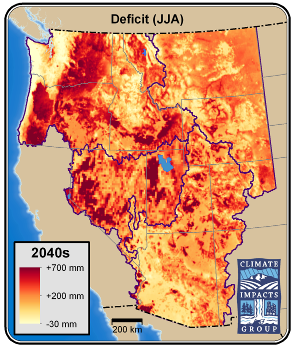

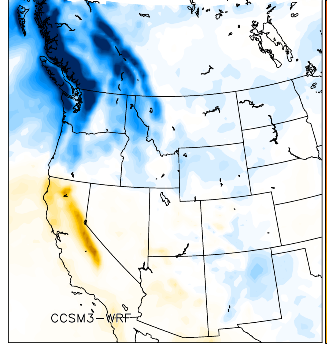

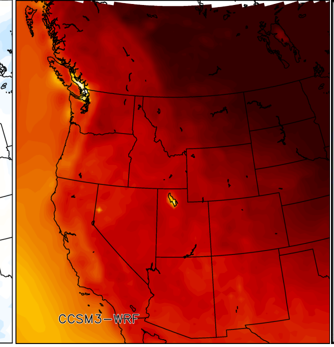

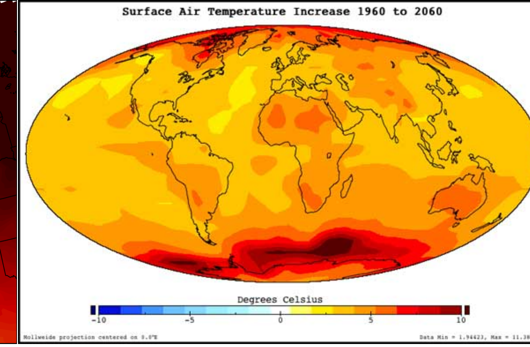

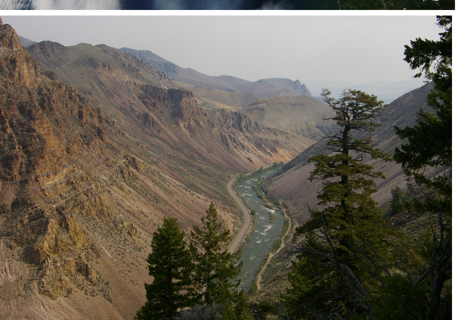

Projected climate-driven changes in fire regimes* in Cascadia

Jeremy Littell

Don McKenzie, Rich Gwozdz, David Peterson,
David Battisti, Phil Duffy, Tom Pruitt, Gabriela Choy

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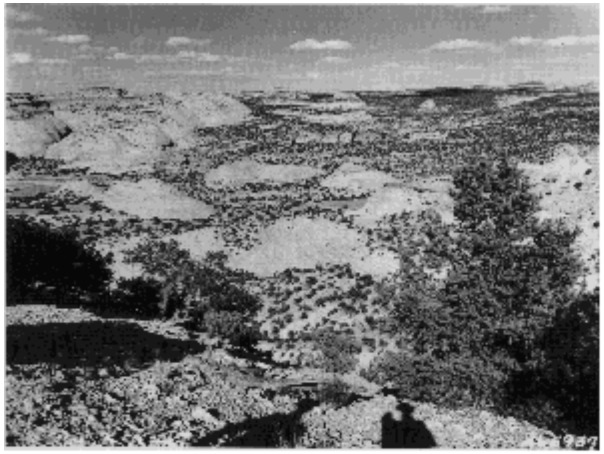
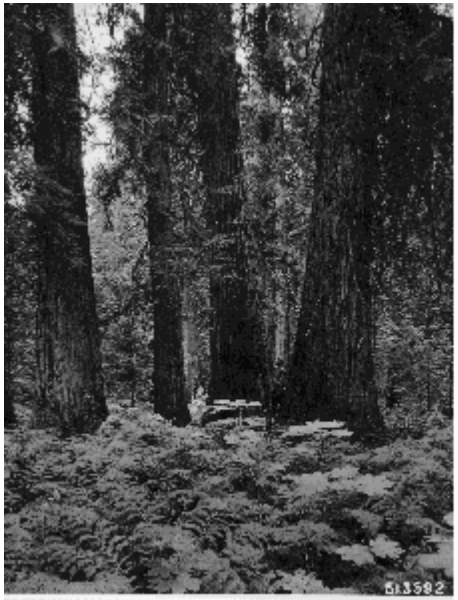
Climate science in the public interest

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

Forested systems:

+Tmax, -precip, +drought → fire

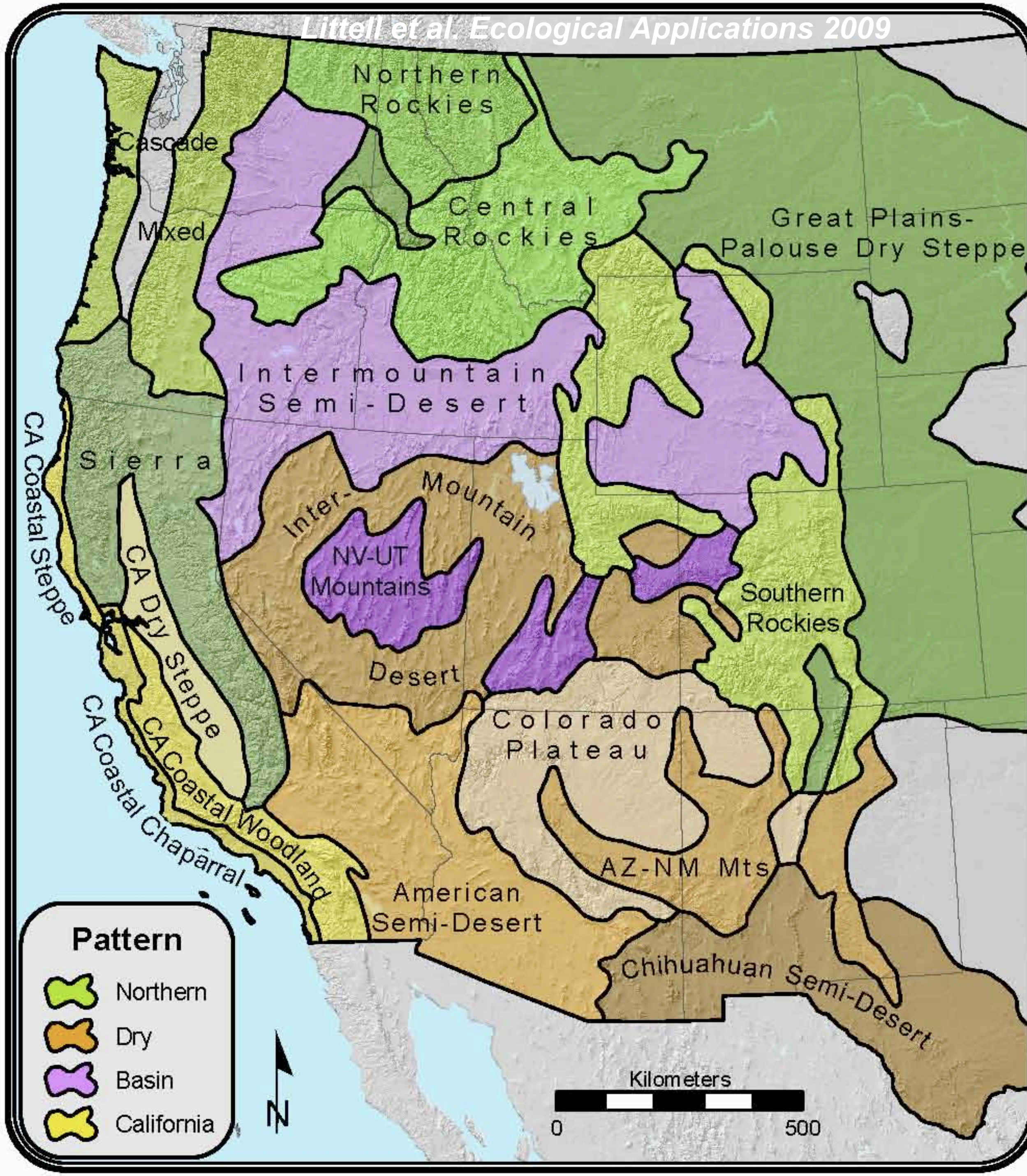
Desert systems:

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

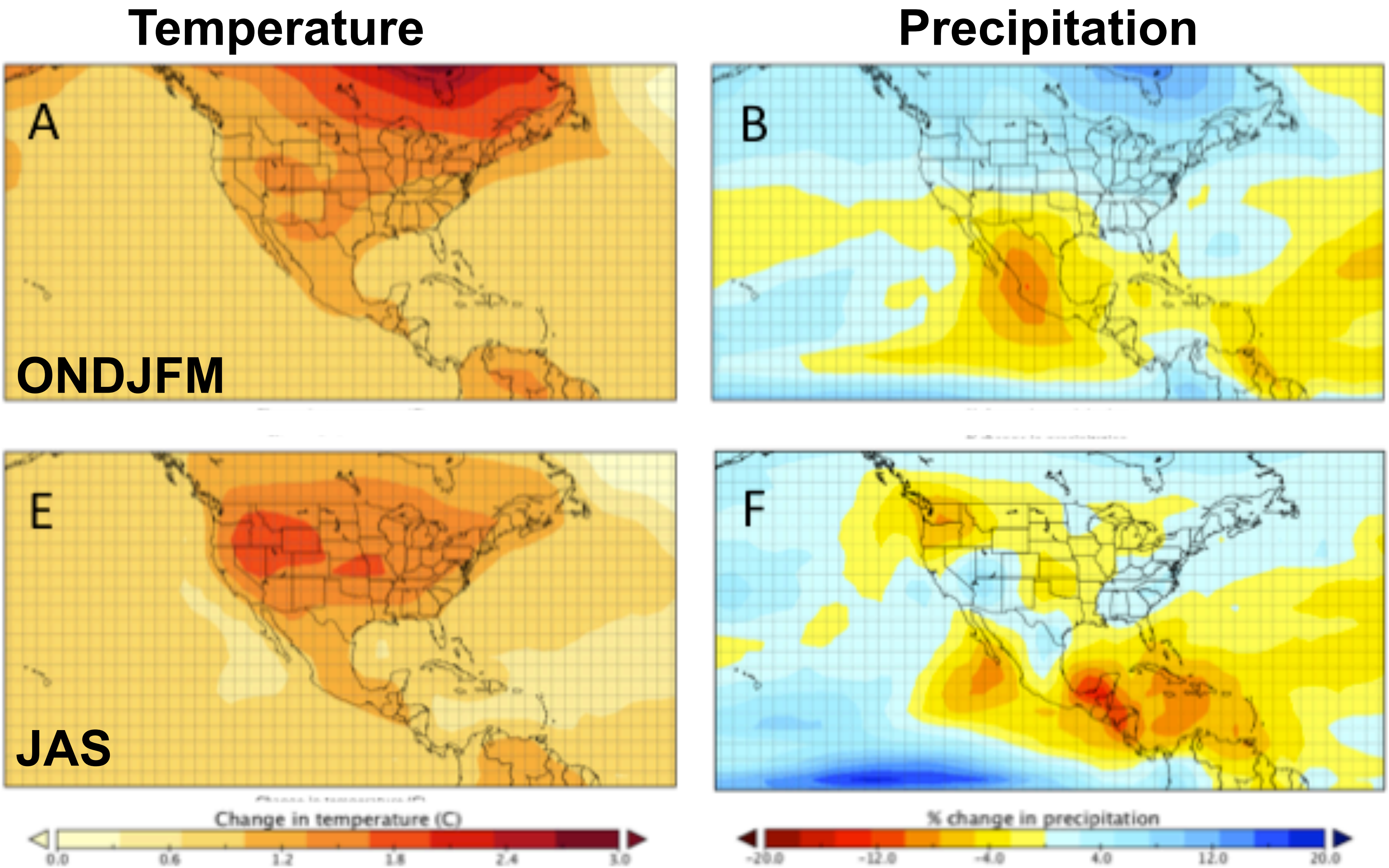
Hybrid systems:

elements of both

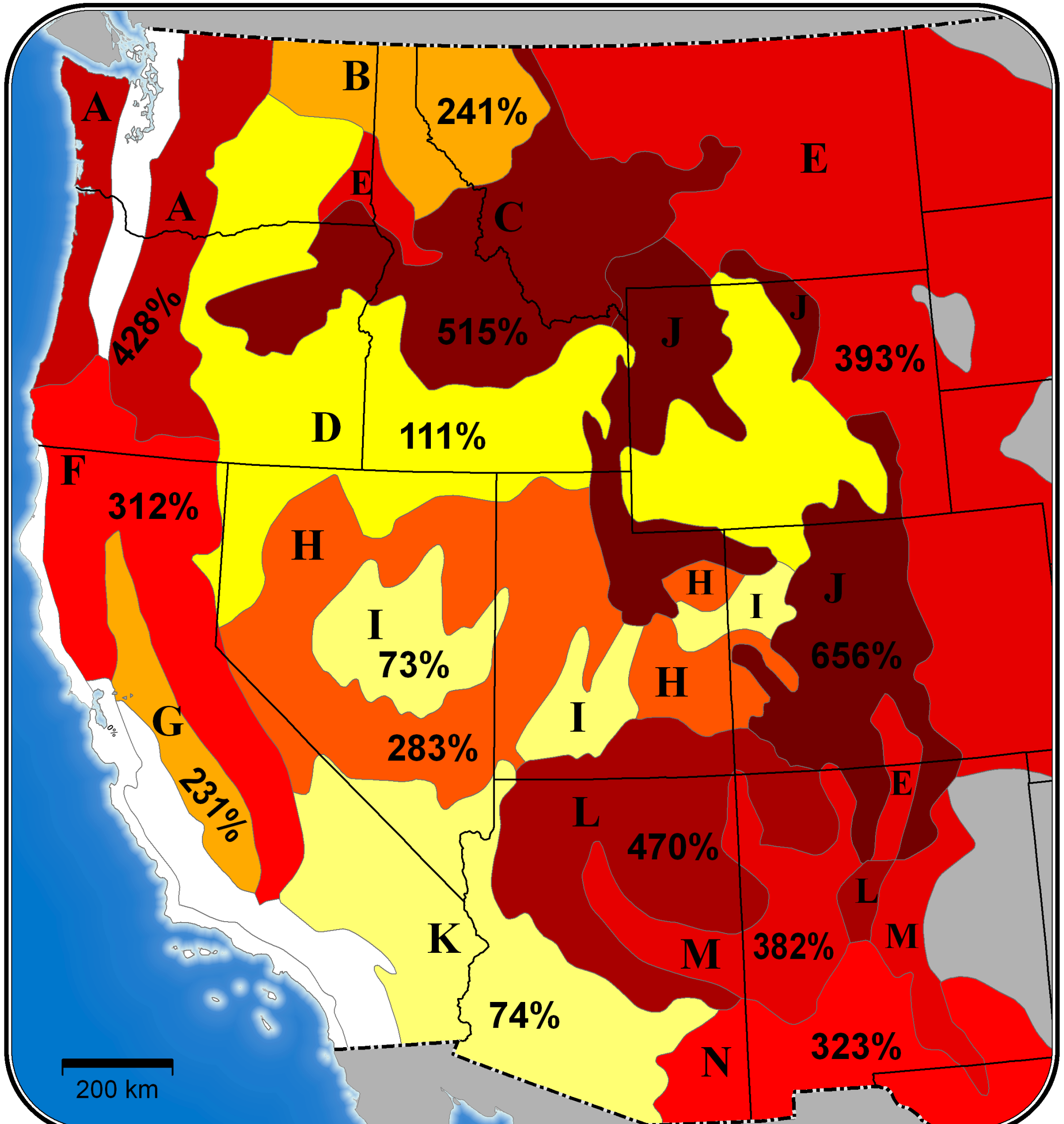
Antecedent pulse of precip + drought



Map: Rob Norheim



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



- 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

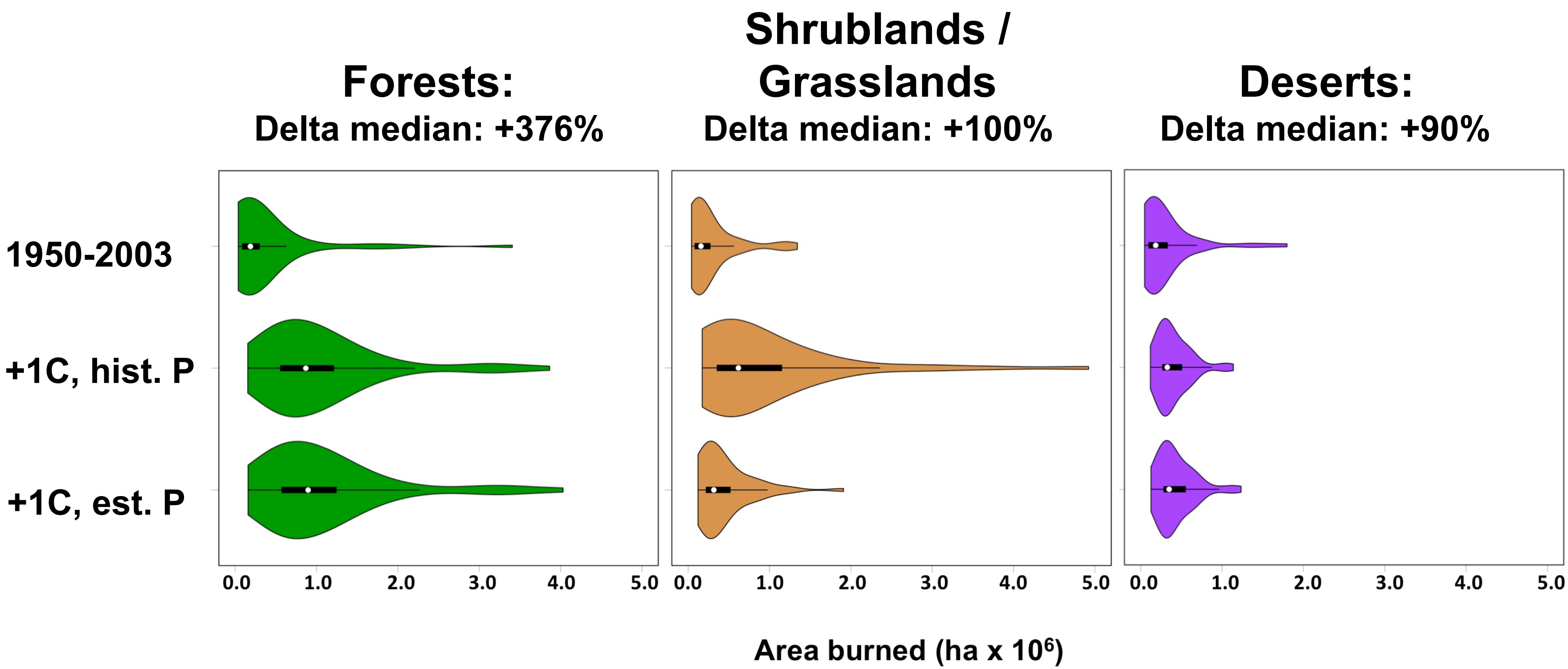
Littell et al., forthcoming

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

- Statistical fire-area regression models from temp and precip
- CMIP 3 models normalized to TCR, ensemble projection of sub-regional climate expected with +1C and % change in precipitation.
- Forested / mountain ecosystems increase much more than shrub and grassland systems

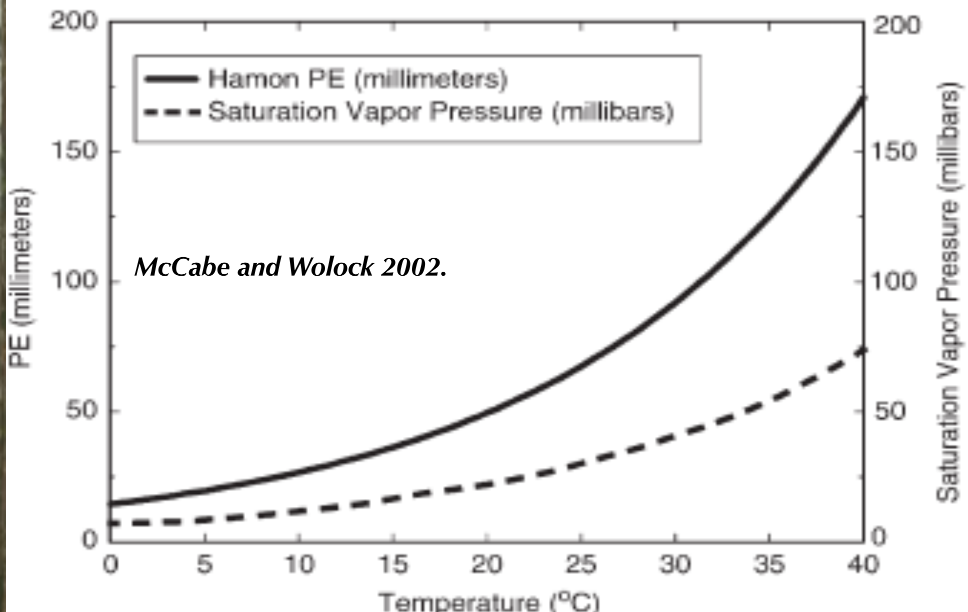
Map. R. Norheim,
Climate projections: Battisti & Tebaldi
Fire data and analysis: Littell

Changes in fire area probability by fire-climate sensitivity



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

The role of increased evapotranspiration



Water balance deficit is the Difference (or ratio) between potential evapotranspiration an actual evapotranspiration

PET – AET = deficit

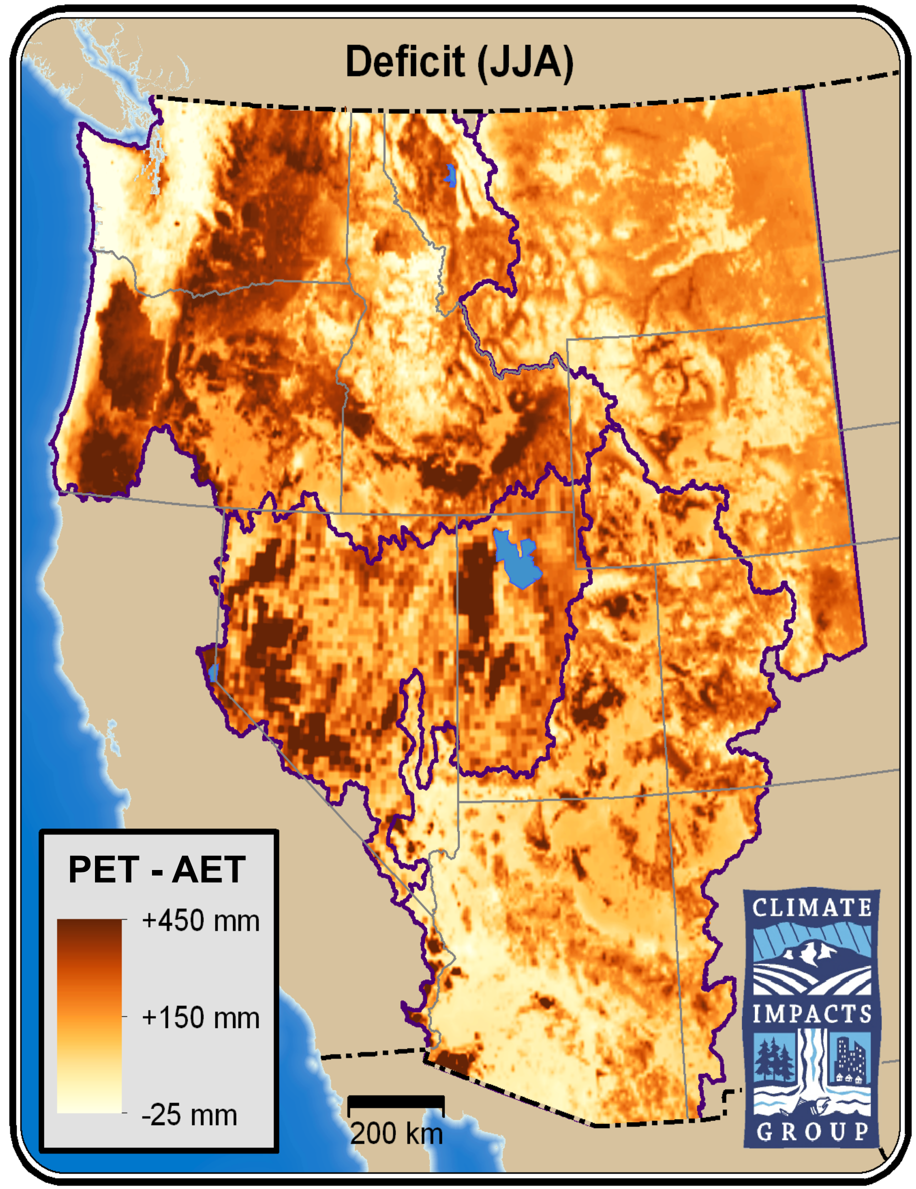
Water balance and disturbance

- ***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

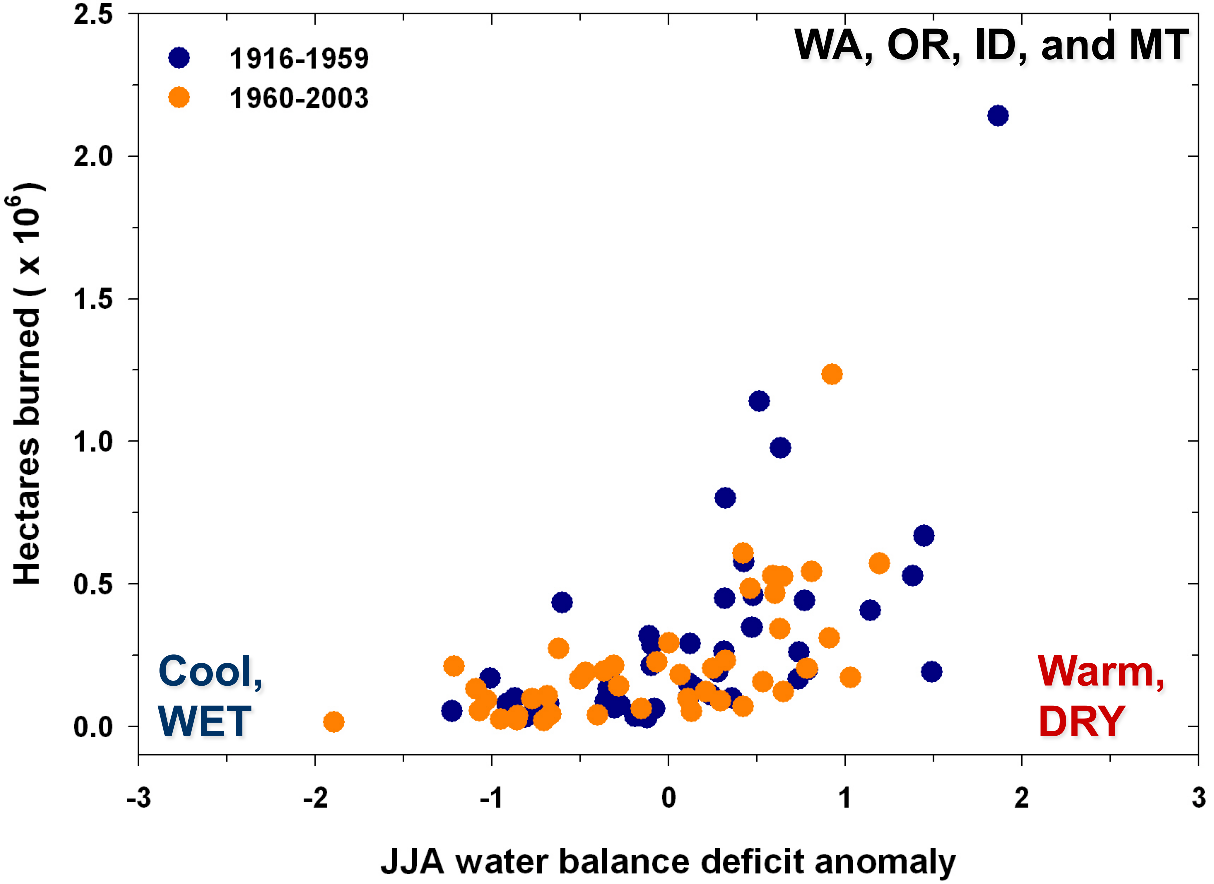
- +Deficit = more drought
- - Deficit = surplus



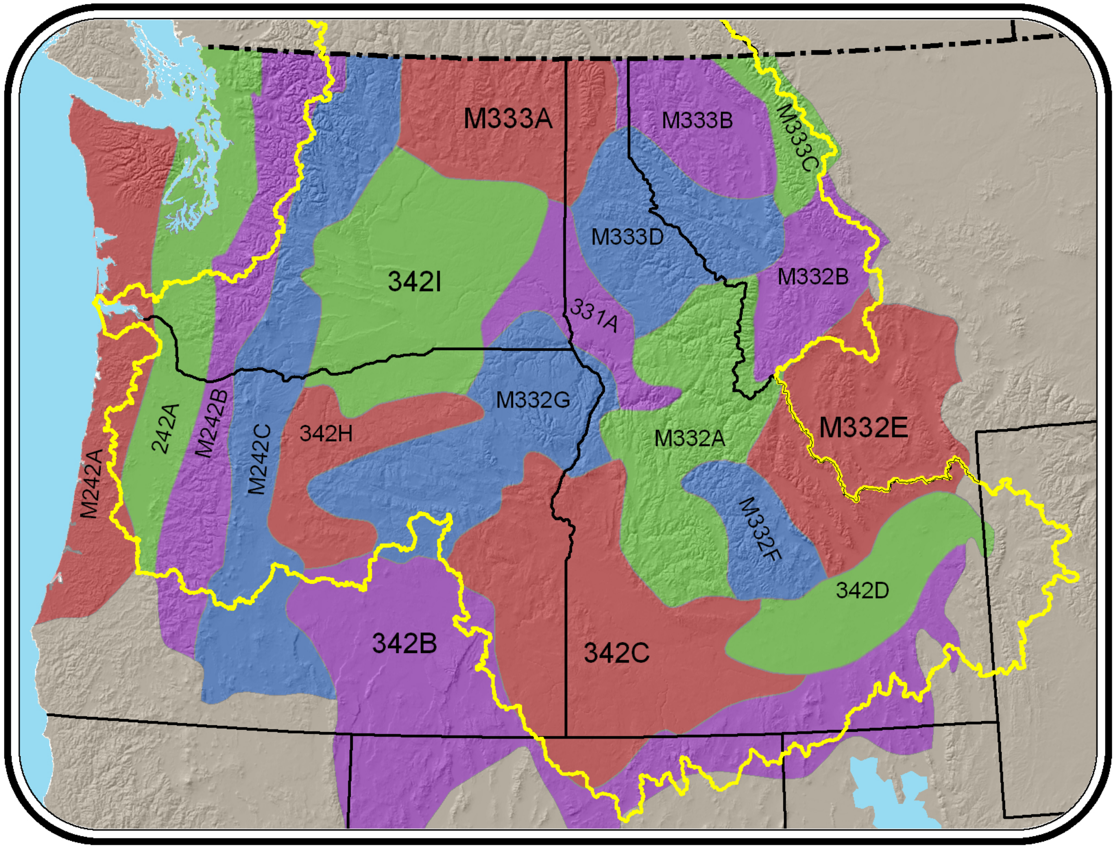
Littell et al. 2011. Ensemble of 10 GCMs, VIC hydrologic modeling

Map: Rob Norheim

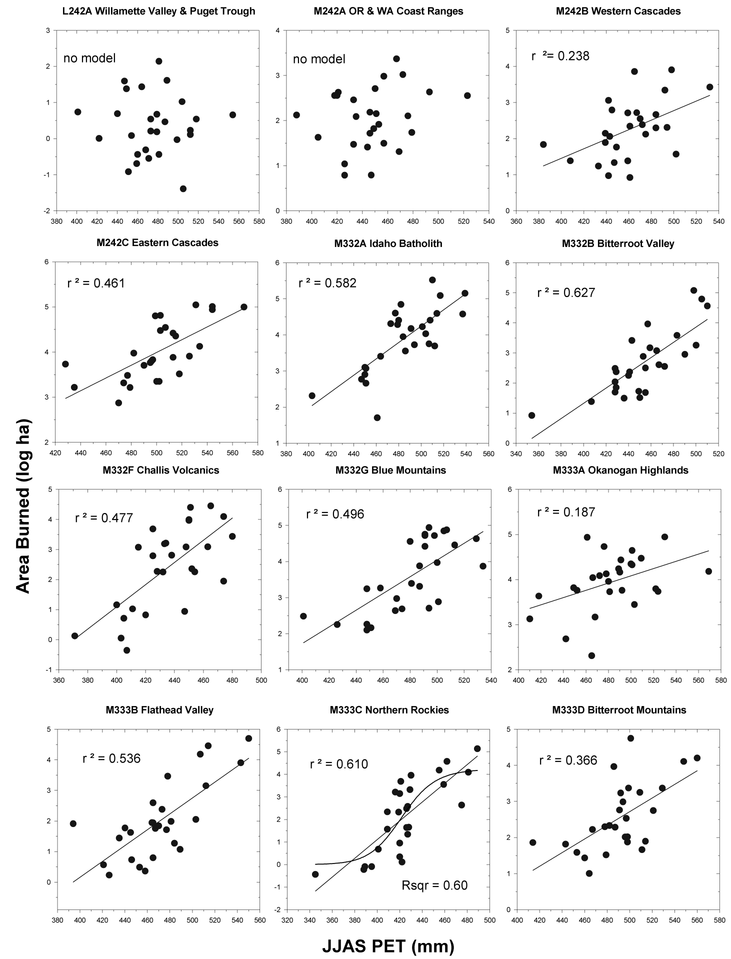
Fire Area Burned and Summer Climate: A Non-linear Relationship in the 20th Century



Fire – water balance ad PET regressions optimized for 1980-2006 fire in Bailey's ecosections in the Columbia Basin



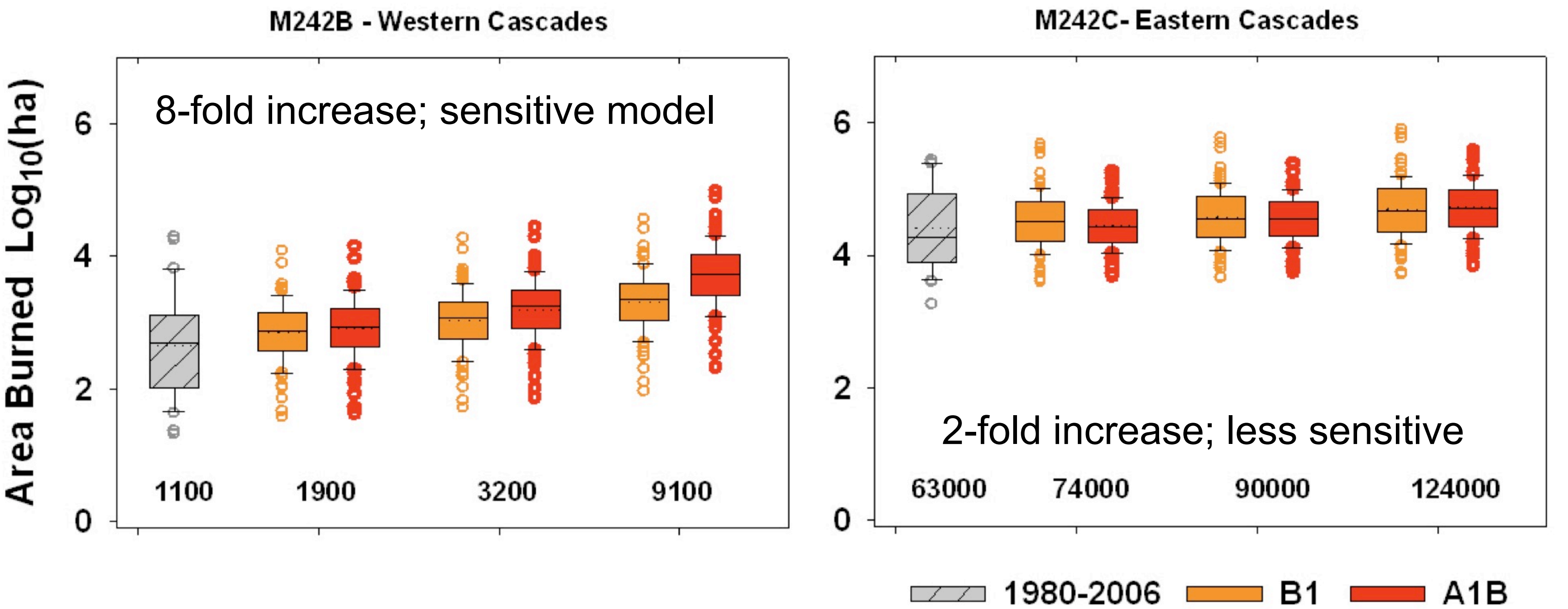
Map: Rob Norheim



Statistical fire models vary in skill: mean R^2~0.6

Most skill in best models is from JJAS PET

Future area burned in ecosections



- Is the future area burned distributed the same across fire sizes and severity as current fires?

Based on statistical fire models and future climate derived from 20 GCMs and the VIC hydrologic model. Best models include: summer precip + summer temp OR summer water balance deficit. Littell et al. 2010 Climatic Change

Bias Corrected and Downscaled WCRP CMIP3 Climate and Hydrology Projections

RECLAMATION USGS CLIMATE CENTRAL Santa Clara University SCRIPPS INSTITUTION OF OCEANOGRAPHY

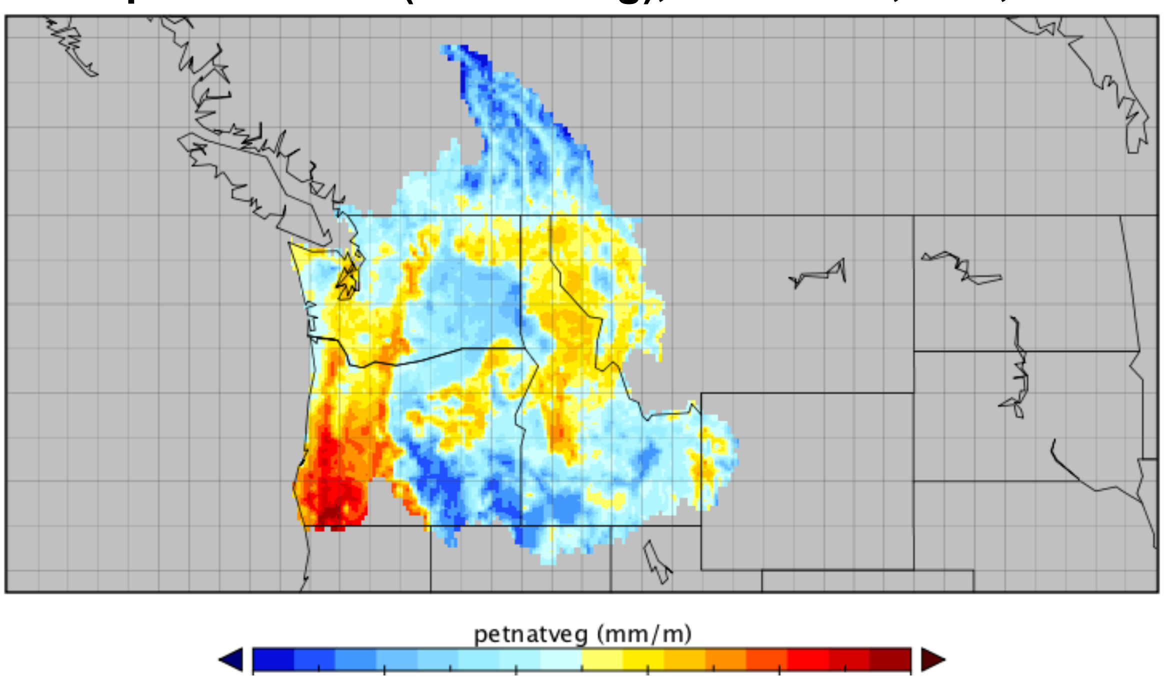
http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections/

1) Bias corrected, empirically downscaled temperature and precipitation: up to 39 realizations of GCMs for B1, A1B, A2

2) For each: VIC hydrological model forced by temperature and precipitation projections to get PET, AET, snowpack etc. at ~12km

3) Variables used in statistical fire models

September PET (natural veg), Echam 5.1, A1B, VIC



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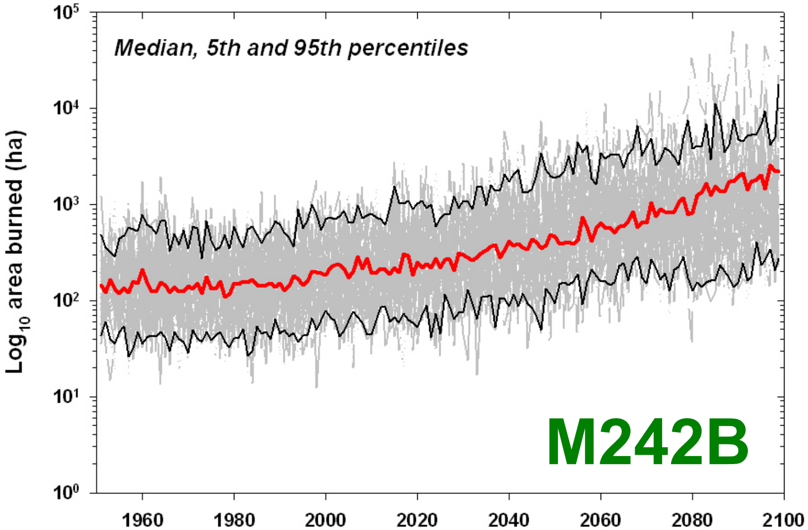
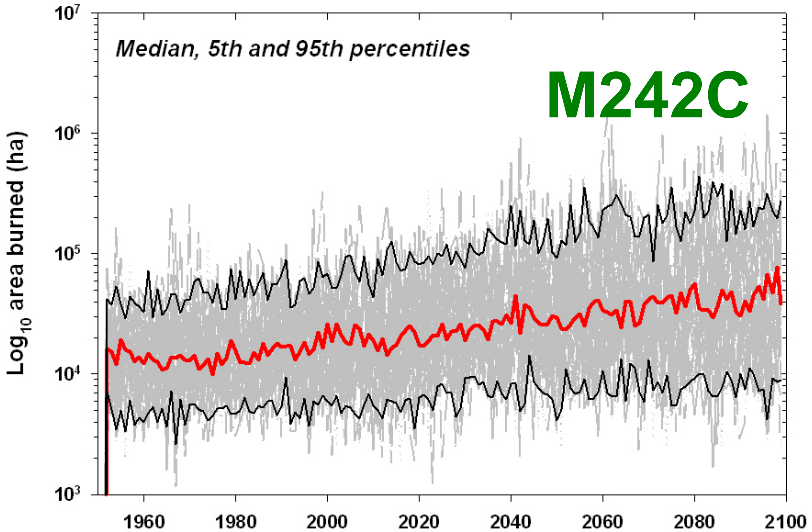
Ensemble response in different fuel types:

Hybrid models decrease,
Forest models increase



% Change: 2040s	median	5%ile	95%ile
A1B	210	150	260
A2	165	135	230
B1	144	87	135



% Change: 2040s	median	5%ile	95%ile
A1B	100	40	180
A2	90	50	170
B1	75	30	115

39 CMIP3 A1B GCM realizations

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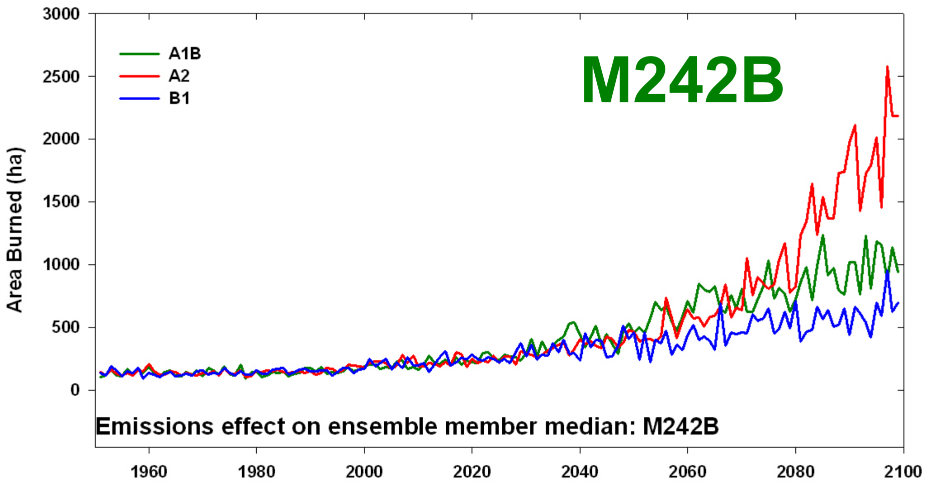
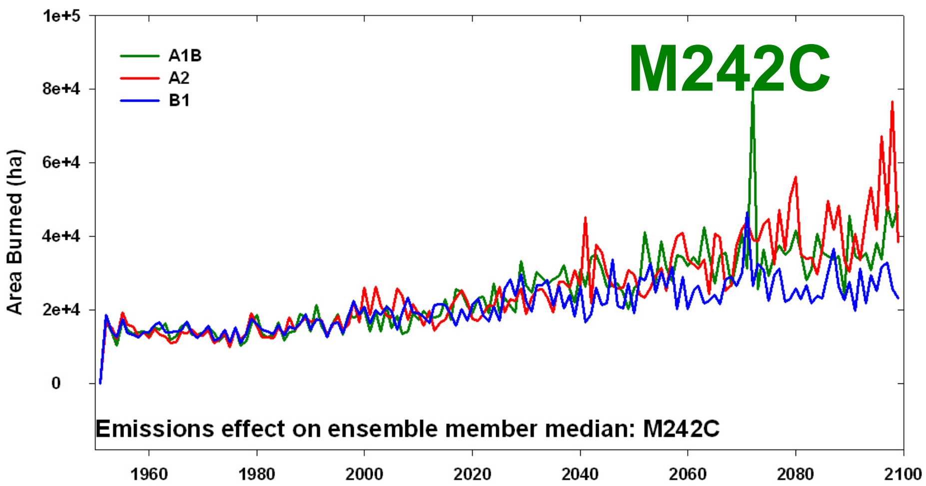
Ensemble median response across emissions scenarios:

Where fire is driven by precip. facilitation, scenarios similar.
Where fire is driven by PET or PET-AET, scenarios different.





Limits of statistical fire modeling

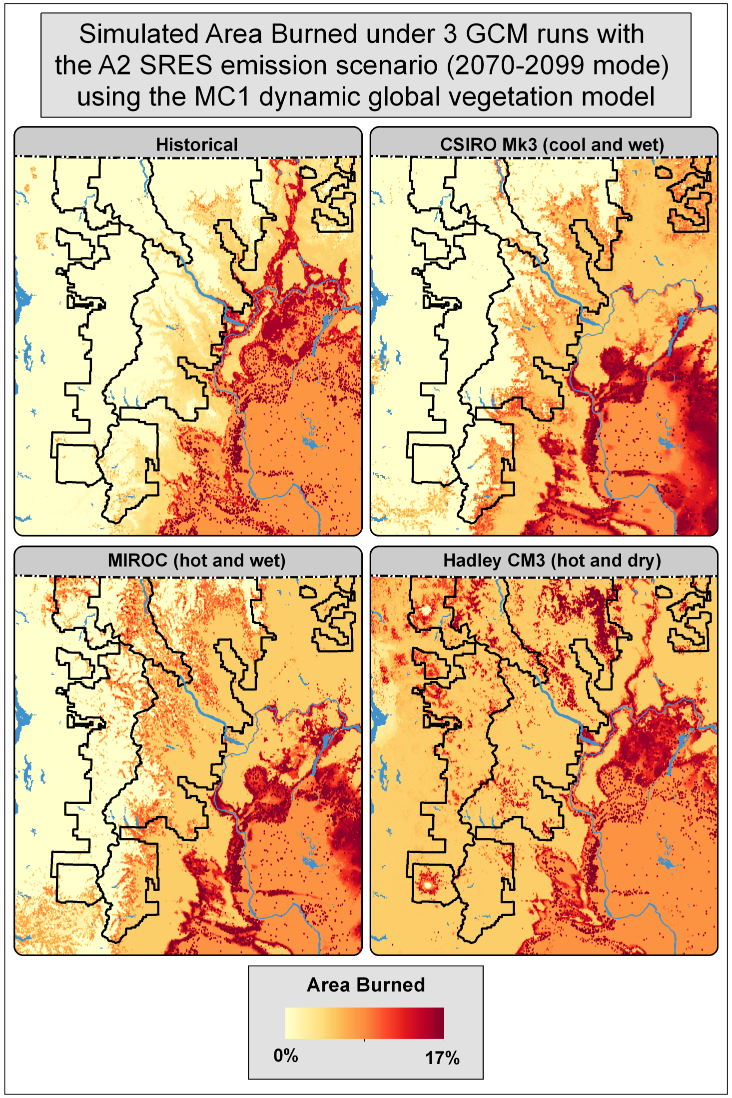
Rate of area burned suggests vegetation will be dynamic; regression models assume range of observed variability.

Extreme events projected outside envelope of observed values more uncertain.

Some fire models are too sensitive, others not sensitive enough – limits of regression

Ecology and local constraints or facilitating effects

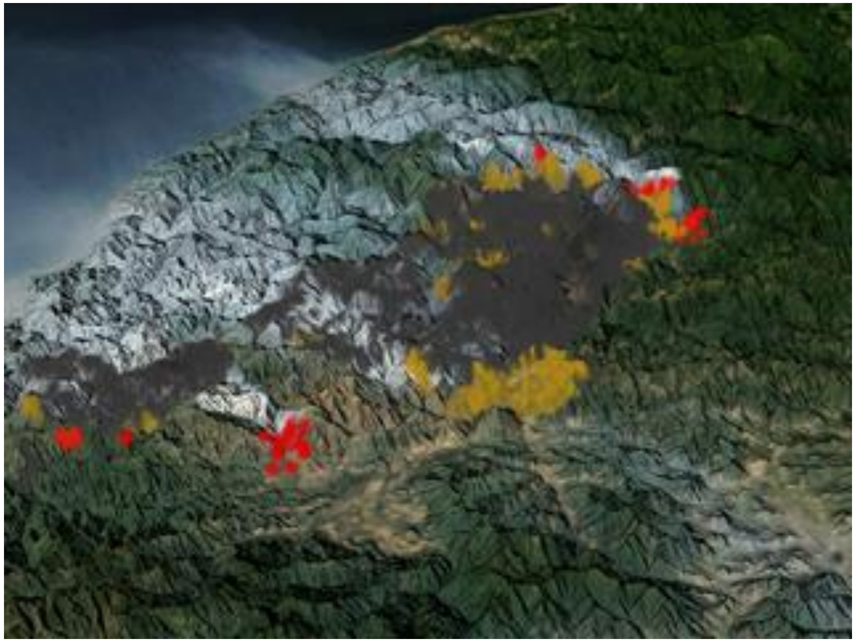
Dynamic Vegetation Models



Map: R. Norheim, after Rogers et al. 2011

What does all this 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 larger fires? How severe are they?
- Is it simply just a longer fire season full of more of the same?



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

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