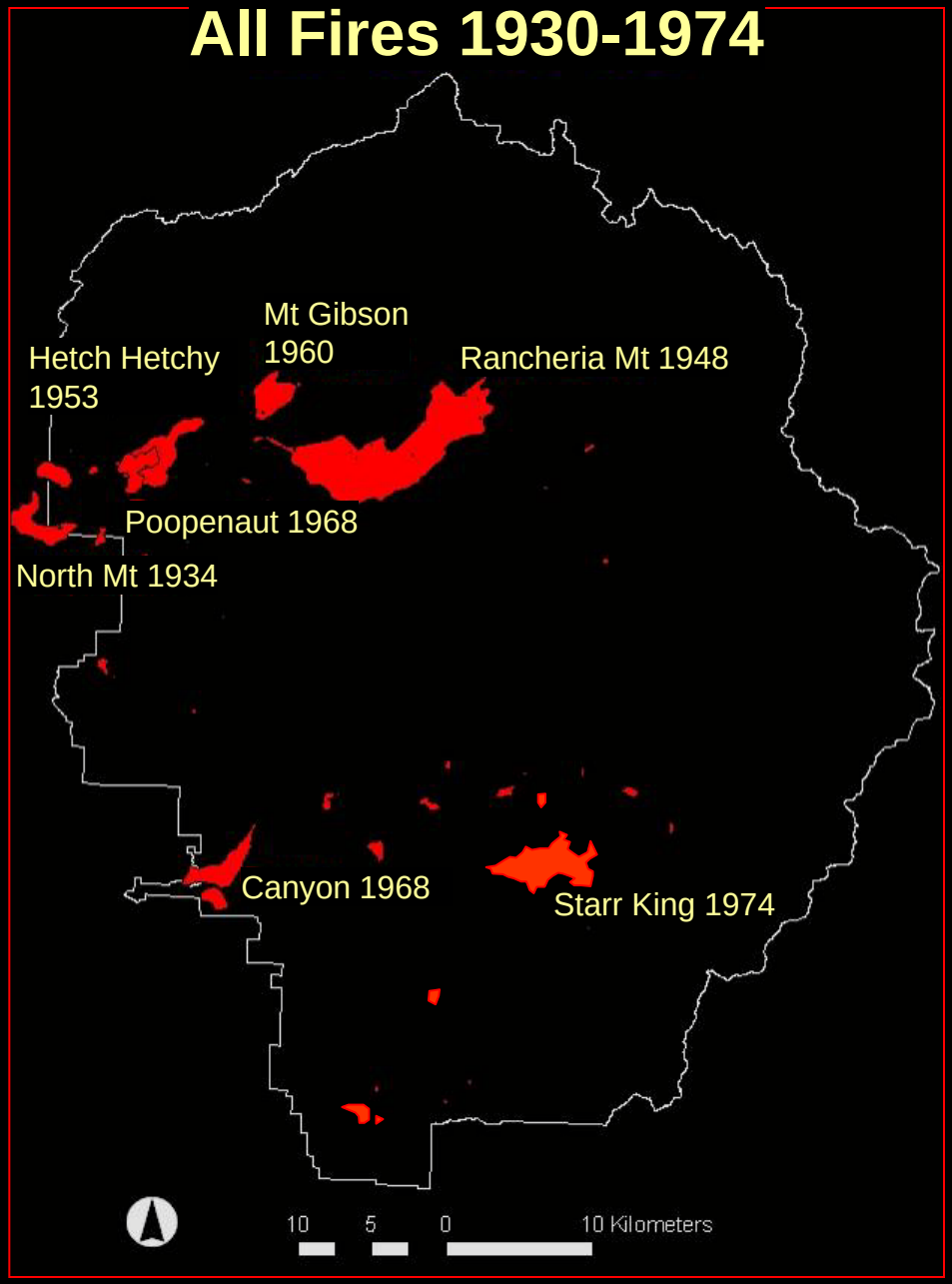
Years with Wetter August have smaller fires, but they burn with greater severity...

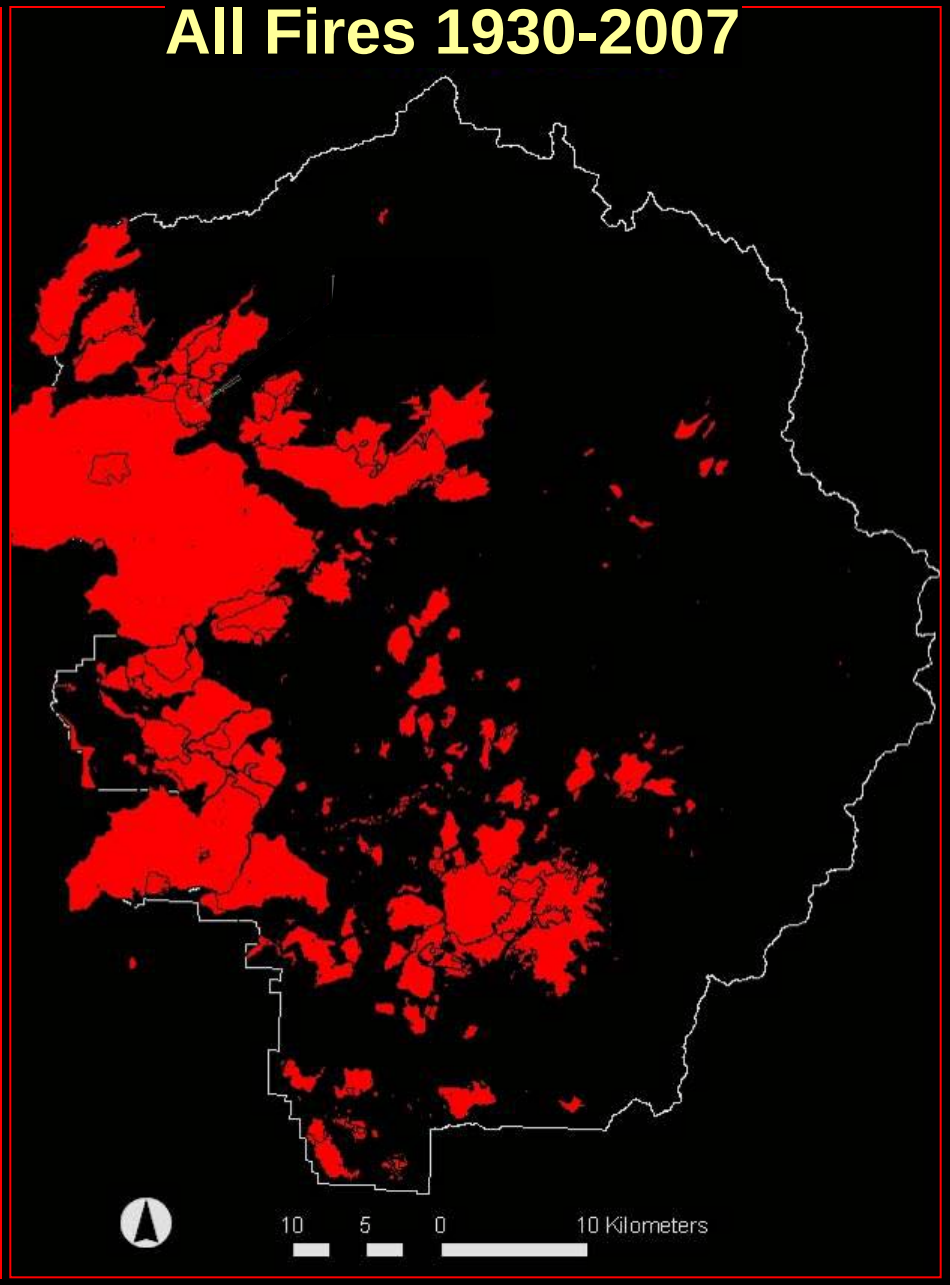
Kolden et al.

Yosemite National Park



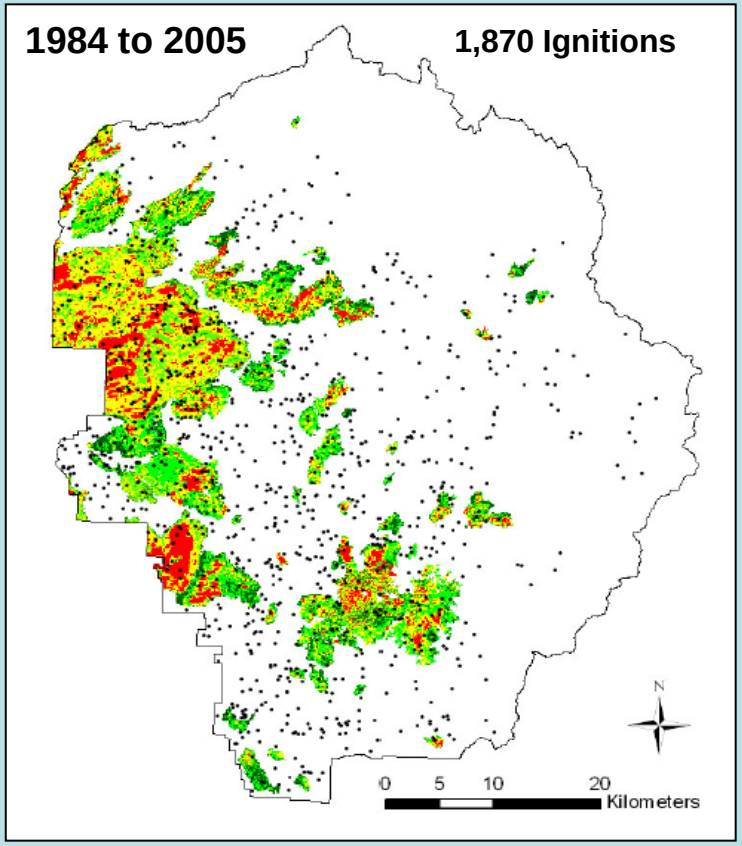


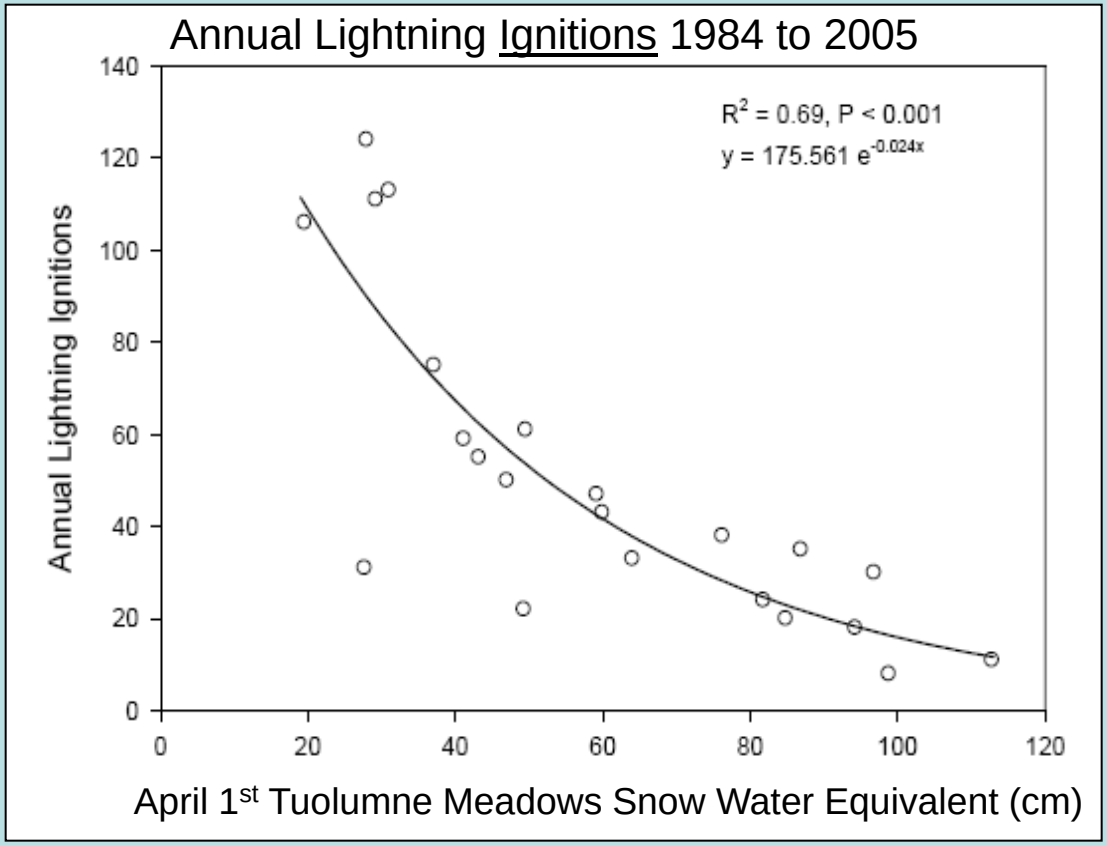




vanWagtendonk et al.

YOSEMITE Fire Potential 1984-2005





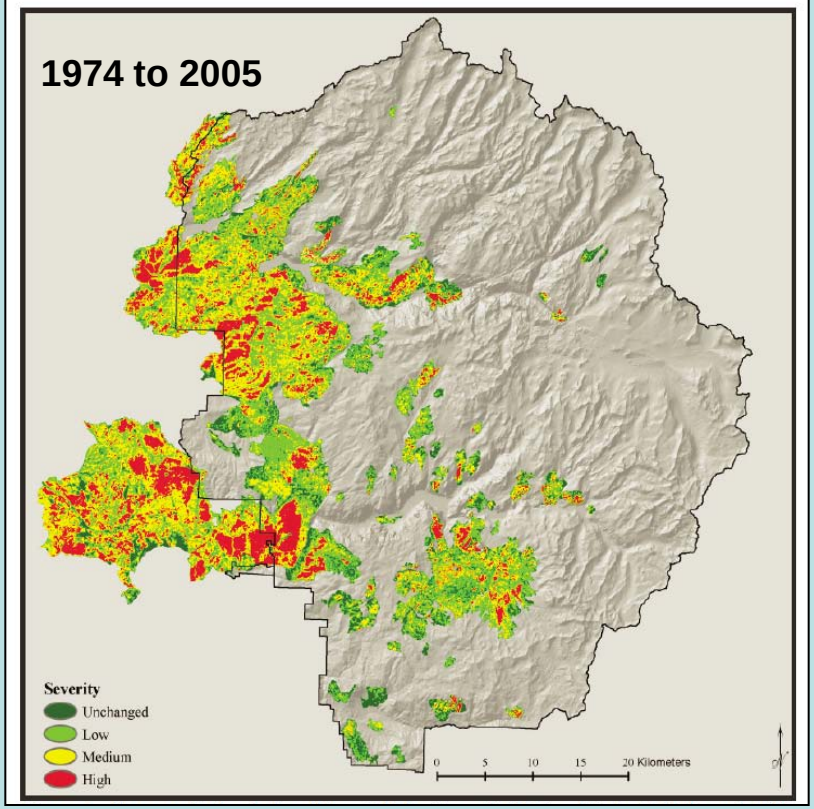
vanWagtendonk et al

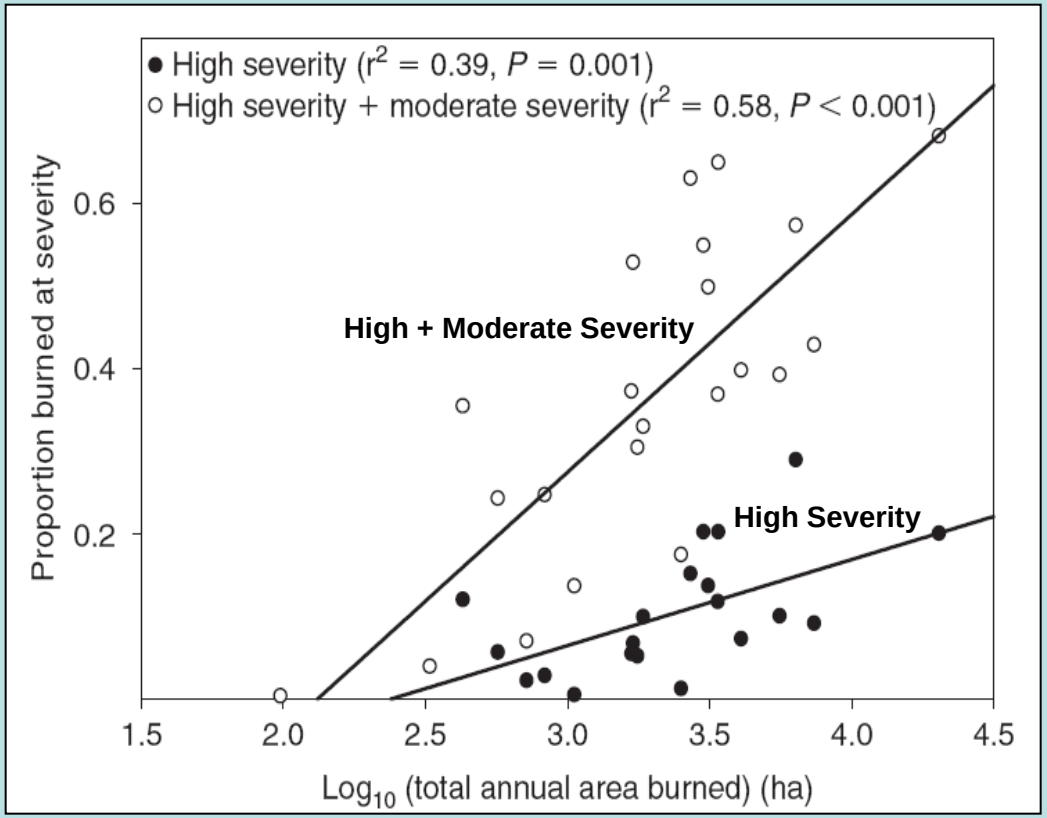
Ignitions by Lightning have a strong negative relationship to spring snow pack.

- Less spring snow pack means potentially more ignitions.

Lutz et al.

YOSEMITE Burn Severity 1984-2005





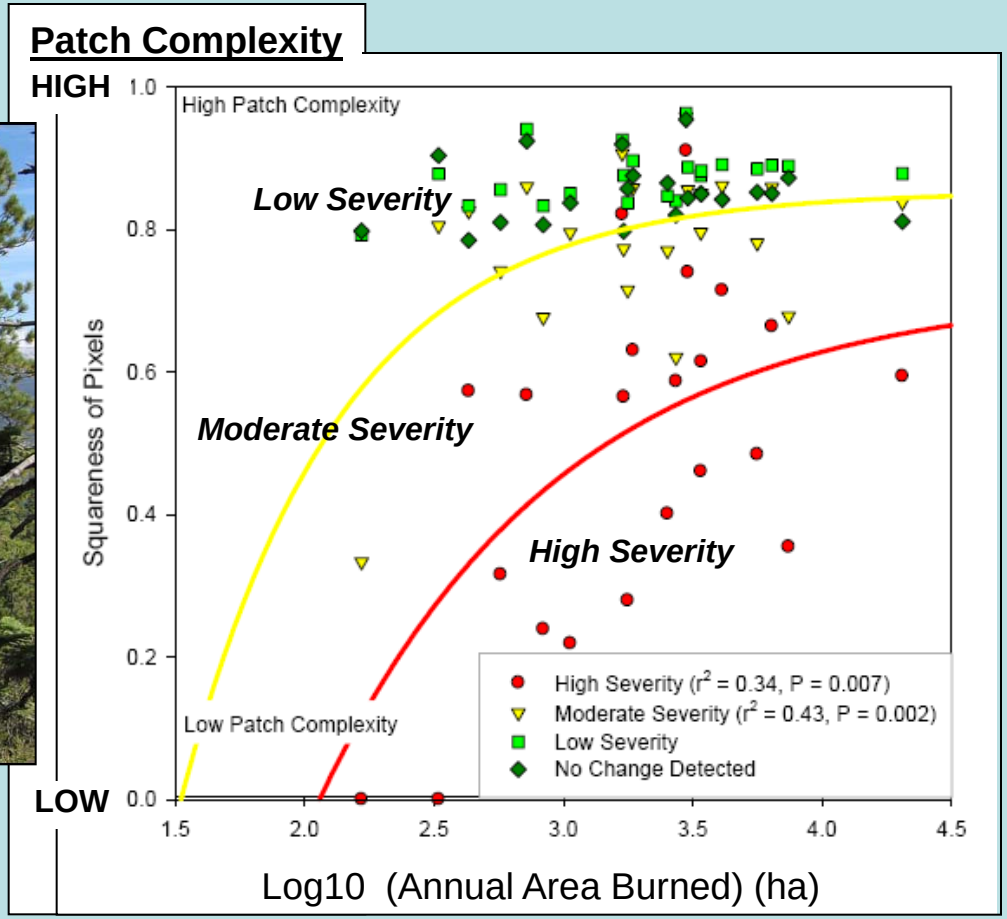
vanWagtendonk et al

Proportion burned at higher severities is related to total area burned.

- Larger burns mean greater proportion burned at high and moderate severity.

Lutz et al.

YOSEMITE Burn Landscape Characteristics 1984-2005



Spatial complexity increases with <u>area burned</u> for moderate and high severity. However, increasing severity leads to less complex <u>patches</u>.

- Patch complexity is lower with higher severity
- More spatially complex areas tend to be lower severity
- Higher severity areas are more homogeneous

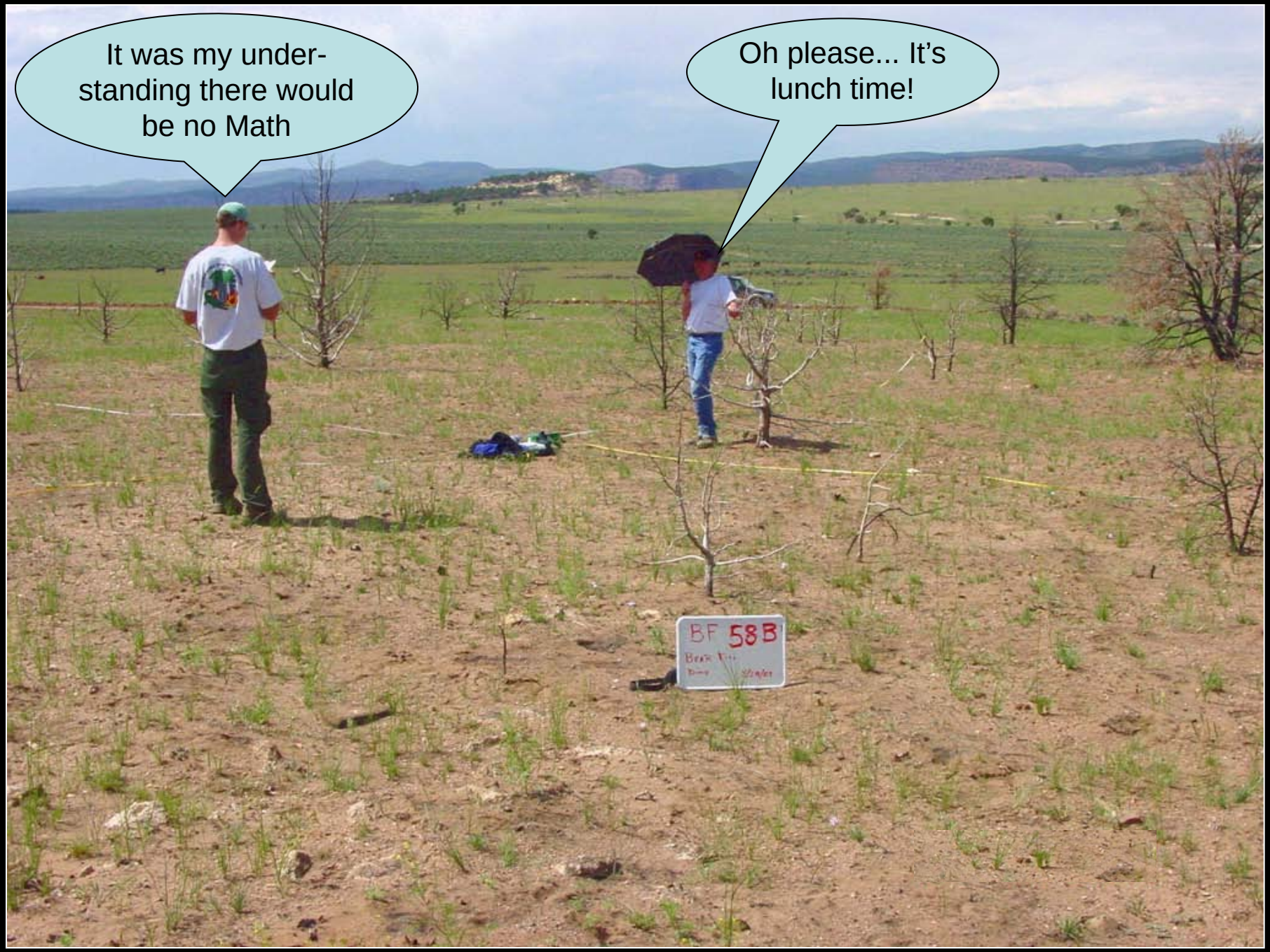
Lutz et al.

Outcomes:

New statistical approaches and modeling of continuous severity data, relating spatial fire dynamics to climatic influences

Better understanding of factors that may enhance or reduce wildfire frequency, size or severity, e.g. seasonal changes and drought .... or increased moisture, and alterations to the fuel matrix from past fires.

This understanding, then, can lead to better projections of future burning potential, and conditions expected from future climate forecasts


It was my under-
standing there would
be no Math
Oh please... It's
lunch time!
BF 58B