Smokey Bear and Prometheus Fistfight in Heaven:

The past, present and future of fire and climate

Jeremy S. Littell
Alaska Climate Science Center

USGS
science for a changing world

AK CSC
Alaska Climate Science Center

"Prometheus carrying fire"
Cossiers, 17th century

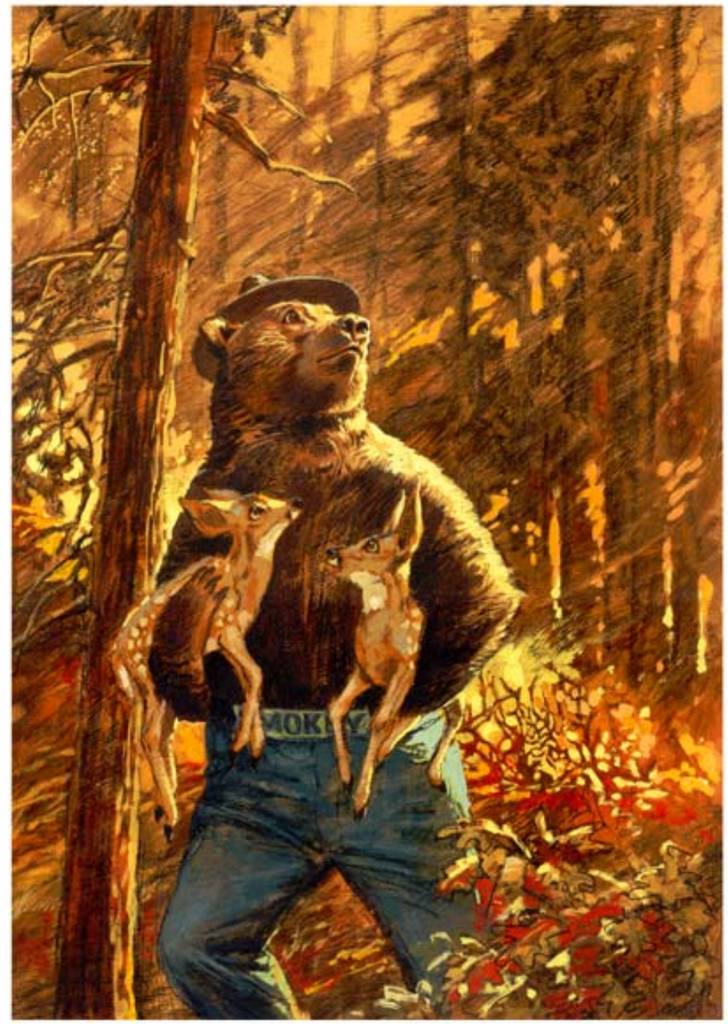
Smokey carrying fawns
uknown, 20th century

?

Where do we go from here?

There are some mutually-exclusive mythologies regarding people and fire.

"Prometheus carrying fire", Cossiers, 17th century

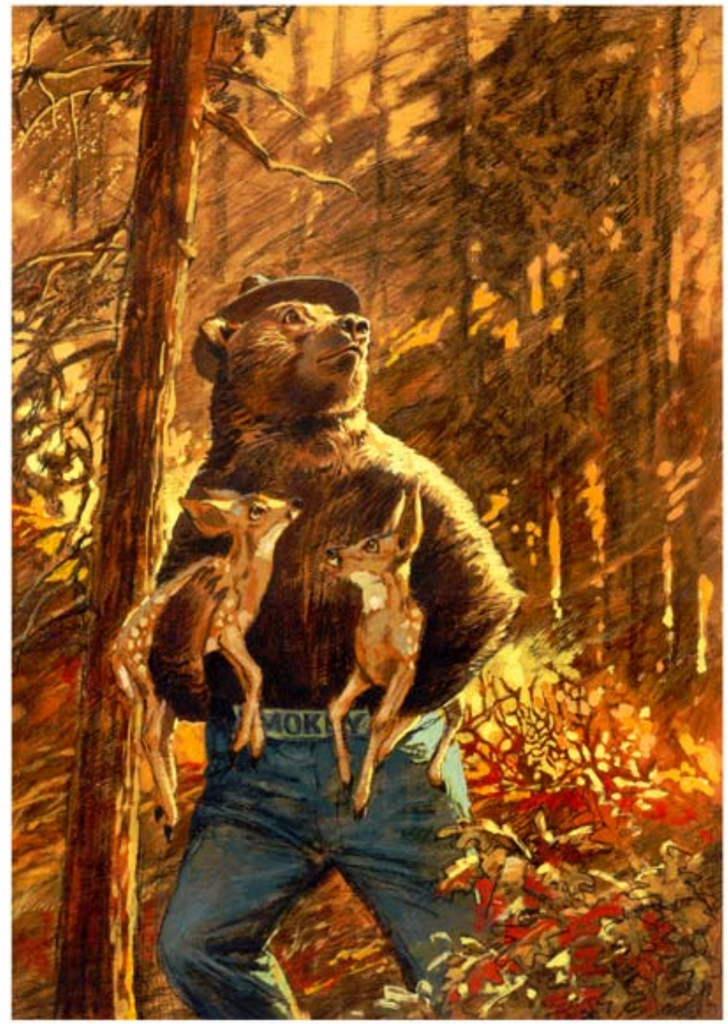


Smokey carrying fawns, uknown, 20th century

"Prometheus carrying fire", Cossiers, 17th century

Did a titan thief steal fire from the gods and give it to mere mortals, bringing us light, heat, … and a **tool to manage landscapes?**

Or did a pious, near-martyr of a bear save us (and the trees and other forest residents) from our fallen, mortal selves?



Smokey carrying fawns, uknown, 20th century

http://www.firelab.org/con-ed/91-80-years-change

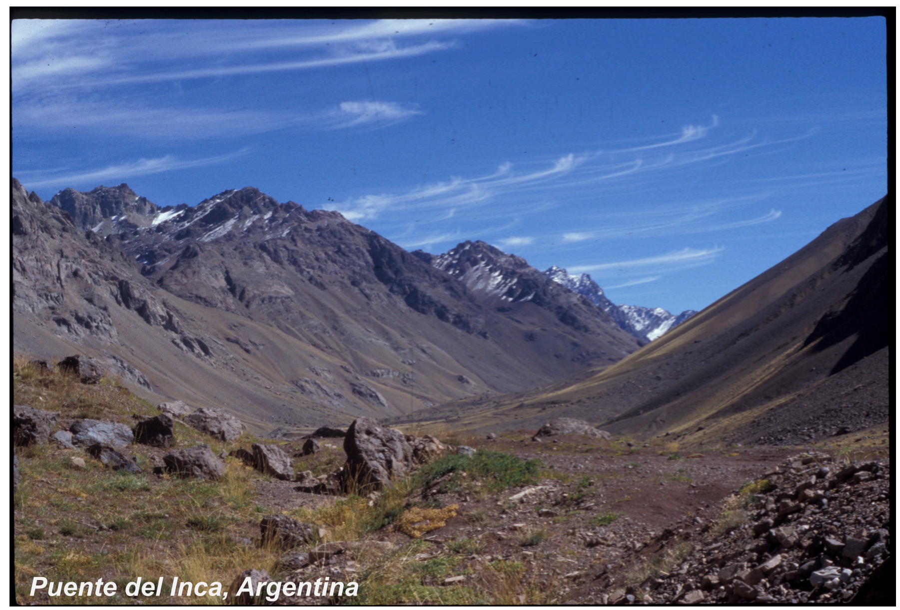
NASA MODIS Image, August 22, 2004

Climate

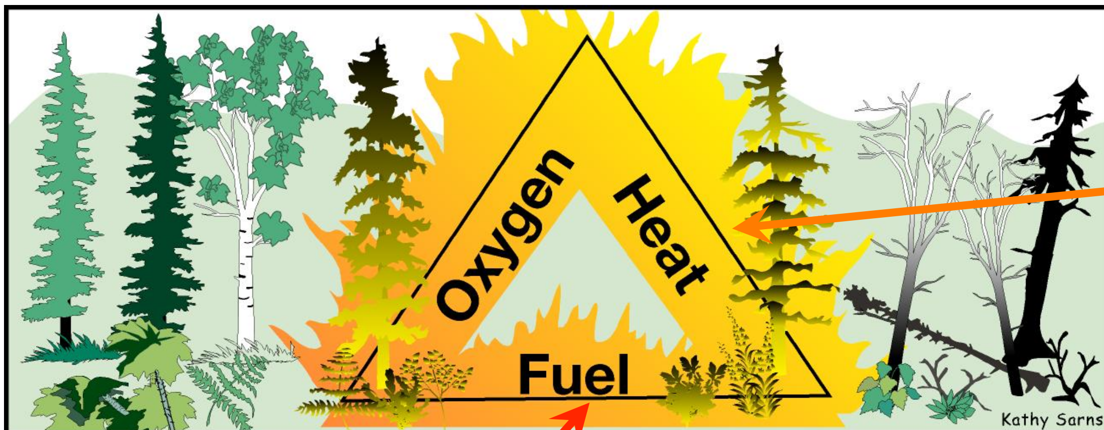
- Climate is the statistics, or synthesis, of weather over longer time periods

- Ex.: Thirty-year climate normal (avg. precipitation for 1980-2009)

- Precipitation, temperature, pressure, wind, cloudiness, humidity, etc.

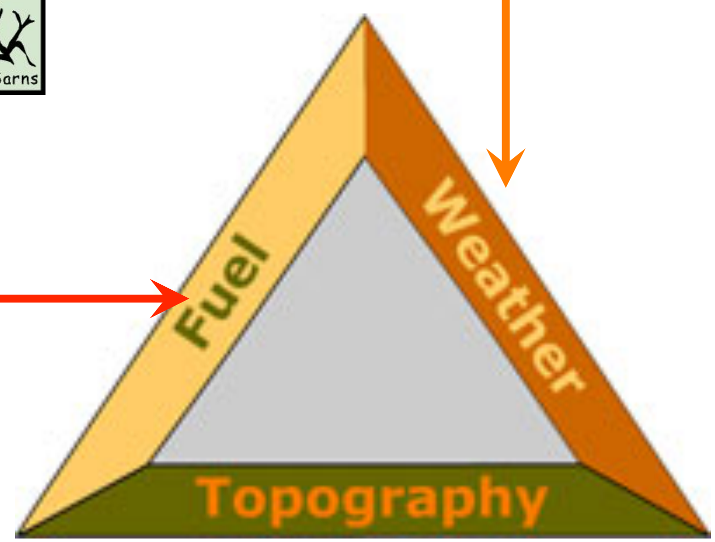


Why is climate important for understanding fire regimes?



Climate also influences the **probability of weather conditions** and, over time, weather extremes

Climate influences **what kind of vegetation and how much vegetation** (fuel) a site can support AND how often it is **available** to fire – its flammability.

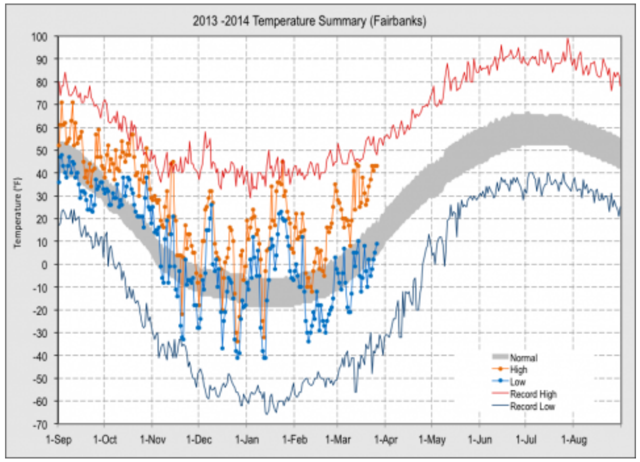


http://alaska.fws.gov/fire/role/unit2/firetriangle.cfm

http://thewmpa.org/resources/forest-fire-info

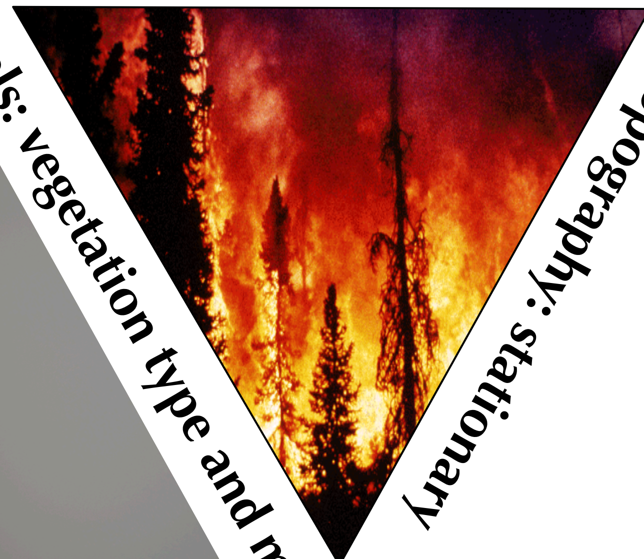
Climate and "fire regimes"

- Climate affects the components of a fire regime:
  - **Fuels** – climate affects the species, fuel structure, biomass available, and fuel availability to fire
  - **Area** – climate affects how big a fire can get - partly a function of fuel availability and connectivity
  - **Frequency** – climate affects how often fuels are abundant enough and available to burn, and also background natural ignitions
  - **Severity** – climate affects how much fuel there is, how much of it is available, how it is arranged
- Climate varies through time and space, so fire regimes are NOT "stationary" – they vary from place to place, and ***TIME to TIME*** within a place

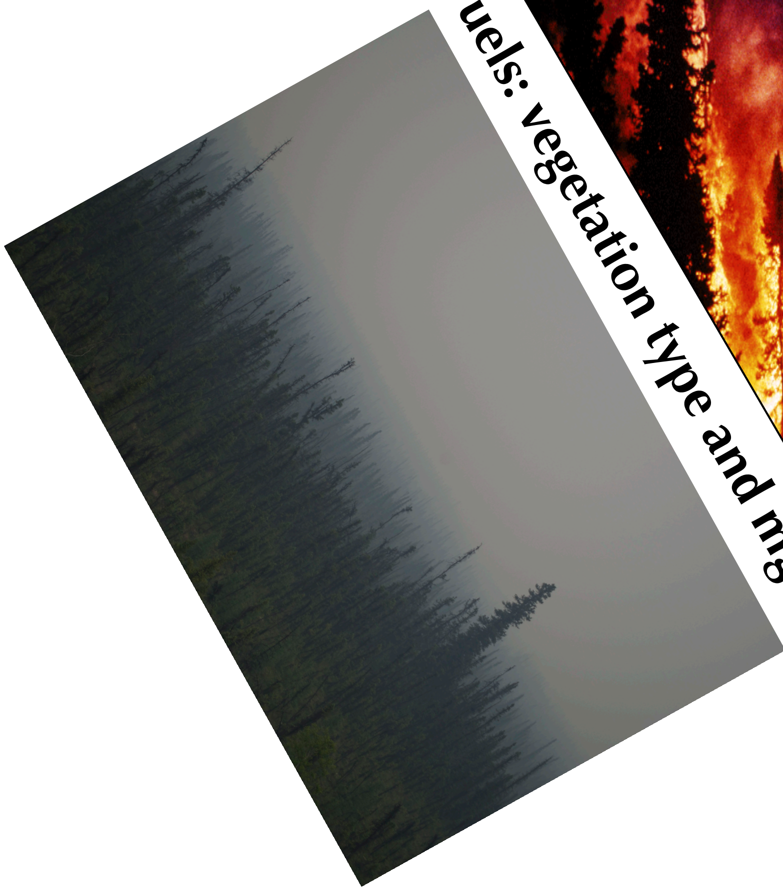


Climate: 30 years

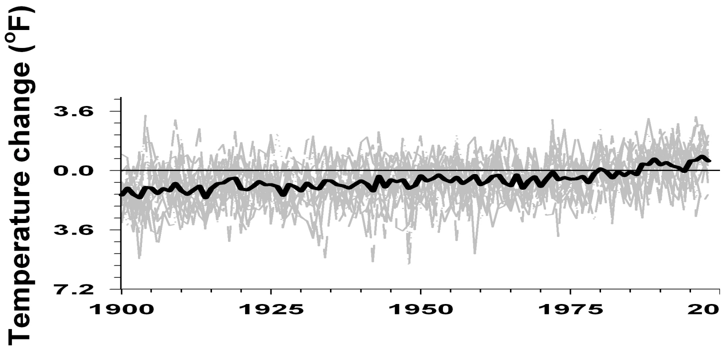
Fuels: vegetation type and mgmt.



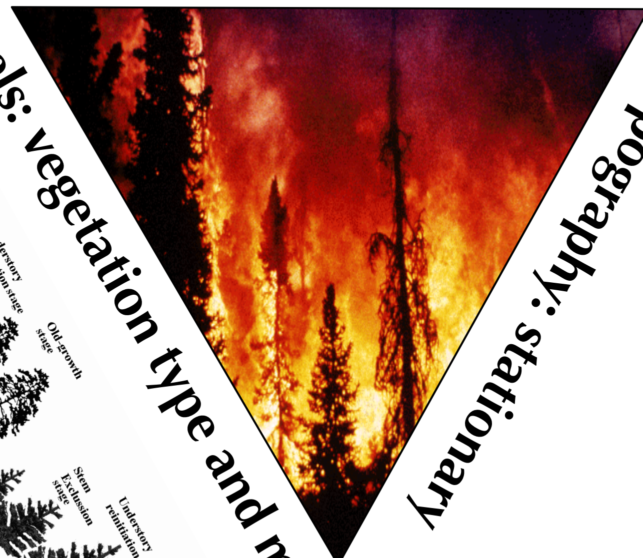
Topography: stationary

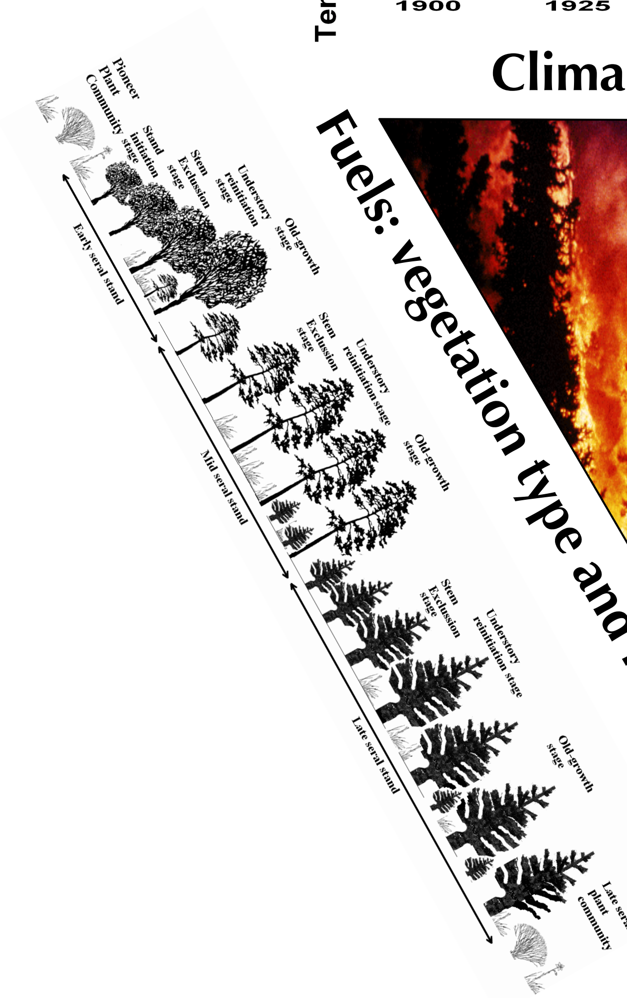


This is the time scale we're most familiar with.



Climate: 100s years

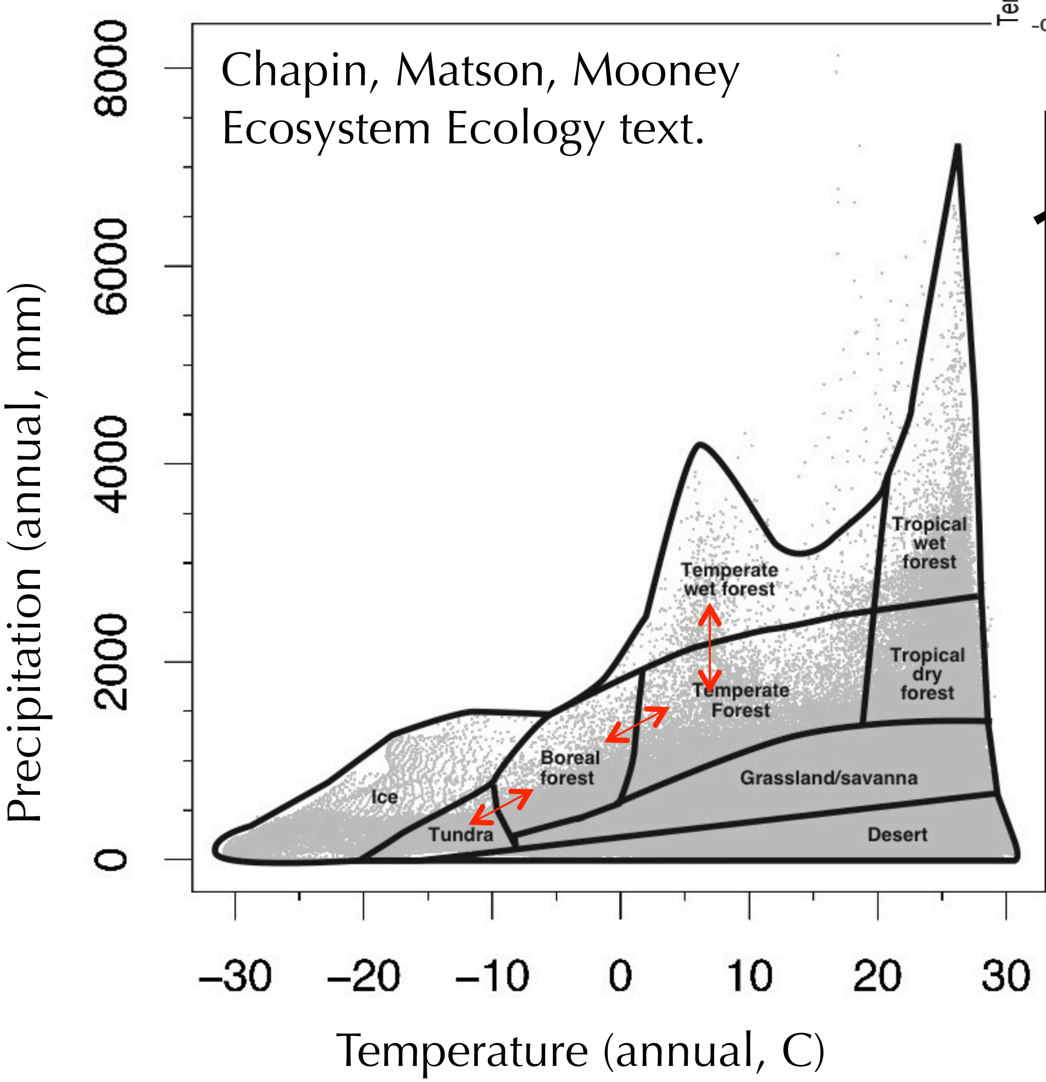


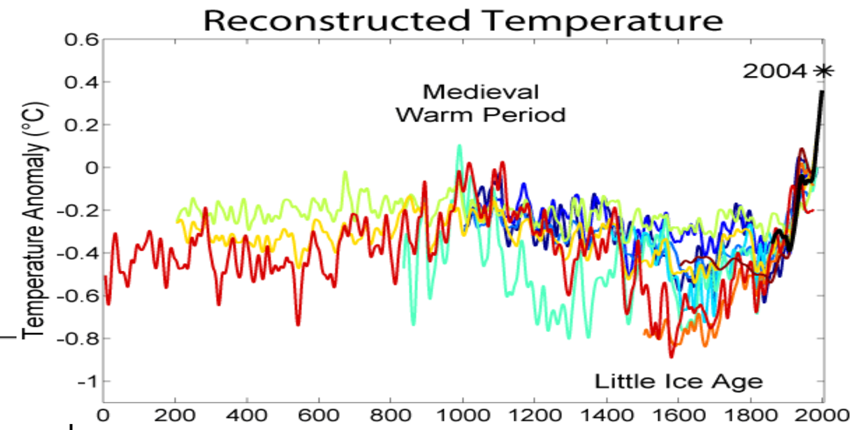


Fuels: vegetation type and mgmt.

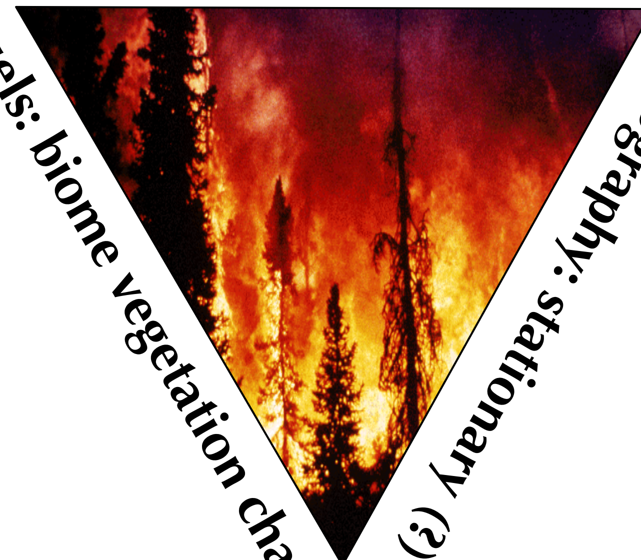
Topography: stationary

This is the time scale of changes in ecosystems we're familiar with.





Climate: 1000s of years

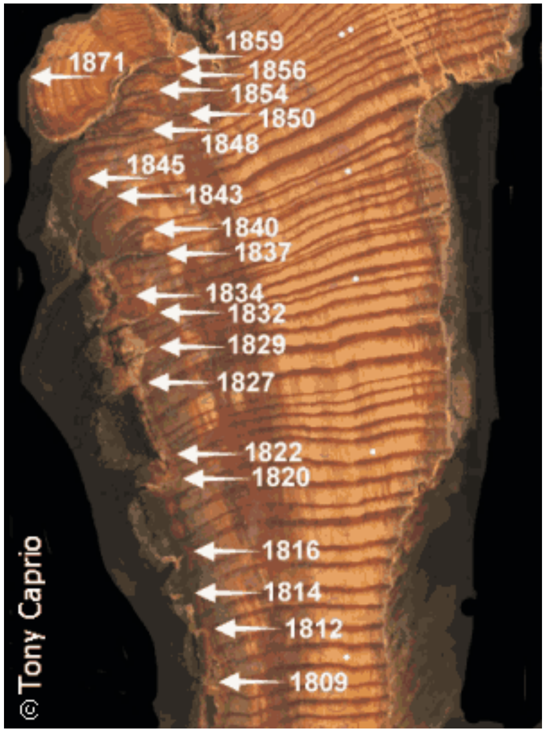


Fuels: biome vegetation changes

Topography: stationary (?)

Climate and the natural range of variability: short fire intervals

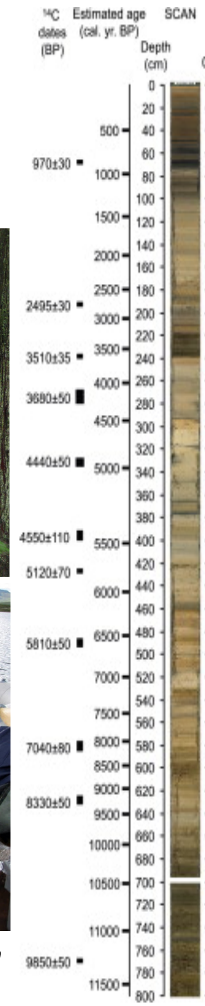
- In some landscapes, the fire return interval for a point or watershed might be between 5 and 15 years.
- Historically, we have experience with 10 or so fire return intervals in those landscapes.
- IF the role of fire in the landscape were the same as pre-settlement, we might rightfully expect to know something about the "natural" fire return interval given the historical.



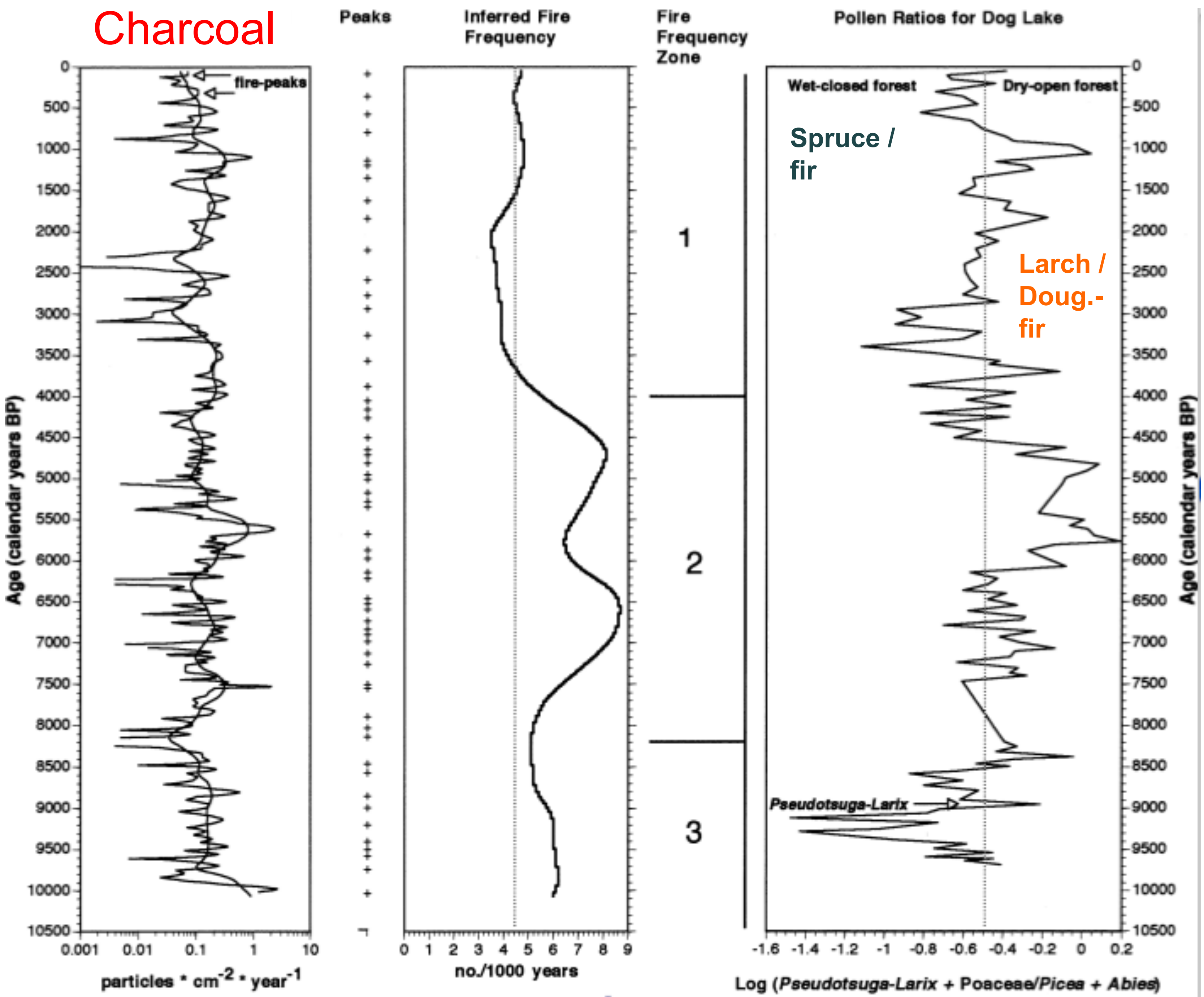
Climate and the natural range of variability: long fire intervals

- In other landscapes, the fire return interval might be between 300 and 1000 years.
- Historically, we could expect to have experience with between 0.1 and 0.2 fire return intervals.
- The historical range of variability isn't even long enough for us to understand one fire return interval, much less the *variability* in it. So our historical frame of reference may not be a good barometer of "natural".

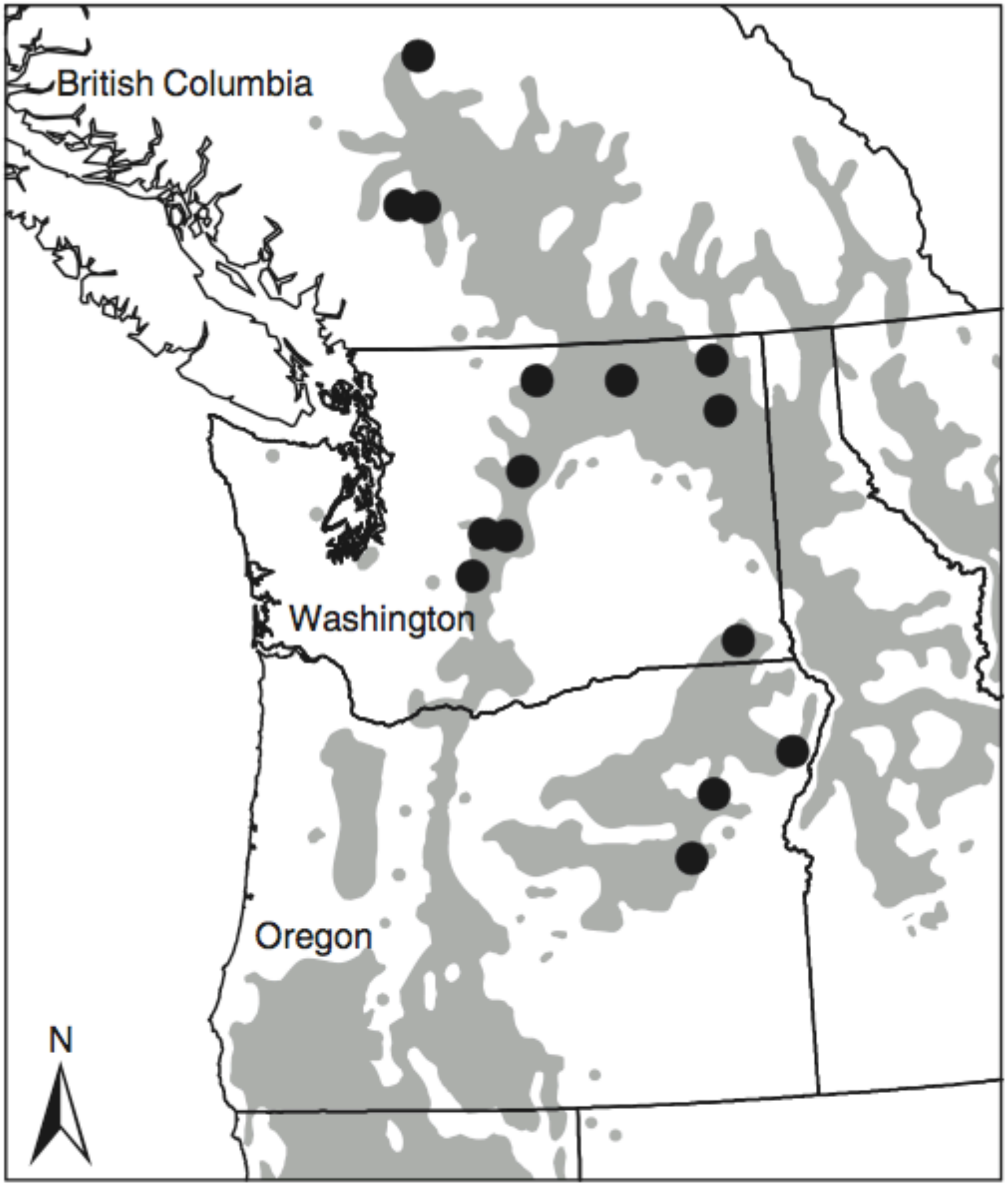
Image: P. Higuera



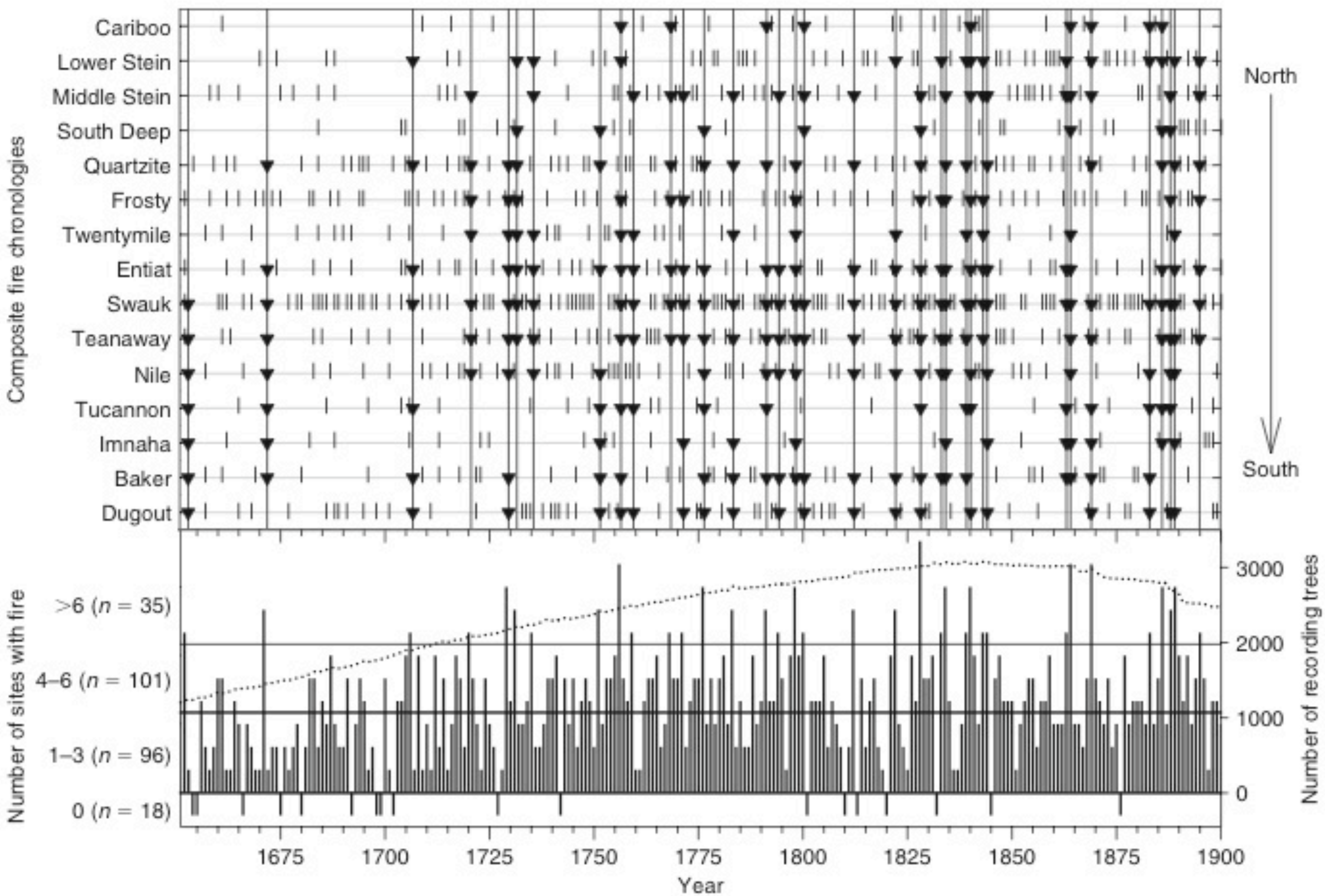
Vannière et al. 2008



Hallett et al., 2003

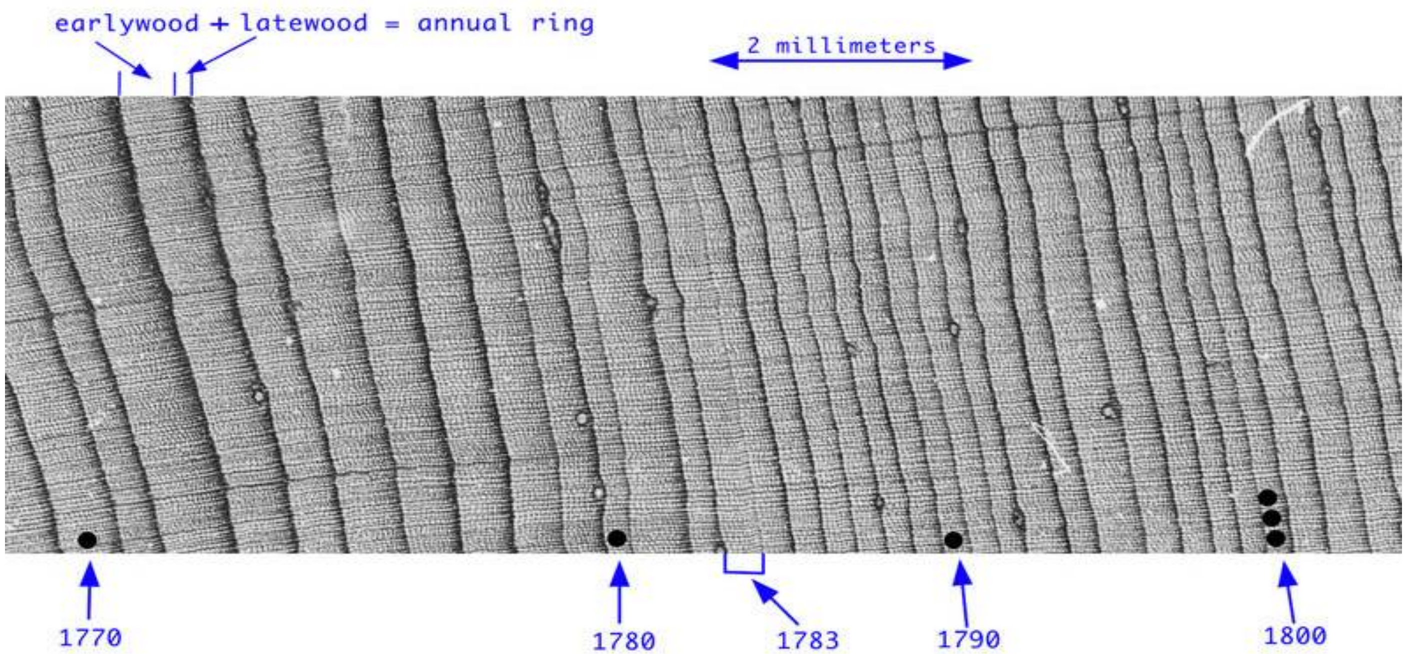


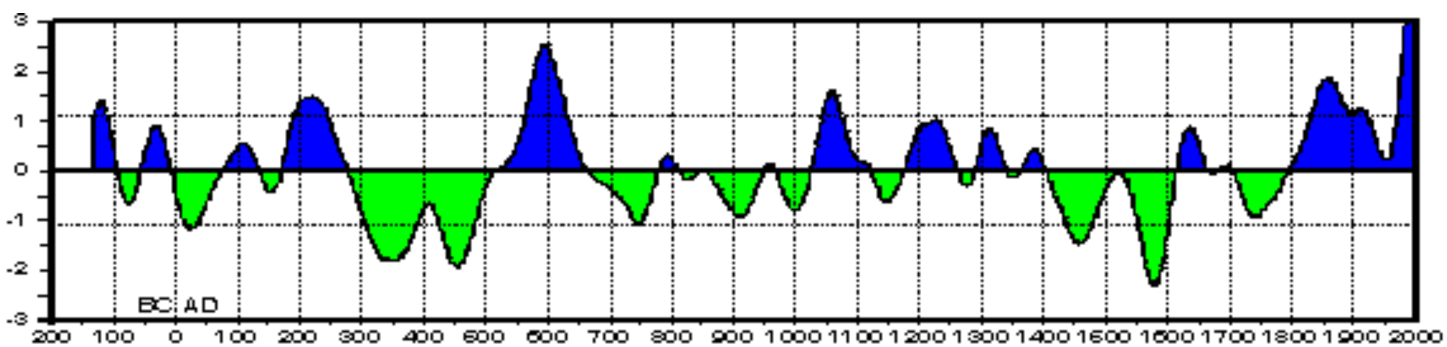
Heyerdahl et al. 2008



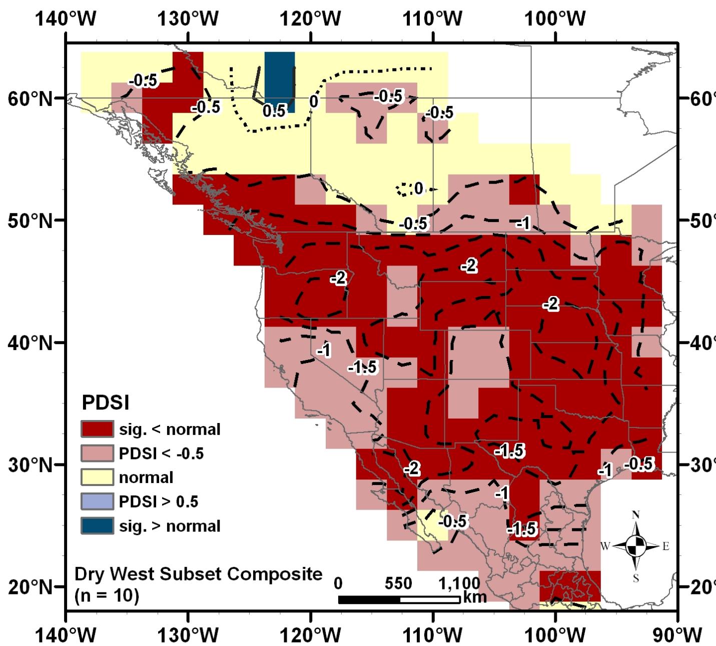
Composite fire chronologies
Cariboo
Lower Stein
Middle Stein
South Deep
Quartzite
Frosty
Twentymile
Entiat
Swauk
Teanaway
Nile
Tucannon
Imnaha
Baker
Dugout
North
South
Number of sites with fire
>6 (n = 35)
4–6 (n = 101)
1–3 (n = 96)
0 (n = 18)
Number of recording trees
3000
2000
1000
0
1675
1700
1725
1750
1775
1800
1825
1850
1875
1900
Year

Climate (precipitation, temperature) reconstructed from tree rings

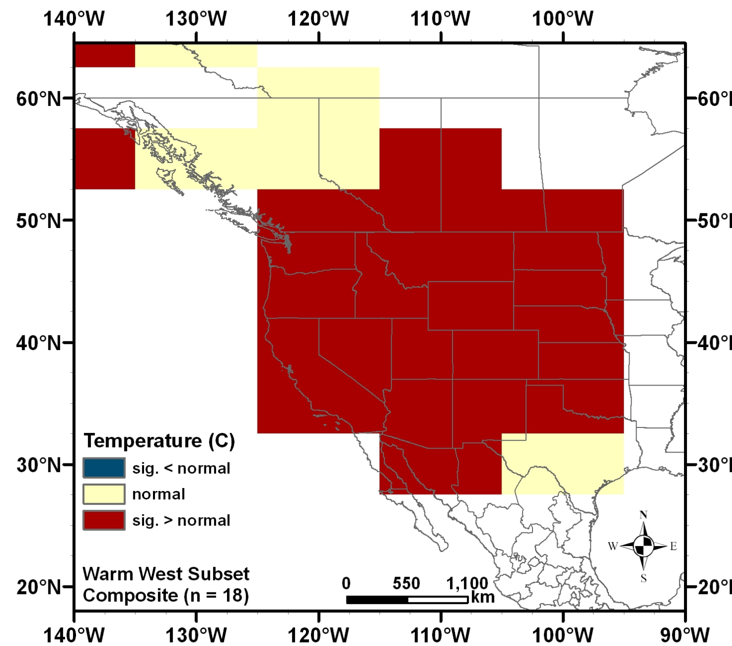


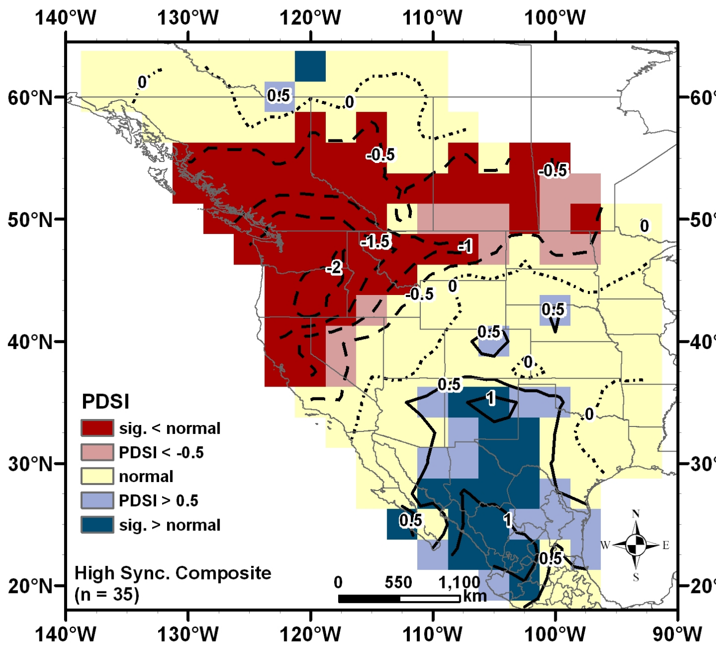


Tree-ring reconstruction of precipitation in northern New Mexico (HG Grissino-Mayer)

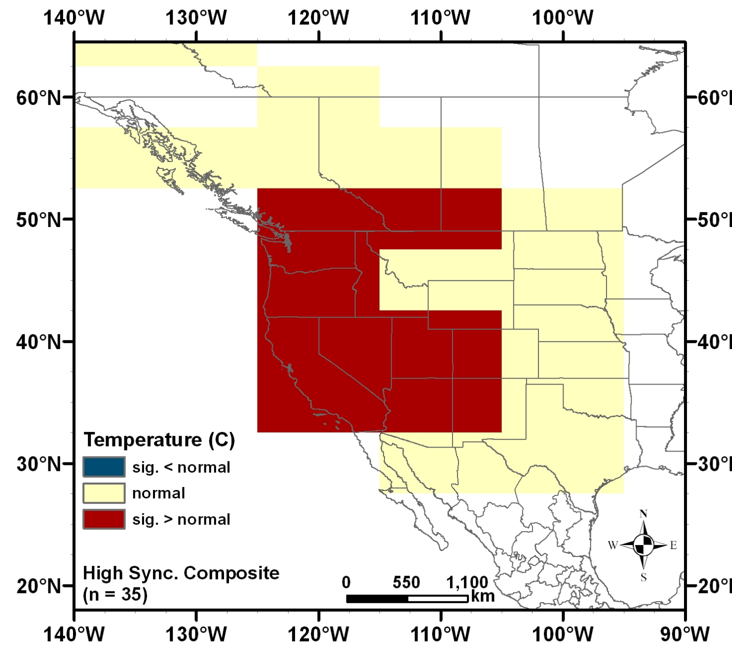


West is all dry and warm:
10 of 35 largest fire years in PNW

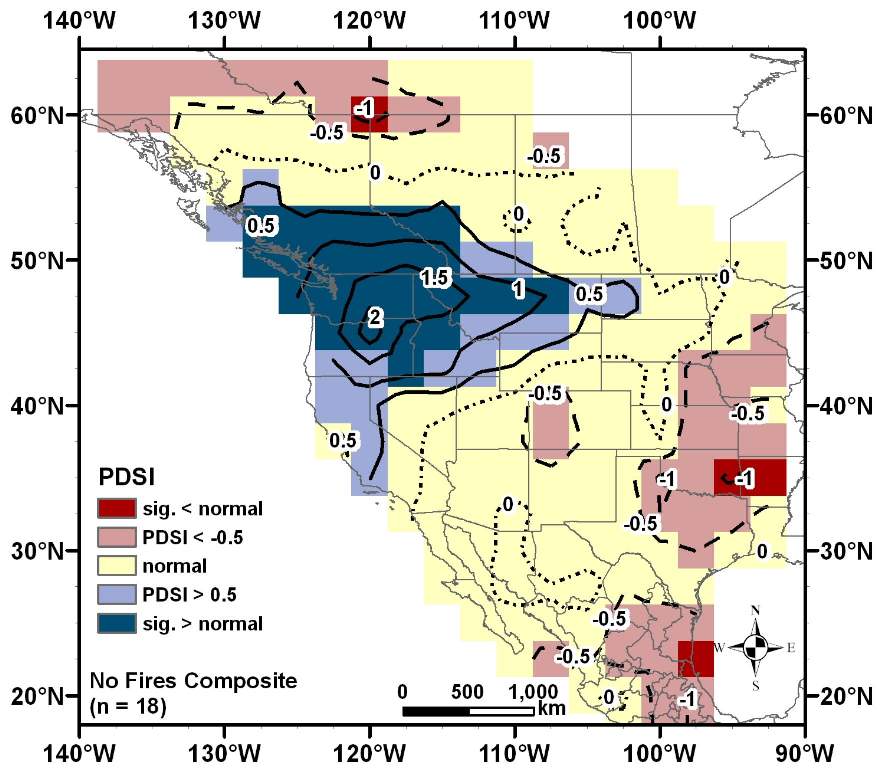


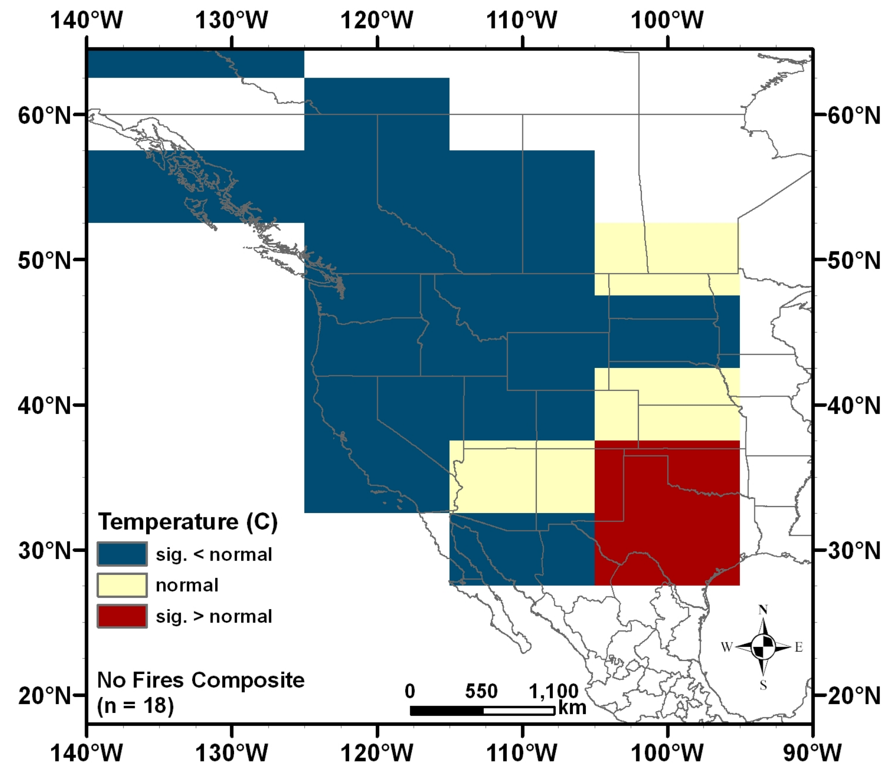


PNW/SW dipole
25 of 35 largest fire years in PNW



Heyerdahl, McKenzie, Daniels, Hessl, Littell, and Mantua. 2008, IJWF. Climate drivers of regionally synchronous fires in the inland Northwest (1651-1900)





PNW/SW dipole (?)
18 smallest
fire years in PNW:
conditions in PNW are
cool and wet


"Prometheus carrying fire", Cossiers, 17th century

We know that fire occurrence and area are strongly related to climate prior to Euro-American settlement of the West.

Federal Lands Fire Suppression Policy history in a Nutshell

Full suppression policy in many National Forests and Parks, with some wildland fire use (strategic let-it-burn for resource promotion)

1910-1920: All fires out by 10am next morning

1930s: Slash burning decline

1945-55: Rise of widely "effective" suppression

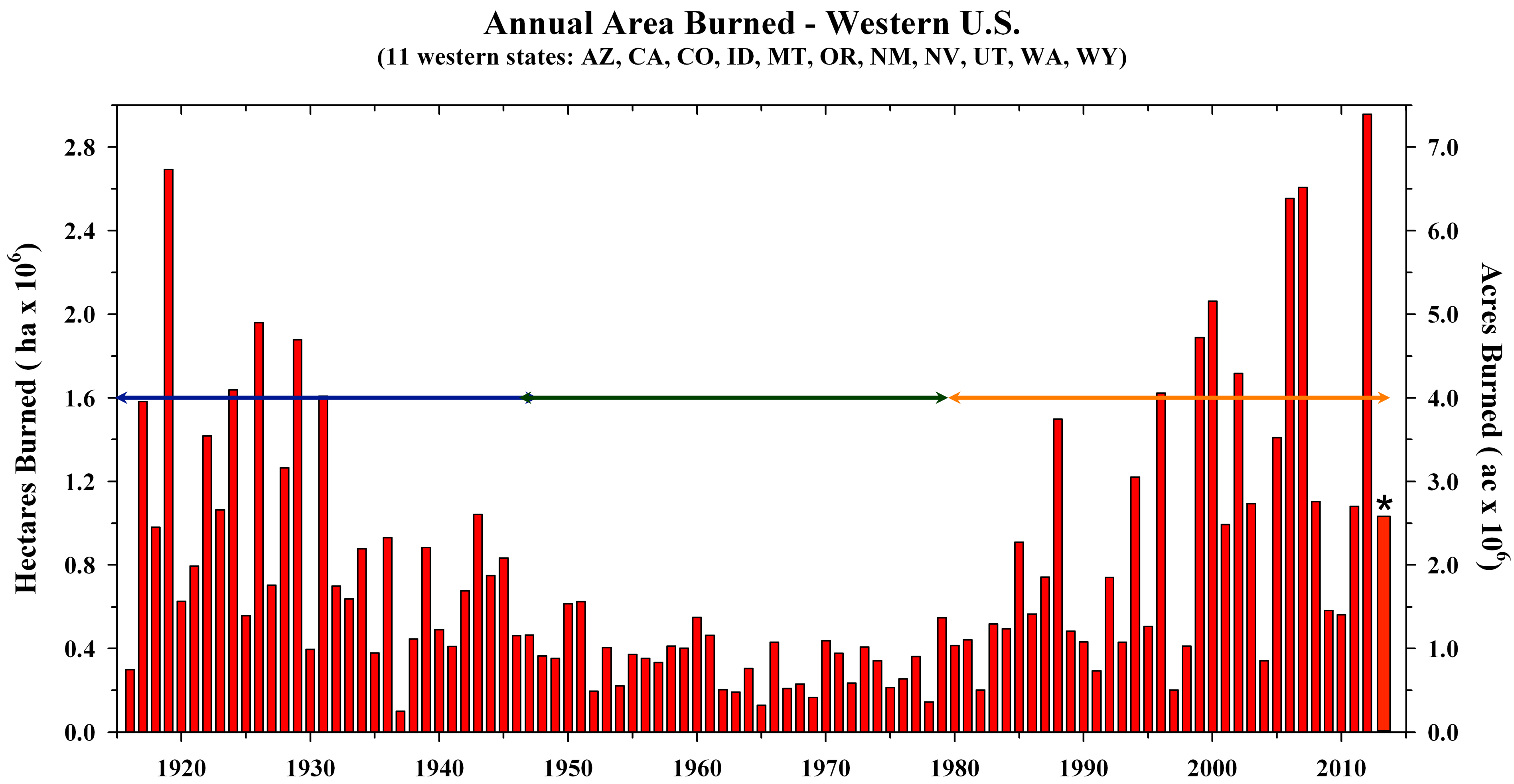
1970s: Re-recognition of role of fire (and suppression) in ecosystems

1990s plus: Continued suppression and the rise of the "mega" and "catastrophic" fire

Actually, >90% of the area burned is burned by <10% of the fires, right?

>97%? <3%?

Area burned in 11 Western states, 1916-2012



Period of post-settlement fire

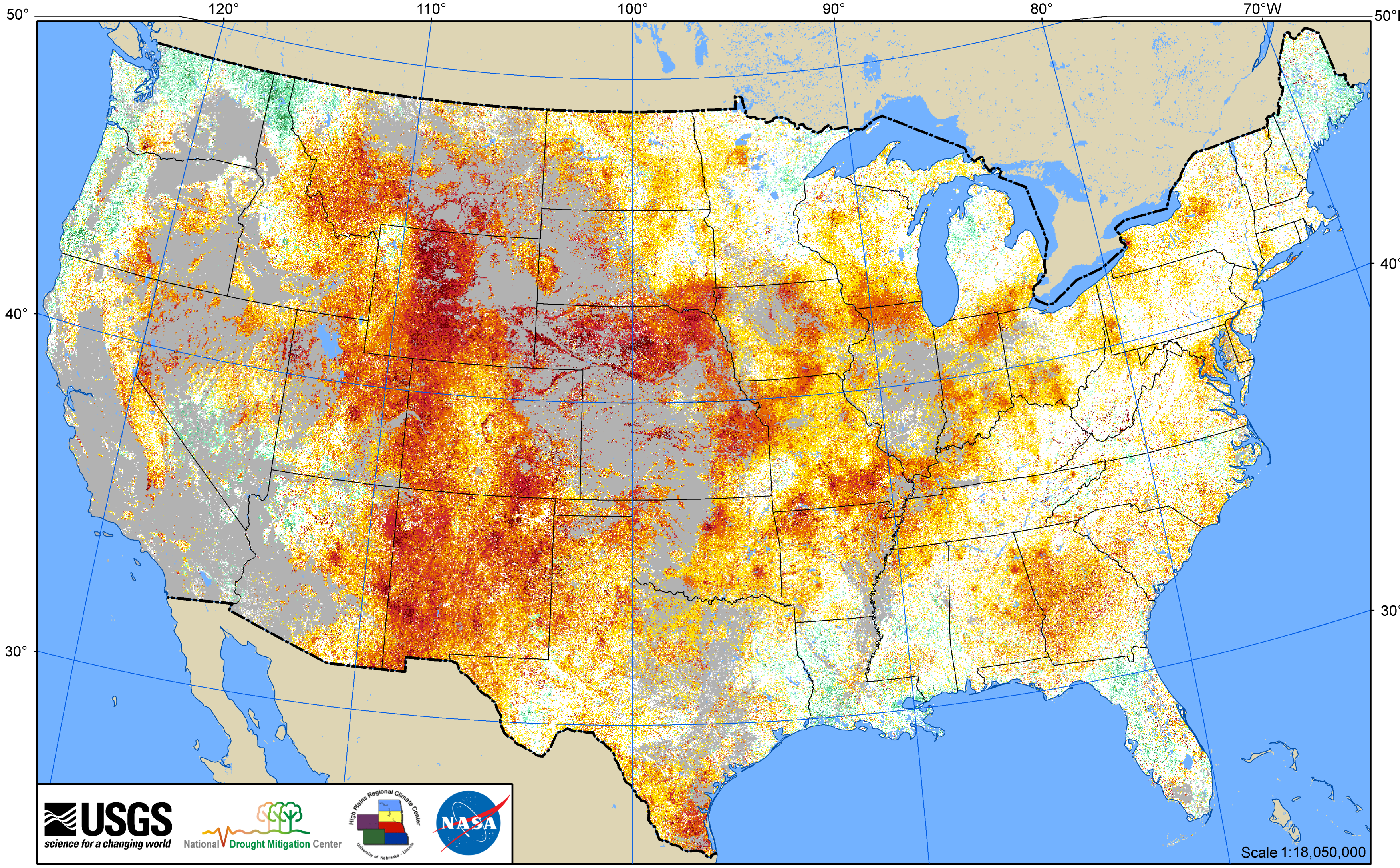
Period of active fire suppression and fuel accumulation

Period of fire increase

Updated from Littell et al. 2009, Ecological Applications

*2013 Data as of Nov 7, 2013 (last NIFC update)

Vegetation Drought Response Index (VegDRI) Oct 28, 2012



Vegetation Condition

- Extreme Drought
- Severe Drought
- Moderate Drought
- Pre-Drought
- Near Normal
- Unusually Moist
- Very Moist
- Extremely Moist
- Out Of Season
- Water

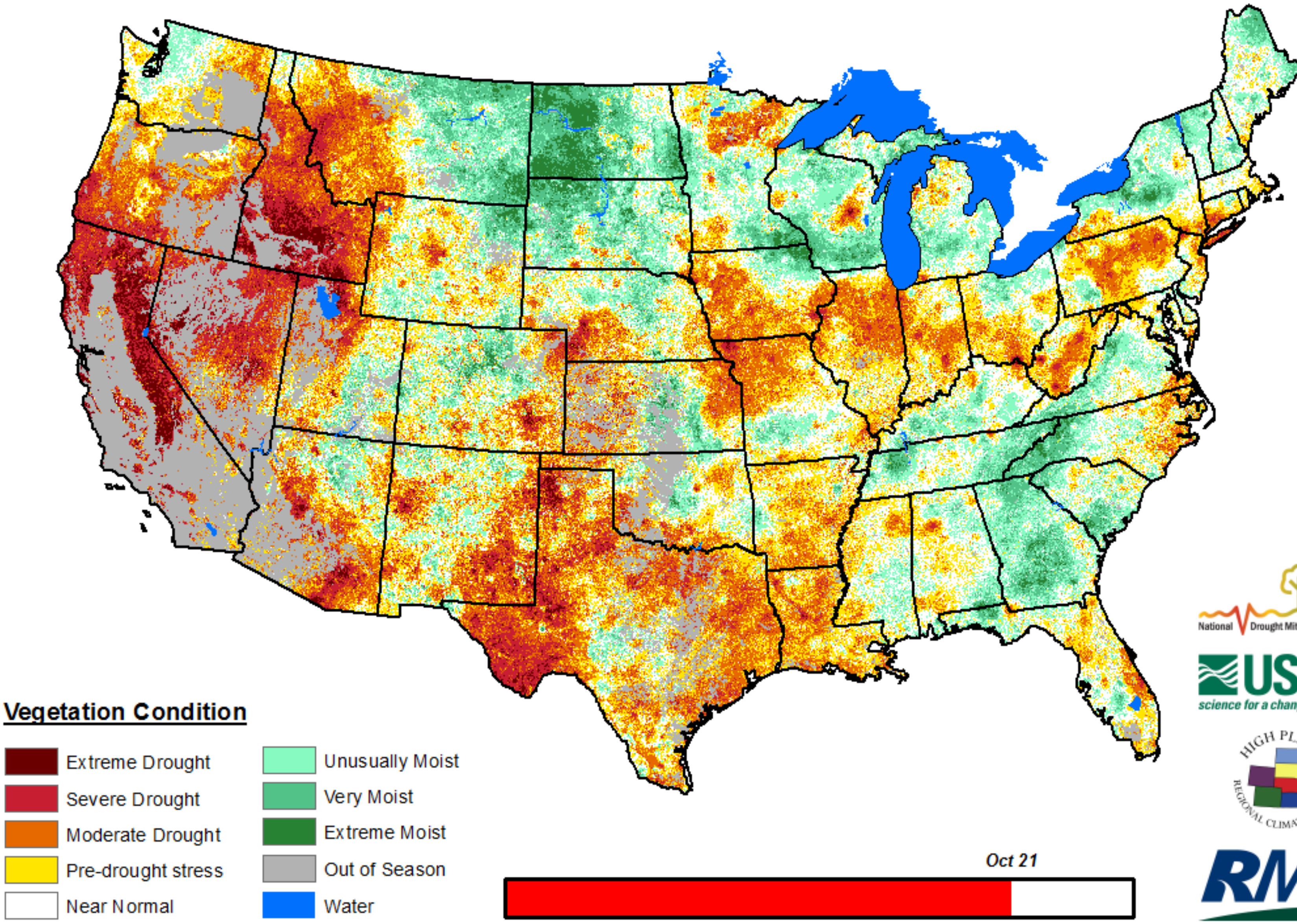
Period: Oct 22 - Oct 28 (Week44)

Data Source: eMODIS 7 Day Composites

http://dds.cr.usgs.gov/emodis/

For Interactive Drought Maps: http://vegdri.cr.usgs.gov/viewer/viewer.htm

2013 Vegetation Drought Response Index (VegDRI)



National Drought Mitigation Center

USGS science for a changing world

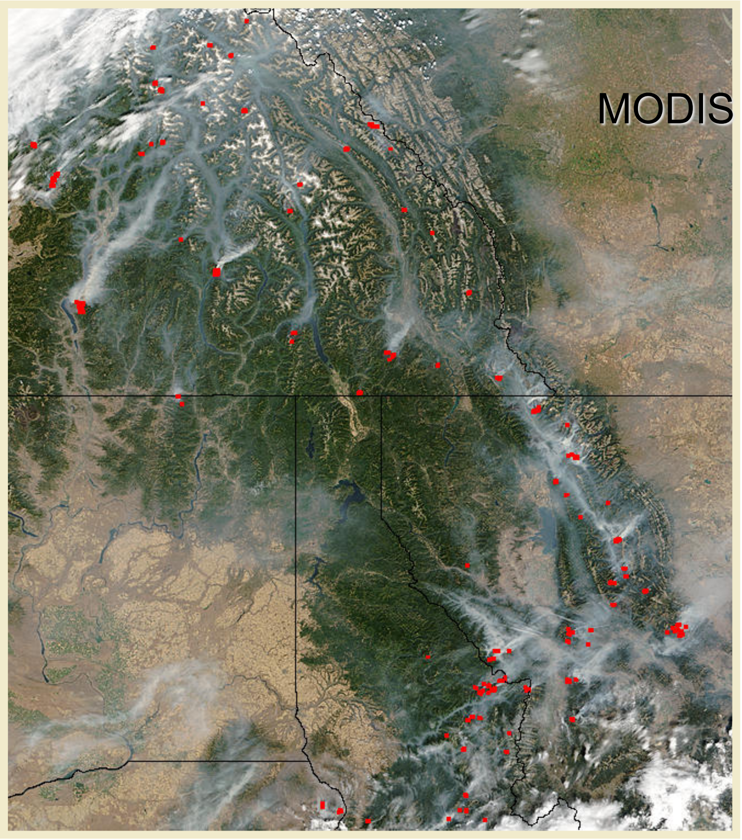
High Plains Regional Climate Center

RMA

http://seca.unl.edu/web_archive/VegDRI/pics/animations/2013/TitledMaps/131021.png

Regional fire "episodes" and climate

- As temperature increases, the atmosphere evaporates more water from the landscape, plant tissues, and fine fuels
- This produces larger than normal, and more connected areas of depleted fuel moisture during the fire season
- Regional synchronization of fires occurs
- Fire blowups are driven by extreme weather, but are contingent on climatically-driven fuel moisture.



Northern Rockies, July 2003

Forested systems:

+Tmax, -precip, +drought → fire

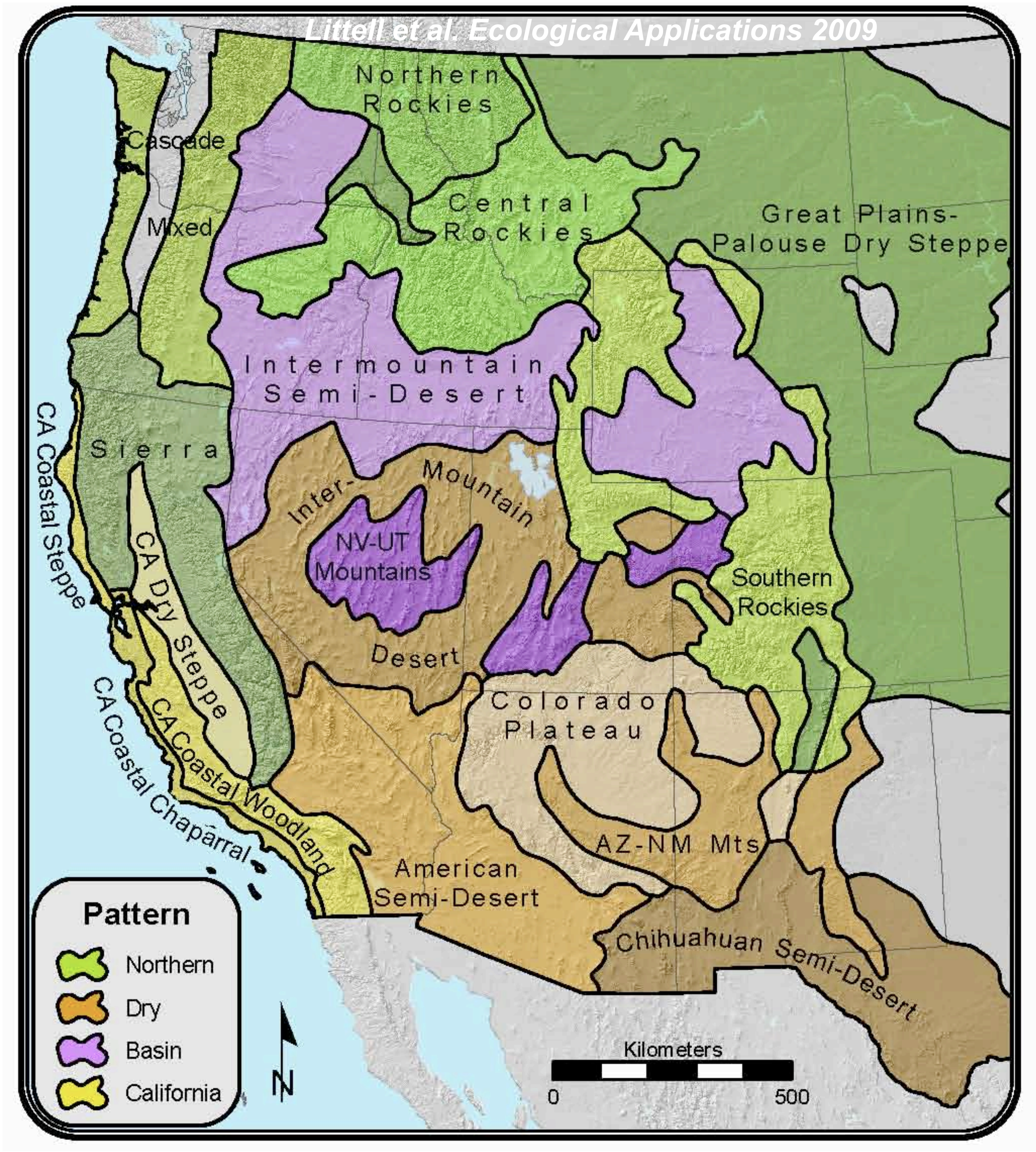
Desert systems:

+precip, -drought → fire in subsequent year(s)

Hybrid systems:

elements of both

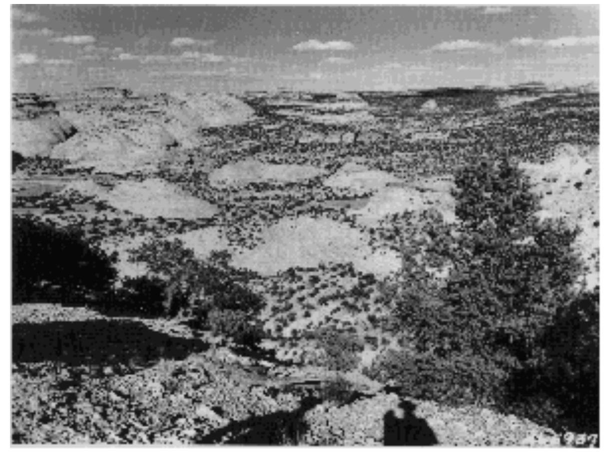
Antecedent pulse of precip + drought



Littell et al. 2009
Map: Rob Norheim

Fuels and ecosystem pattern influence climate ~ fire relationships

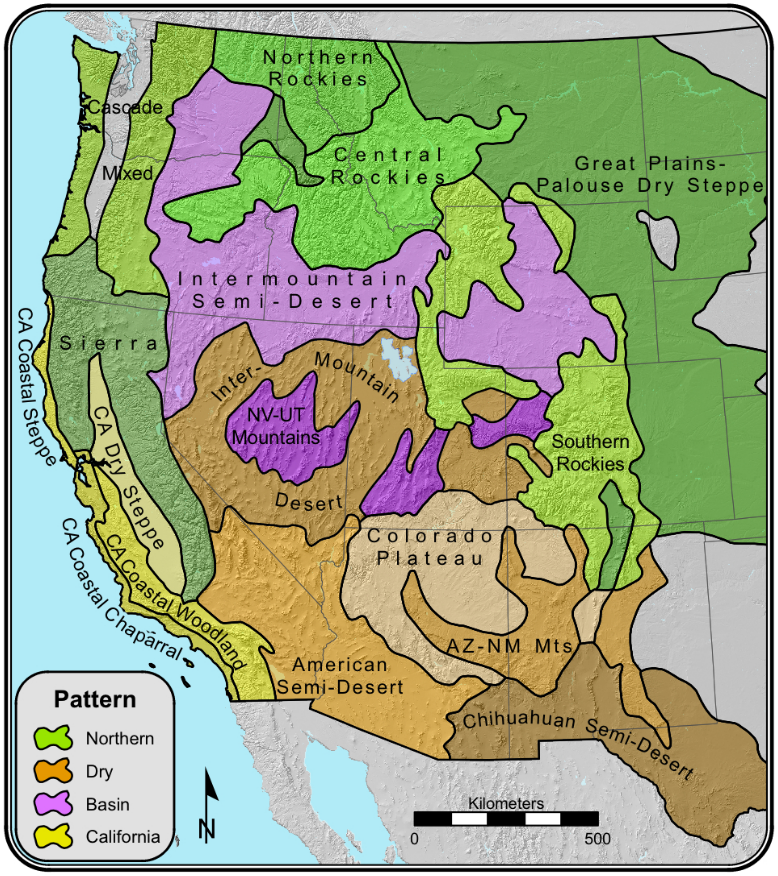
- Different fuel types respond differently to climate
- Two mechanisms: *drying* of fuels and *production* of fuels
- Fuel (moisture) - limited systems: fire is facilitated by increased water → fine fuels
- Climate (energy) - limited systems: plenty of fuel, sensitive to drought, water deficit, Tmax
- Ignition - limited systems



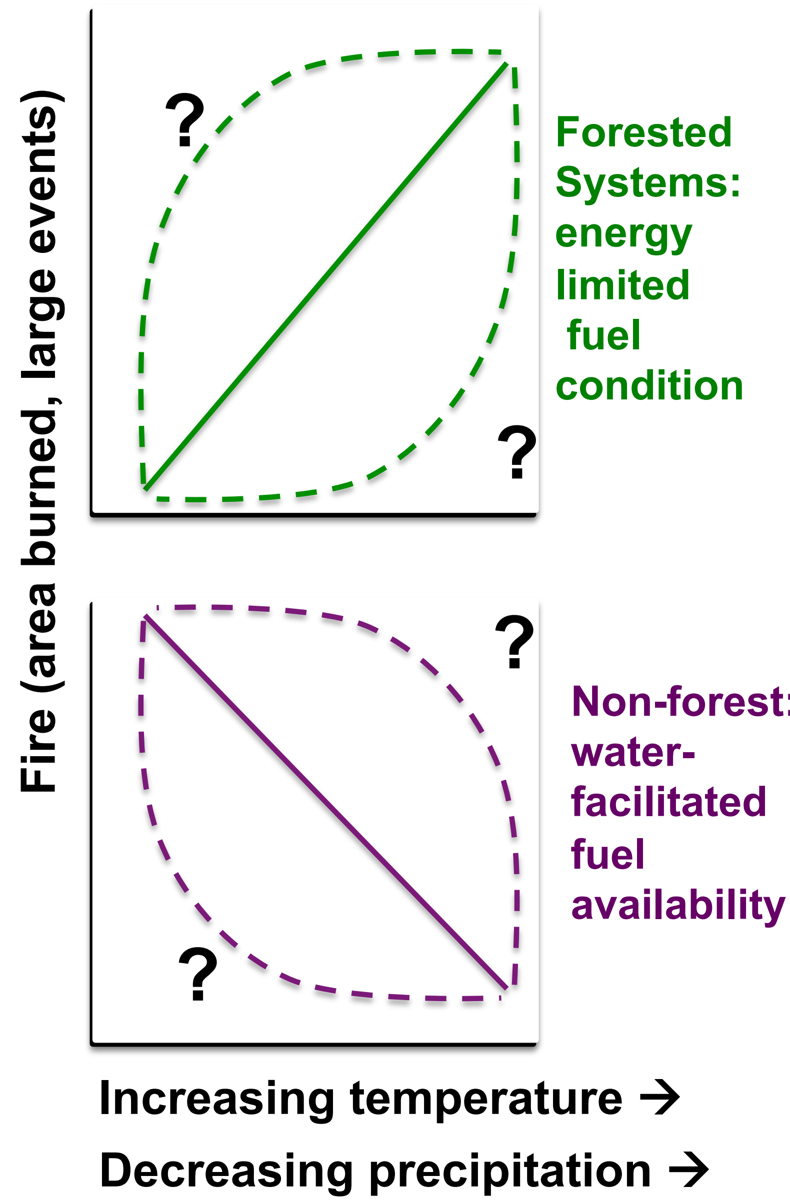
Littell et al. 2009, Ecological Applicaitons

Photos: Bailey 1995

Climate and future fire area burned:
we need an ecologically based study in the American West

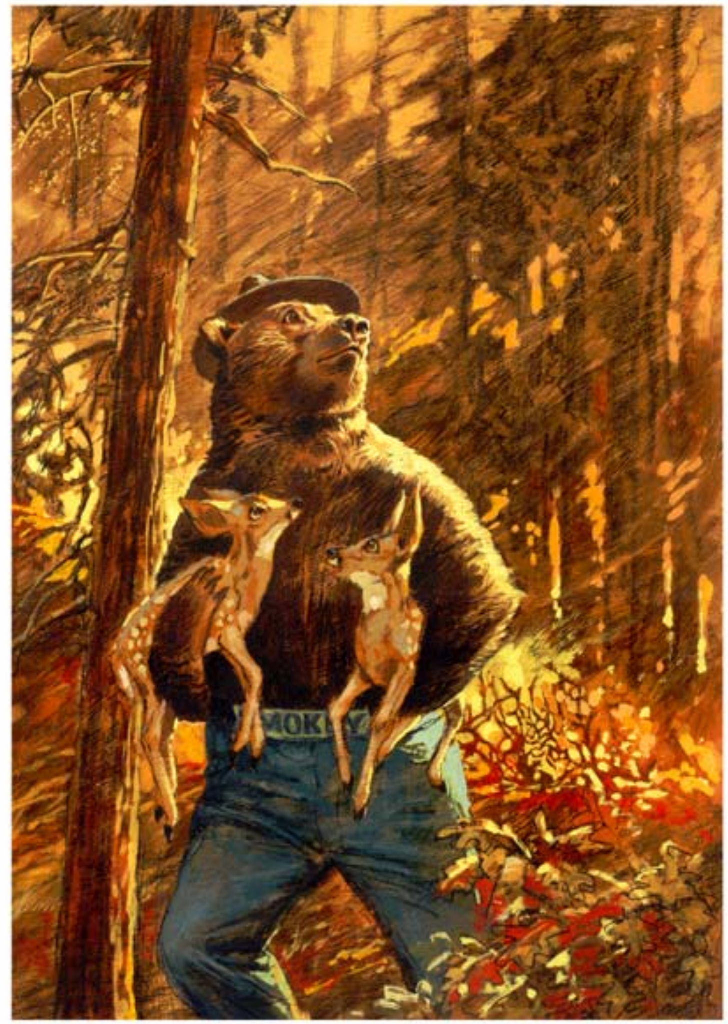


Littell, McKenzie, Peterson, Westerling (2009)
Map: Rob Norheim



Fire danger doesn't get us to landscape change; linear projection by ecosystem isn't by itself ecological, and ignores vegetation transience

We know that despite fire suppression, climate still exerts considerable control on fire occurrence, area, and probably severity.



Smokey carrying fawns, uknown, 20th century

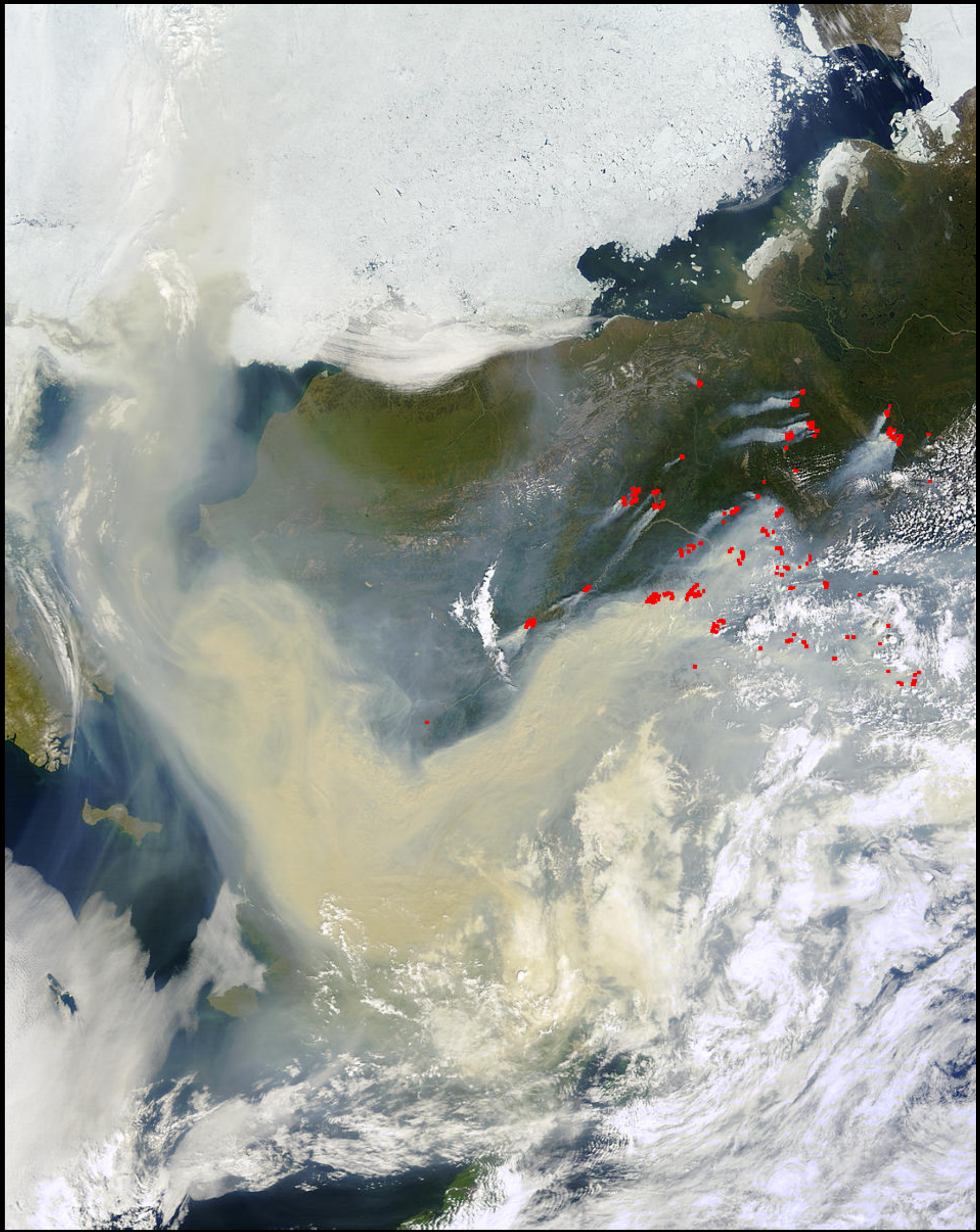
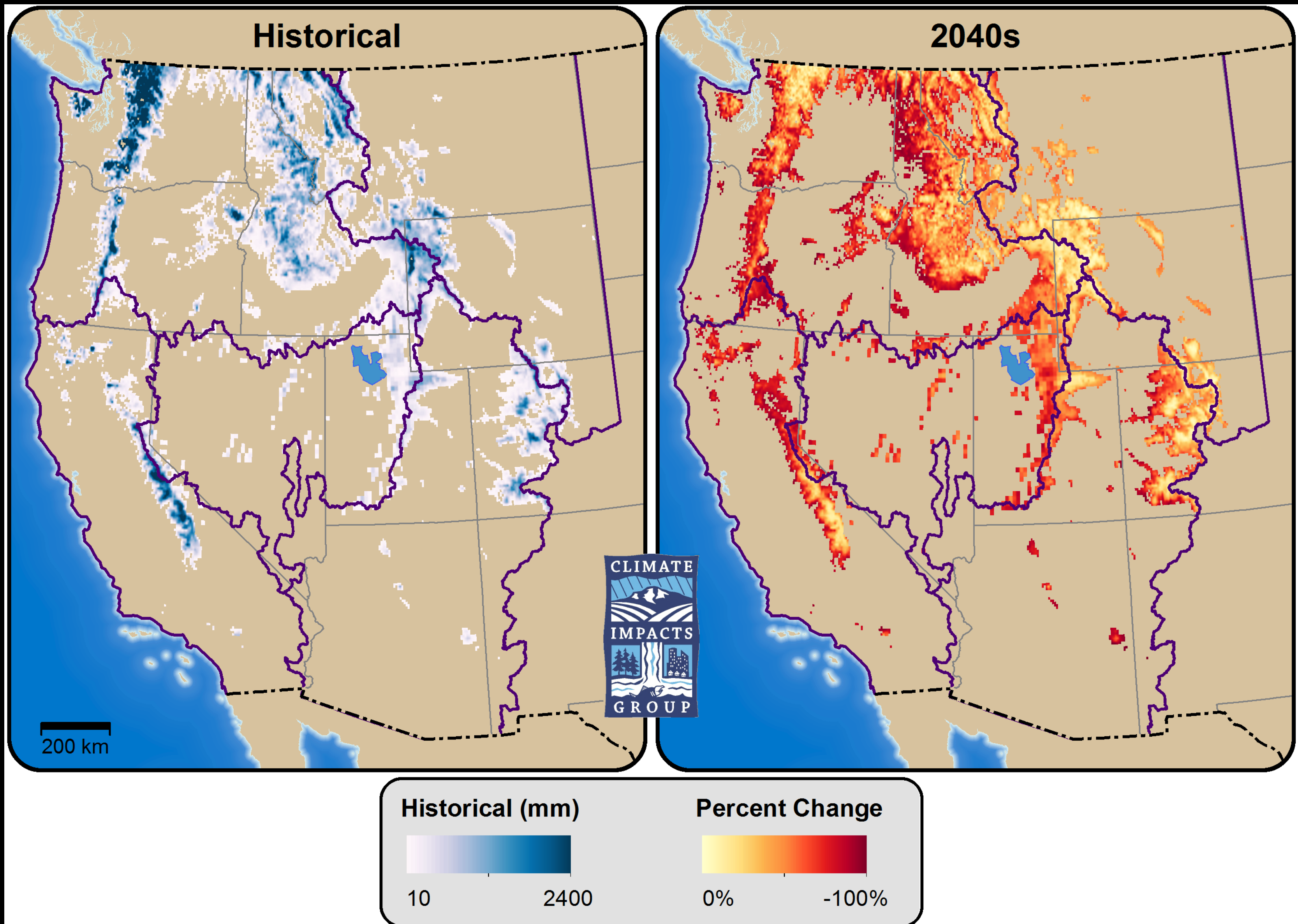


Image: MODIS

So….

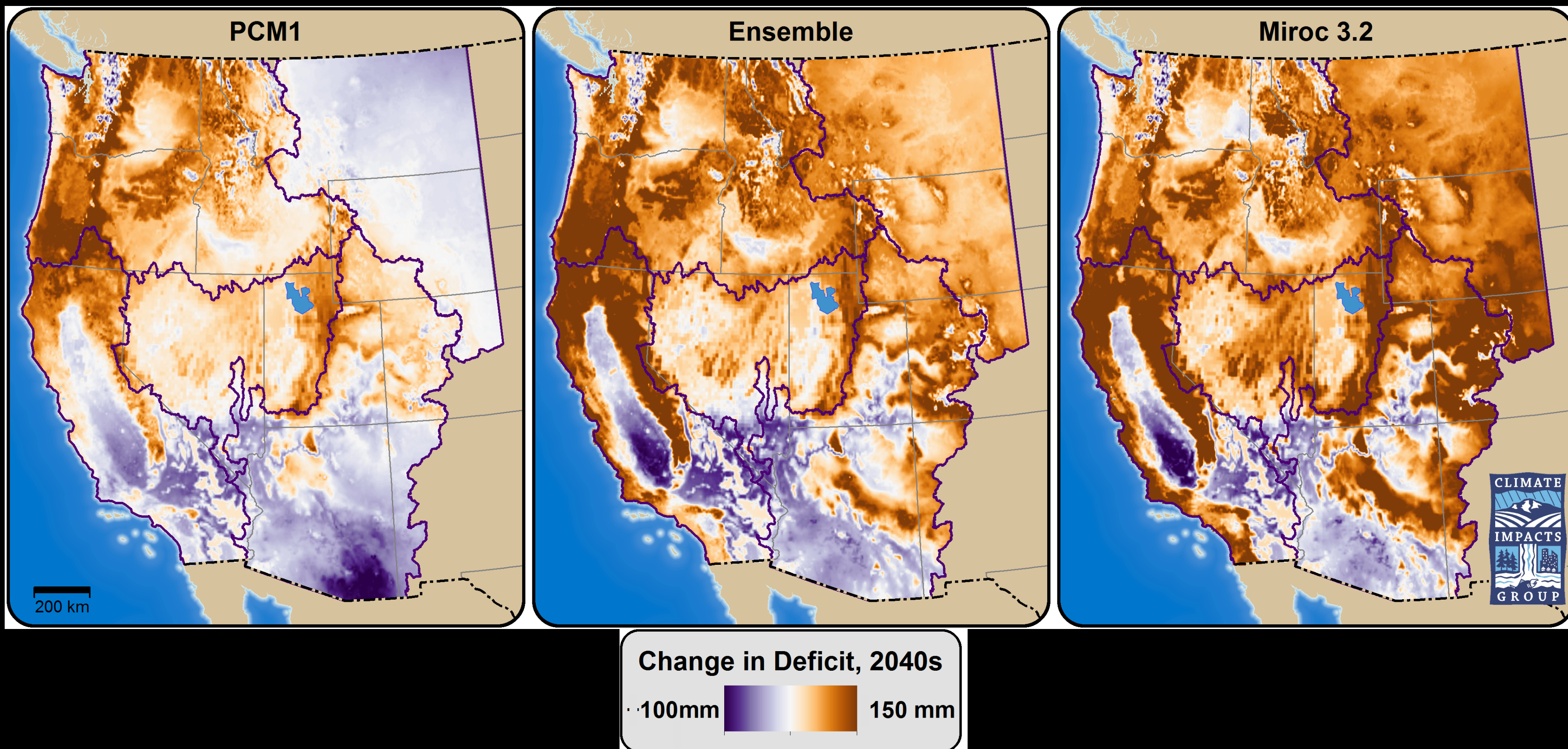
Where *do* we go from here?



Map: R. Norheim

Historical and ensemble mean 2030-2059 change in snow water equivalent

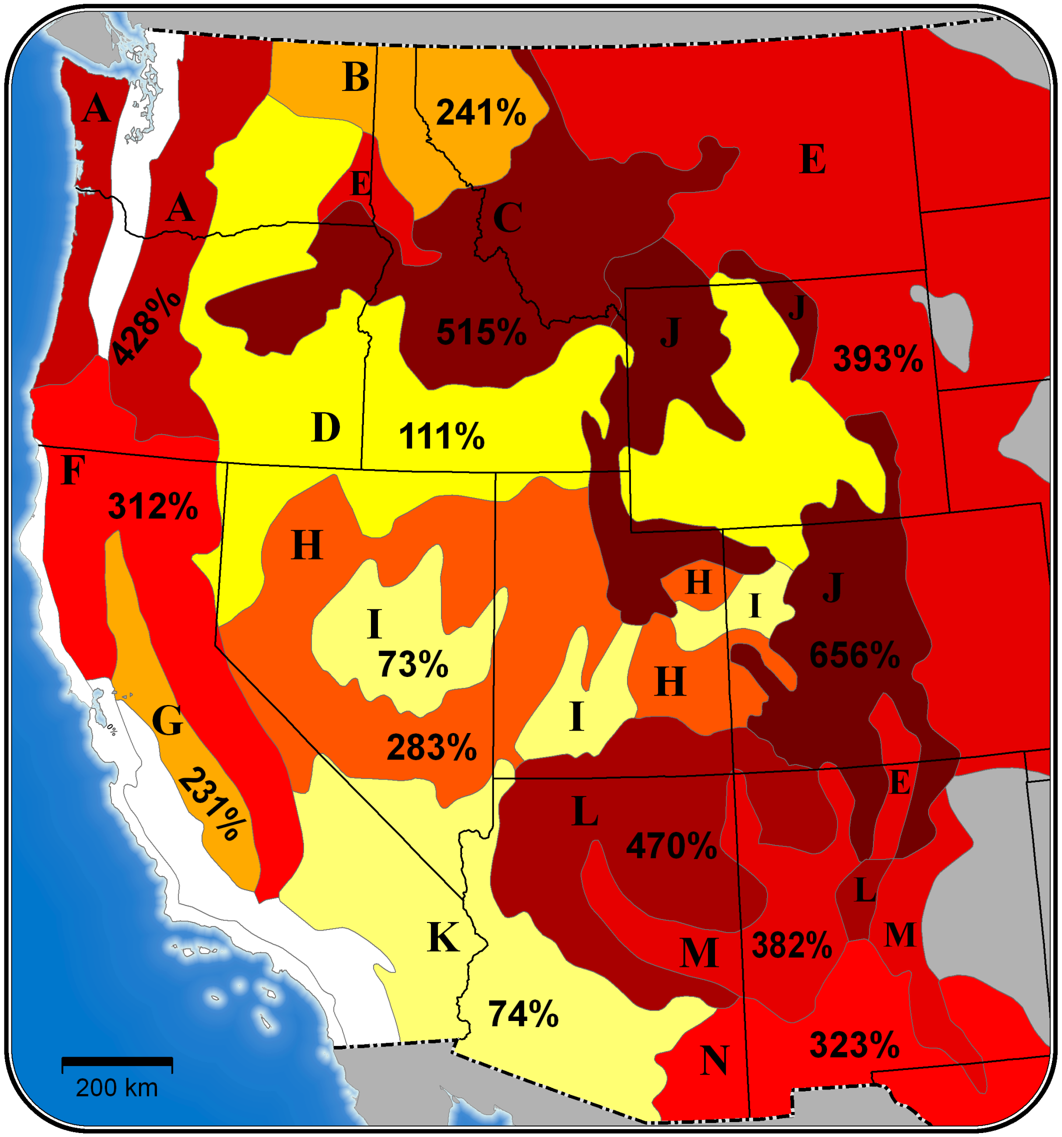
Elsner et al. 2010, Littell et al. 2011



Map: R. Norheim

PCM1 (warmer, wet Northern Rockies), ensemble mean, and Miroc 3.2 (much warmer, drier Northern Rockies) 2030-2059 change in water balance deficit

Elsner et al. 2010, Littell et al. 2011



- A - Cascade Mixed Forest
- B - Northern Rocky Mt. Forest
- C - Middle Rocky Mt. Steppe-Forest
- D - Intermountain Semi-Desert
- E - Great Plains-Palouse Dry Steppe
- F - Sierran Steppe-Mixed Forest
- G - California Dry Steppe
- H - Intermountain Semi-Desert / Desert
- I - Nev.-Utah Mountains-Semi-Desert
- J - South. Rocky Mt. Steppe-Forest
- K - American Semi-Desert and Desert
- L - Colorado Plateau Semi-Desert
- M - Ariz.-New Mex. Mts. Semi-Desert
- N - Chihuahuan Semi-Desert

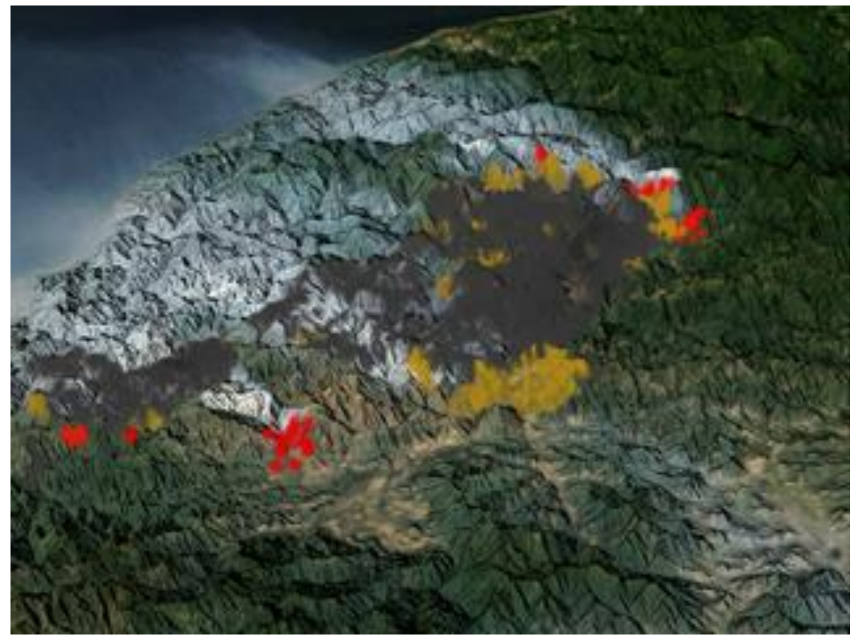
From *Stabilization Targets for Atmospheric Greenhouse Gas Concentrations* (BASC, 2010)

- Statistical fire models from temperature and precipitation
- +1°C and expected % change in precipitation.
- Forested / mountain ecosystems increase much more than shrub and grassland systems

Map. R. Norheim,
Climate projections: Battisti & Tebaldi
Fire data and analysis: Littell

What does that mean for fire on *real* landscapes, and what do we do about it?

- Is it more fires like the ones we have experience with?
- Is it more big, severe fires?
- Is it simply just a longer fire season full of more of the same?
- Whatever the case, ecosystems and services will change rapidly.



Biscuit fire, image: NASA

What we do about it may actually be informed by experience as much as science…..we manage our expectations and risk

Fires don't create catastrophe – people do

Kelowna, B.C. (Photo: summit post)

Scripps Canyon fire, CA, USA (Photo: LA Times)

Kelowna, B.C., Canada 2003
(239 structures)

Victoria, "Black Sunday" fires, Australia (2009, 175 deaths, 3500 structures)

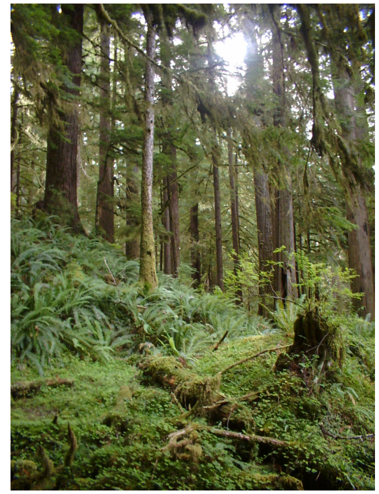
Santa Ana wind fire events in southern CA, USA (1970, 2003, 2007)

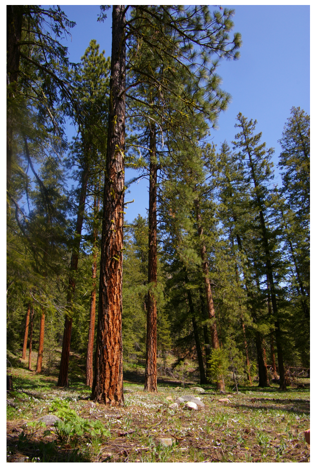
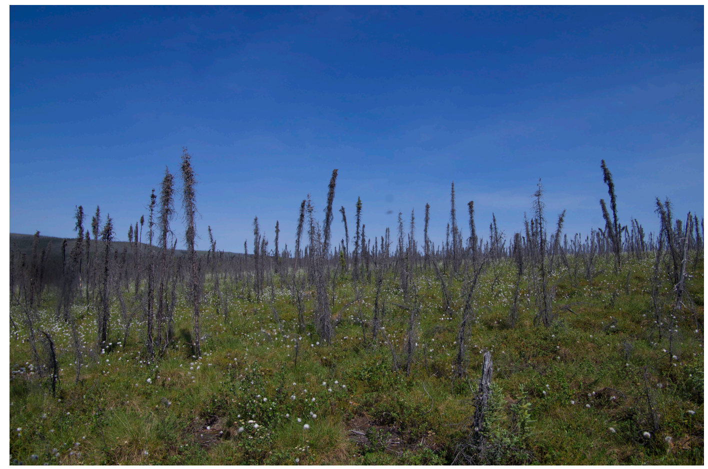
Western Russia (2010, 56000 deaths)

Historical policies (fire suppression) and land use (settlement in ex-urban areas) appear to have increased the number of events and their costs.

If climate change has not already affected frequency of catastrophic fires, it likely will.*






Tools to mitigate exposure: fuel treatments, prescribed fire

Goal: Manage fuels to make fires easier to control, less intense

Rationale: Less intense fires have smaller impacts on other resources (forest products, water supplies, human values); fire suppression is easier

Fuel treatments and prescribed fires manipulate the fire hazard by modifying the amount and arrangement of fuels IN THE NEAR TERM…but not permanently

http://www.northernautoparts.com/

Fuel treatment efficacy

- Far more area than can be treated
- Treatments not prioritized for wildland-urban interface (about 11% area)

Graphic: Schoennagel et al. 2009, PNAS

Tools to mitigate exposure: policy

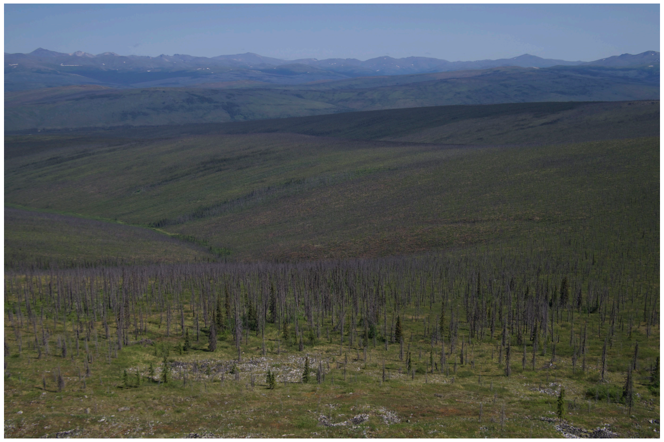
Goal: Use incentives and disincentives to minimize exposure (population in the wildland-urban interface, lack of defensible structures, poor preparedness, reinsurance costs)

Rationale: We can behave differently and affect which human values are at risk even if we can't control fires. Part of the problem is we build (and re-build) our communities and infrastructure in vulnerable areas.

This alters our relationship with the landscape and its tendency to burn by changing the part of it we can control, not depending on our poor ability to control the parts we cannot control.

Tools to adapt/cope: post-disturbance management

Goal: Know how and when to use large disturbances as opportunities* to change landscape trajectory after fire – different species? Different patch arrangements? Fire breaks? With more effective future prescribed fire in mind?



Rationale: It is easier to influence landscape evolution in early successional stages, and possibly easier to get consensus on what should be done

**Littell et al. 2012. U.S. national forests adapt to climate change through science management partnerships. Climatic Change.*

"Prometheus carrying fire"
Cossiers, 17th century

Smokey carrying fawns
uknown, 20th century

?

Where do we go from here?

"Prometheus carrying fire"* *Cossiers, 17th century

Smokey carrying fawns* *uknown, 20th century

FIRE WANTS TO BE FREE.
http://xkcd.com/1228/


AK CSC
Alaska Climate Science Center
jlittell@usgs.gov

FIRE WANTS TO BE FREE.

http://xkcd.com/1228/

Barriers to implementation

Fuel treatments: Science is robust, conceptually unpopular for some, expensive to implement over whole landscape

Prescribed fire: Science is less robust, conceptually unpopular for some, difficult to implement in populated areas, air quality concerns

Post-disturbance adaptive management: Expensive, requires pre-planning for regulatory compliance, requires waiting for a locally rare event, implementation (seed / plant sources, planning), monitoring

Policy / social instruments: increased insurance, individual property requirements, and preparedness require different community values; some opposed to regulation

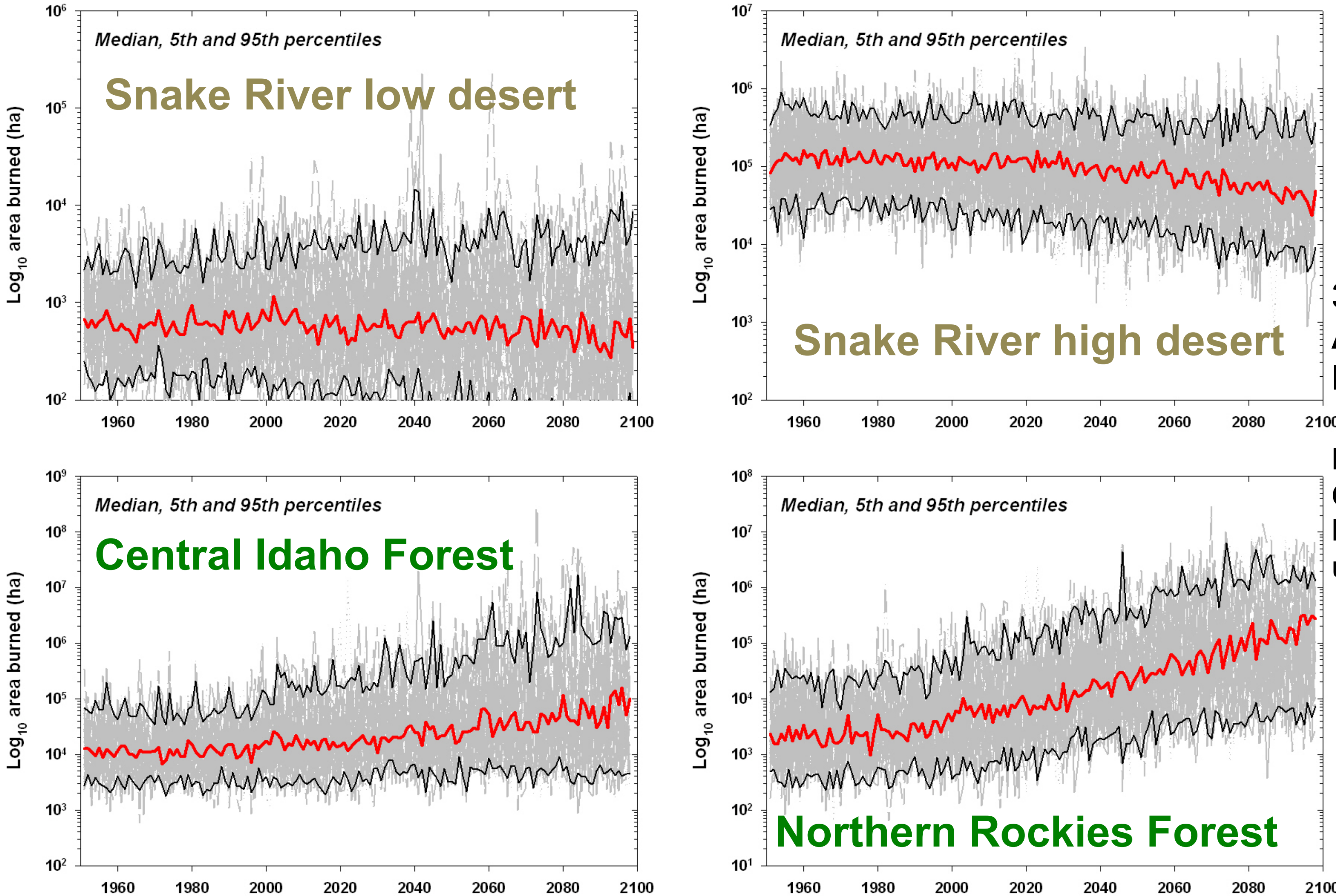
Barriers to implementation (continued)

Fire and fuels management occurs in a complex management landscape: many conflicting boundaries, mandates, interests

Natural role of fire in landscapes varies with ecosystem, within a landscape, and across time with climate variability: solutions are sometimes very context dependent, other times relatively broadly applicable

Encouraging progress in science-management agency partnerships to identify general adaptation approaches in forests and local adaptation strategies and actions for managed forest systems

Statistical fire modeling of fire regimes, but not yet *local* extreme events



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