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science for a changing world

Fighting drought with fire:
Can forest management increase resistance to drought?

van Mantgem, P.J.[1], A. Caprio[2], N.L. Stephenson[3], and A.J. Das[3]

1 U.S. Geological Survey, Redwood Field Station, 1655 Heindon Road, Arcata, CA 95521.

2 National Park Service, Sequoia and Kings Canyon National Parks, 47050 Generals Hwy., Three Rivers, CA 93271.

3 U.S. Geological Survey, Sequoia and Kings Canyon Field Station, 47050 Generals Hwy., Three Rivers, CA 93271.

U.S. Department of the Interior
U.S. Geological Survey

Credit: N. Stephenson

STATE NOVEMBER 3, 2015

California gov. declares emergency over dead trees

The Associated Press

A dead-tree census by the U.S. Forest Service found that 22 million trees have died during California's four-year drought, and tens of millions more are expected to follow.

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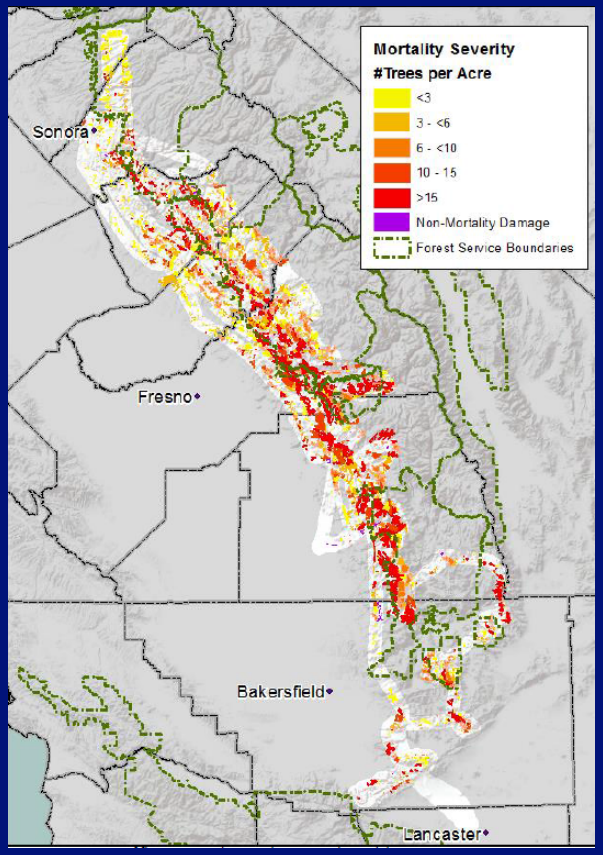
Credit: N. Stephenson

Southern Sierra Nevada die-back event of 2015

USFS Region 5 Aerial Detection Survey – July 6th to 7th , 2015
Area surveyed: 3.6 million acres
Areas with mortality: 0.5 million acres
Estimated number of trees killed: 6 million



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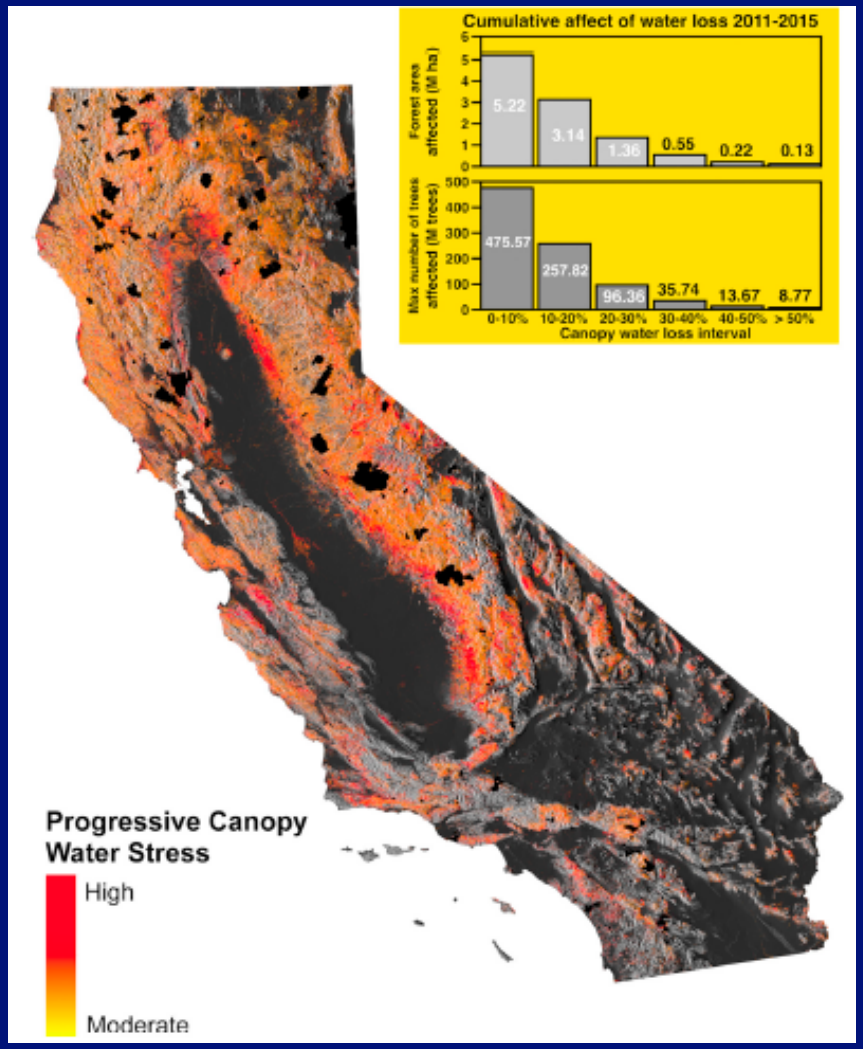
http://www.fs.usda.gov/detail/r5/forest-grasslandhealth/?cid=fsbdev3_046696

California state-wide die-back event?



Approximately 10.6 million ha of forest containing up to 888 million large trees experienced measurable loss in canopy water content… Asner et al. 2016 *PNAS*

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What, if anything, can be done?

Adaptation strategies

Resistance: ability to remain essentially unchanged following disturbance

Resilience: ability to recover quickly from disturbance

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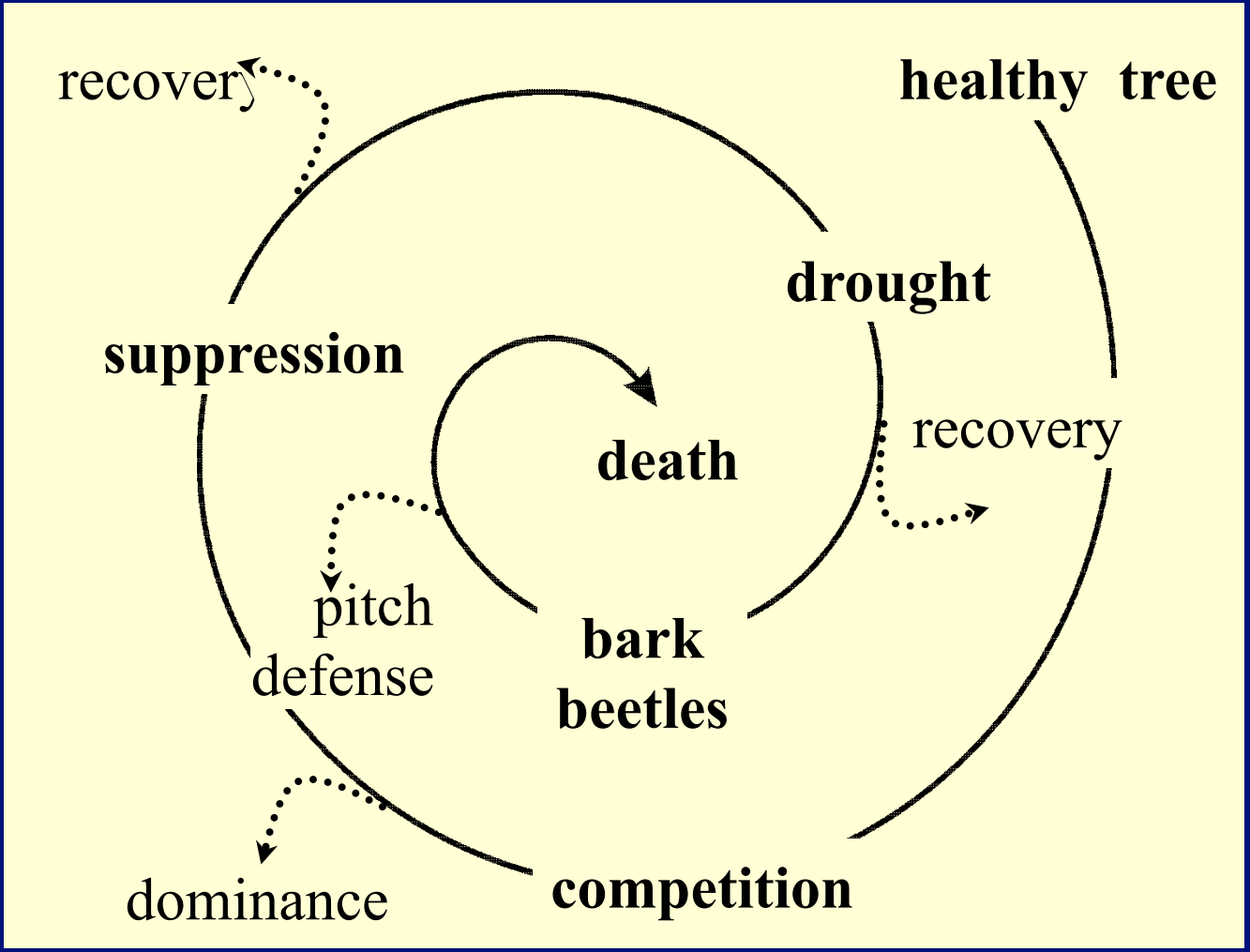
Credit: N. Stephenson

The decline spiral model of tree death



Franklin, 1987 *Bioscience*

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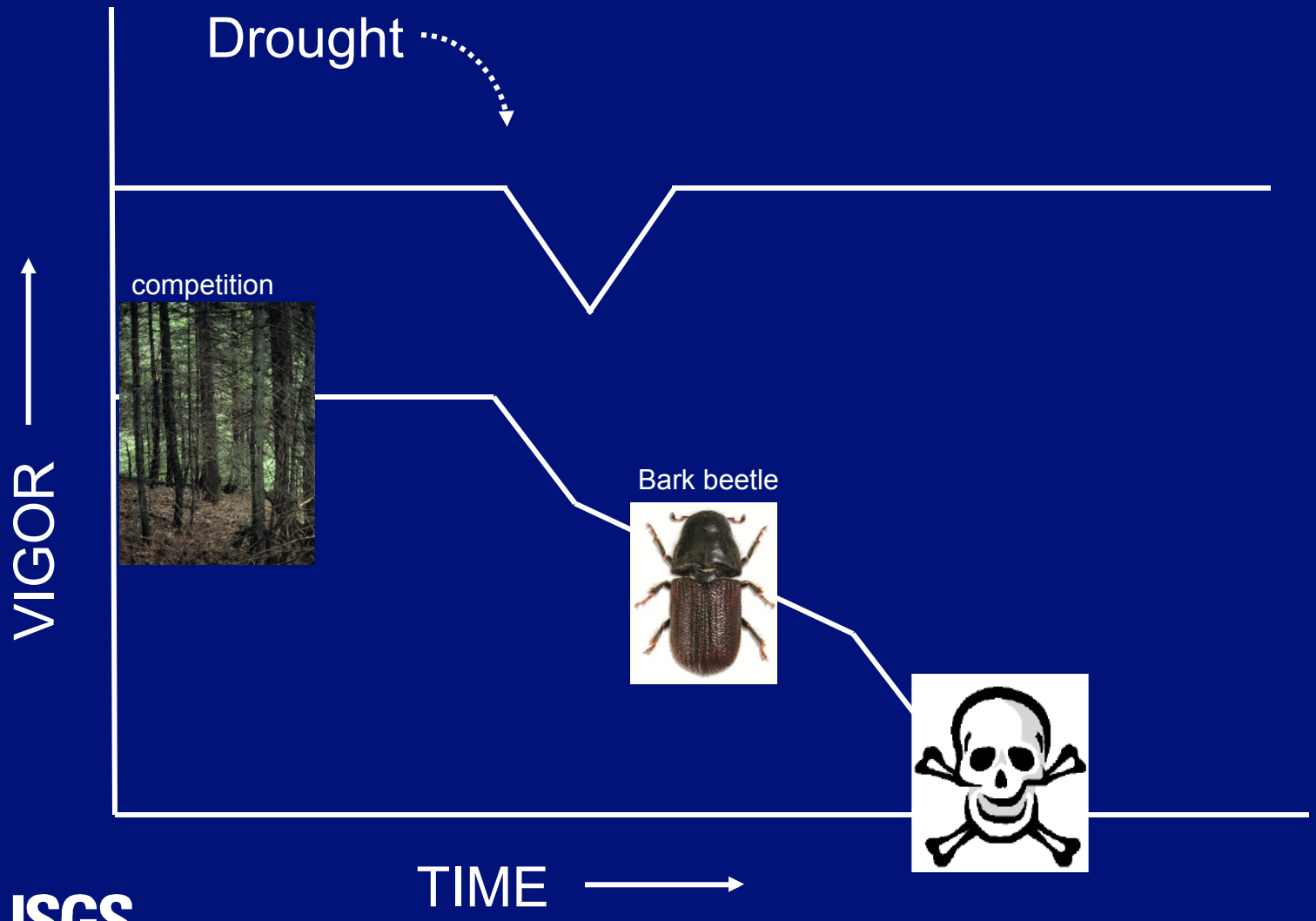
The decline spiral model of tree death



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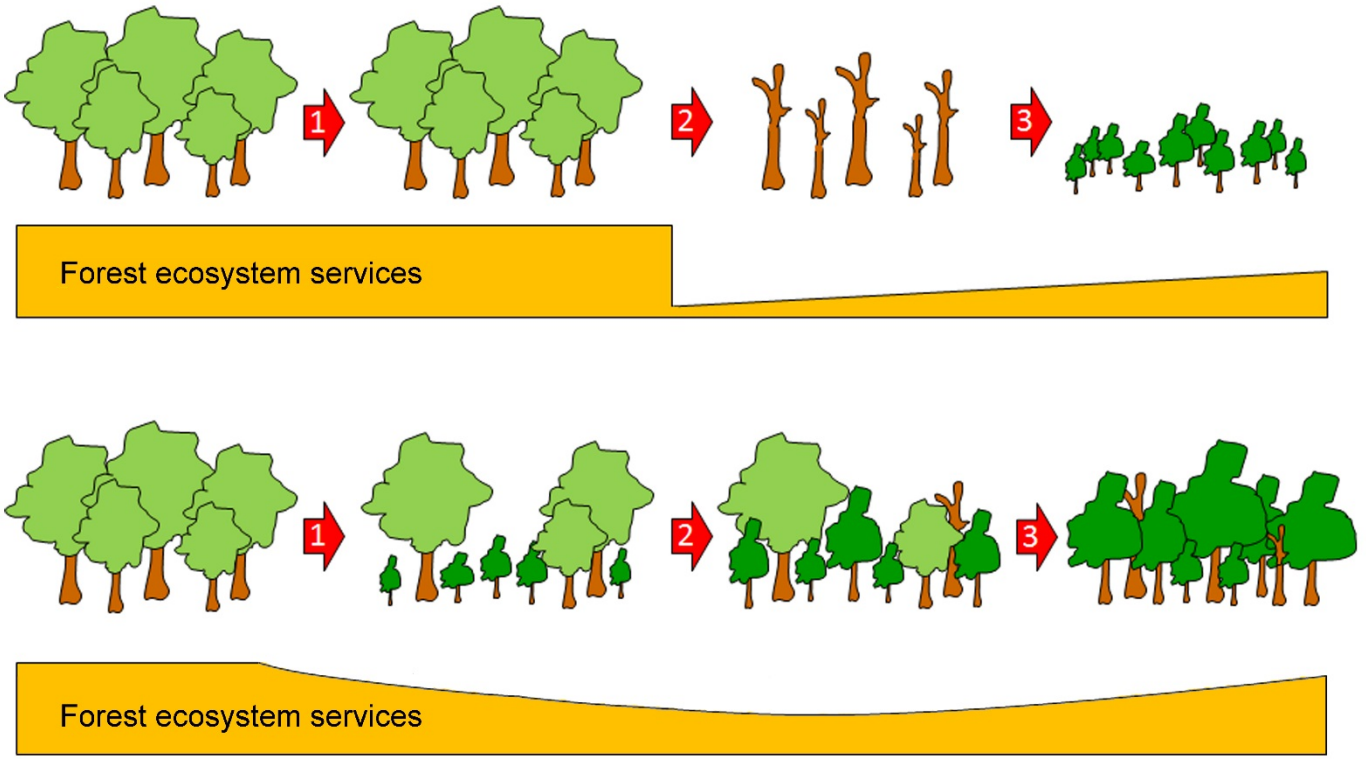
Pederson 1998, *Ecol. Appl.*

Adaptation:
Can forest management increase resistance/resilience to drought?



Millar and Stephenson, 2015 *Science*

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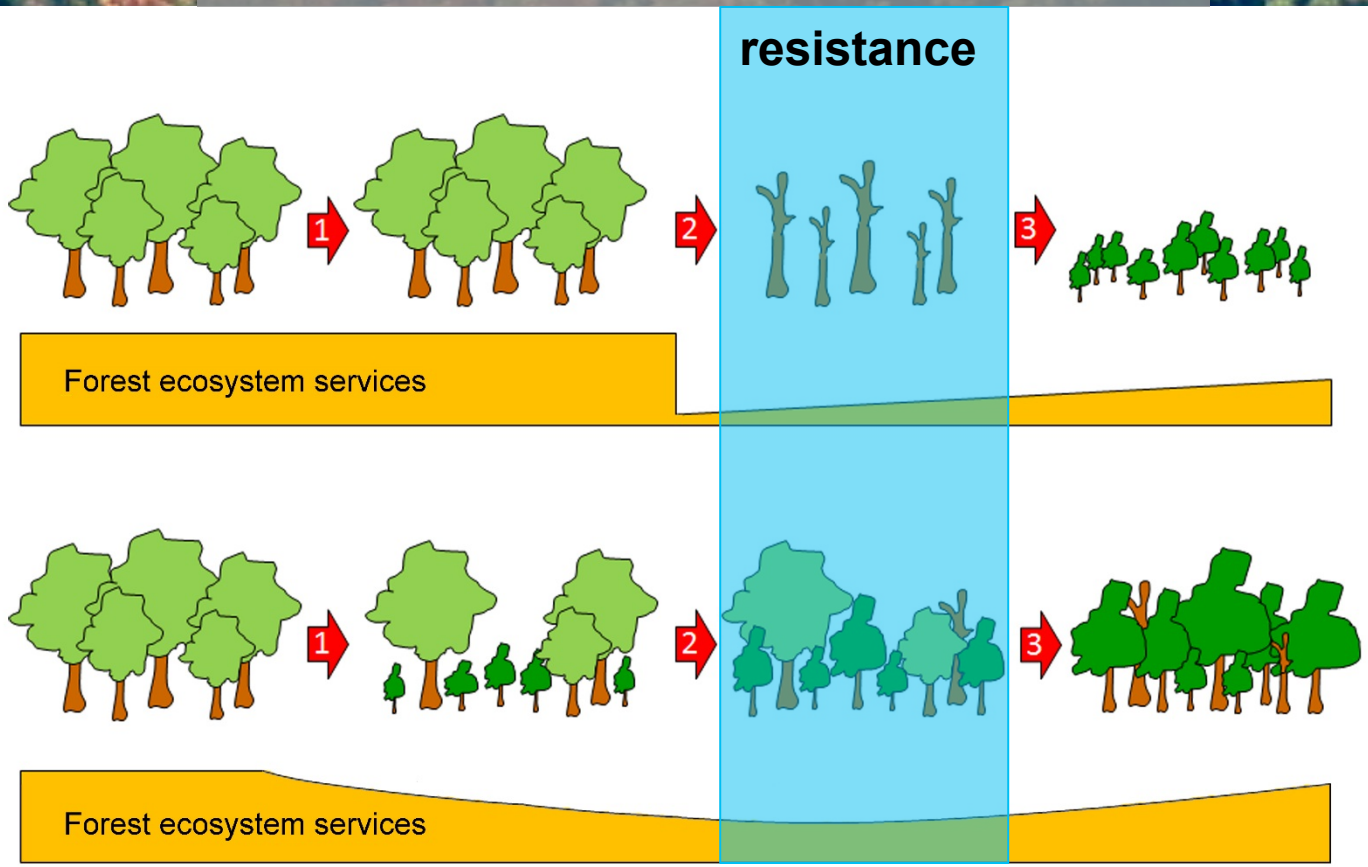

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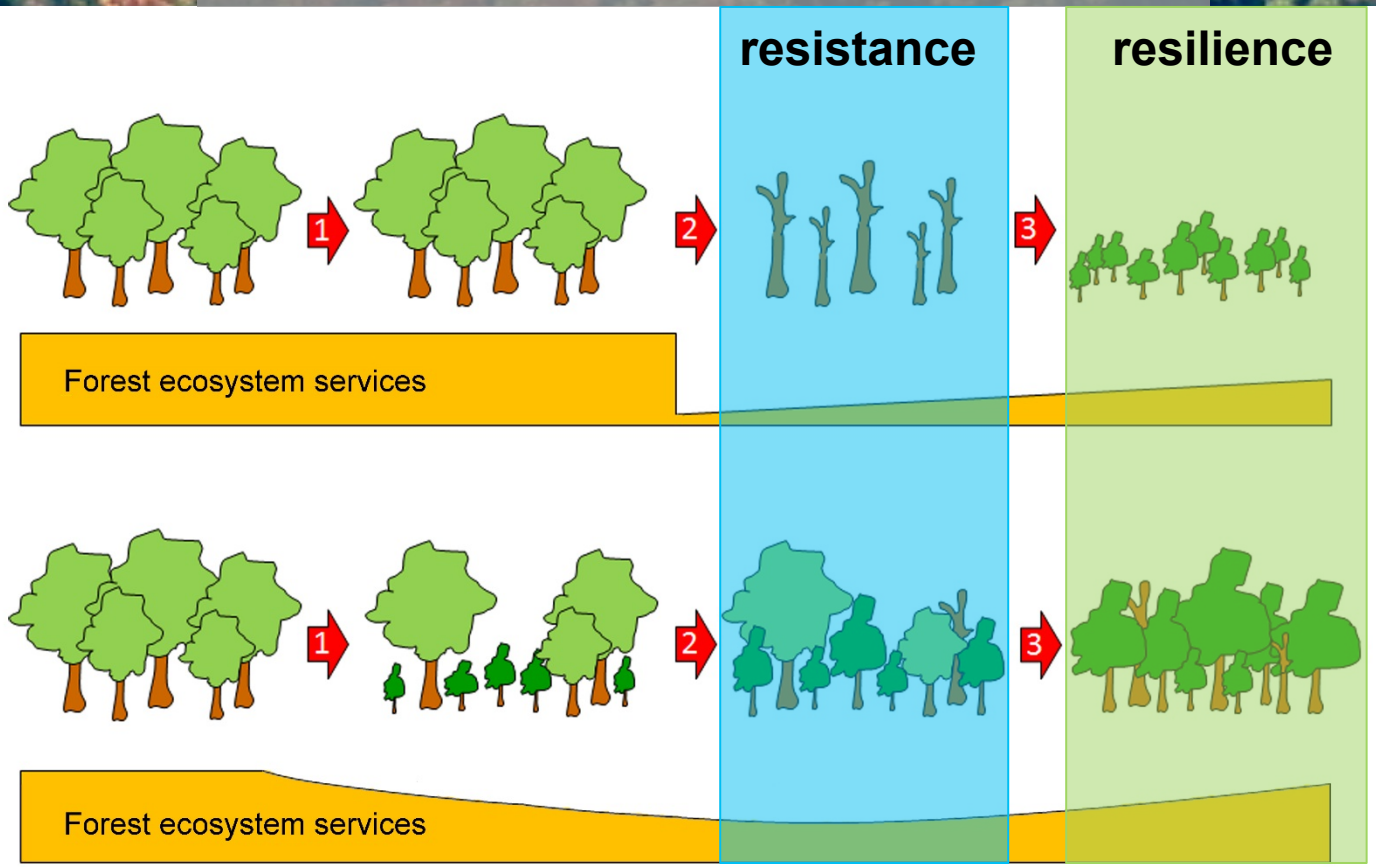

Millar and Stephenson, 2015 *Science*

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Credit: N. Stephenson

Can prescribed fire increase forest **resistance** to drought?

Mechanical thinning at Lassen Volcanic NP

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Credit: N. Stephenson

Second growth forest thinning at Redwood National Park

USGS

Credit: J. Teraoka, NPS

Can prescribed fire increase forest resistance to drought?

Late season prescribed fire effects at Sequoia NP

Pre-fire

1 year post-fire

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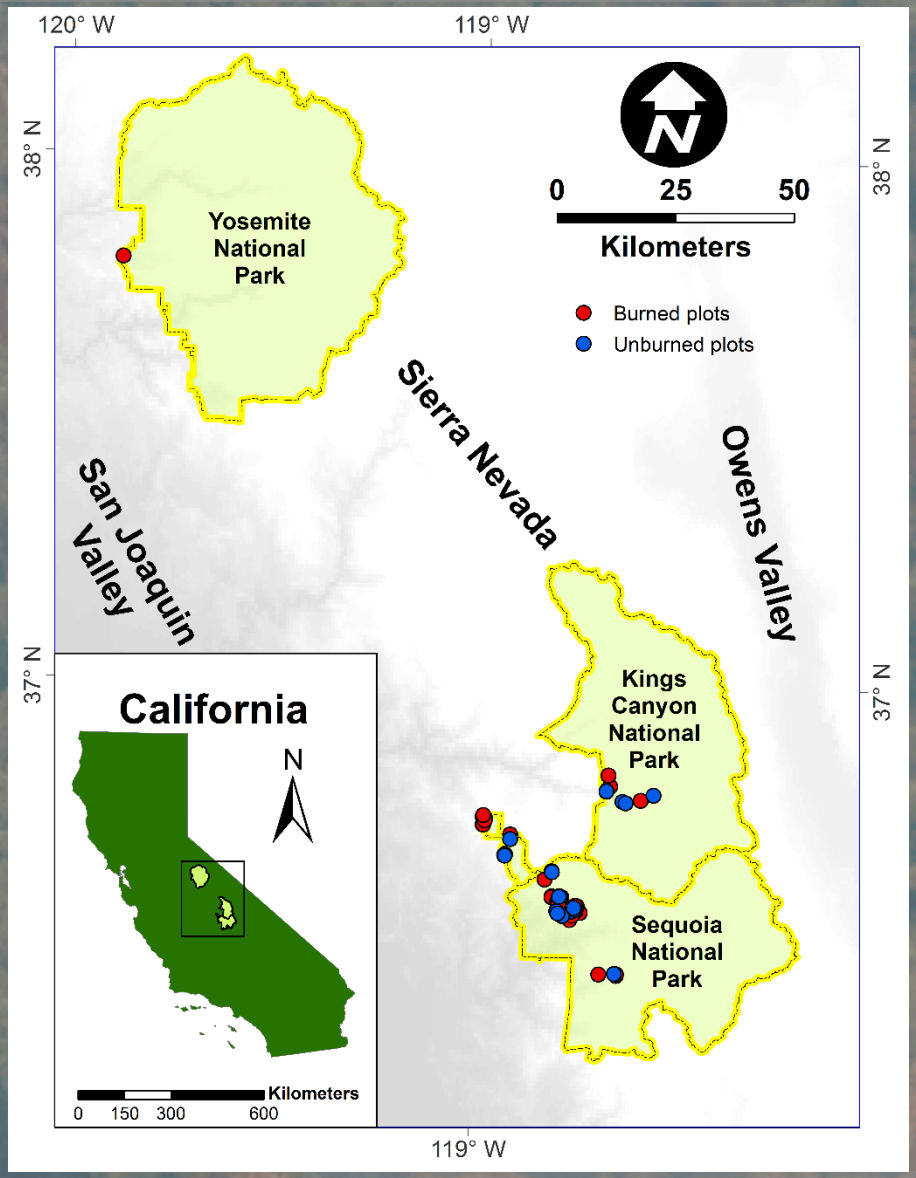
Credit: N. Stephenson

Can prescribed fire increase forest resistance to drought?

- Long-term forest plot data
- Surveys in 2014

- Ponderosa pine – mixed conifer forests (mostly *A. concolor*)
- 38 burned plots, 18 unburned plots
- ≥ 6 years post-fire
- ~10,000 trees



van Mantgem *et al.* in press *Fire Ecology*

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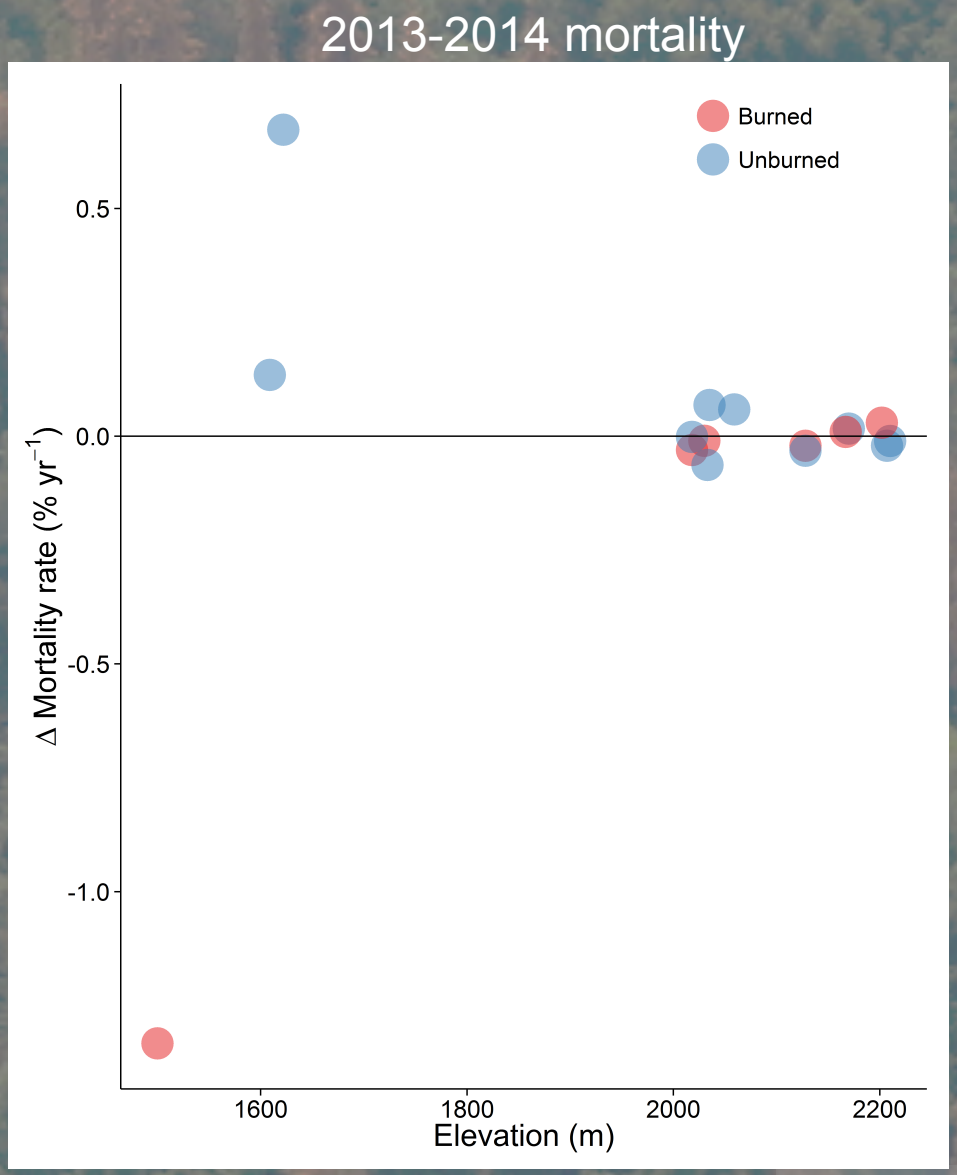
Credit: N. Stephenson

Can prescribed fire increase forest resistance to drought?



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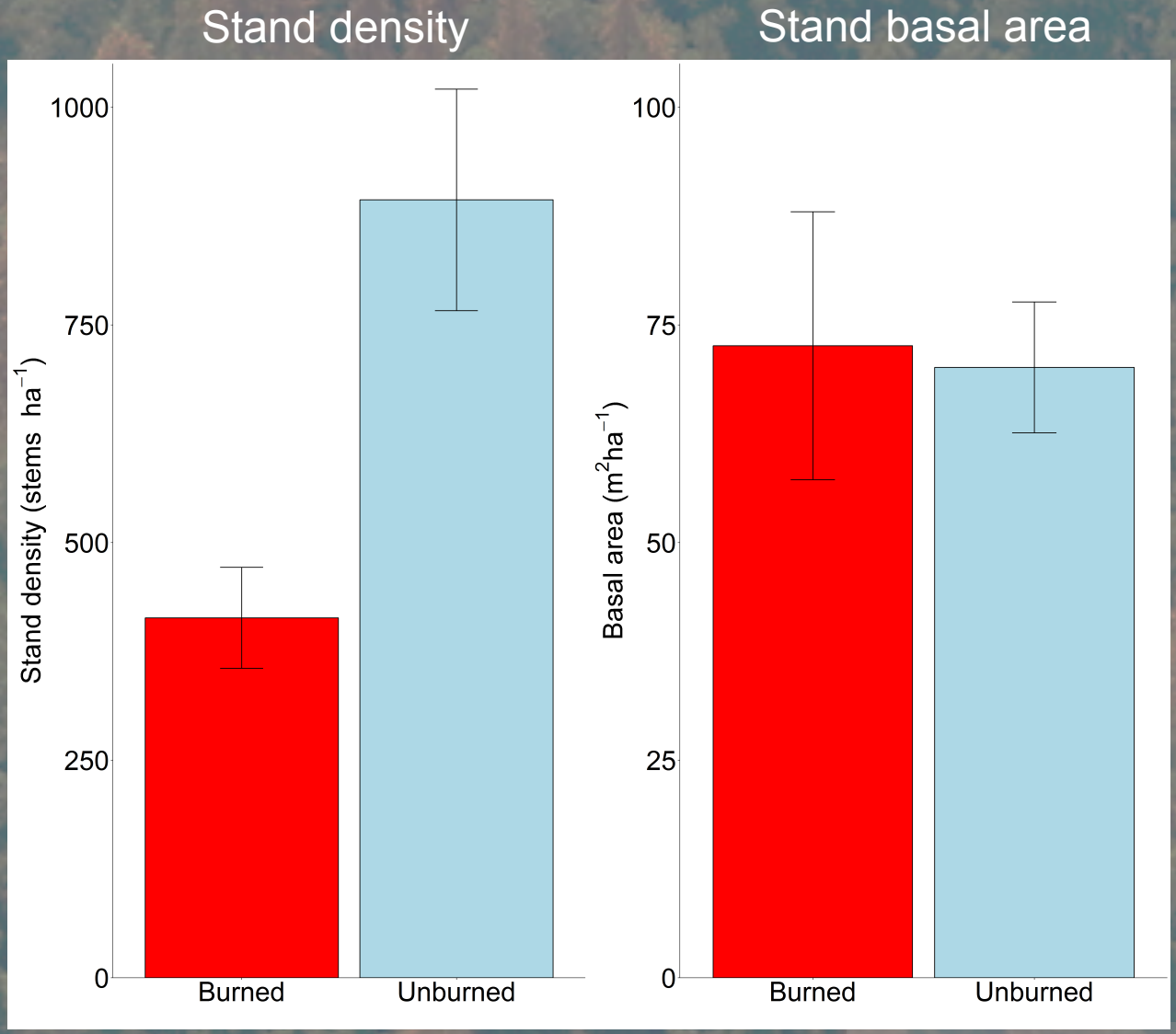
Can prescribed fire increase forest resistance to drought?



van Mantgem *et al.* in press *Fire Ecology*

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Credit: N. Stephenson

Can prescribed fire increase forest resistance to drought?

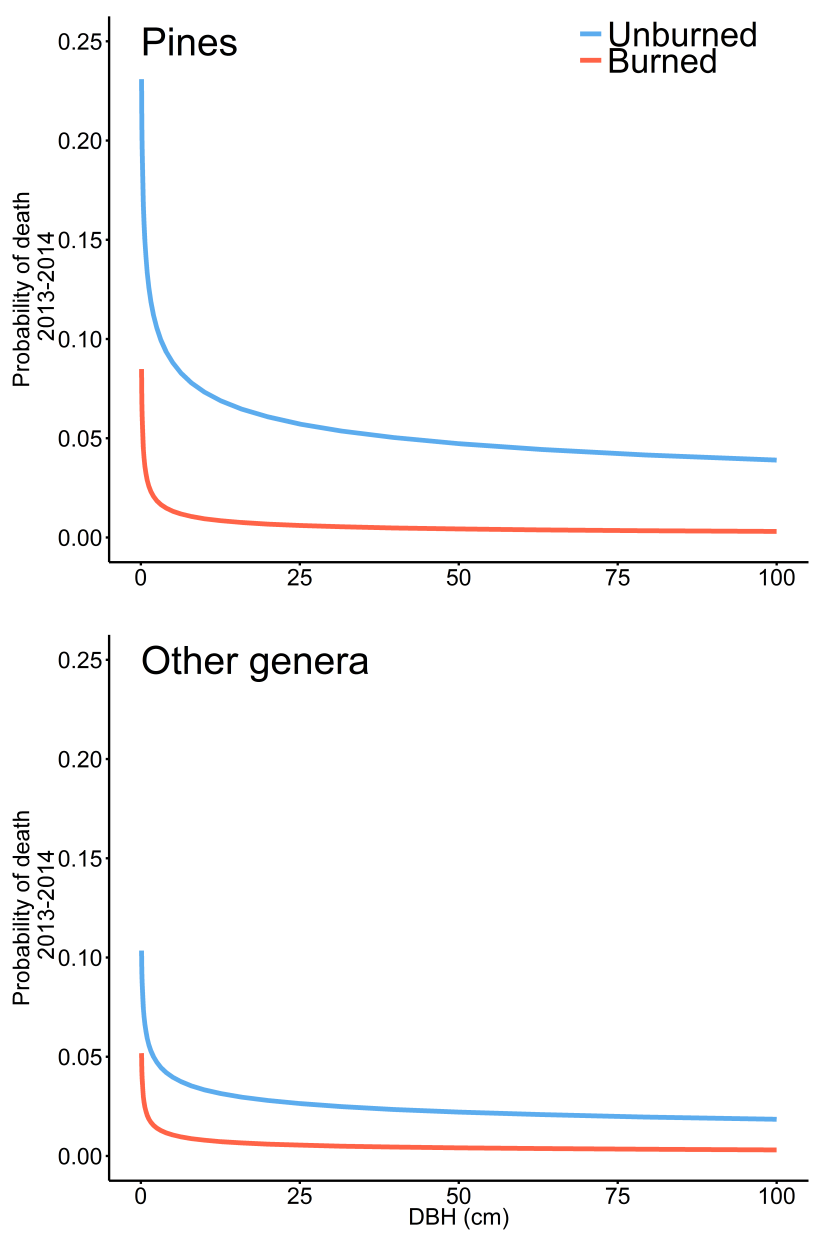
Findings

Probability of death lower in burned stands in 2013, 2014 (after accounting for tree size and taxonomic group).

What is the impact of continued drought in 2015?

Can we explicitly identify the mechanisms of tree mortality??
i.e., roles of competition, pathogens, insects?

Other species, other regions???



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Credit: N. Stephenson

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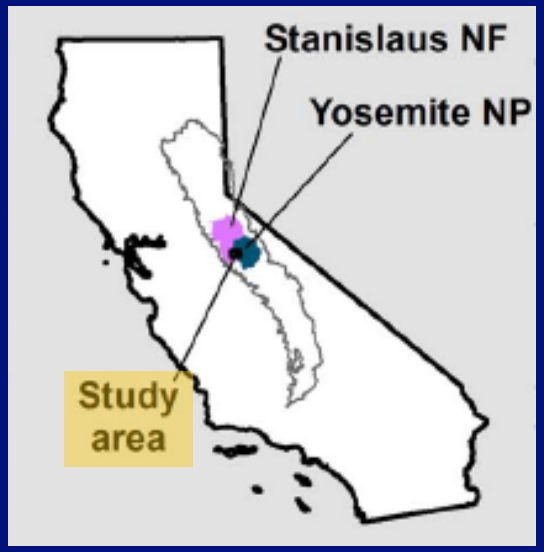
Can prescribed fire increase forest resistance to drought?

ponderosa pine stand structure, central Sierra Nevada
Trees ≥15.2 cm DBH



1911 USFS inventories
TPH: 72.7 trees ha^{-1}
Basal area: 21.5 m^2 ha^{-1}
(Collins *et al.* 2015 *Ecol. Appl.*)

2013 Post-fire Yosemite, Kings Canyon and Sequoia NP
TPH: 159 trees trees ha^{-1}
Basal area: 74.0 m^2 ha^{-1}
(van Mantgem *et al.* in press *Fire Ecology)*

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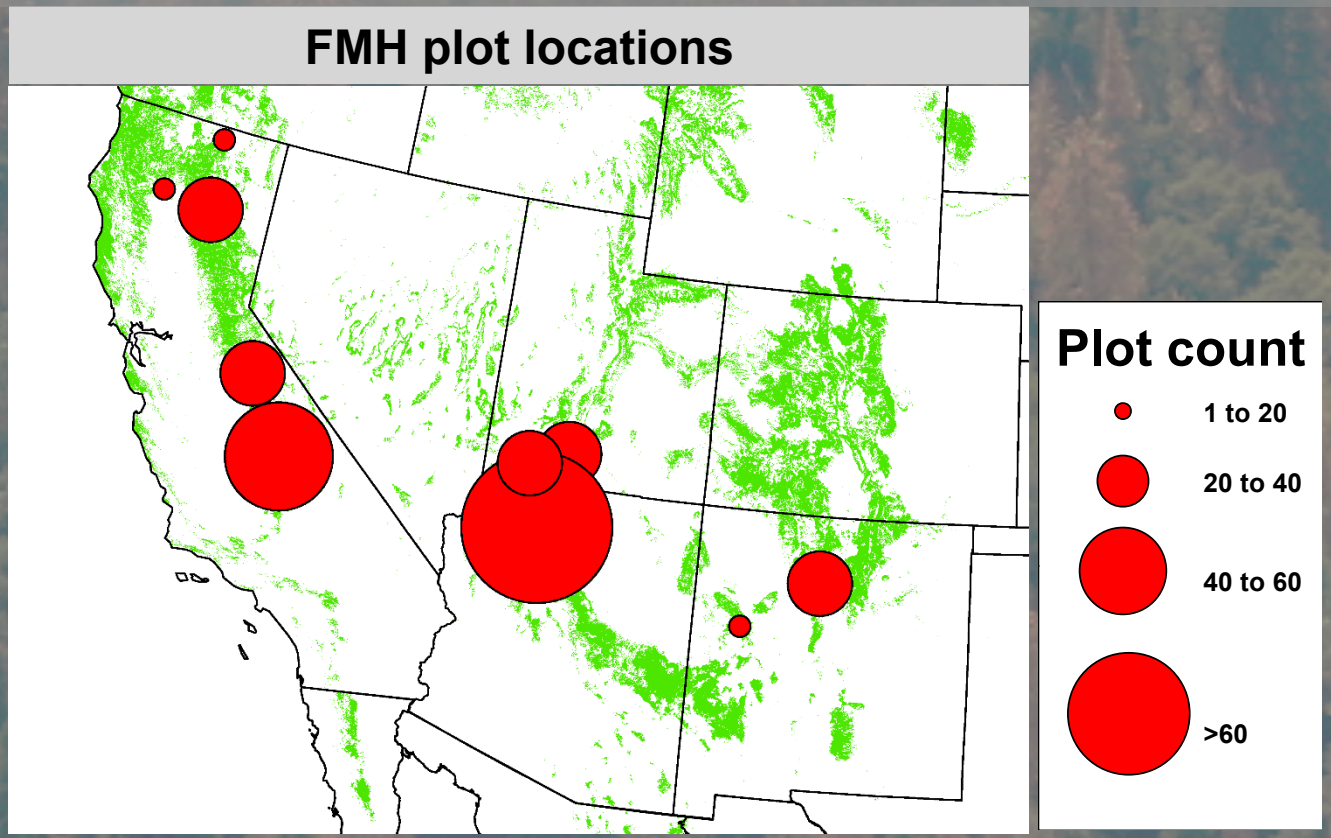
Can prescribed fire increase forest resistance to drought? Next steps…

www.werc.usgs.gov/DroughtForestFire

1) Survey tree mortality in burned and unburned areas.
2) Construct mortality models in burned and unburned stands (using tree rings).



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Credit: N. Stephenson

Can prescribed fire increase forest resistance to drought? Next steps…

Potential study sites

California

- FMH plots
- Fire & Fire Surrogate sites (Goosenest, Sequoia NP)
- USGS Forest Dynamics plot network (YOSE, SEKI only)
- Teakettle Experimental Forest

Colorado Plateau

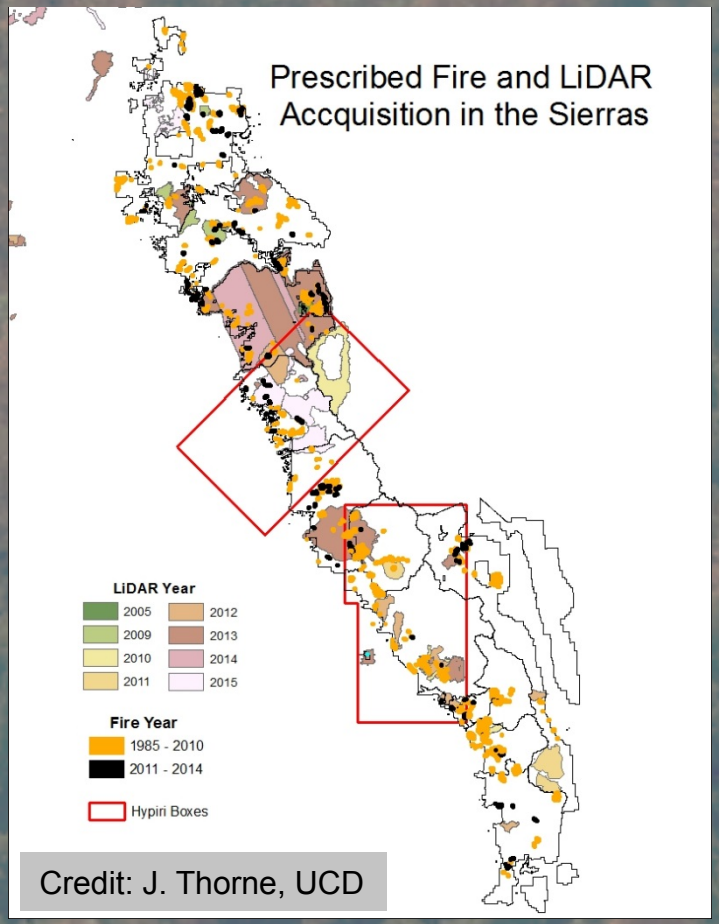
- FMH plots
- Fire & Fire Surrogate sites (Jemez Mountains, N. Arizona)

USGS

Credit: N. Stephenson

Can prescribed fire increase forest resistance to drought? Next steps…

In the central and southern Sierra Nevada relate forest structure and management history (thinning, prescribed burning) to remotely sensed indices of drought response (e.g., aerial mapping of forest dieback, Landsat time series, hyperspectral data).



Credit: J. Thorne, UCD

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Credit: N. Stephenson

What, if anything, can be done?

Adaptation strategies

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Resilience: ability to recover quickly from disturbance

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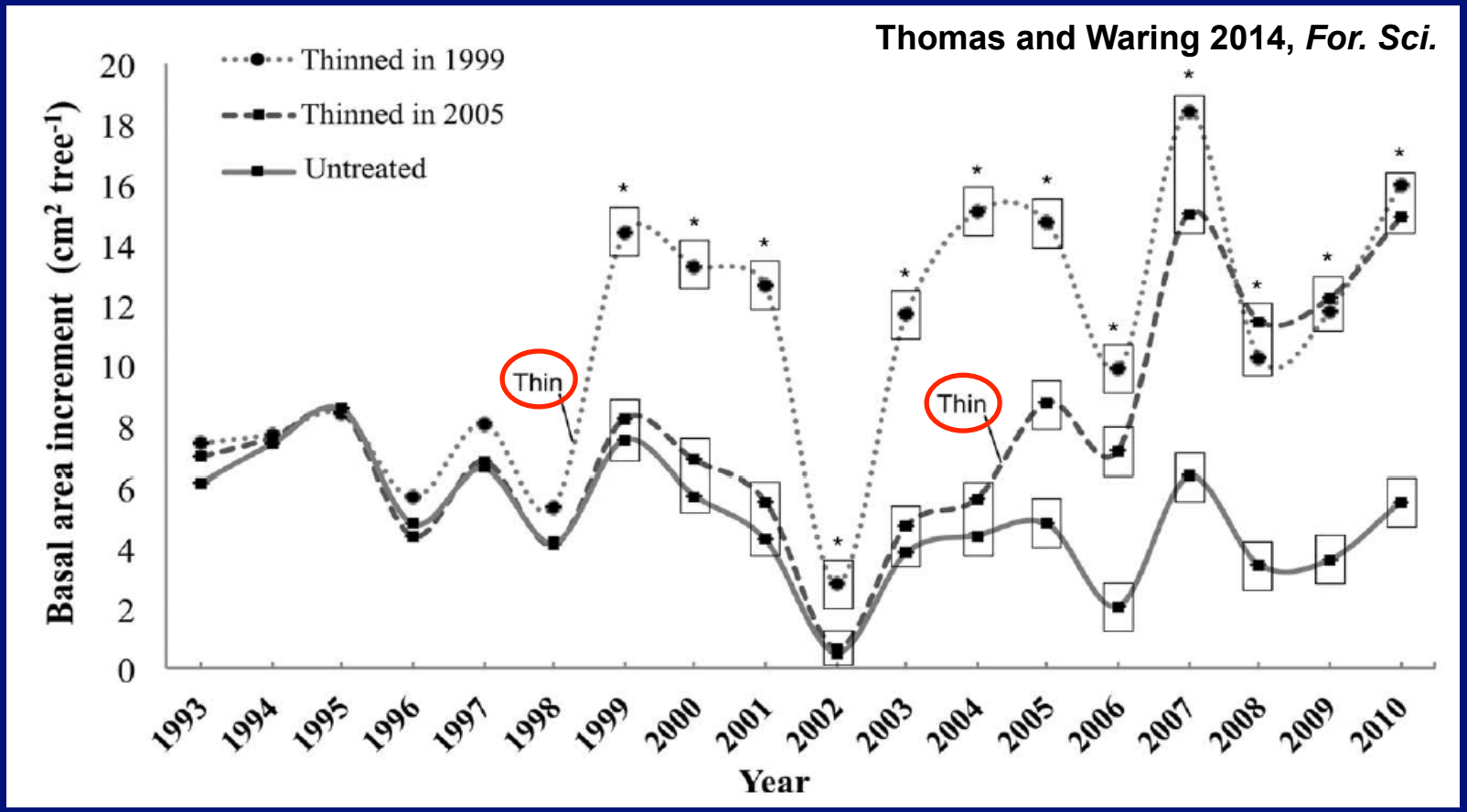
Credit: N. Stephenson

Resilience?

- 30 *P. ponderosa* stands in northern NM
- History of high grading logging and grazing
- Thinned and Rx fire in 1999 (n=11) or in 2004 (n=7)
  Treatments lowered stand density and BA



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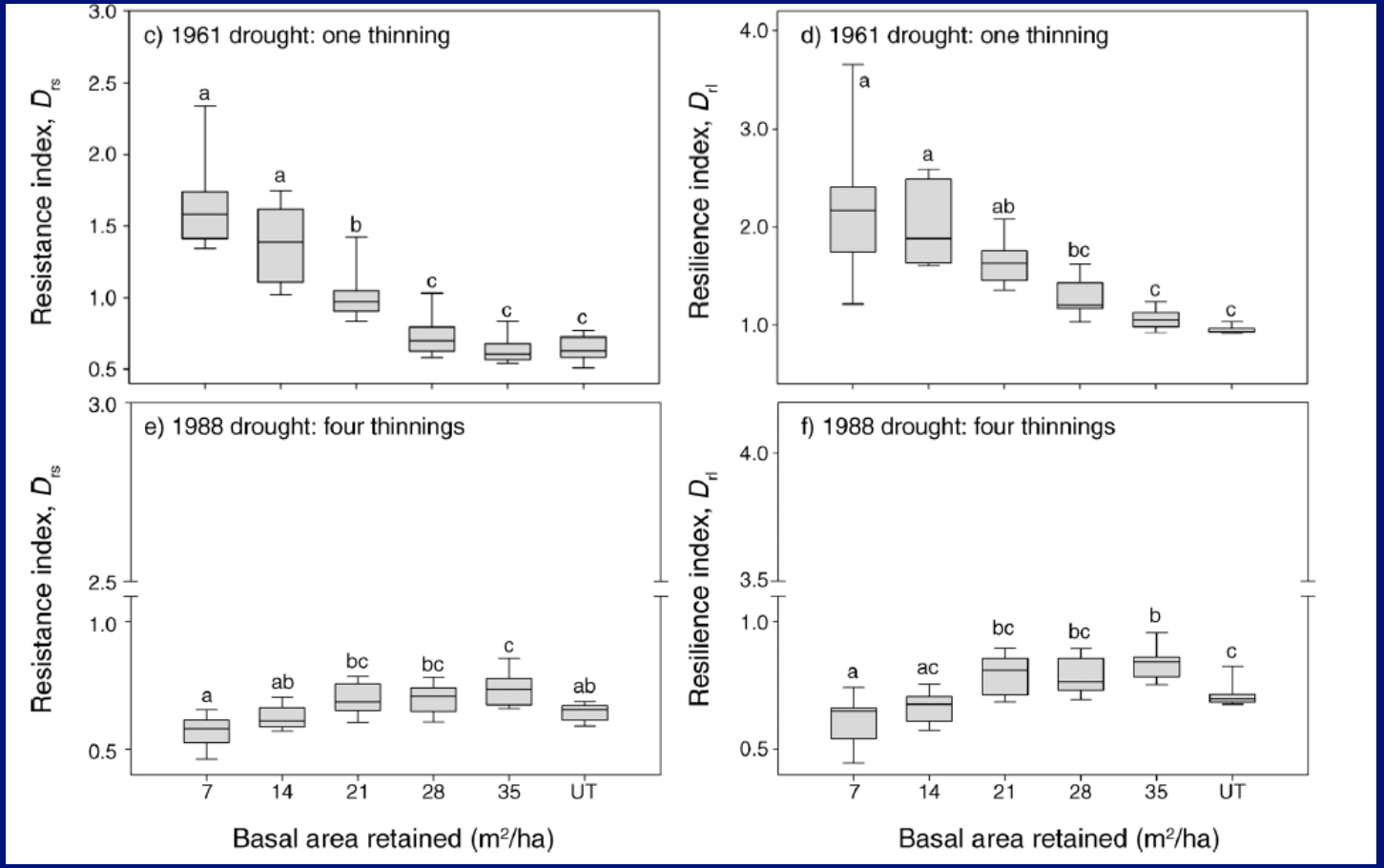
Resilience?

D'Amato et al. 2013 *Ecol. Appl.*

- Long-term thinning experiment on *P. resinosa* (red pine) in MN
- Varied levels of BA retention (7 to 35 m^2 ha^{-1})

1961 Drought
+ thinning effects

1988 Drought
- thinning effects



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Ponderosa pine stand, repeatedly treated with prescribed fire, Lava Beds NM, California

Barriers to implementation

Prescribed fire funding, air quality, burning windows, site accessibility

Prescribed fire may not be sufficiently severe *(Higgins IJWF 2015)*

Hotter droughts may produce stresses that exceed potential management responses

www.werc.usgs.gov/DroughtForestFire

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The take home!

- The 2012-2015 drought may be a “sneak peak” of future conditions.
- Thinning treatments (mechanical, prescribed fire, or both) have the potential to increase forest resistance and resilience to drought.
- Thinning treatments may represent “no regrets” management options, though barriers exist to implementation.

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Thanks!

Countless field crews and data managers…

National Park Service, USGS,
Southwest Climate Science Center

USGS