RESTORATION OF SOUTHWESTERN FREQUENT FIRE FORESTS: HOW DID WE GET HERE AND WHERE ARE WE GOING?

Andrew Sánchez Meador, Ph.D.
The Ecological Restoration Institute
Northern Arizona University

NORTHERN ARIZONA UNIVERSITY
Ecological Restoration Institute


Old Ponderosa pine in Monument Canyon RNA, New Mexico
photo: Sánchez Meador

OVERVIEW

- Background
- Where are we?
- How did we get here?
- What is coming at us?
- Where are we going?

THE LEAST YOU NEED TO KNOW

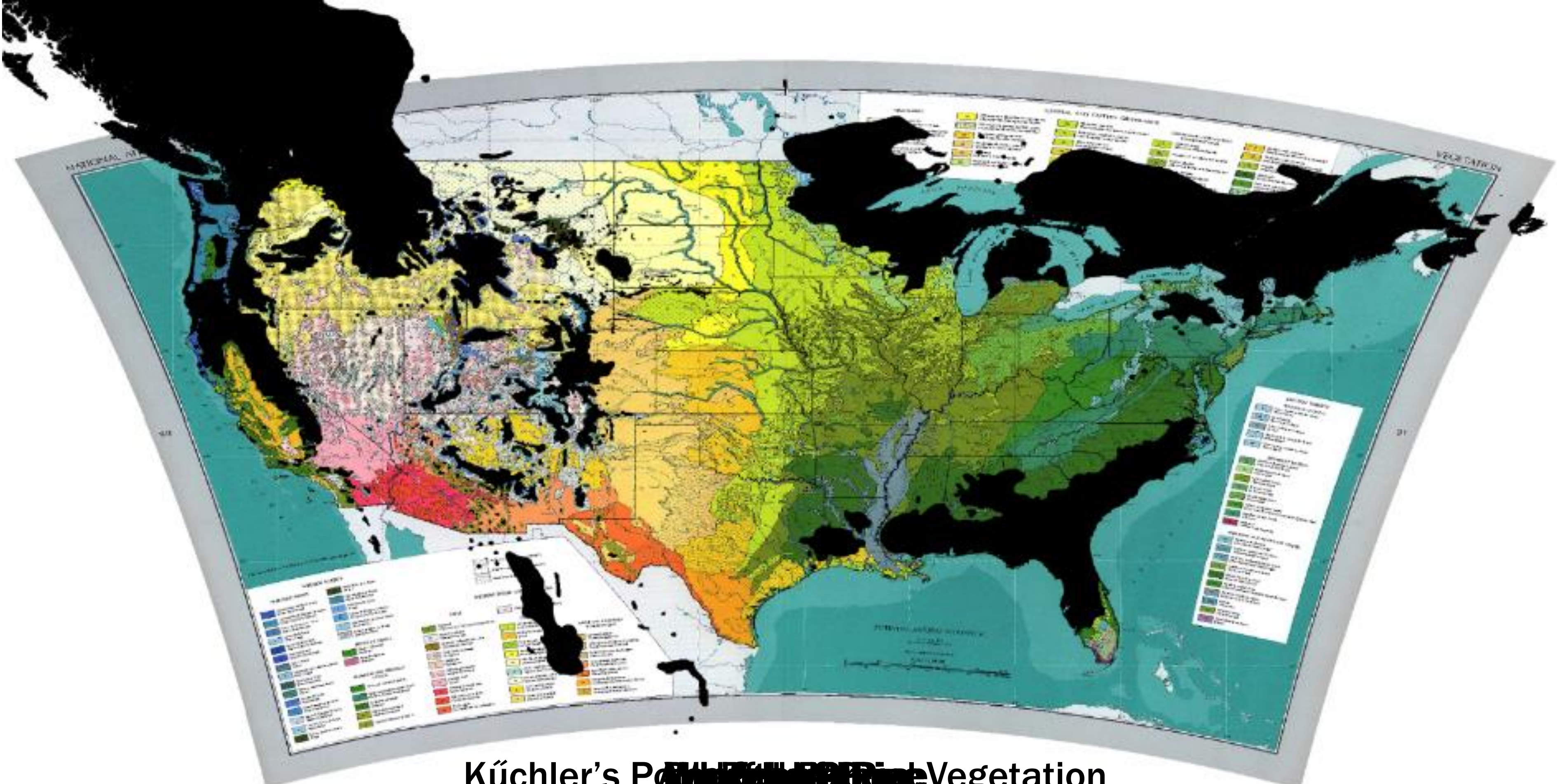
- Many of America's forests show signs of degradation
- Frequent fire forests, in particular, have unnaturally high tree densities and fuel loads as a result of past land use
- Resource values have declined and fire intensity and size have increased
- Restoration addresses forest health problems and can provide economic benefits
- We must increase the scale and pace of treatments and do so immediately

Little Bear Fire, Lincoln National Forest
June 13, 2012.
photo: Kari Greer

WHAT ARE “FREQUENT FIRE FORESTS”?


Iconic Ponderosa pine bark
photo: Sánchez Meador

- Forests in which, over evolutionary time, species have become adapted to frequent, low intensity surface fire as a regulatory mechanism
- Under natural conditions, frequent fires kept tree populations in check, prevented fuel accumulation, and contributed to ecological function, e.g., nutrient cycling, understory productivity



Kűchler's Potential Natural Vegetation

Kuchler, A.W. 1966. Potential Natural Vegetation of the Conterminous United States. American Geographical Society, Special Publication No. 36

Table 1. Main fire traits that define the three fire syndromes in pines[a]

Fire trait[b]	Syndrome		
	Fire tolerator	Fire embracer (post-fire seeder)	Fire avoider
Serotiny	No	Yes	No
Early reproduction	No	Yes	No
Thick basal bark	Yes	No	No
Resprouting	No/Juveniles	No/Epicormic	No
Seedling grass stage	(Yes)	No	No
Self-pruning	Yes (low tree flammability)	No (branch retention; high tree flammability)	~
Litter flammability	High (long, thin needles)	Low	Low
Examples	*Pinus ponderosa, Pinus nigra*	*Pinus attenuata, Pinus halepensis*	*Pinus albicaulis, Pinus cembra*

Pausas, J.G., 2015. Evolutionary fire ecology: lessons learned from pines. Trends in Plant Sciences 20: 318-324

EVOLUTIONARY ECOLOGY OF FREQUENT FIRE FORESTS

- Shows up in fossil record 70-100 million years ago (Ma)
  - At 25 Ma evidence from SW Colorado (A)
- Following a period of increased burning
  - As shown by models (B) and charcoal (C)
- Communities have tracked favorable climatic regimes (up and down in elevation and latitude) over time
  - Swings in O_2 and CO_2 (D) and sudden changes in temperature (E)
- Frequent fire forests were resilient to these changes under natural densities and self-regulatory mechanisms

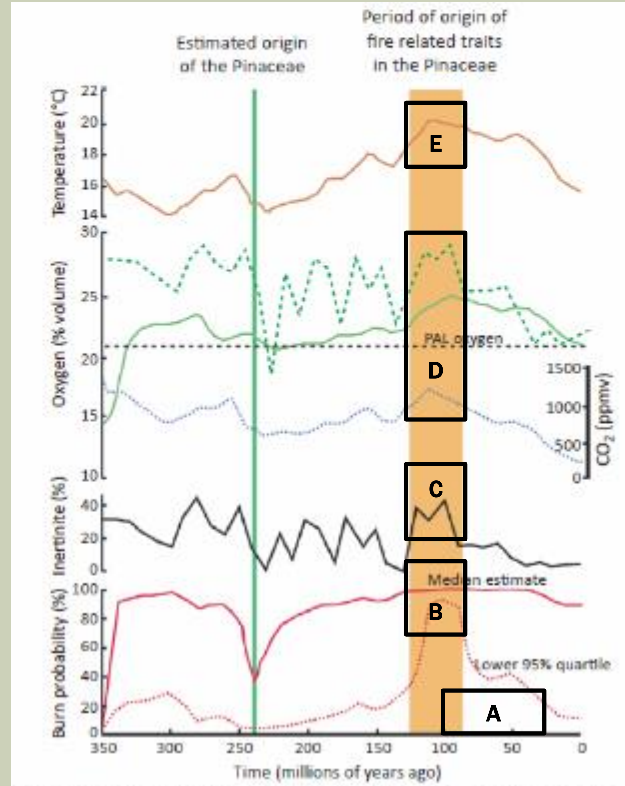


Fig. 3 Time of origin of fire-related traits in the Pinaceae set against the probability of burning estimated using the FIREOX model of Belcher *et al.* (2010) (red lines), abundance of inertinite (fossil charcoal) from Glasspool & Scott (2010) (black line), atmospheric oxygen concentrations as estimated by the COPSE model of Bergman *et al.* (2004) (solid green line) and from the oxygen proxy method of Glasspool & Scott (2010) (dashed green line) (black broken horizontal line corresponds to the ambient oxygen level at present), estimates of atmospheric carbon dioxide (dashed blue line) and mean average global temperatures (orange line), both from the COPSE model of Bergman *et al.* (2004). PAL, present atmospheric level.

He et al., 2012. Fire-adapted traits of *Pinus* arose in the fiery Cretaceous. New Phytologist 194: 751-759

WHERE ARE WE?

Frequent fire forests of the West are exhibiting alarming disease symptoms

Insect mortality around low water levels at Grindstone Reservoir, Lincoln National Forest
photo: Sánchez Meador

- Population irruptions and crashes
- Decreasing diversity, increasing homogeneity at all levels
- Uncharacteristic disturbance regimes
- Decreased resource availability
- Spiraling decline of ecological and social system health
- Declines are greatest in frequent fire forests

HOW DID WE GET HERE?

photos: Fort Valley Archives

- Unregulated, overgrazing of fine surface fuels
- Fire exclusion
- Overcutting of old-growth trees
- Failure to control density and composition of young trees

WHAT IS COMING AT US?

" . . . we anticipate an acceleration of historical changes in the Inland West including increased fuel accumulations, lengthened fire seasons and intensified burning conditions, all contributing to larger and more catastrophic fires."

Covington and Moore. 1994. Postsettlement changes in natural fire regimes and forest structure: ecological restoration of old-growth ponderosa pine forests. Journal of Sustainable Forestry 2: 153-181

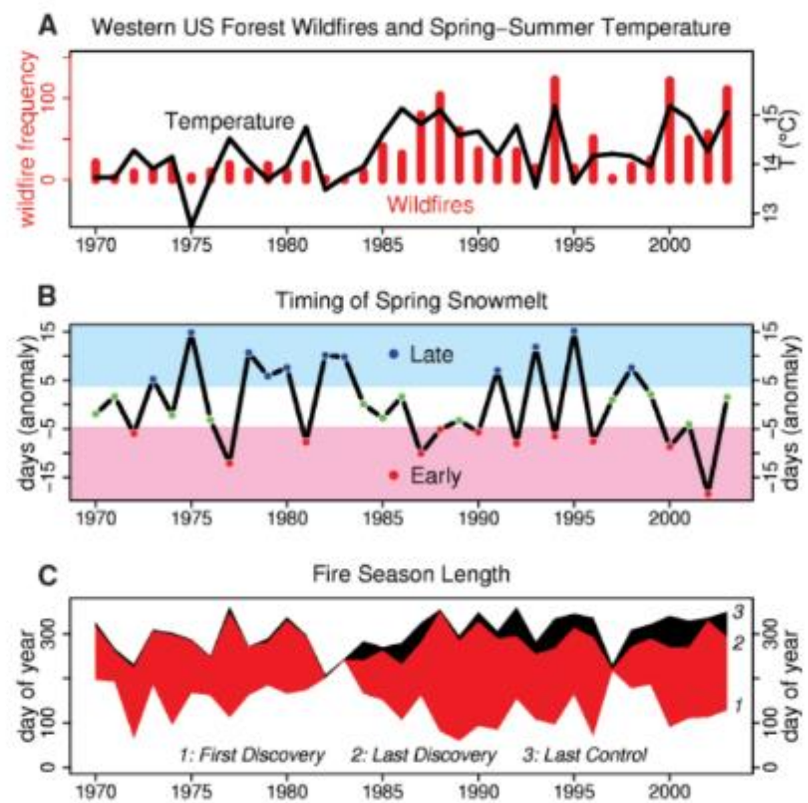
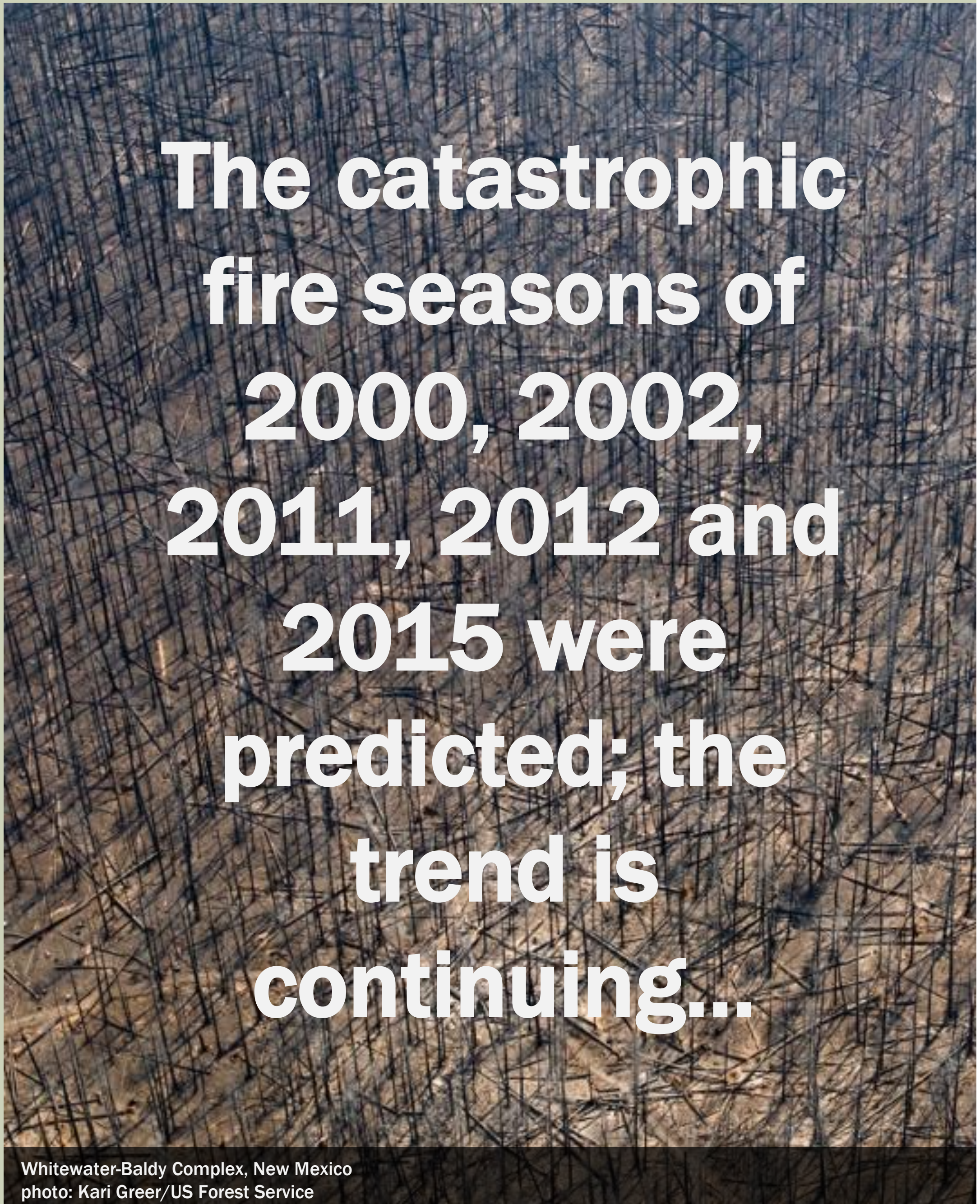


Fig. 1. (A) Annual frequency of large (>400 ha) western U.S. forest wildfires (bars) and mean March through August temperature for the western United States (line). (B) First principle component of center timing of stream-flow in snowmelt dominated streams (line). Low (pink shading), middle (no shading), and high (light blue shading) tercile values indicate early, mid-, and late timing of spring snowmelt, respectively. (C) Annual time between first and last large-fire ignition, and last large-fire control.

Westerling et al., 2005. Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity. Sciecne 313: 940-943

The catastrophic fire seasons of 2000, 2002, 2011, 2012 and 2015 were predicted; the trend is continuing…



Whitewater-Baldy Complex, New Mexico
photo: Kari Greer/US Forest Service

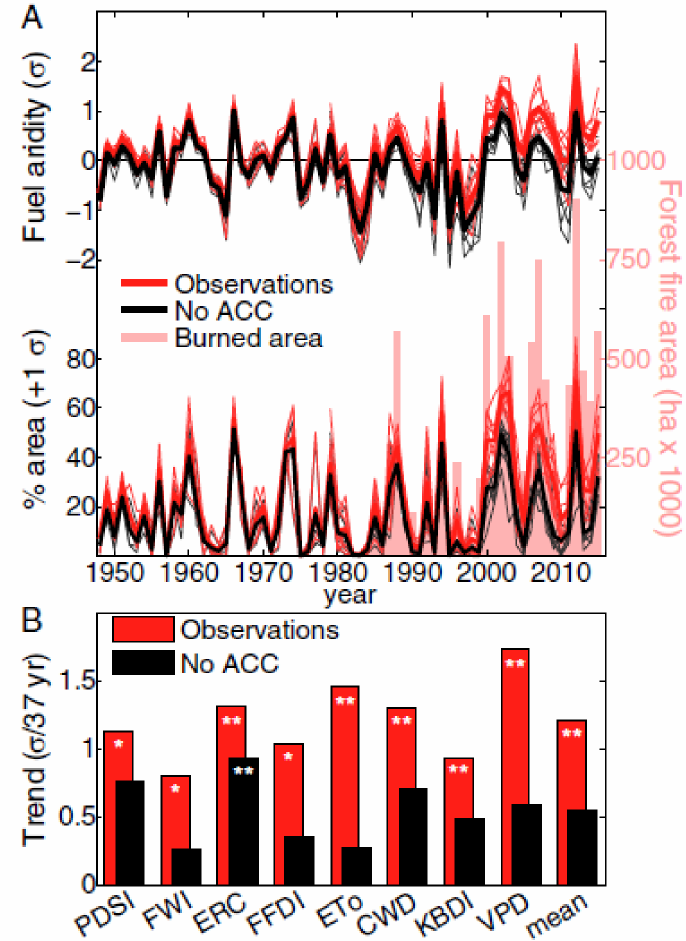


Fig. 3. Evolution and trends in western US forest fuel aridity metrics over the past several decades. (*A*) Time series of (*Upper*) standardized annual fuel aridity metrics and (*Lower*) percent of forest area with standardized fuel aridity exceeding one SD. Red lines show observations and black lines show records after exclusion of the ACC signal. Only the four monthly metrics extend back to 1948. Daily fire danger indices begin in 1979. Bold lines indicate averages across fuel aridity metrics. Bars in the background of *A* show annual forested area burned during 1984–2015 for visual comparison with fuel aridity. (*B*) Linear trends in the standardized fuel aridity metrics during 1979–2015 for (red) observations and (black) records excluding the ACC signal (differences attributed to ACC). Asterisks indicate positive trends at the (*) 95% and (**) 99% significance levels.

Abatzoglou and Williams. 2016. The impact of anthropogenic climate change on wildfire across the western US. *Proceedings of the National Academy of Sciences USA*. doi:10.1073.pnas.1607171113.

WHAT IS COMING AT US?

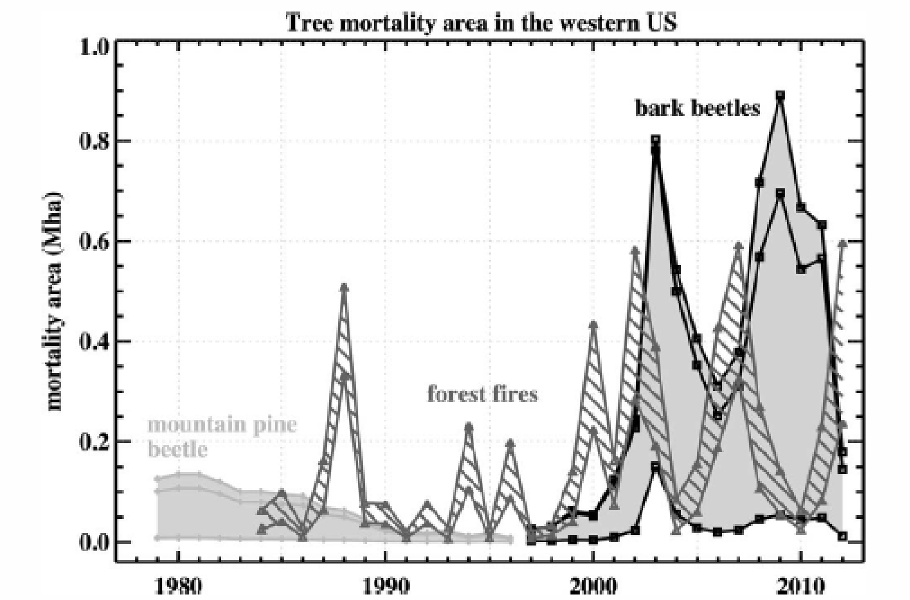


Figure 3. Cumulative tree mortality from bark beetles (black lines, lower, middle [most realistic], and upper estimates) and forest fires (gray lines and hatching, high, moderate+high severity) and an estimate of mountain pine beetle-caused mortality during 1979–1996 (light gray lines, lower, middle [most realistic], and upper estimates).

Hicke, J.A., A.H.J. Meddens, and C.A. Kolden. 2016. Recent tree mortality in the western United States from bark beetles and forest fires. Forest Science 62: 141-153. http://dx.doi.org/10.5849/forsci.15-086

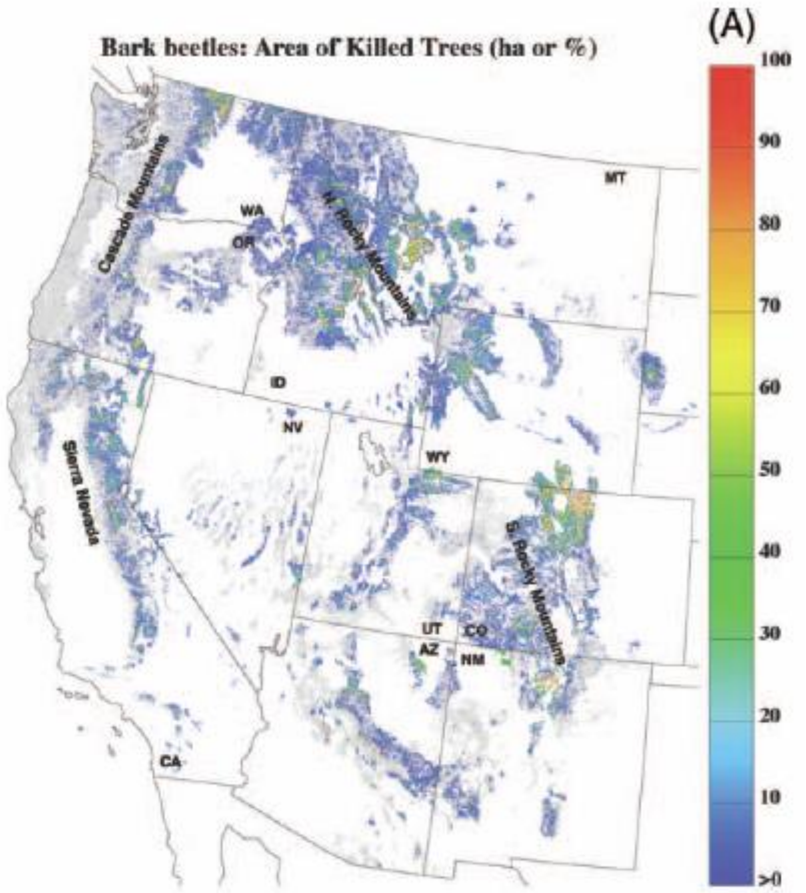
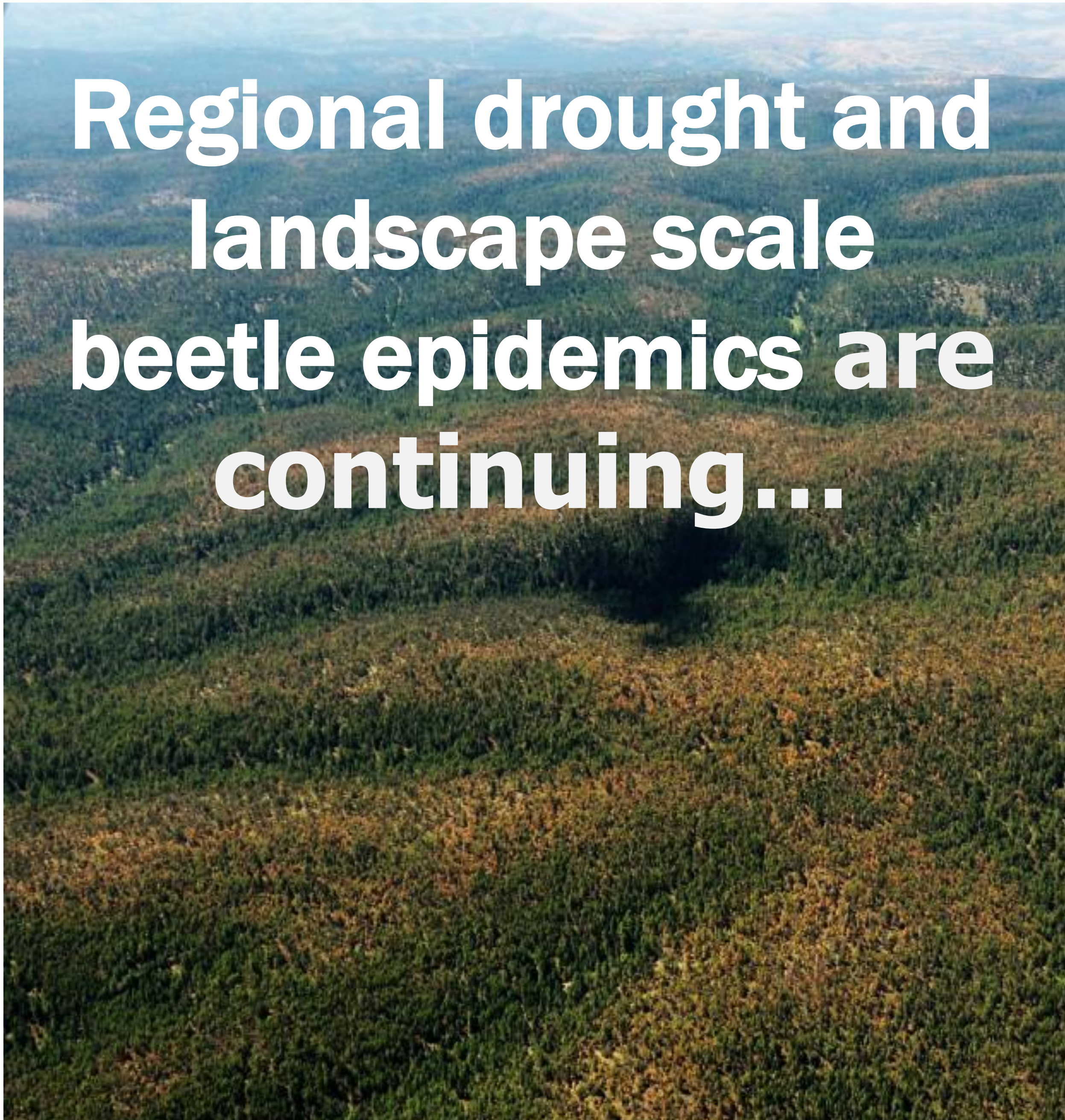
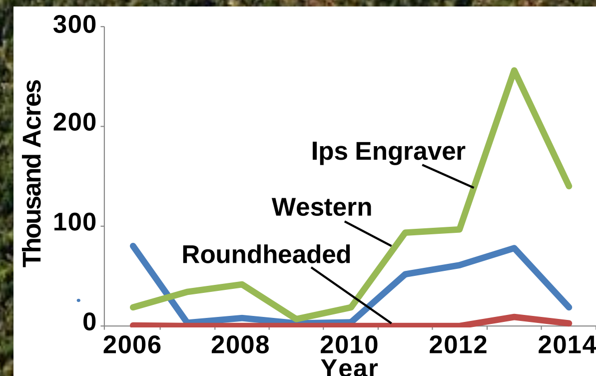


Figure 5. (A) Bark beetle-caused tree mortality, 1997–2012. (B) Forest fire-caused tree mortality, 1984–2012. Colors show numbers of hectares of tree mortality within each 1-km grid cell (which equals the percentage of the grid cell).

Regional drought and landscape scale beetle epidemics are continuing…



2011 Bark Beetle/Drought Mortality in Southern Sacramento Mountains, New Mexico
photo: Daniel Ryerson/US Forest Service



Figue 5. Acres of ponderosa pine mortality 2006-2014 by bark beetle species.

USDA Forester Service, R3. 2015. Forest Insect and Disease Conditions in the Southwestern Region, 2014.

WHAT IS ECOLOGICAL RESTORATION?

"The process of assisting the recovery of an ecosystem that has been degraded damaged or destroyed"

Society for Ecological Restoration International 2004

- Restoration rests on a solid foundation of strong science and systematic clinical trials
- Based on evolutionary biology, ecosystem ecology, and conservation principles
- Reference conditions are fundamental—natural patterns and processes are the starting point for practicing land health
- Departures should be based on best available science and clear objectives

REFERENCE CONDITIONS

- Biological evidence
  - Fire scars
  - Tree ages
  - Dead structures
  - Charcoal
- Cultural evidence
  - Historical data
  - Photos
  - Written reports
  - Elders
- Process models

photo: Sanchez Meador

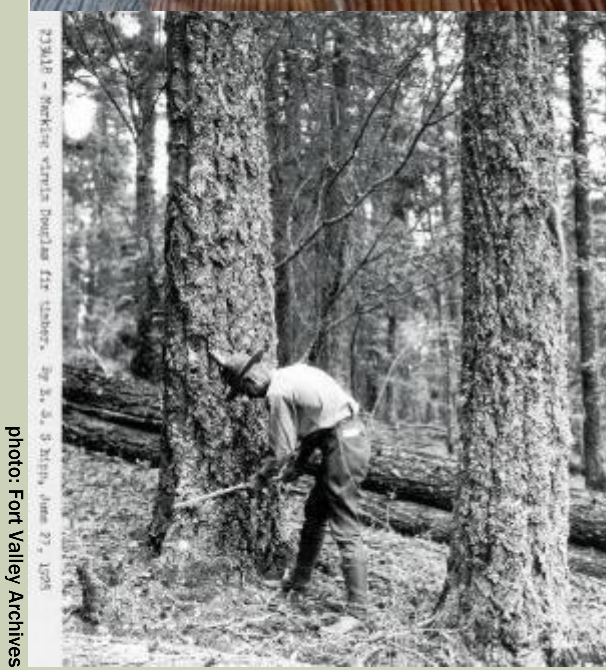
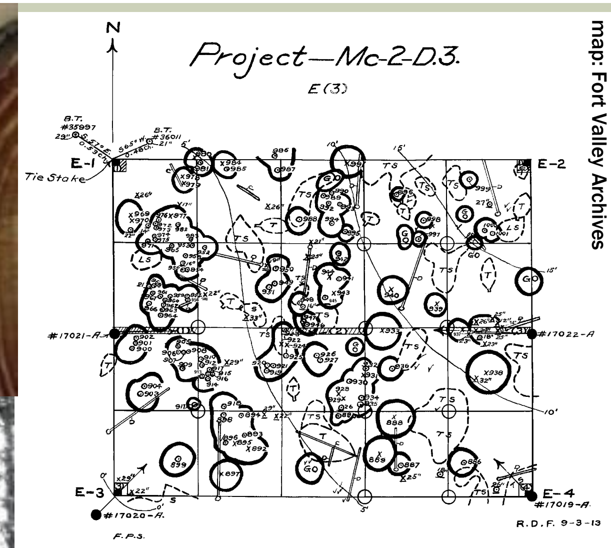


photo: Fort Valley Archives



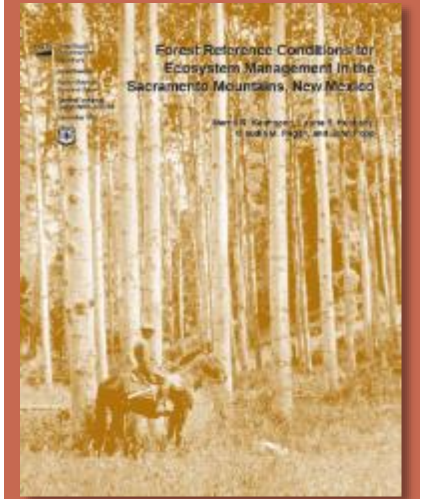
map: Fort Valley Archives

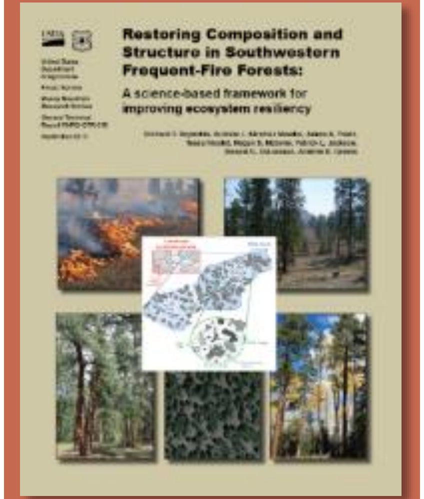

photo: Sanchez Meador

REFERENCE CONDITIONS VARY WITH SOIL TYPE, ELEVATION, AND CLIMATIC REGIME

Broad similarities exist, but variations in pattern and processes do occur

- Fort Valley Experimental Forest AZ
- Sacramento Mountains, NM
- Pringle Falls Experimental Forest, OR
- Black Hills National Forest, SD



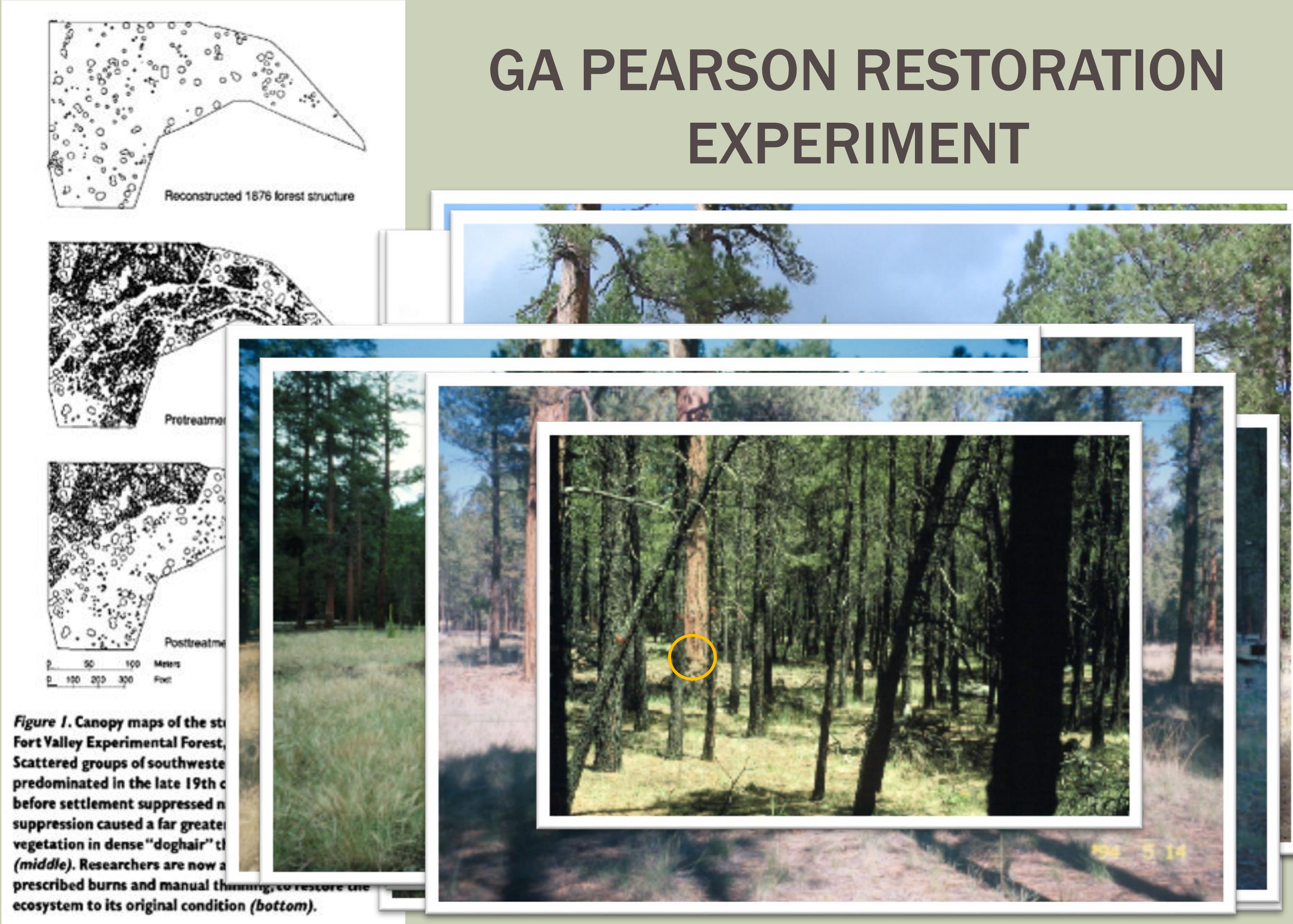


PRINCIPLES FOR DEVELOPING RESTORATION PRESCRIPTIONS

- Protect old trees which are rare
- Retain post-settlement trees needed to re-establish sustainable forest structure
- Stay within an envelope of sustainability
- Thin and remove excess trees; where feasible, provide wood for economic uses
- Burn at more or less natural intervals to hold tree densities and fuel loads in check and return functional qualities

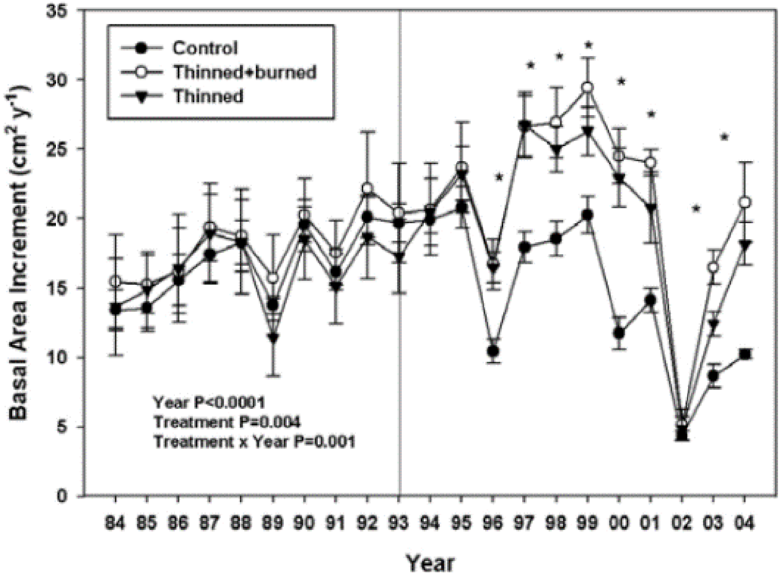

Railsplitter Rx, Sacramento RD
photo: Sanchez Meador

GA PEARSON RESTORATION EXPERIMENT

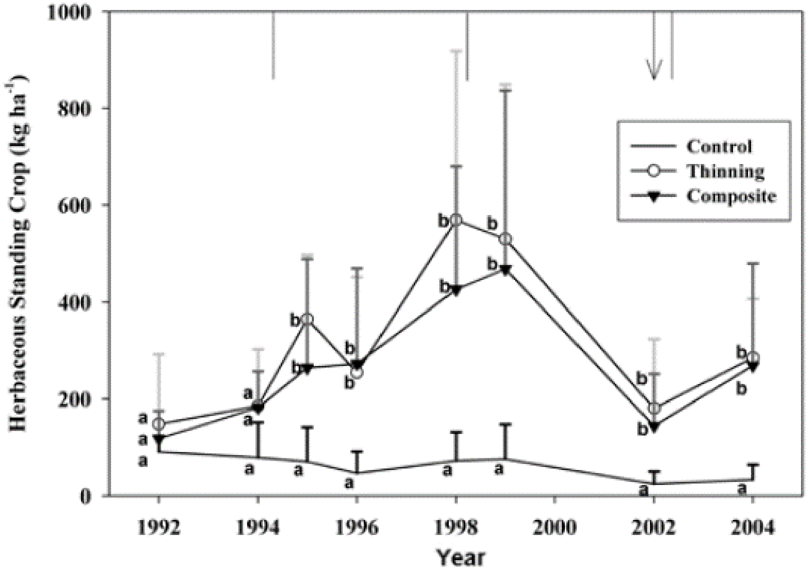


Covington, W.W., P.Z. Fulé, M.M. Moore, S.C. Hart, T.E. Kolb, J.N. Mast, S.S. Sackett, and M.R. Wagner. 1997. Restoring ecosystem health in ponderosa pine forests of the Southwest. Journal of Forestry 95(4):23-29.

GA PEARSON RESTORATION EXPERIMENT



Kolb, T. E., Agee, J. K., Fulé, P. Z., McDowell, N. G., Pearson, K., Sala, A., Waring, R. H. 2007. Perpetuating old ponderosa pine. Forest Ecology and Management 249:141-157.



Moore, M.M., C.A. Casey, J.D. Bakker, J.D. Springer, P.Z. Fulé, W.W. Covington, and D.C. Laughlin. 2006 Herbaceous responses to restoration treatments in a ponderosa pine forest, 1992-2004. Rangeland Ecology and Management 59:135-144.

CHANGE BASIC PRESCRIPTION FOR SPECIFIC RESOURCE OBJECTIVES

- Maybe leave more trees to accommodate specific resource management objectives,
  - Future wood harvesting
  - Screening cover for human or wildlife habitat goals
- Maybe leave fewer trees to accommodate other objectives,
  - Favor viewsheds
  - Wildlife goals
  - Grazing
  - Water balance

RESTORATION PRESCRIPTIONS

Alternative restoration treatments produce very different outcomes for fire behavior and resource responses

there appear to be thresholds

Full Restoration

Moderate Thinning

Burn Only

RESTORATION RESPONSES

Predicted Fire Characteristics
June 97th-percentile weather, 30 mph

	1876	1997	1.5:1	3:1
Tree/ac	47	383	70	141
Fire type	surface	active	surface	passive
% crown	0	100	20	69
btu/ft^2	491	2331	673	1790
herbage	856	112	571	134

RESTORATION PRINCIPLES

Comprehensive ecosystem restoration approaches not only reduce crown fire threat, but also improve forest health and resource use opportunities for present and future generations.

Little Bear Fire - Lincoln National Forest, 2012. photo: Kari Greer

We must act at scale and pace in keeping with the character of the crises at hand. Large, collaborative landscape scale projects are our best hope.

Las Conchas Fire – Sante Fe National Forest, New Mexico,2011. photo: Jon Williams