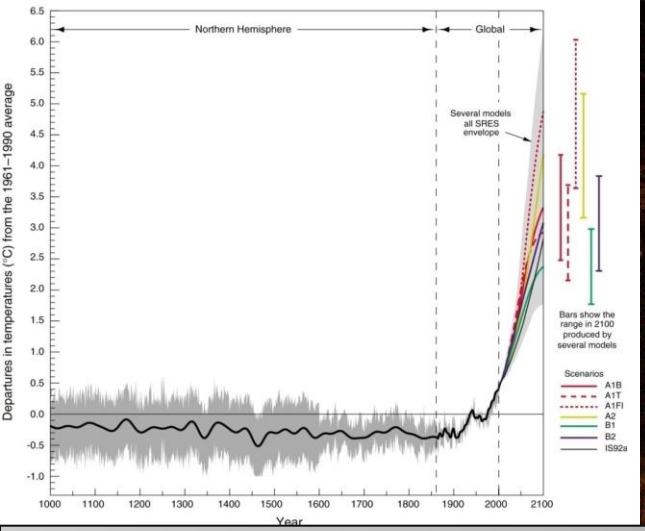
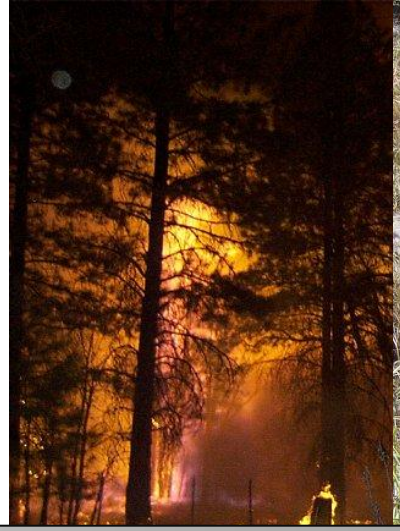
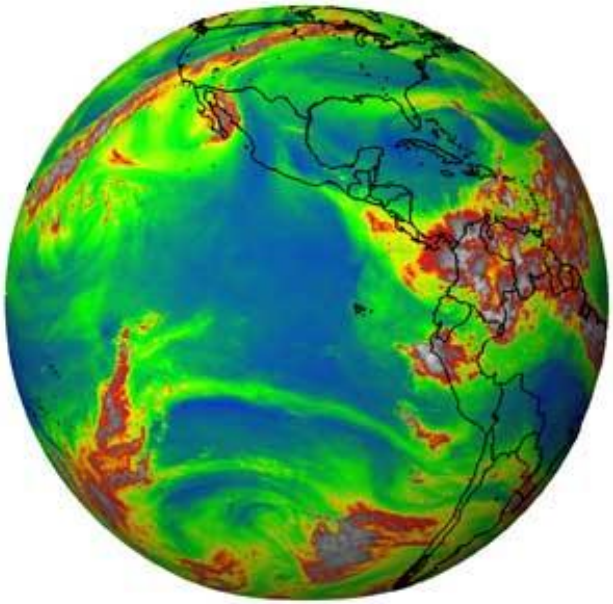


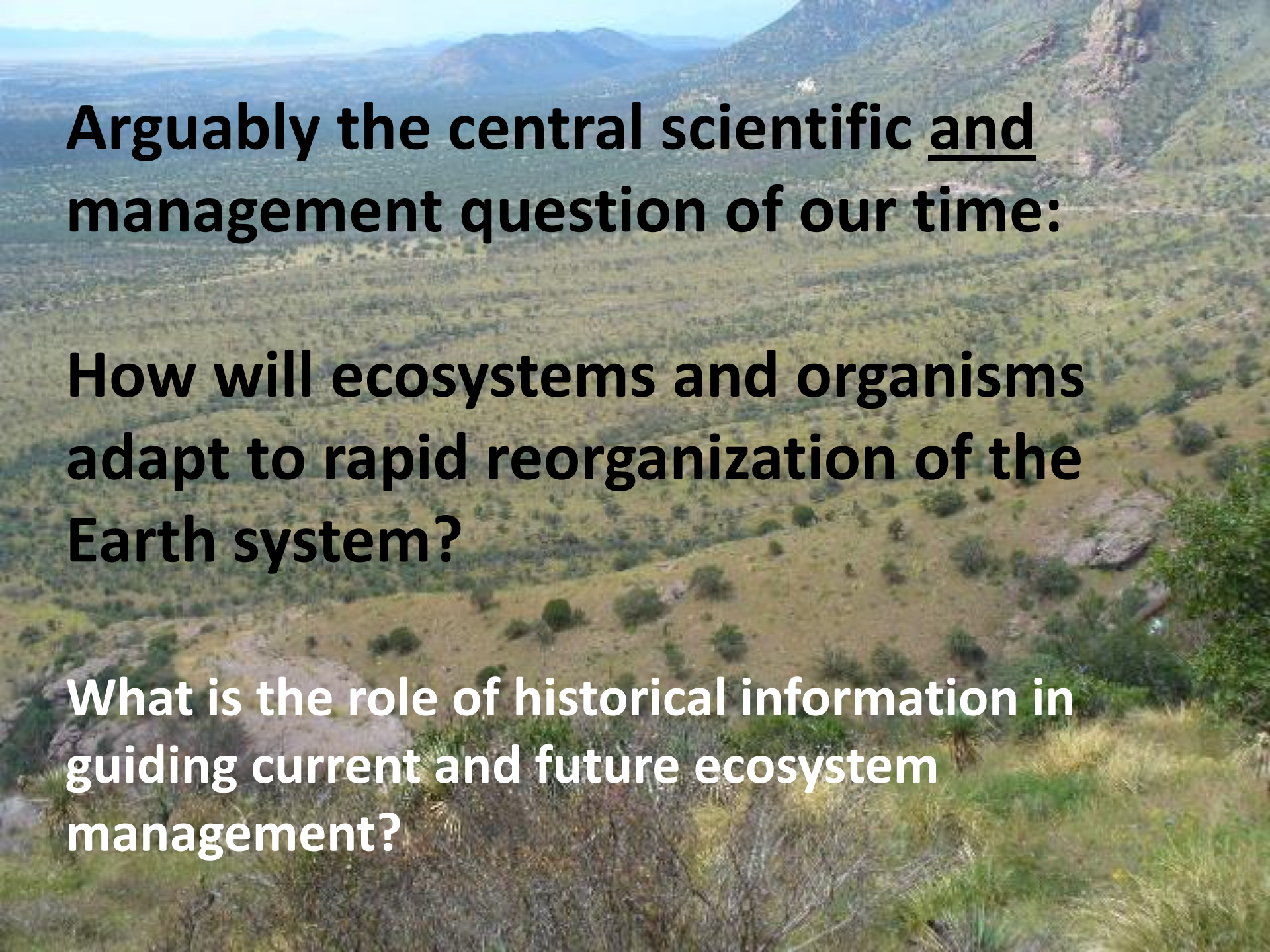


Don Falk, University of Arizona
Julio Betancourt, US Geological Survey



Monitoring Resilience and Restoration in a Changing World

Forest Health Monitoring Working Group, April 2012



Arguably the central scientific <u>and</u> management question of our time:

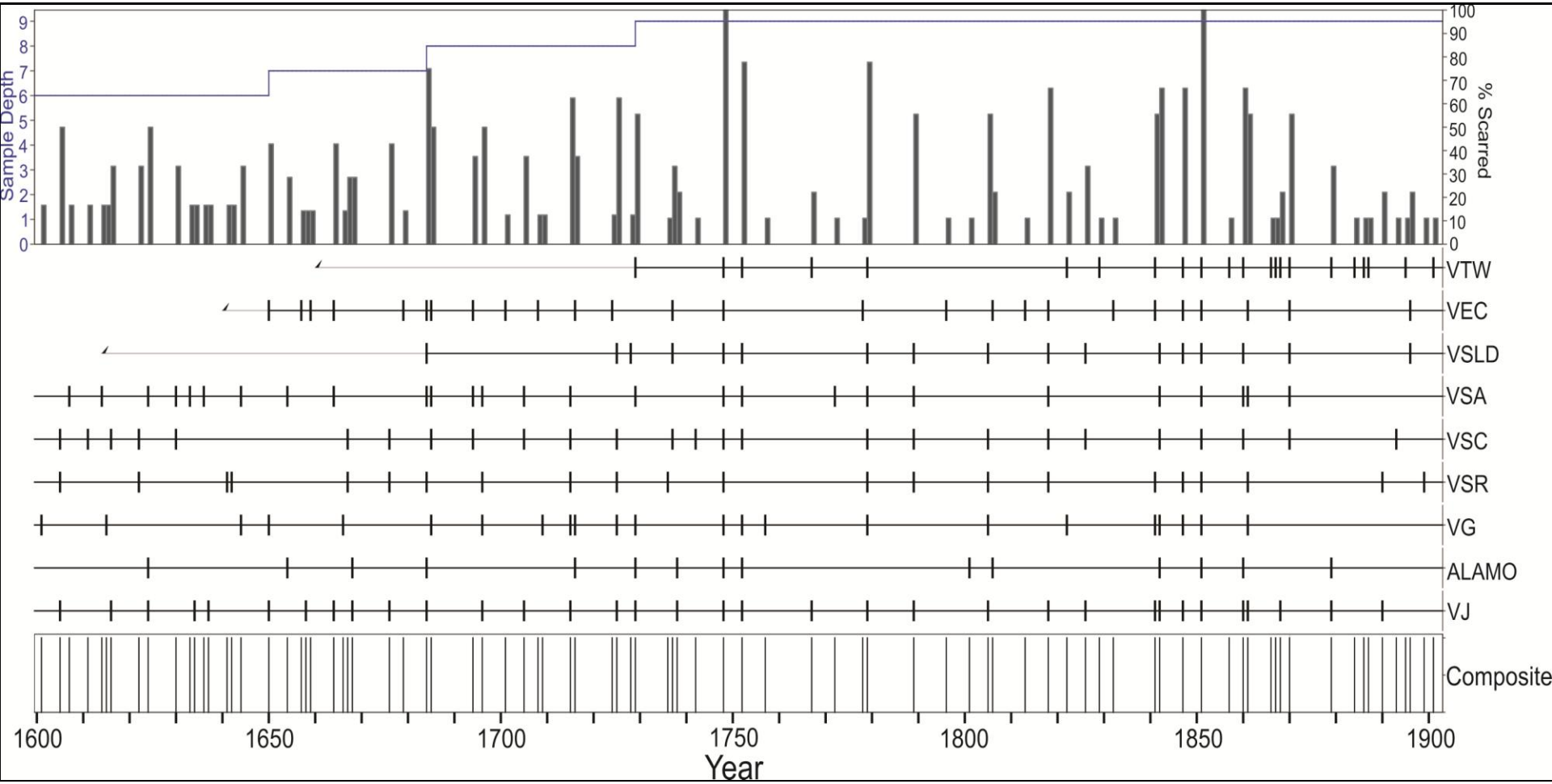
How will ecosystems and organisms adapt to rapid reorganization of the Earth system?

What is the role of historical information in guiding current and future ecosystem management?

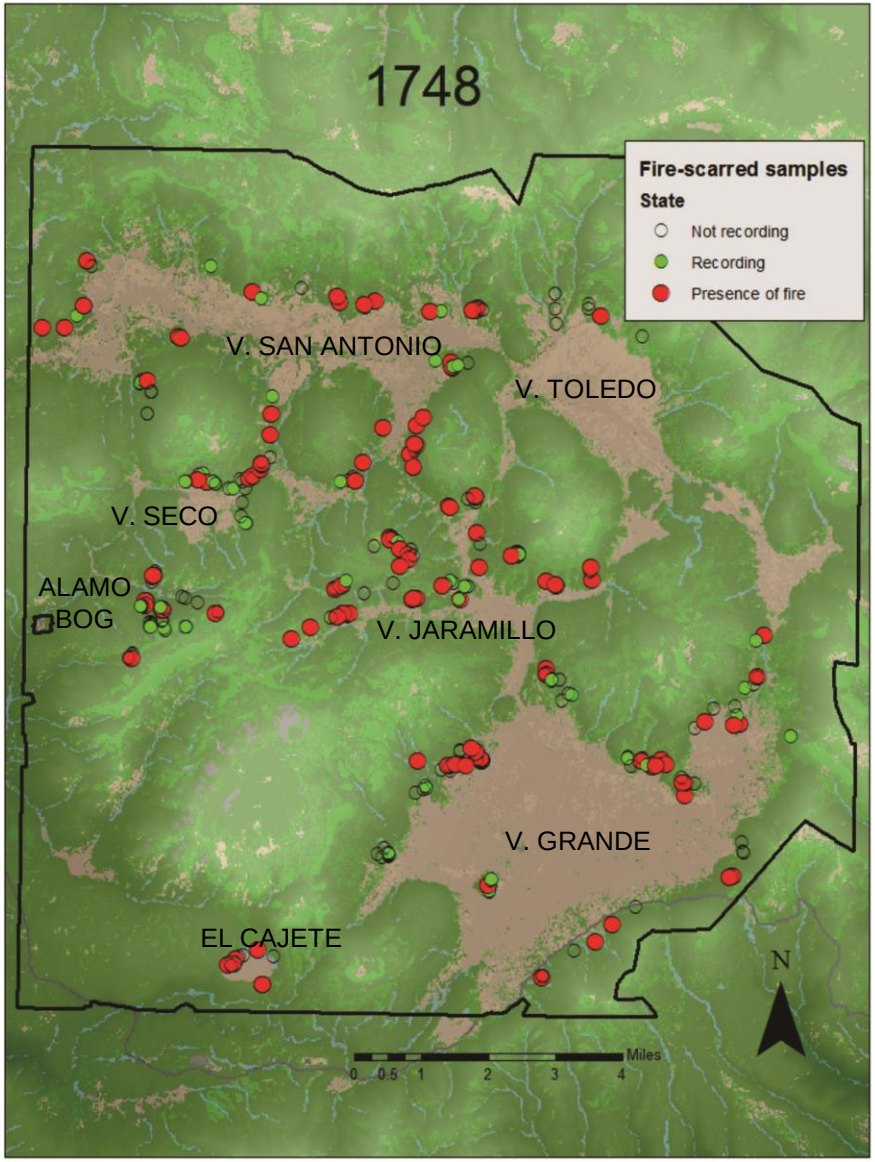
Constituent questions:

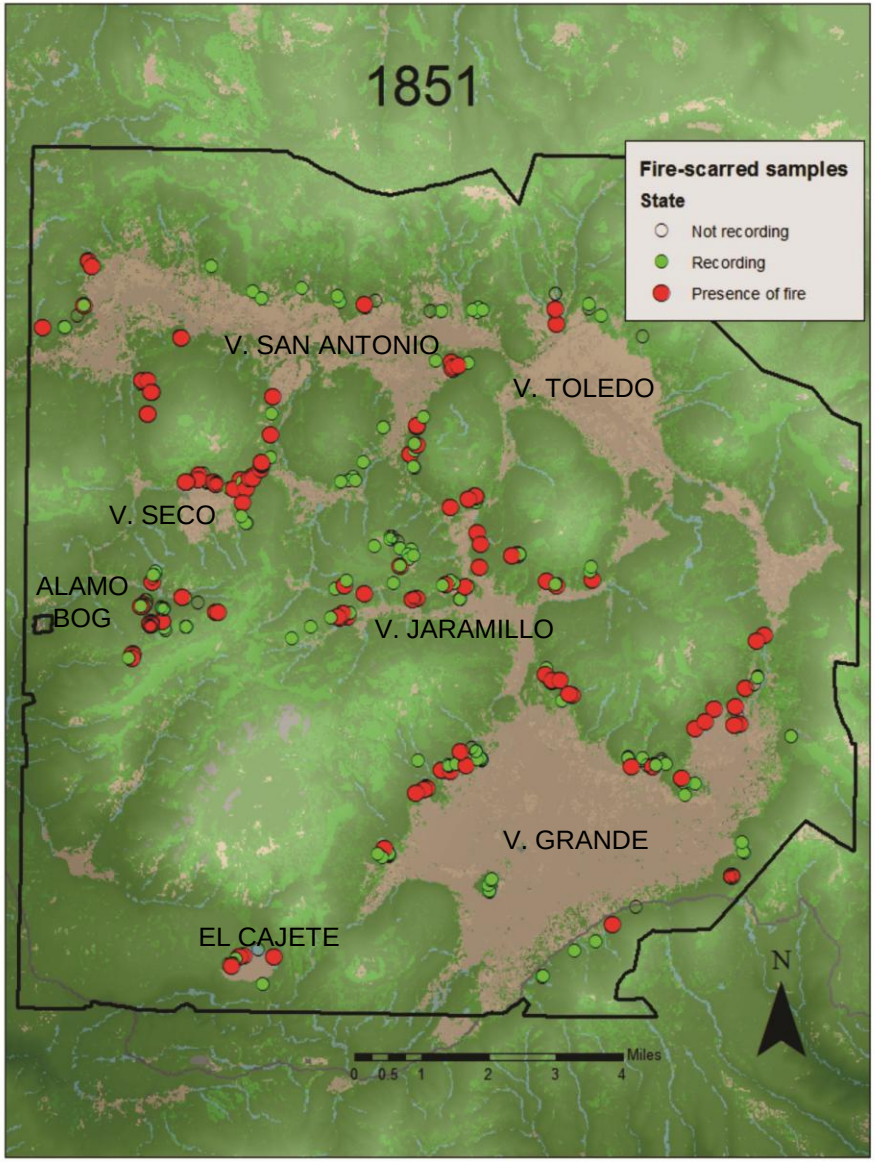
1. What is the role of **ecological history** in guiding current and future ecosystem management?
2. What are the trajectories of **restoration ecology** and land management under novel conditions?

VCNP fire timeline (25% filter)



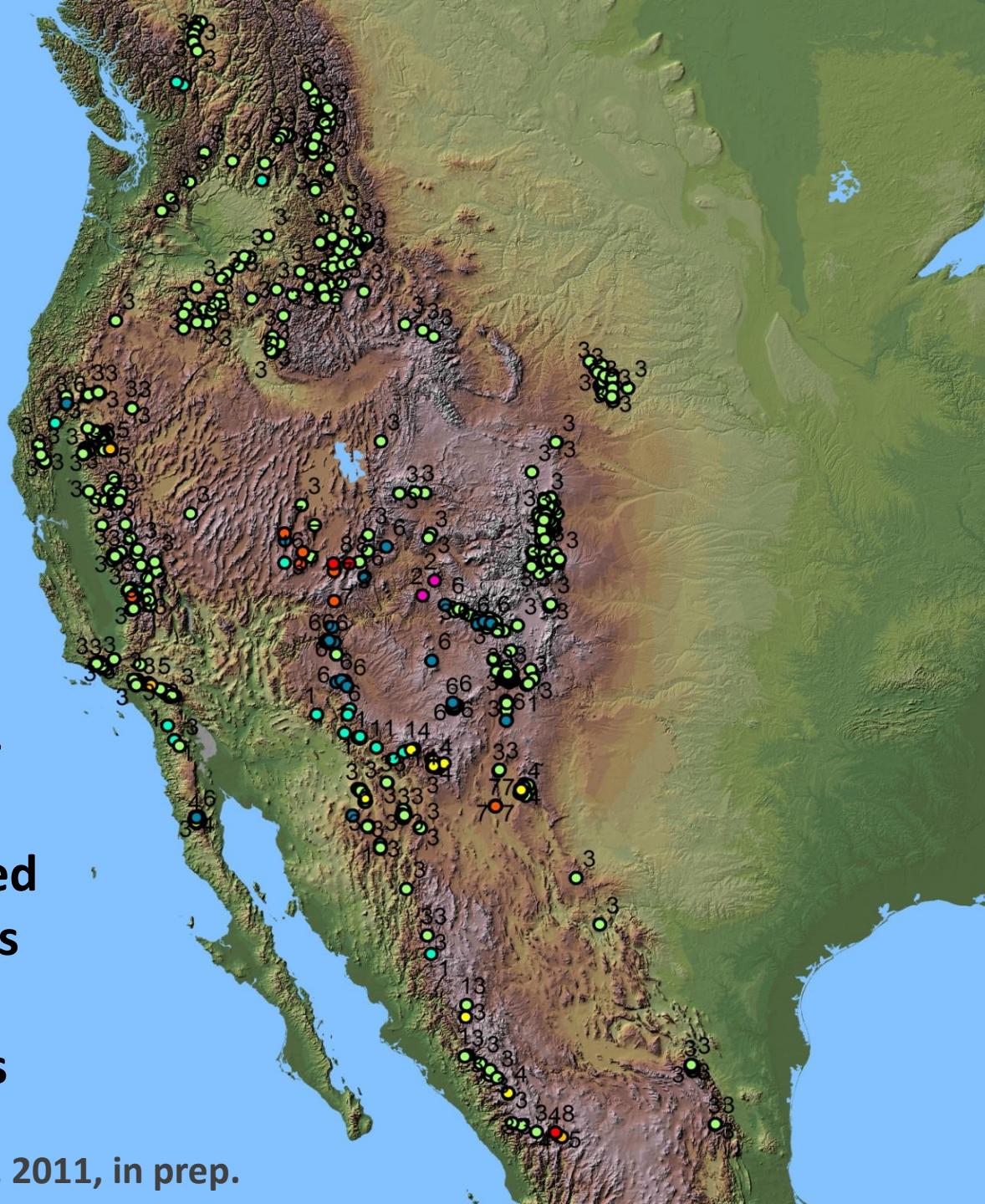
Widespread fire years





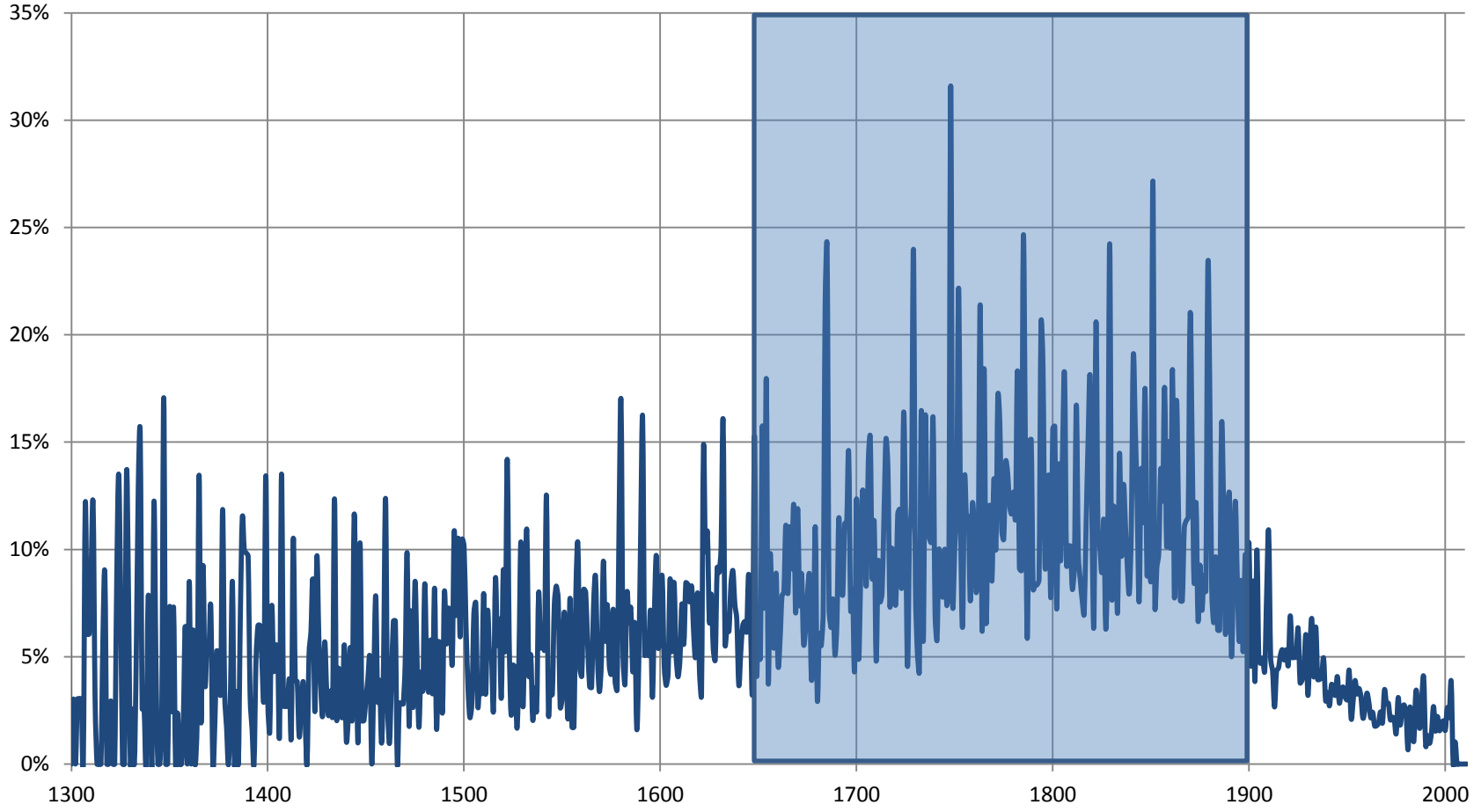
Fire and Climate Synthesis (FACS): A major new network for continental paleoecology

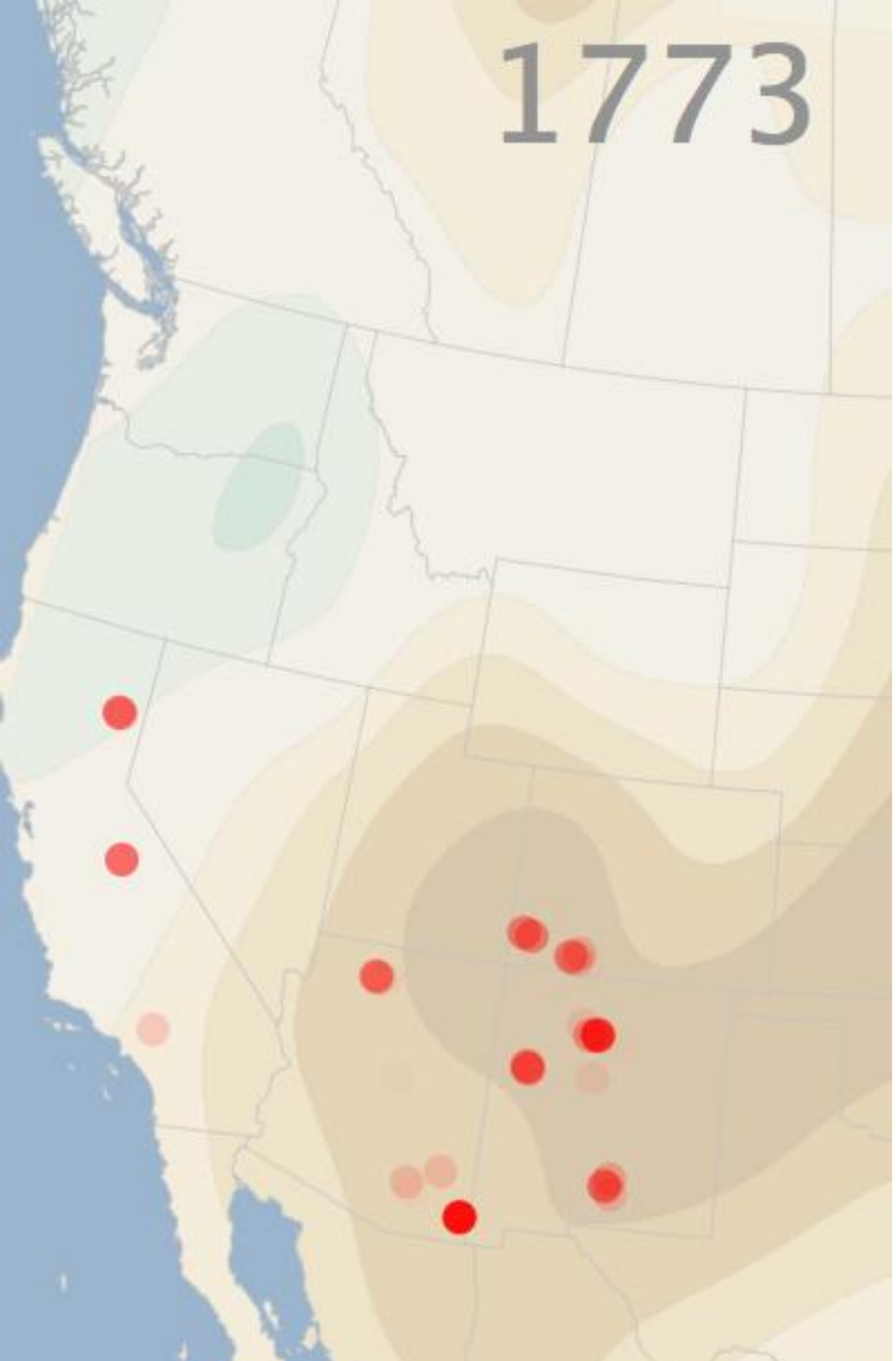
- 1,248 sites
- 64 contributors
- 3,248 years (1248 CE – 2011 CE)
- Fire-scar based, focused on frequent-fire systems
- 7 primary forest types
- > 15,000 fire site-years



Falk et al. 2010, 2011, in prep.

Percent of active sites with fire, 1300-2000

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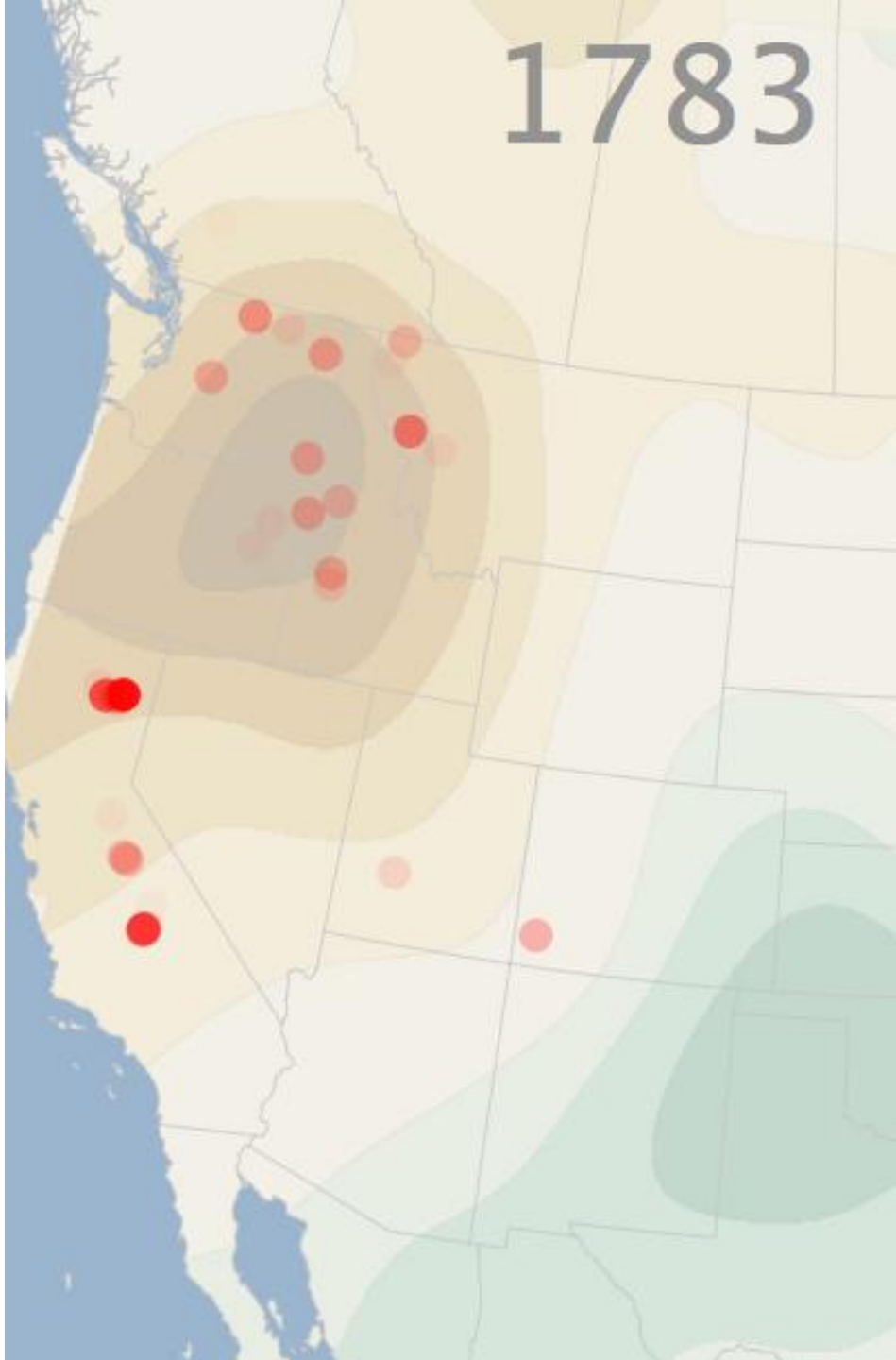
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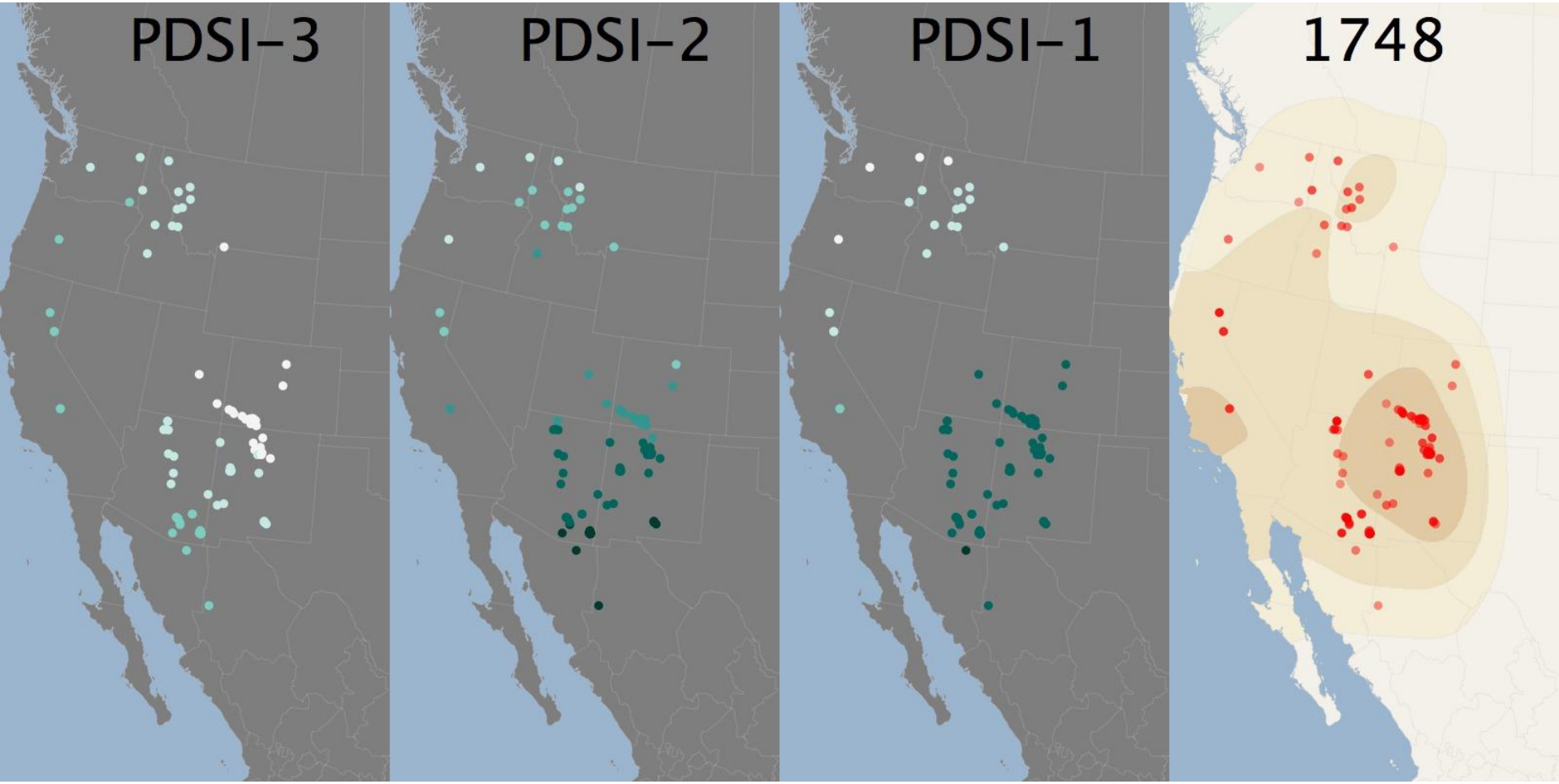
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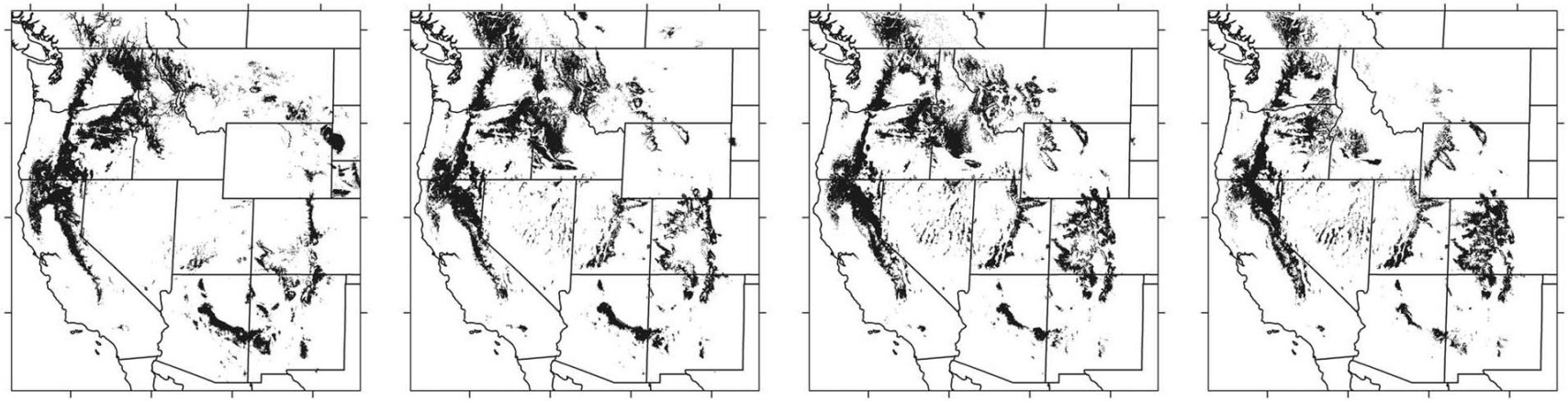
PDSI-1
1748

Are species range shifts an example of adaptation, or a "problem" to be addressed?

Pinus ponderosa

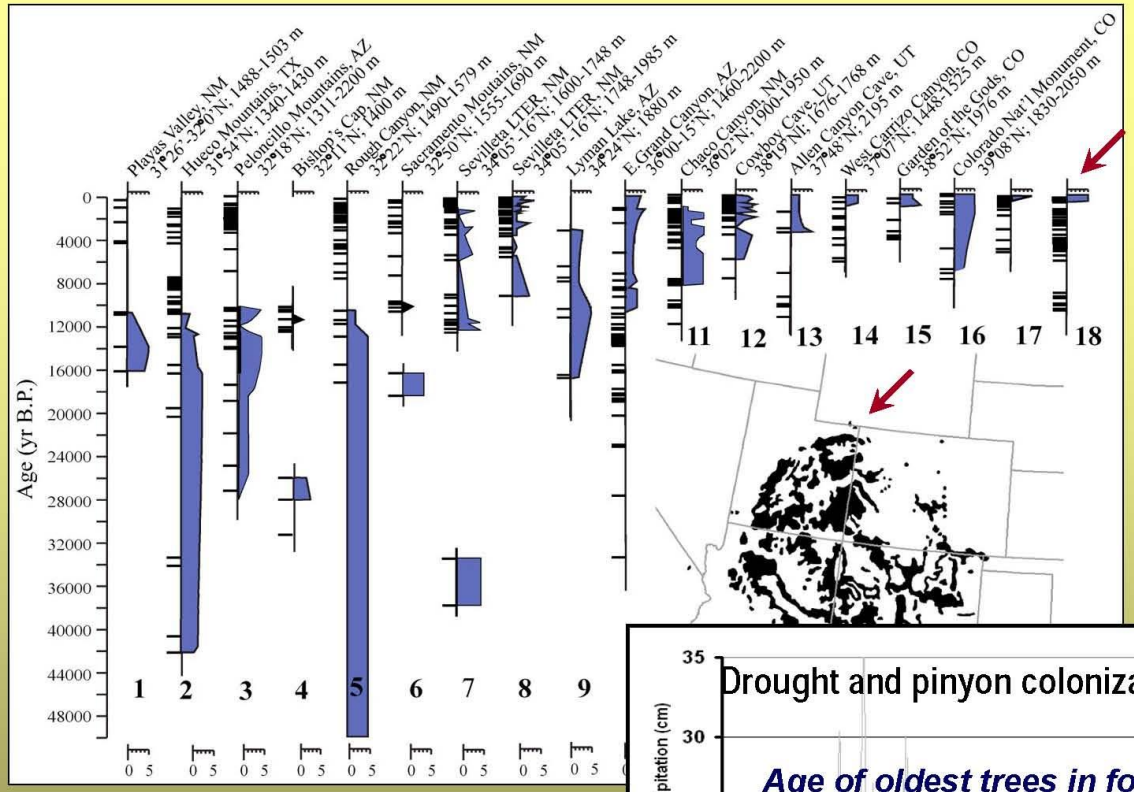


Now 2030 2060 2090

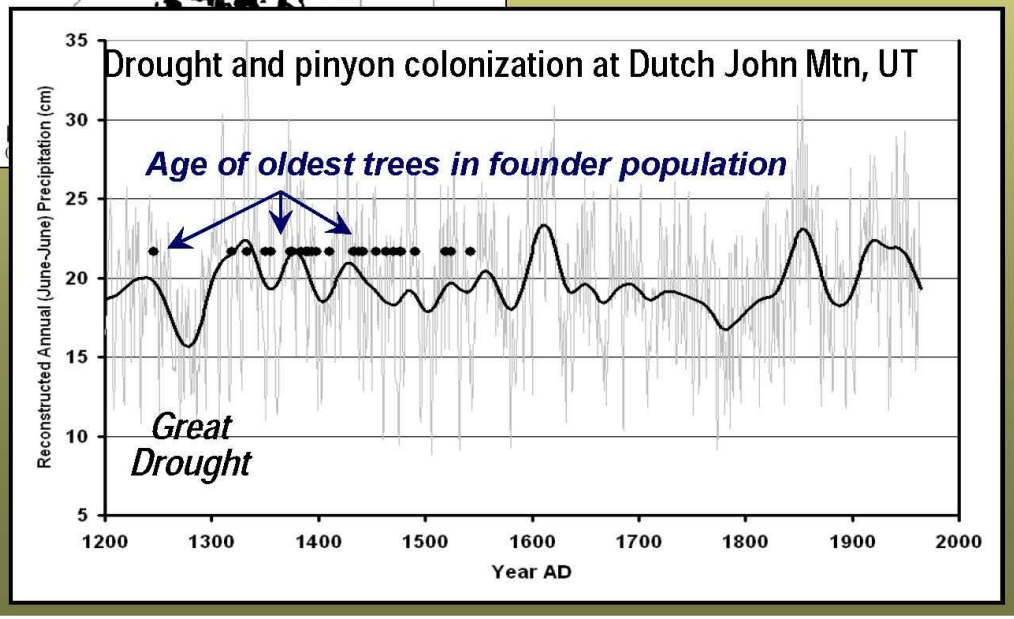
Overall prediction:

- PIPO abundance declines 13% by 2090
- 18% of 2090 distribution is in new areas not currently occupied
- 27 – 36% of current stands remain *in situ*
- *Most lost area is in southern limit of range*

Rehfeldt *et al.* Int. J. Plant Sci., 2006



Megadrought-driven, regionally synchronized disturbances may account for most plant colonizations and expansions by plants in the West



Gray et al (2006) Role of multidecadal variability in a range extension of pinyon pine. *Ecology*

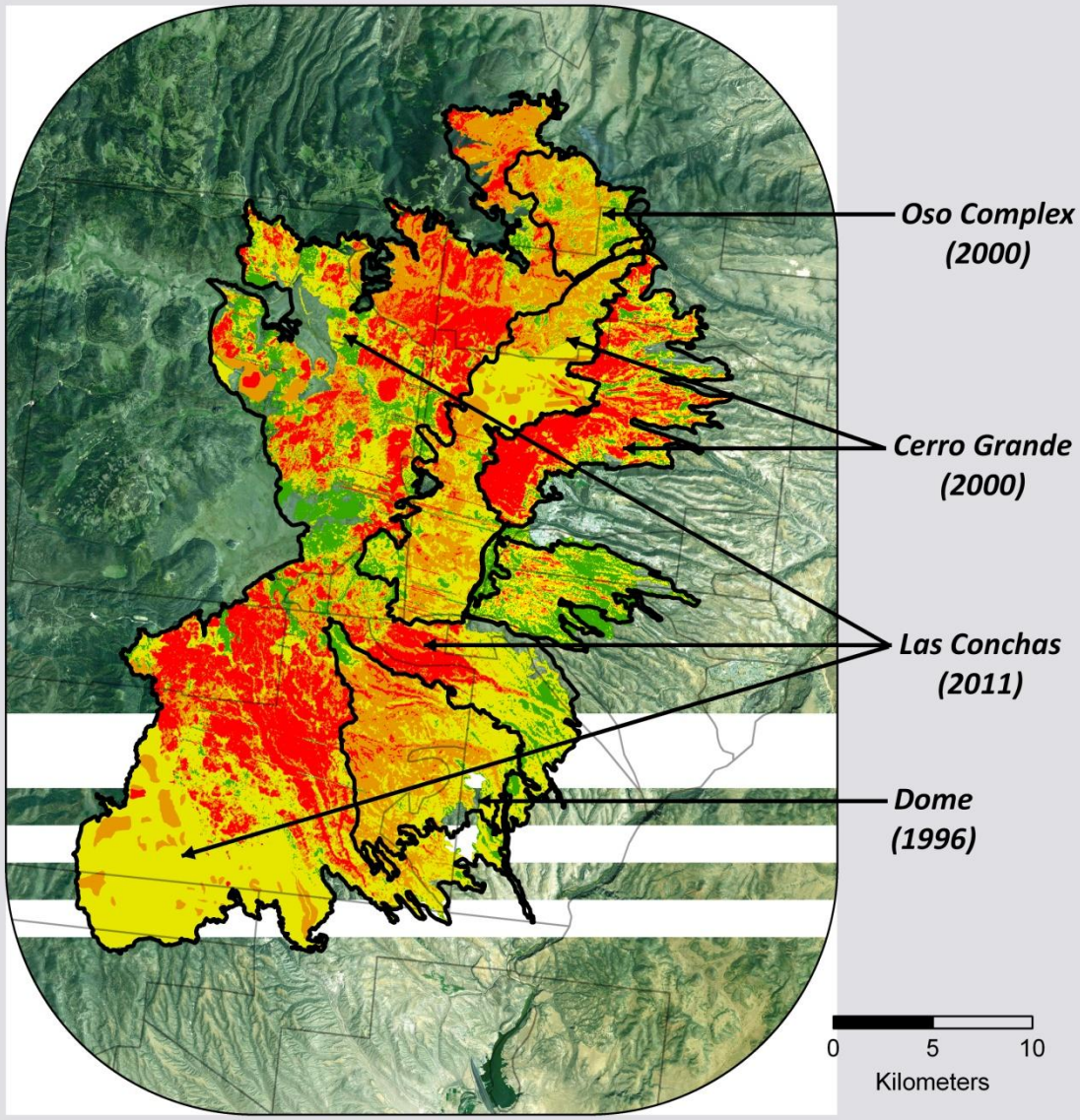
Corta Alloza, Spain

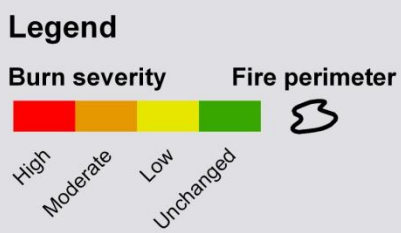
Pune, India

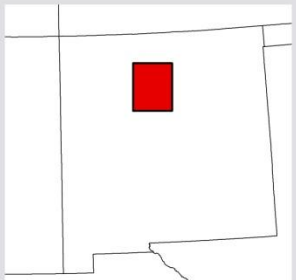
Costa Rica

Port Elizabeth, South Africa

Interactions between climate change, disturbance, and other stressors may be leading ecosystems in new trajectories
Cochiti Canyon, Jemez Mountains, NM, following the 2011 Las Conchas Fire







- Large contiguous high-severity patches (10^4 ha)
- Interactions with previous events (e.g. 1977-1996) fires
- Tipping-point system behavior into new ecosystems

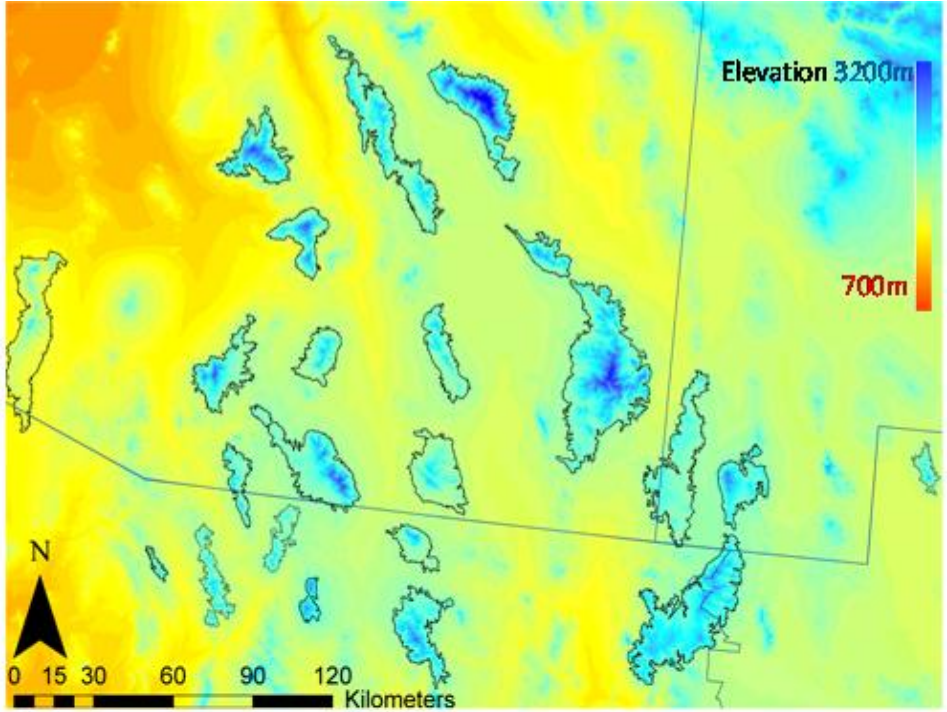
Figure: A. Thode, NAU

Challenges to the traditional restoration paradigm:

- Does future climate create “no-analogue” conditions compared to the ecologically relevant past?
- If future climates move outside the envelope of past variability, then what standard can we use for “restoration”?
- Are some valued restoration objectives moving out of our reach?

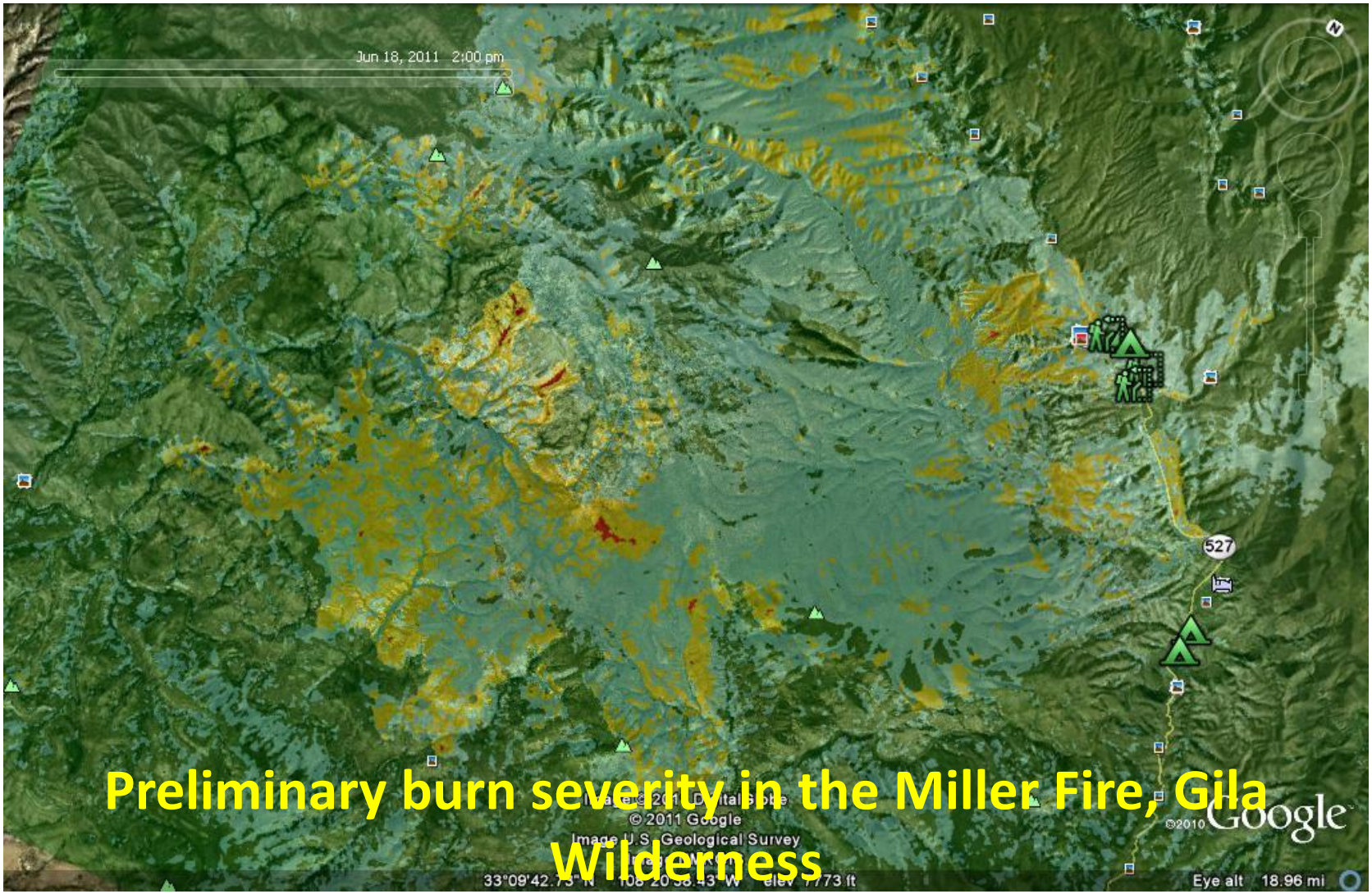
Millar et al. 2007; Fox 2007; Milly et al. 2008; Seastedt *et al.* 2008

Classic restoration paradigm	Resilience ecology paradigm
Target species	Complexity
Equilibrium	Resilience
Persistence	Adaptability
Stasis	Dynamics
Hot spots	Connectivity
Sites	Landscapes
Mean	Variance, higher moments
Composition	Process, function
Past-present reference	Past-present-future continuity
Populations, communities	Ecosystems, fluxes
Predictability	Stochasticity



Can we restore fire and ecosystems at large scales in the Sky Islands bioregion?

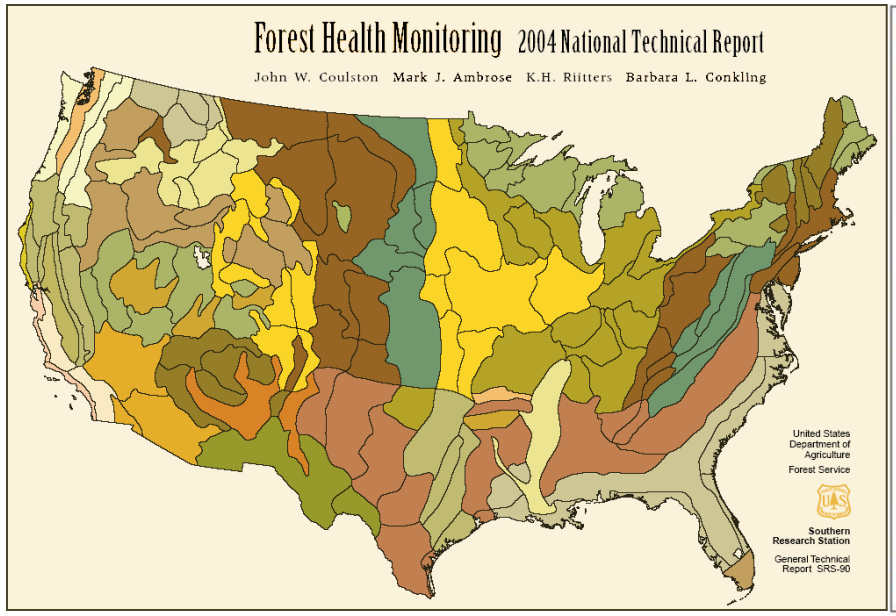
Miller Fire: An important reference fire that demonstrates what happens when fire is allowed to stay in the system



Preliminary burn severity in the Miller Fire, Gila Wilderness

A proposal for a Long-Term Restoration Monitoring Network (LTRMN)

Monitoring outcomes of ecological restoration: a natural extension of National Forest Health Monitoring and NEON?



What would a LTRMN look like?

- Identify restoration projects with longest period of continuous management
- Prioritize projects with ongoing monitoring data and infrastructure
- Distribute strategically among biomes and community types
- Focus on the central question of <u>outcomes</u>

Five principles for monitoring and restoring ecosystems in a changing world

1. Manage for resilience and adaptive capacity, not steady state
2. Allow for the natural range of variability, understand history
3. Emphasize restoration of ecosystem processes
4. Focus on the landscape and regional scales
5. Monitor change across scales of space and time

Thanks:

Erica Bigio, Josh Conver, Jacquie Dewar, Matt Hall, **Tom Swetnam**, University of Arizona

Thomas Kitzberger, Universidad Nacional del Comahue, Argentina

Tony Westerling, University of California – Merced

Peter Brown, Rocky Mountain Tree-Ring Research

Elaine Sutherland, US Forest Service

Craig Allen, USGS

Bob Parmenter, VCNP

Cal Farris, National Park Service

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