


Fire Management, Fire Science, and Climate Change:

Where do we go from here?

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USGS science for a changing world

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First, who is "we" anyway?

- Anyone interested in how fire, climate, and ecosystems may be different in the future than they are now or have been in the past

- Fire and resource managers and other decision makers

- The community of whole-system scientists who study the interacting parts of the land surface

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Second, where is *here**?

– We know fire suppression and fuels management have had different effects on vegetation in different places

– We know that climate affects the occurrence, size, and probably severity of fires in all vegetation types

– We know the climate is changing, and how it will change in the future varies considerably with location and time frame

** - Today, I'm going to use the REST of the American West for my examples, but I'll point out where I think Alaska is different.*

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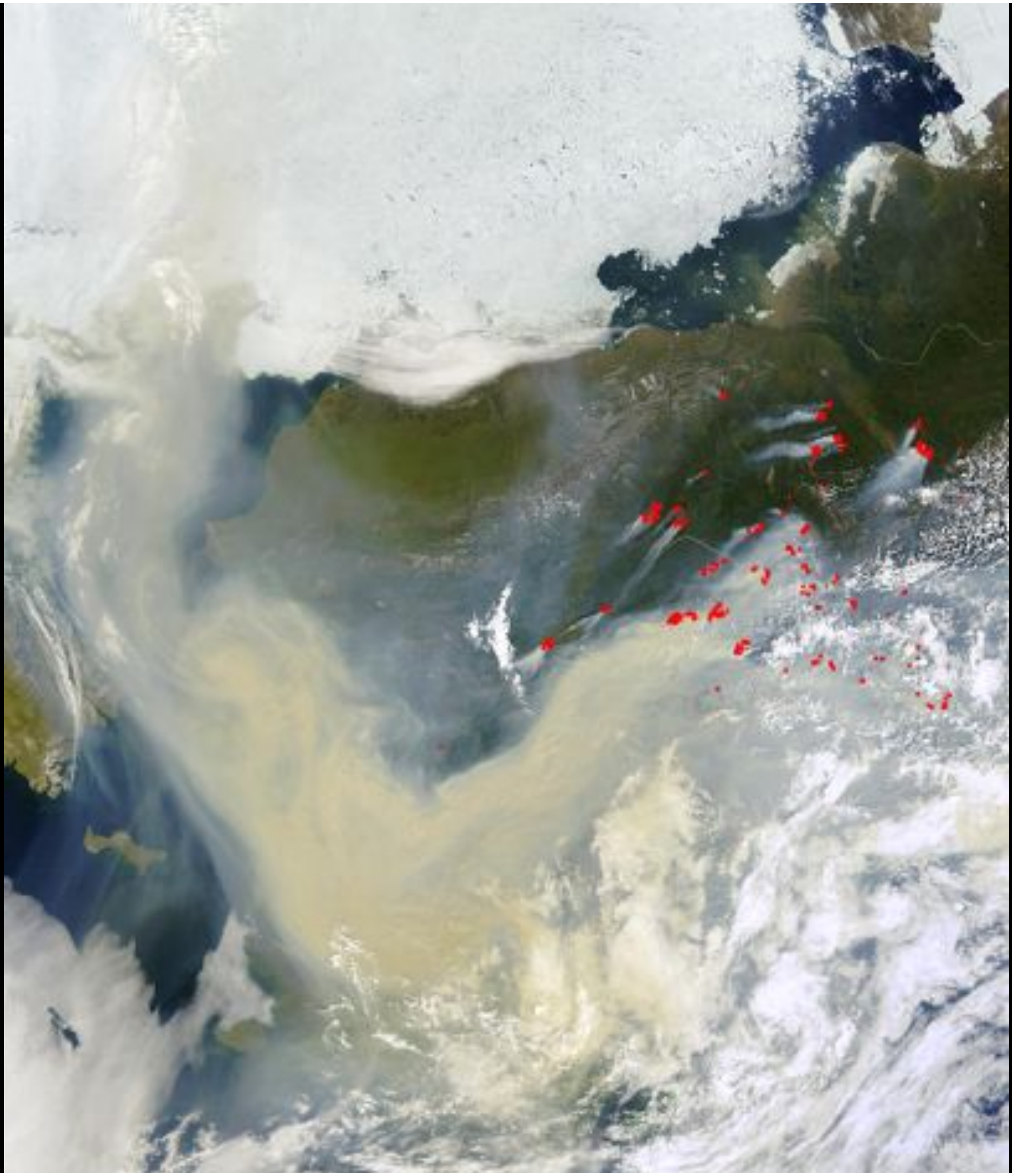

Image: MODIS

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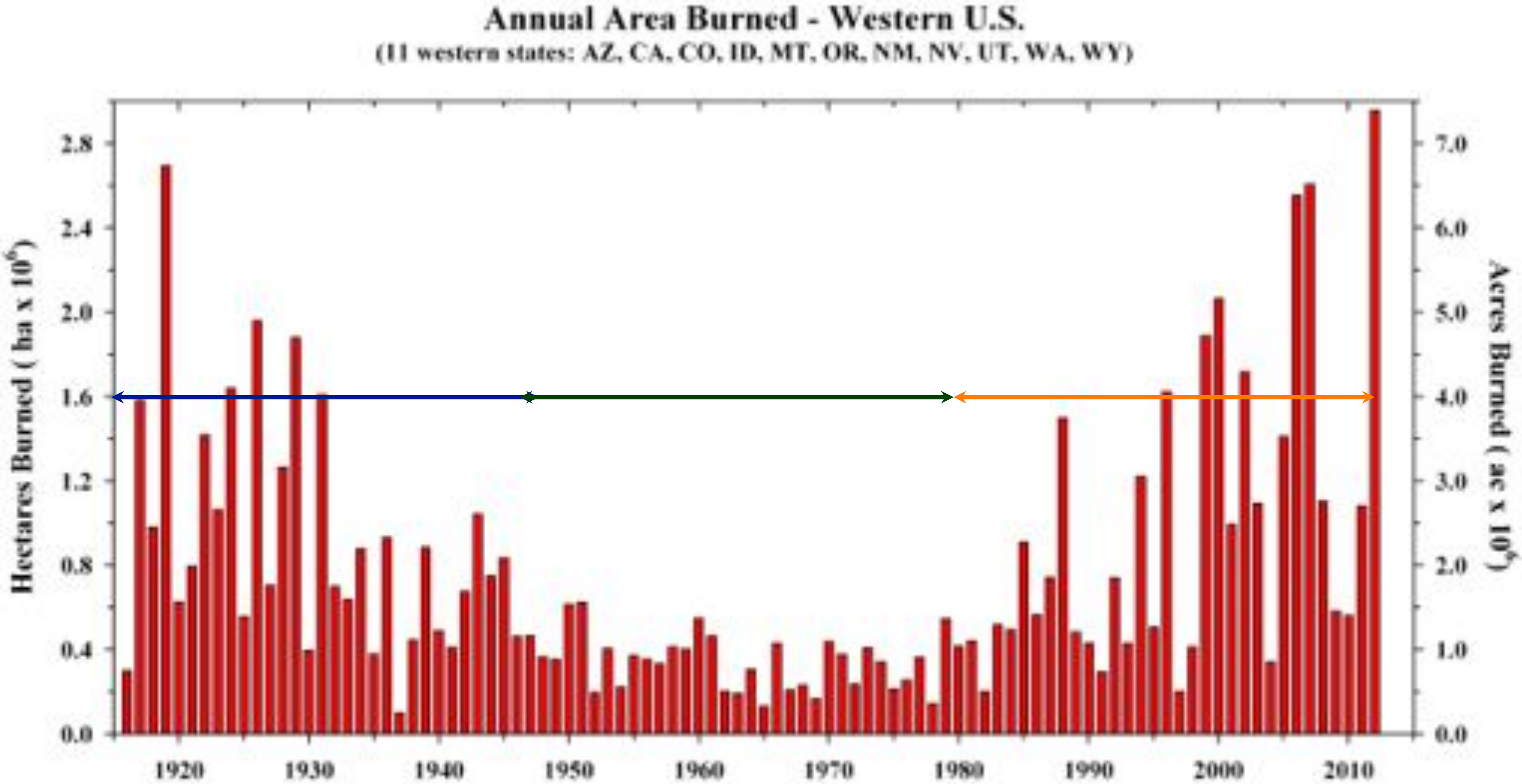
Area burned in 11 Western states, 1916-2012



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

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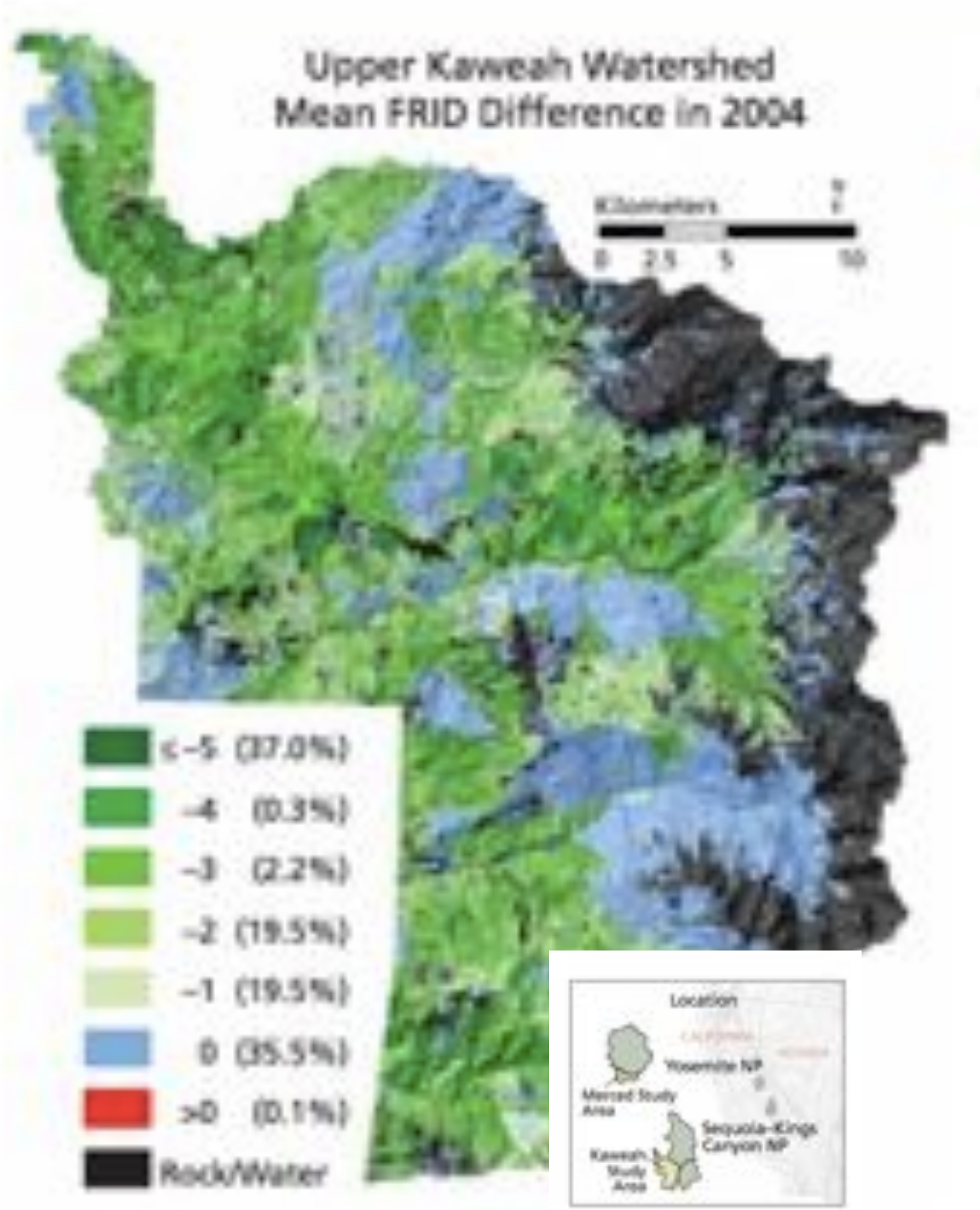

Fire return interval change between actual and modeled landscapes.

C.A. Miller. 2012. The hidden consequences of fire suppression. Park Science 28(3): 75-80.

View to Bunsen Peak, YNP 1907

View to Bunsen Peak, YNP 1992

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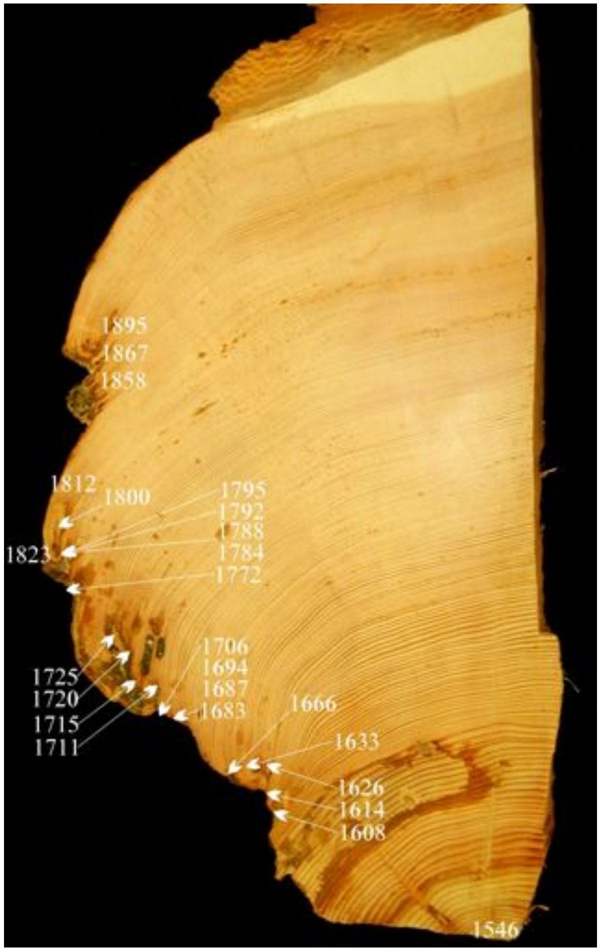

Littell, 2002

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

RMRS-GTR-23, from U.S.D.A. Forest Service, Rocky Mountain Research Station

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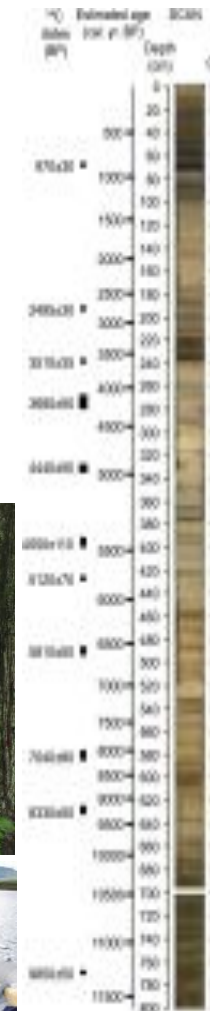
Why is climate important?
Let's start with the "natural range of variability"

- 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

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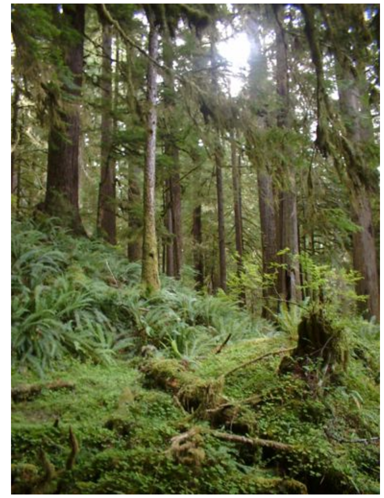

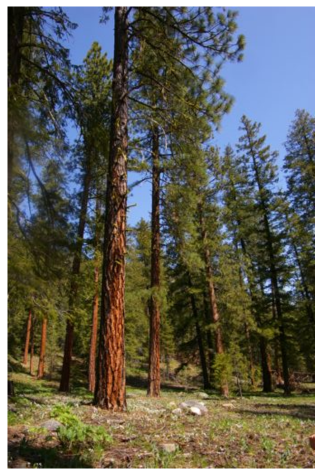



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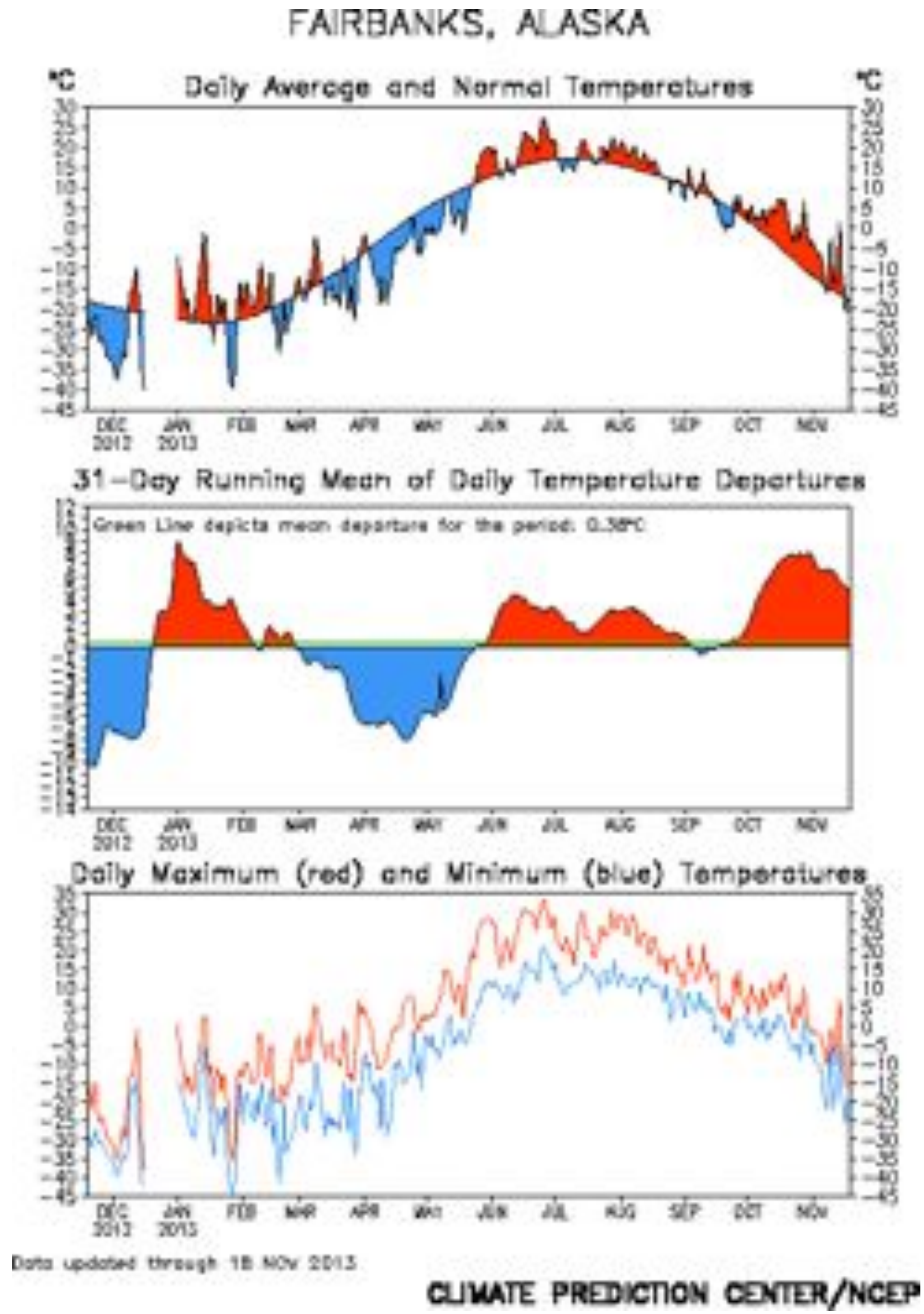
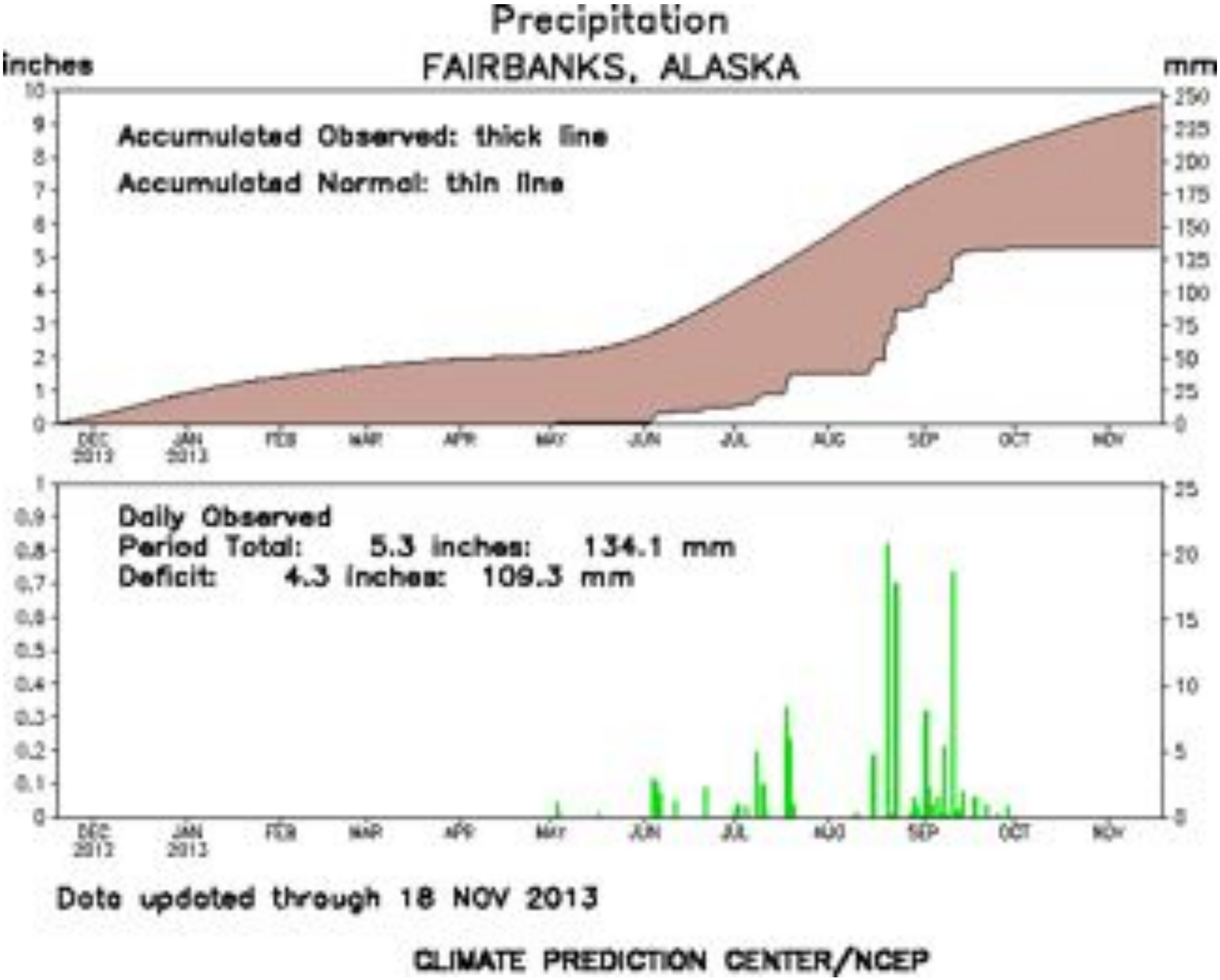
Climate is simply the statistics of weather:

at right are three ways to view Fairbanks' observed daily temperatures from the past year





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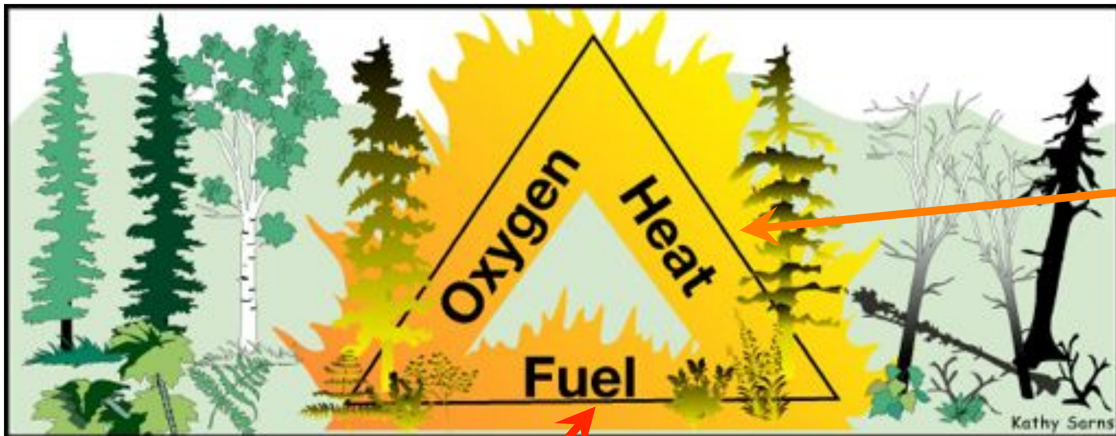
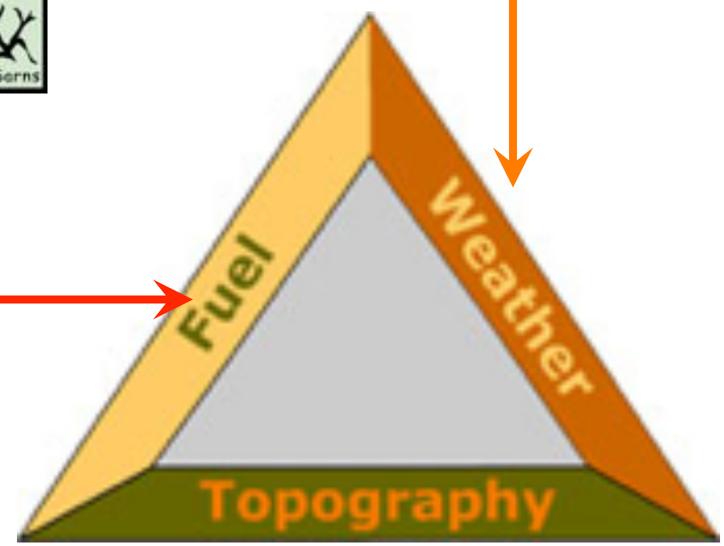
Why is climate important for understanding the landscape ecology of fire?



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.



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

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

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Climate and Fire

- Climate affects the components of a fire regime:
  - **Fuels** – climate affects the species, fuel structure, mass available, and fuel availability to fire
  - **Area** – climate affects how big a fire can get - partly a function of fuel availability and connectivity / fuel continuity
  - **Frequency** – climate affects how often fuels are abundant enough and available to burn, and also natural ignitions
  - **Severity** – climate affects intensity via how much fuel there is, how much of it is available, how it is arranged, and so how it affects the living canopy
- 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

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Forested systems:

+Tmax, -precip, +drought → fire

Desert systems:

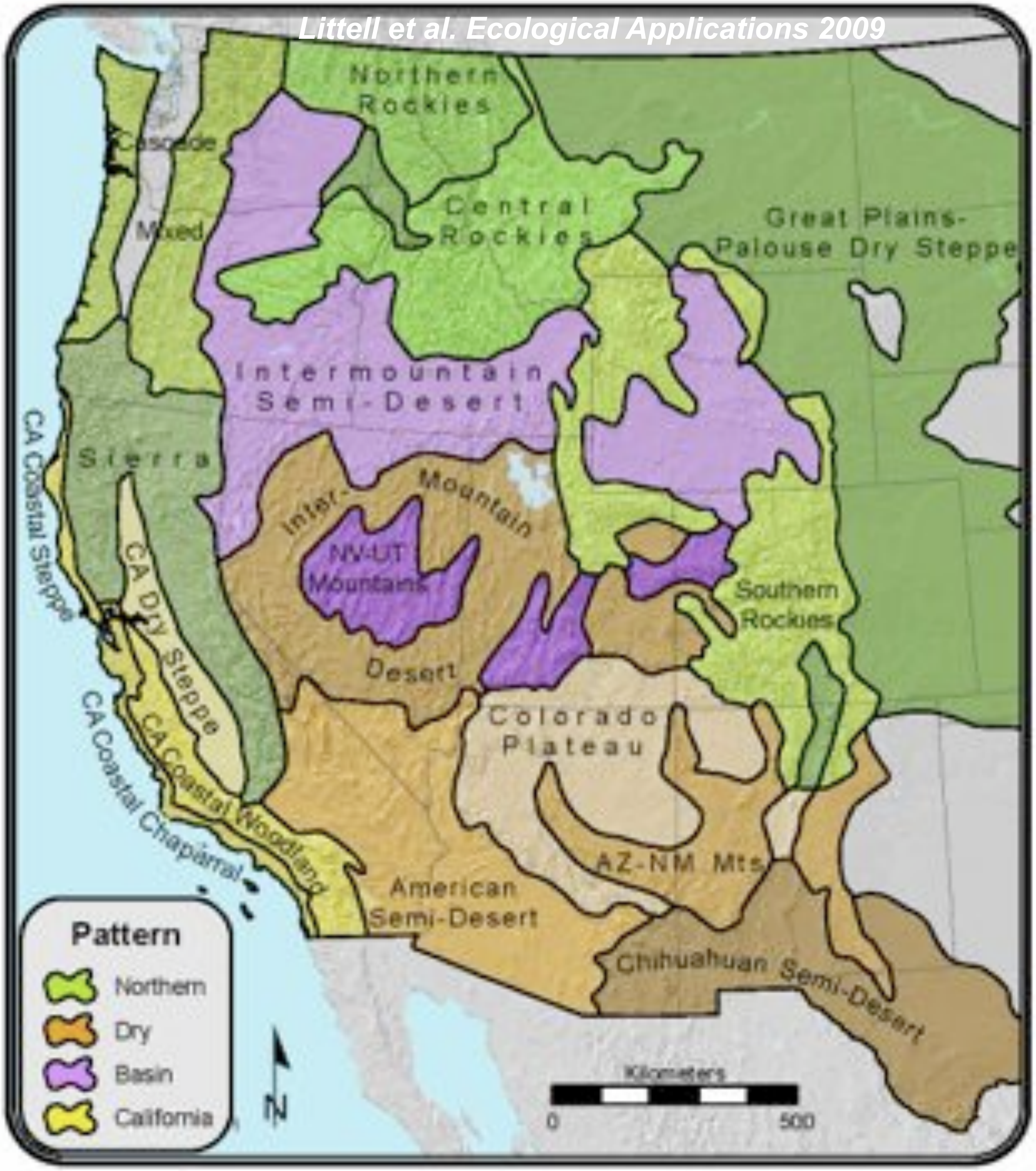
+precip, -drought → fire in subsequent year(s)

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

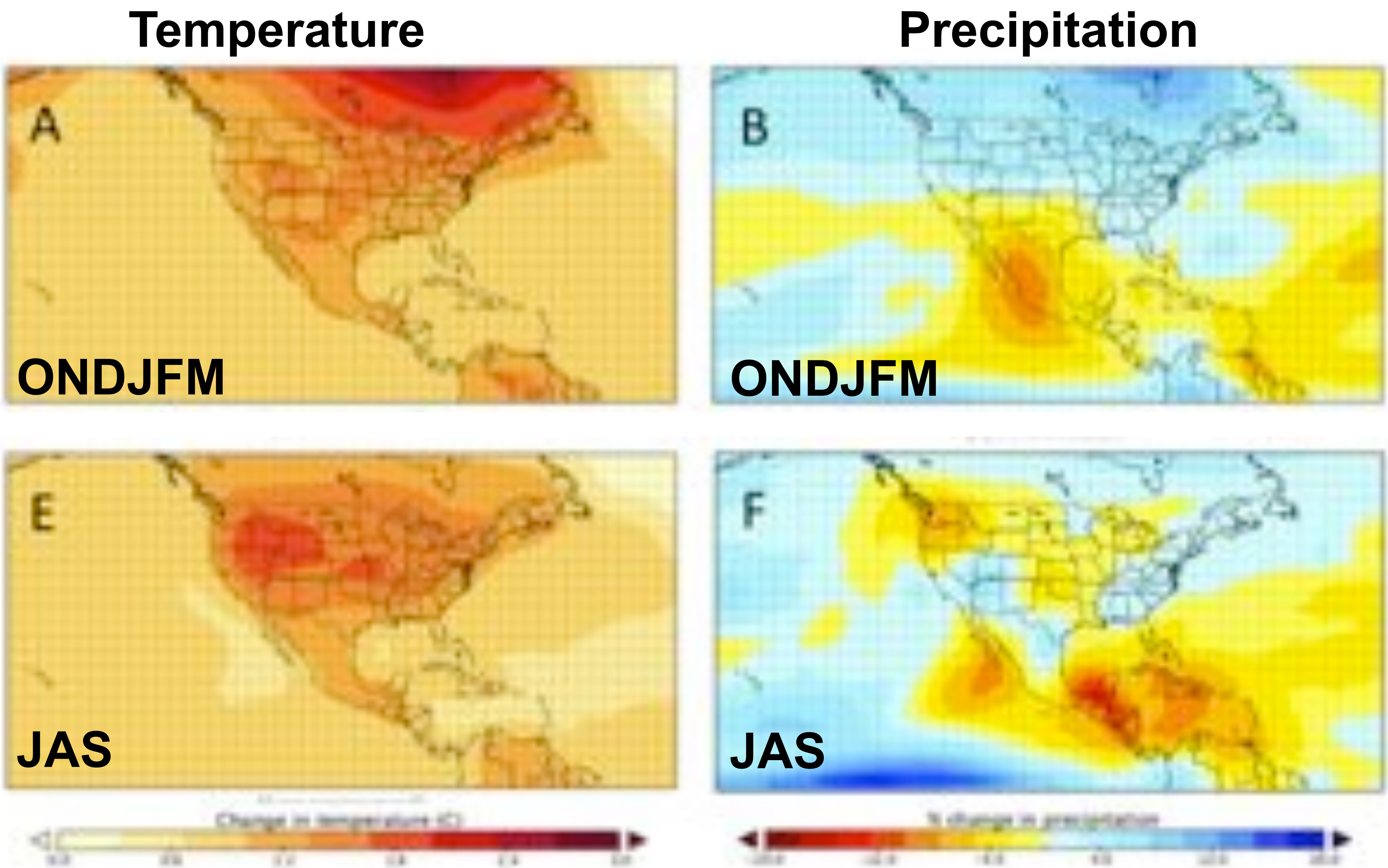
- Different fuel types respond differently to climate
- Two mechanisms: *drying* of fuels and *production* of fuels
- Fuel (moisture) - limited systems: fire is facilitated by increased water → fine fuels
- Climate (energy) - limited systems: plenty of fuel, sensitive to drought, water deficit, Tmax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

Littell et al. 2009, Ecological Applicaitons

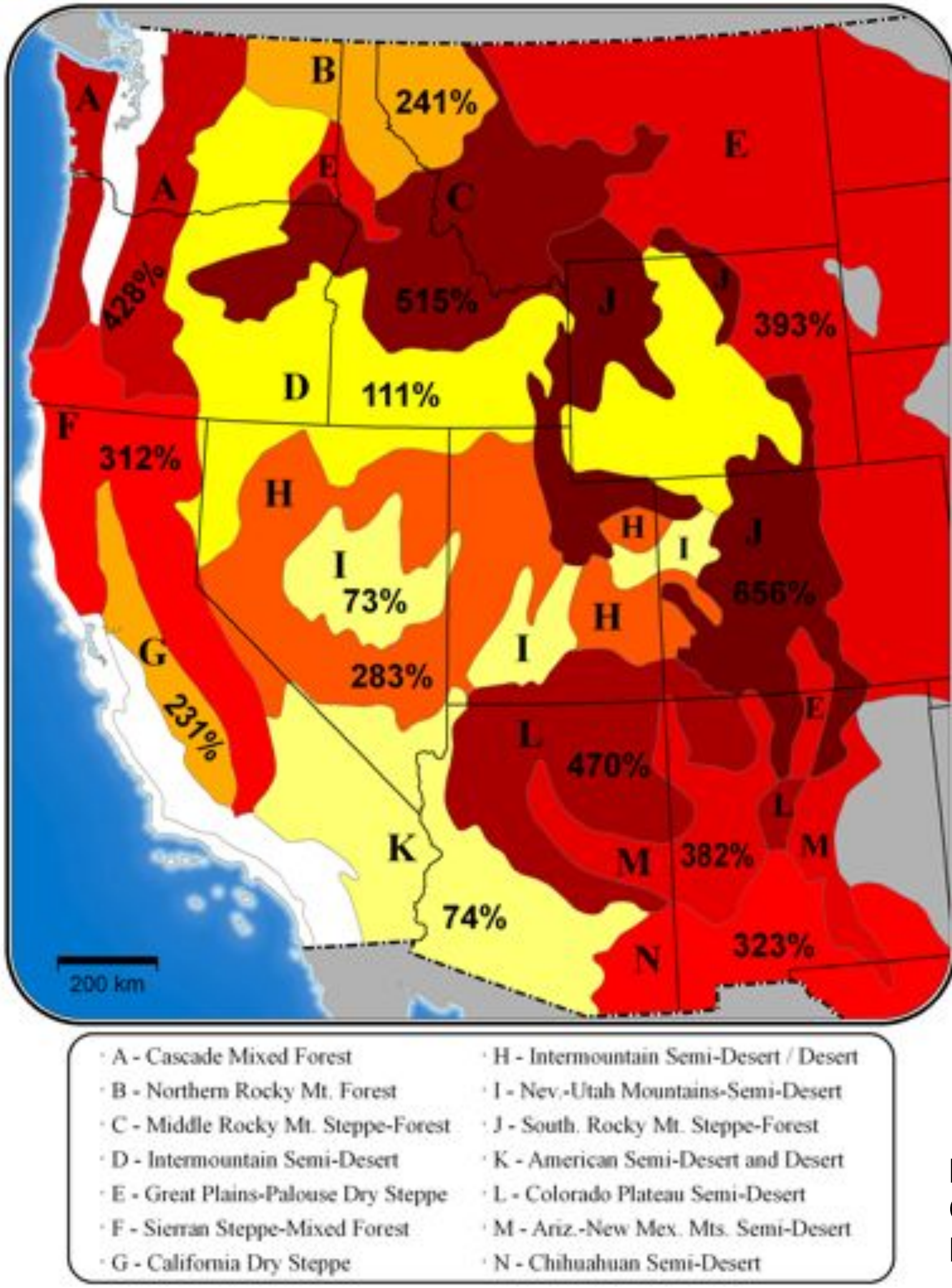
Photos: Bailey 1995

Ensemble global climate 1C response,

IPCC AR4 GCMs normalized by model sensitivity



Climate projections: Battisti & Tebaldi for 1C global temperature increase



Littell et al.
From *Stabilization Targets for Atmospheric Greenhouse Gas Concentrations* (BASC, 2010)

- Statistical fire-area regression models from temp and precip
- Multiple climate models use to project sub-regional climate expected with +1C and % change in precipitation.
- Forested / mountain ecosystems increase much more than shrub and grassland systems

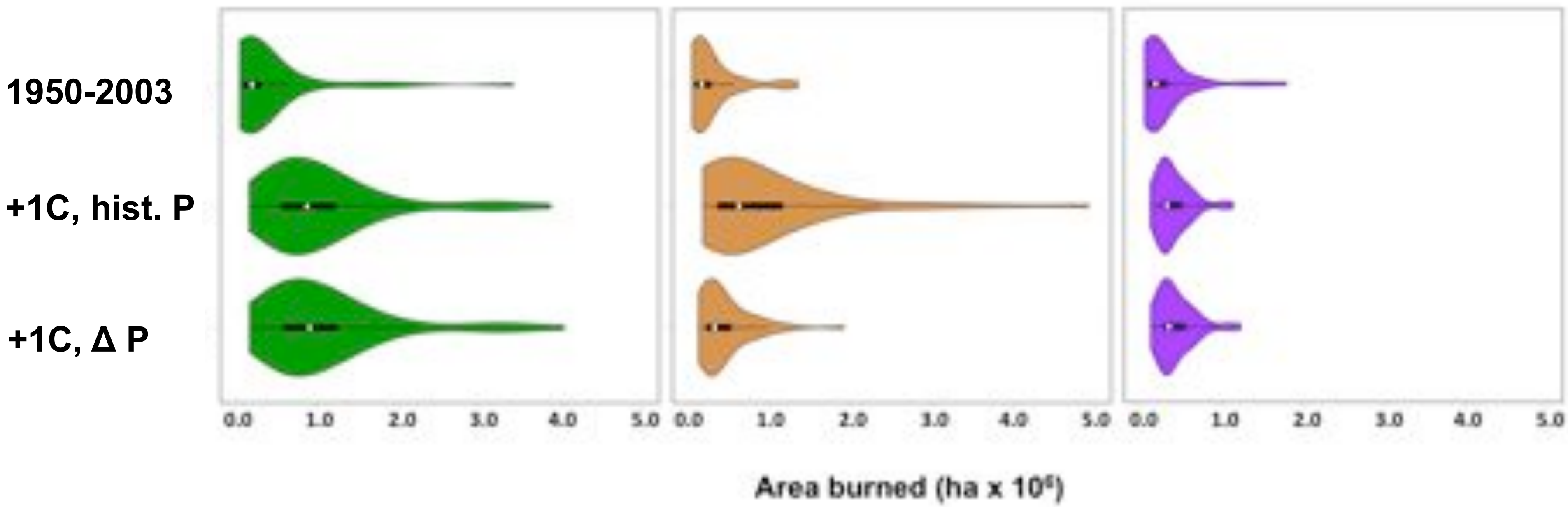
Map. R. Norheim,
Climate projections: Battisti & Tebaldi
Fire data and analysis: Littell

Changes in fire area probability by fire-climate sensitivity

Forests:
Delta median: +376%

Shrublands / Grasslands
Delta median: +100%

Deserts:
Delta median: +90%



Area burned under +1C global warming (over 1950-2000) increases most in forest systems; in hybrid systems, depends on precipitation; less change in decrease in deserts. Decrease in variability could be statistical or climatic

Littell et al., unpublished

Ecologically based means: consider vegetation as fuels and use climate predictors related directly to fuels

- Two mechanisms: *drying* of fuels and *production* of fuels
  - Use finer scale ecological definition: Bailey's ecoprovinces → ecosections
- Fuel (moisture) - limited systems

  vs.

  Climate (energy) - limited systems
  - Use fuel related climate variables: temperature and precipitation → potential and actual evapotranspiration
- Ignition - limited systems

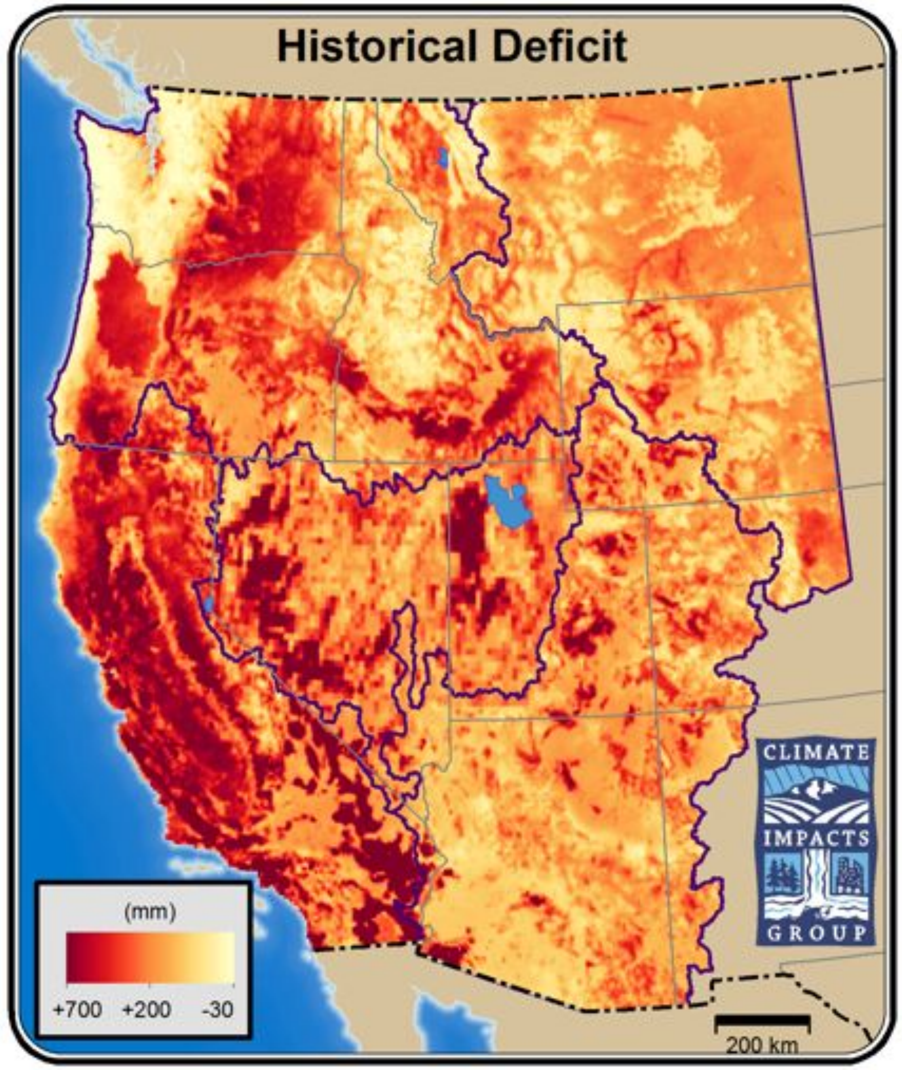
Littell et al. EA 2009

Water balance as control on wildfire

Water balance deficit:
Potential – actual evapotranspiration

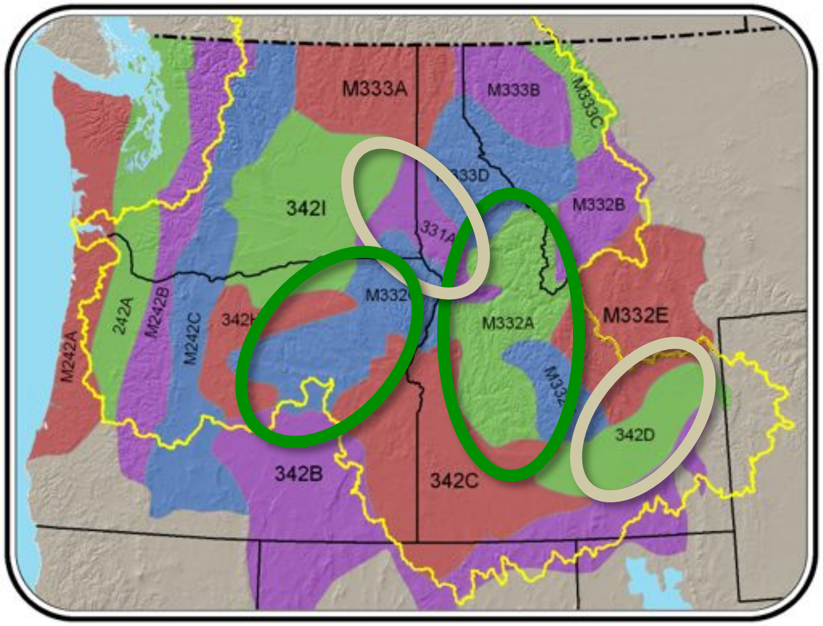
- We use the VIC hydrologic model to estimate water balance from climate and site characteristics.
- Captures atmospheric water demand, soil water supply, radiation, wind, vegetation effects on moisture
- +Deficit = more drought
- - Deficit = surplus

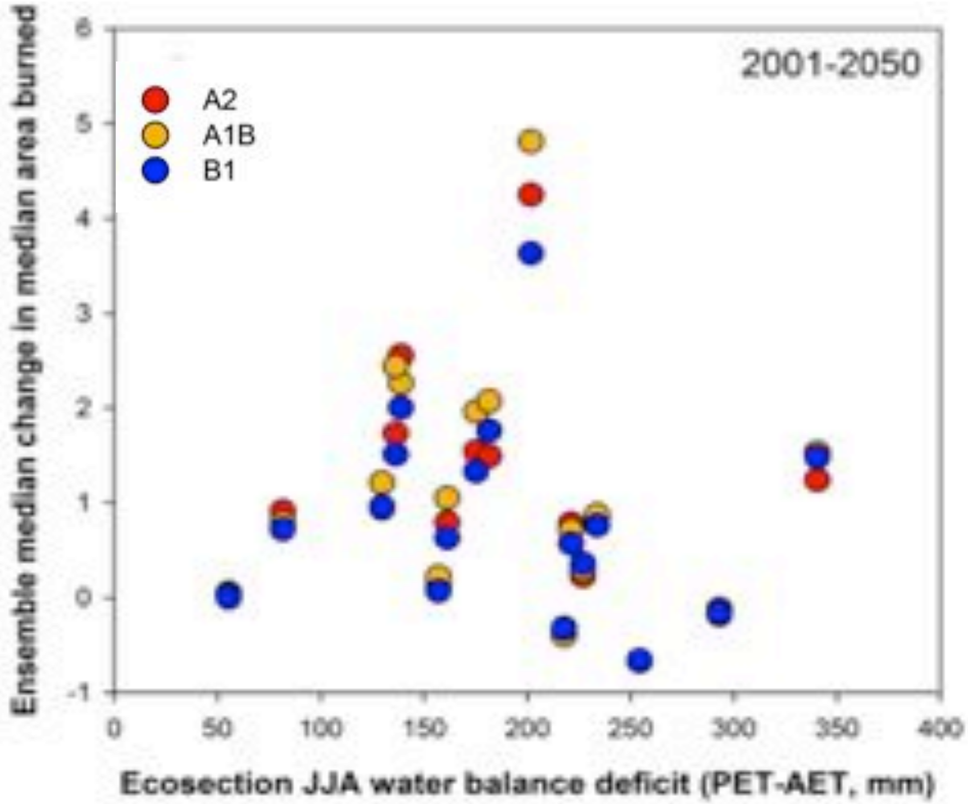
Why not PDSI?



JJA Historical Deficit ***Map: R. Norheim***

Elsner et al. 2010, Littell et al. 2011





Map: Rob Norheim 1980-2006 Fire Data: Littell, after FAMWEB Historical climate and hydrology: Elsner et al. 2010

Map: Rob Norheim

Ecosection level statistical fire models vary in skill but on average explain 60% of historical variability. Most of that skill is from just a couple variables, particularly summer deficit.

Projecting models forward, we see large increases in area burned, but the increase varies considerably with historical deficit – some even decrease.

Littell and Gwozdz, 2011

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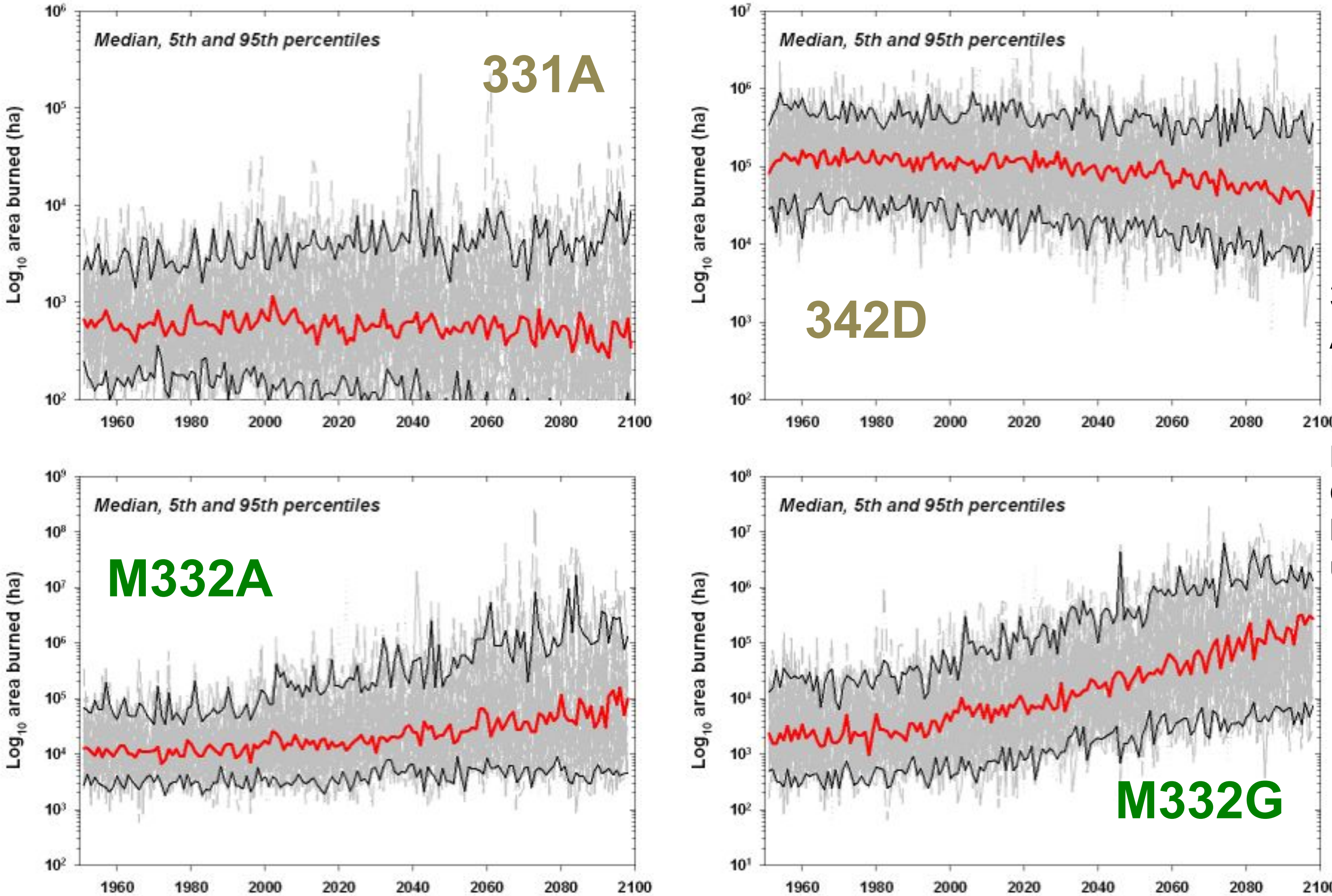
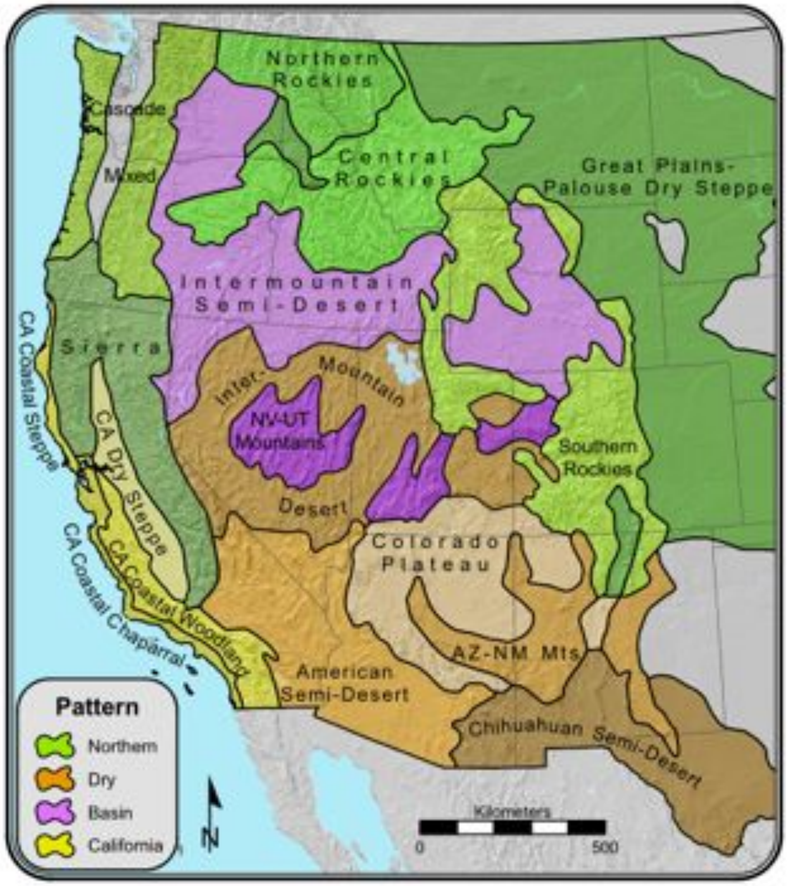
Hybrid models decrease, Forest models increase



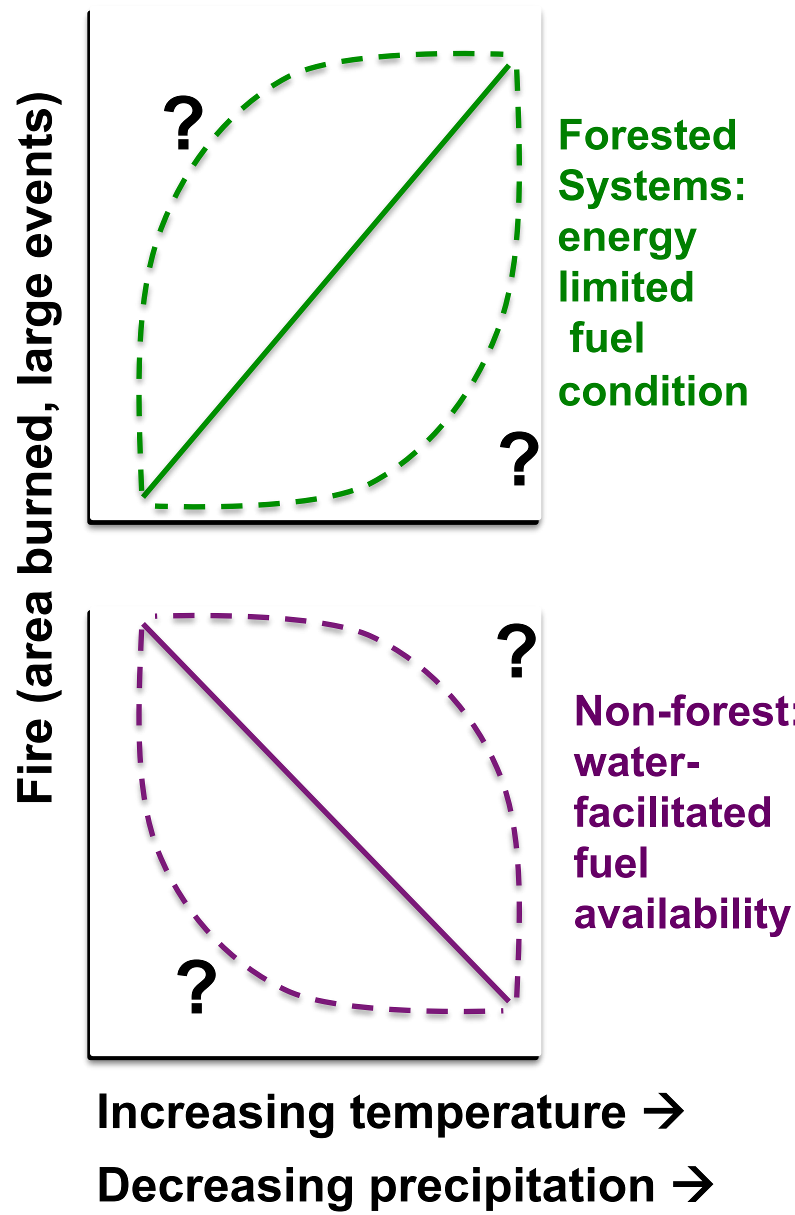
39 CMIP3 A1B GCM Realizations

Littell, Duffy, Choy, Pruitt, McKenzie unpublished

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



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



If climate and fuels are changing at the same time,should we really expect these to be linear responses?

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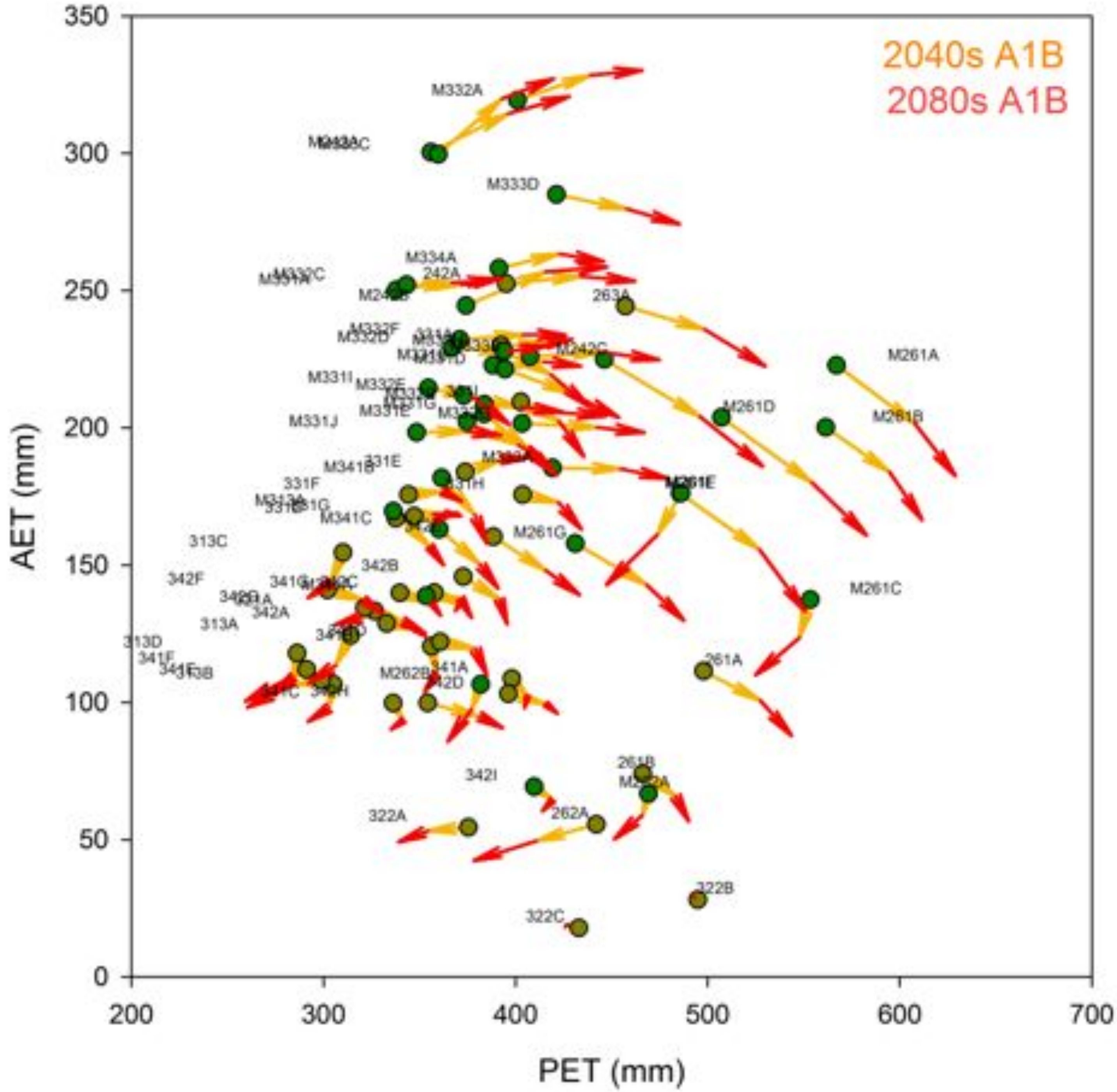
CLIMATE IMPACTS GROUP



Projected JJA deficit, average of 10 GCMs, statistical downscaling, VIC averages by ecosection.

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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 (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.*

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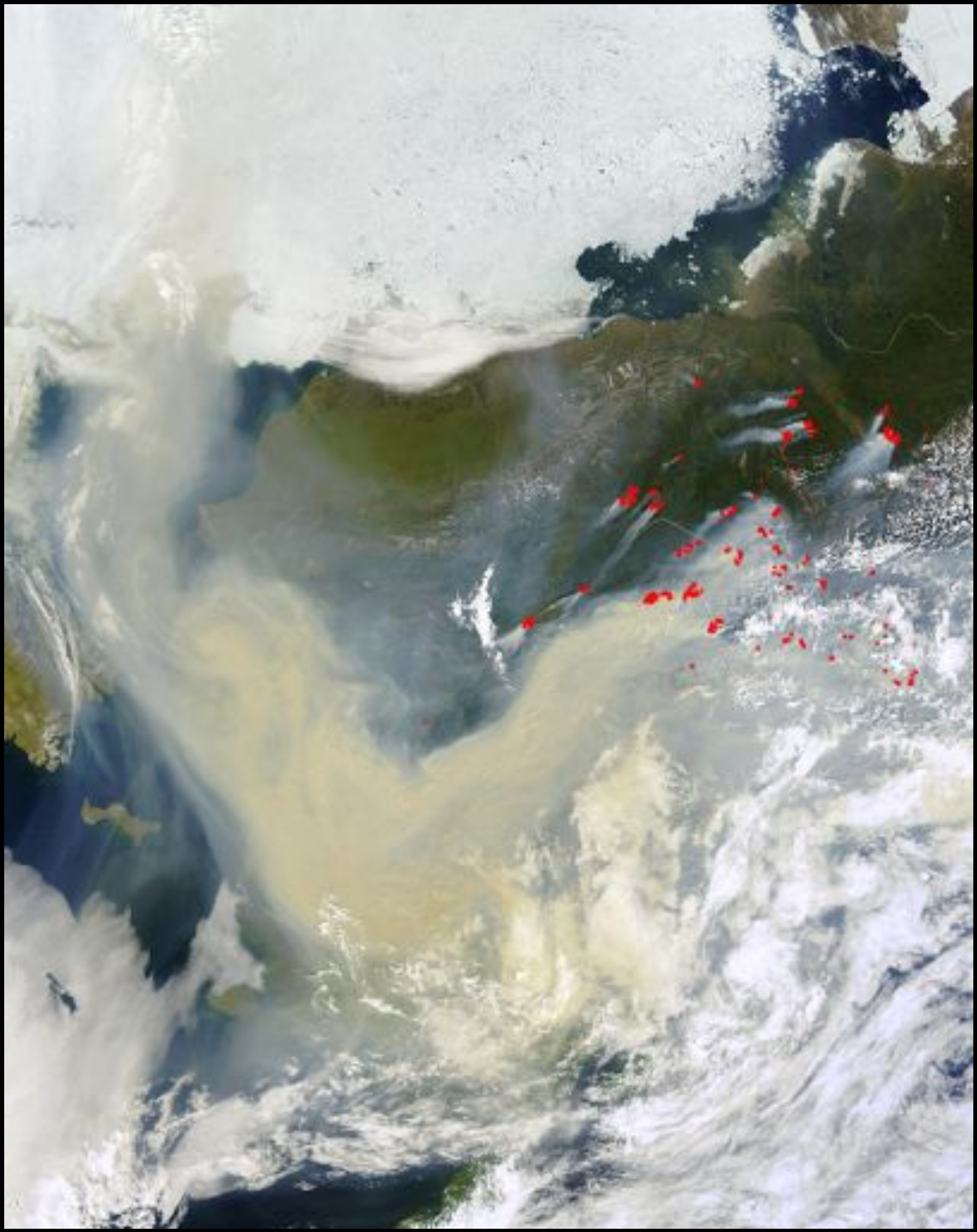

Image: MODIS

So….

Where *do* we go from here?

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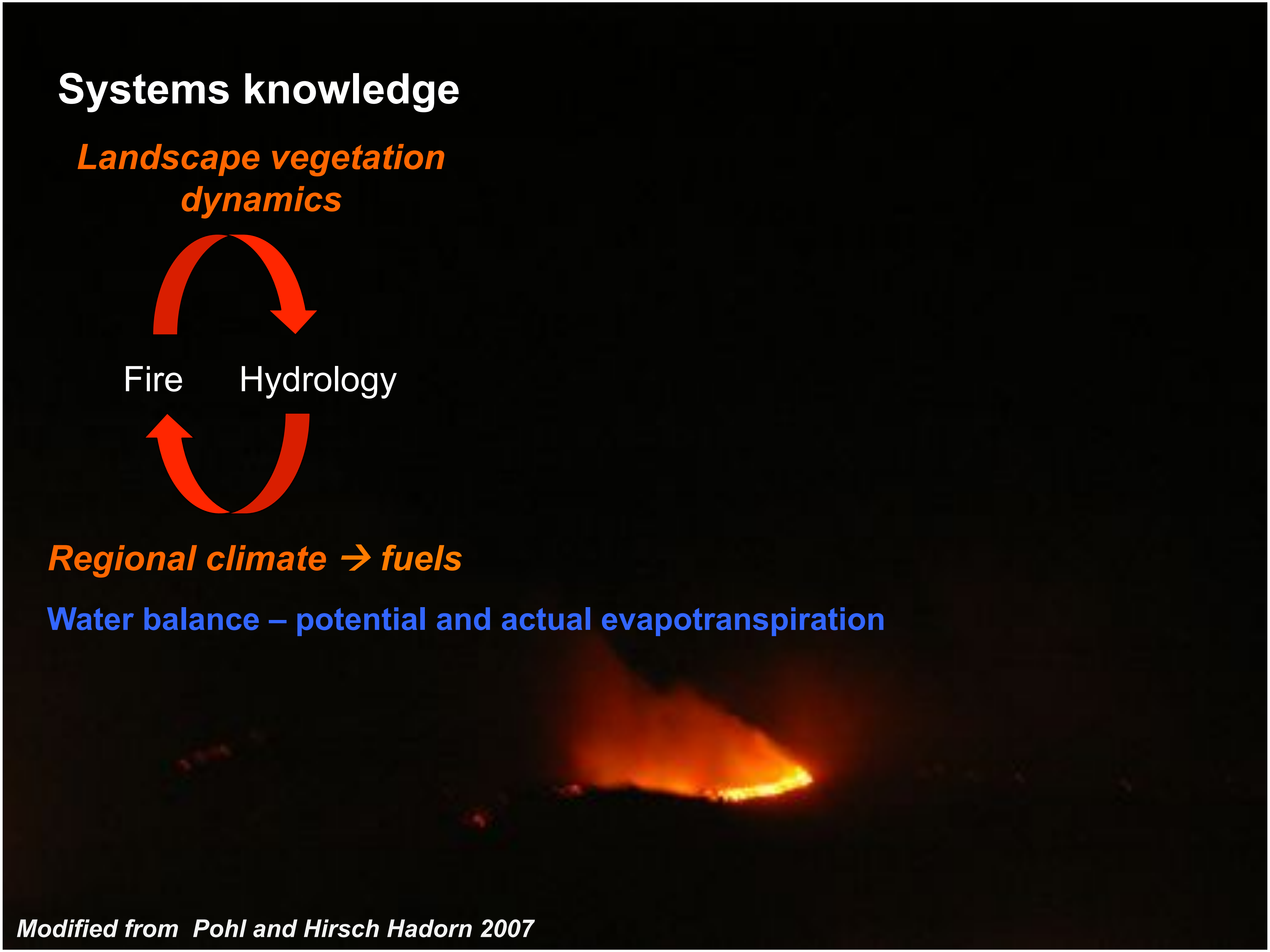
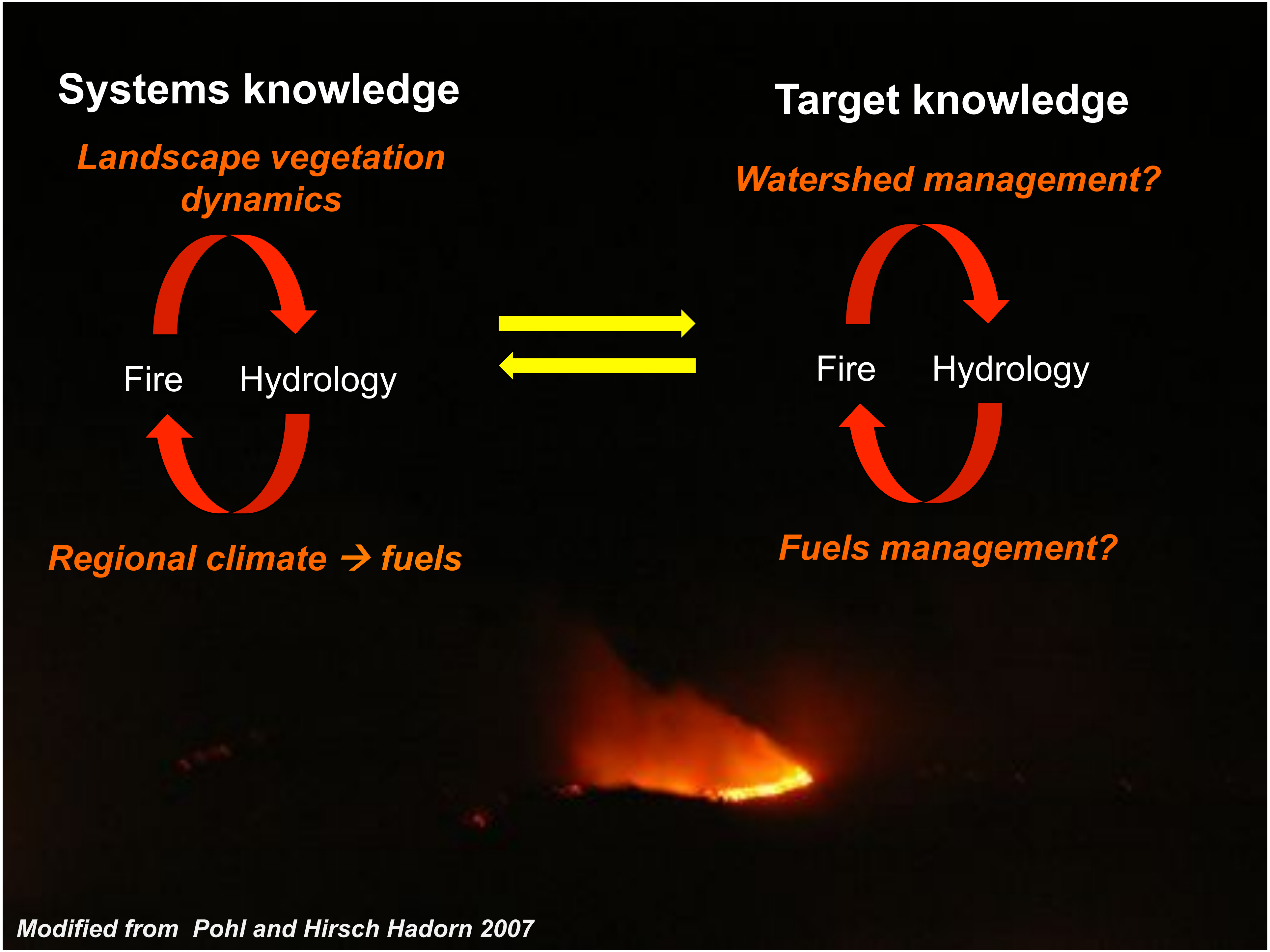
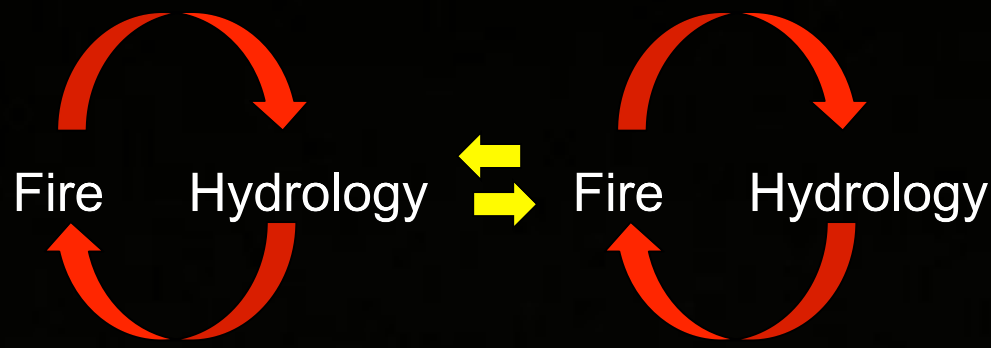

Systems knowledge
Landscape vegetation dynamics
Fire
Hydrology
Regional climate → fuels
Water balance – potential and actual evapotranspiration
Modified from Pohl and Hirsch Hadorn 2007


Systems knowledge
Landscape vegetation dynamics
Fire
Hydrology
Regional climate → fuels
Target knowledge
Watershed management?
Fire
Hydrology
Fuels management?
Modified from Pohl and Hirsch Hadorn 2007

Systems knowledge   Target knowledge



Transformation knowledge

How do we manage the likelihood of changes in fire regimes and their consequences for people?

(How) can/should we revisit fire suppression policy?
(How) should we manage: vegetation, fuels, and after disturbance?
(How) should we think about the role of disturbances in landscapes?
How will we adapt in fire-prone landscapes?

Modified from Pohl and Hirsch Hadorn 2007

Tools to mitigate exposure: fuel treatments, prescribed fire

Goal: decrease fuel loads, canopy density, surface fuels to make fires easier to control and less intense, and alter landscape fuel arrangement

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

http://www.northernautoparts.com/

Fuel treatment efficacy

- Far more area than can be treated
- Treatments not prioritized for wildland-urban interface (about 11% area)
- Prioritized for change in exposure due to fire suppression, *not for total change in exposure due to all factors*

Graphic: Schoennagel et al. 2009, PNAS

Tools to adapt: 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.***

Tools to mitigate exposure: policy

Goal: Use incentives and disincentives to minimize choices that lead to increased 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 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.

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

To support all that, we would need an iterative scientific approach to climate and fire that did three things:

- It would develop <u>local</u> scenarios of climate, vegetation (to species), hydrology, and fire interactions that account for transience (translation: better data, better models)
- It would allow for testing "what if" scenarios of fire response and landscape management (translation: the models have to have dials that mean something and can turn)
- It would allow for testing "what if" policy scenarios (translation: the models have to allow them decide if they want to change their minds)
- Did I mention…it has to be iterative? – nature bats last.

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