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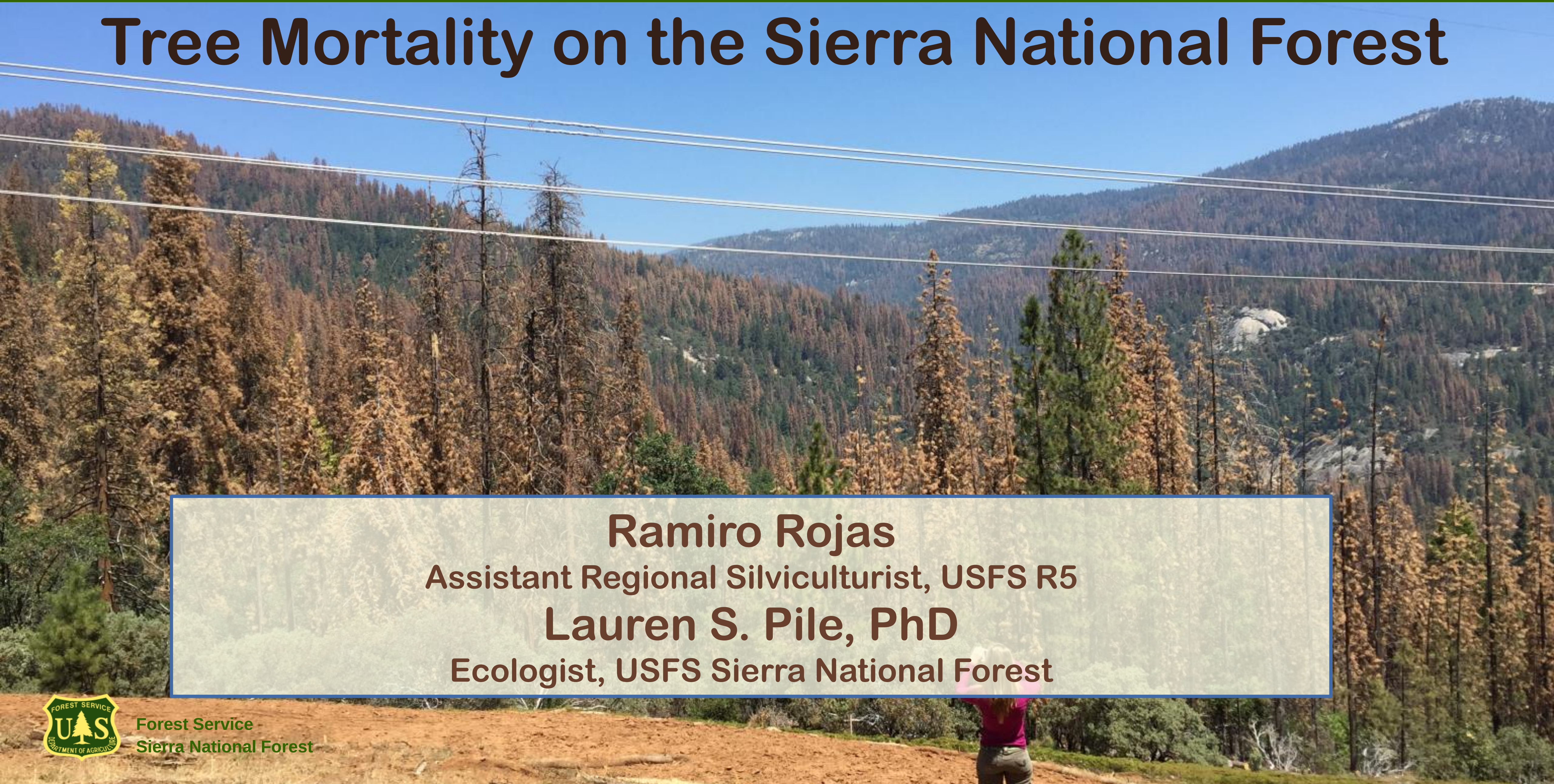
Tree Mortality on the Sierra National Forest



Ramiro Rojas

Assistant Regional Silviculturist, USFS R5

Lauren S. Pile, PhD

Ecologist, USFS Sierra National Forest

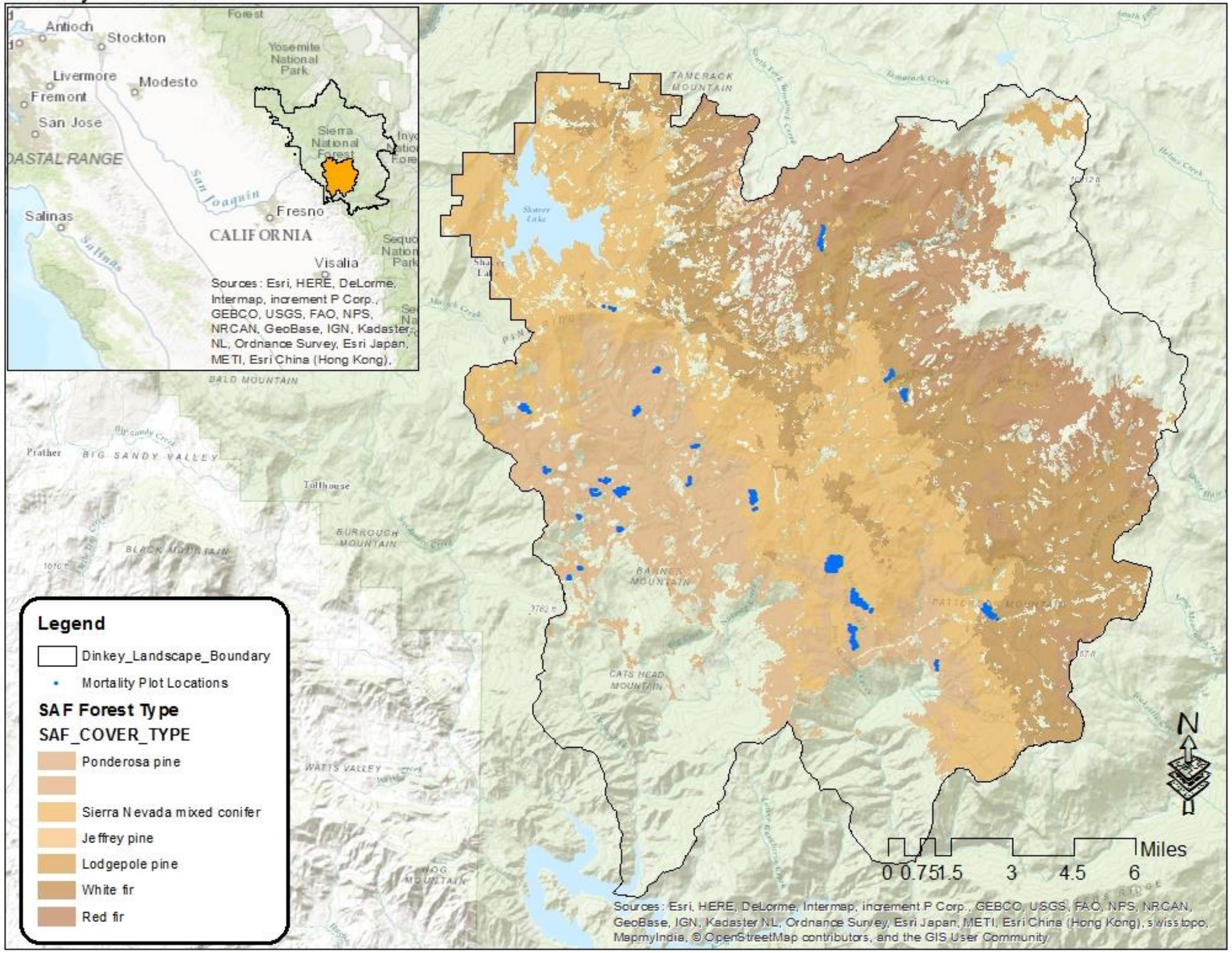
Forest Service
Sierra National Forest

Data Collection

- Repeated measurements were taken across 255 plots and recorded 1699 individual trees
- The plots were established in SPRING 2015 and resampled in SUMMER 2015 and SUMMER 2016

- By using a repeated measurement design approach of the same individual this allows for the comparison of species survivorship across time periods – providing valuable insights into the trends of tree mortality and can guide future forest management

Mortality Plot Locations



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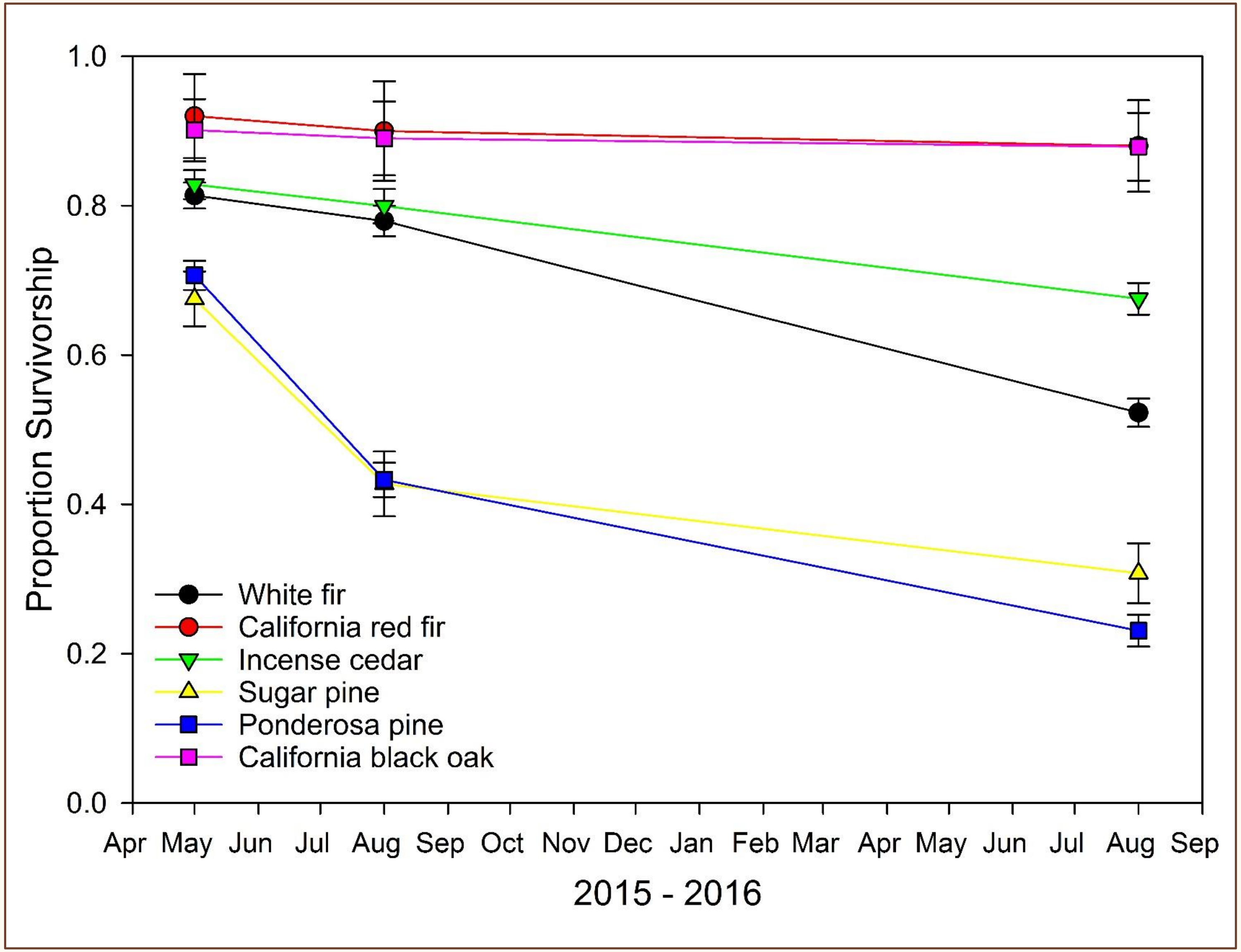

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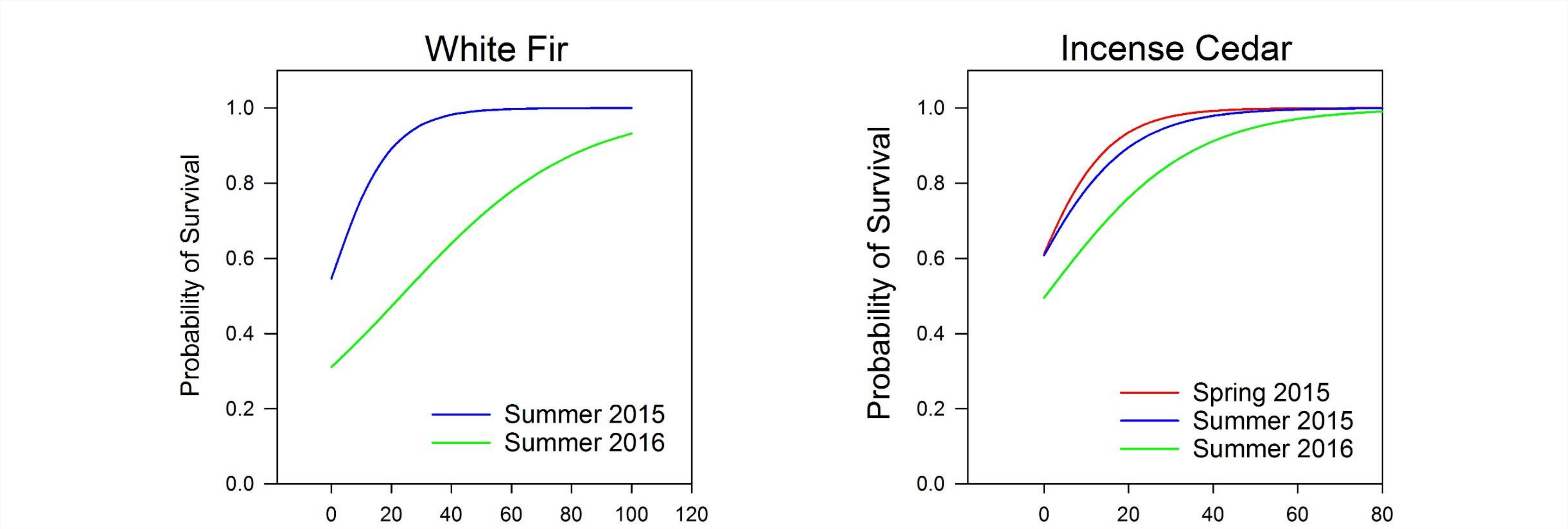
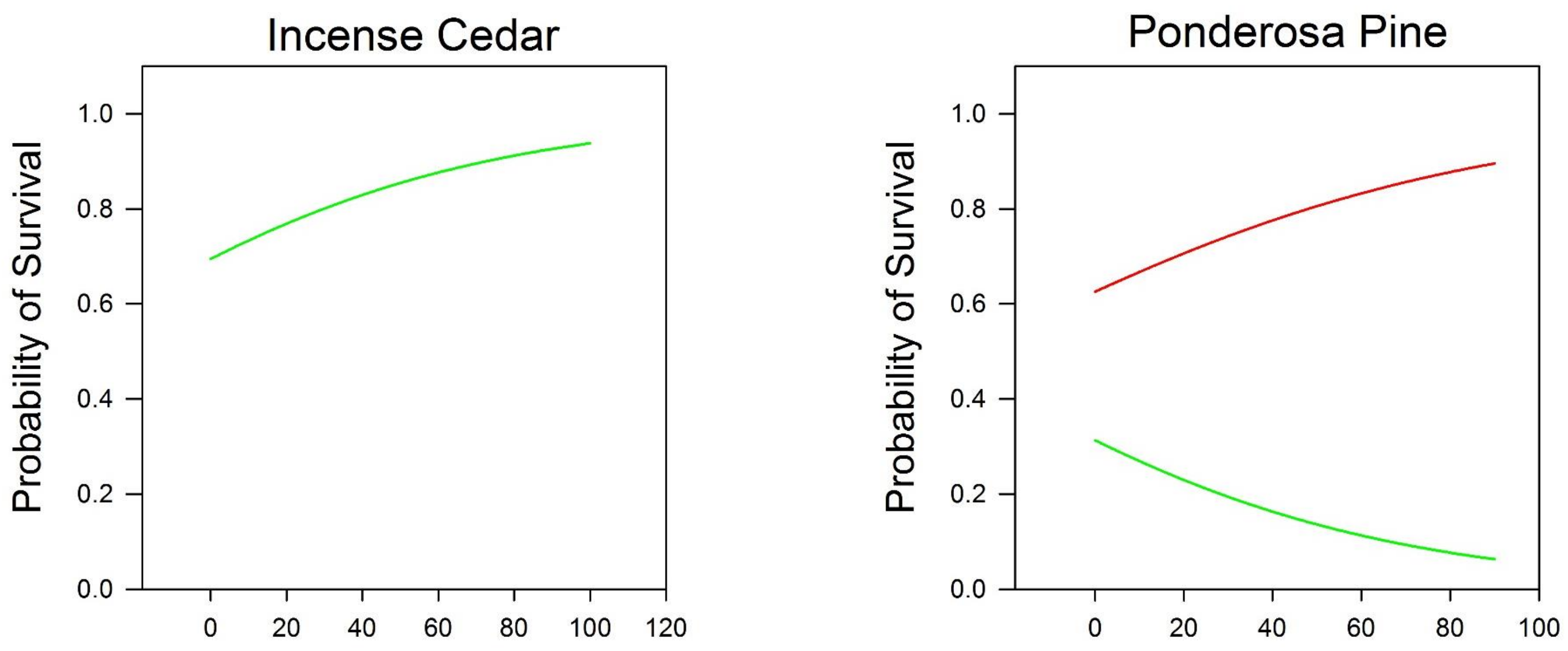
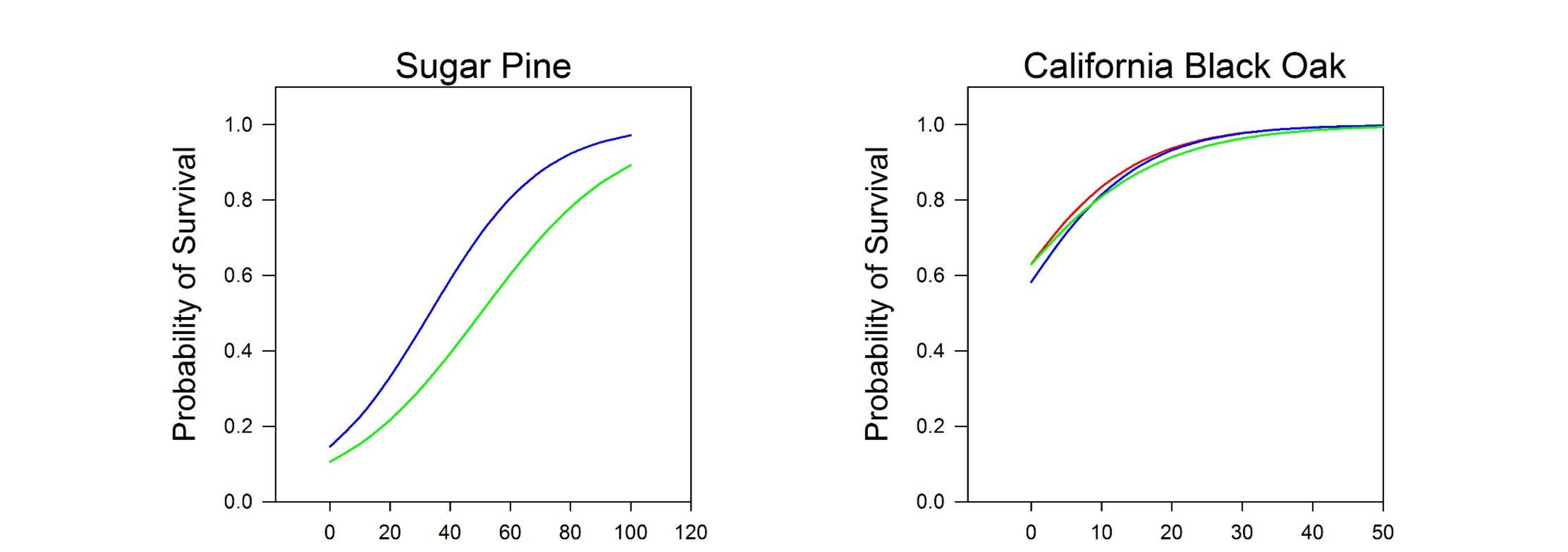


Live Crown Ratio (%)

Diameter Class (inches)



Live Crown Ratio (%) Diameter Class (inches)



Live Crown Ratio (%)

Diameter Class (inches)

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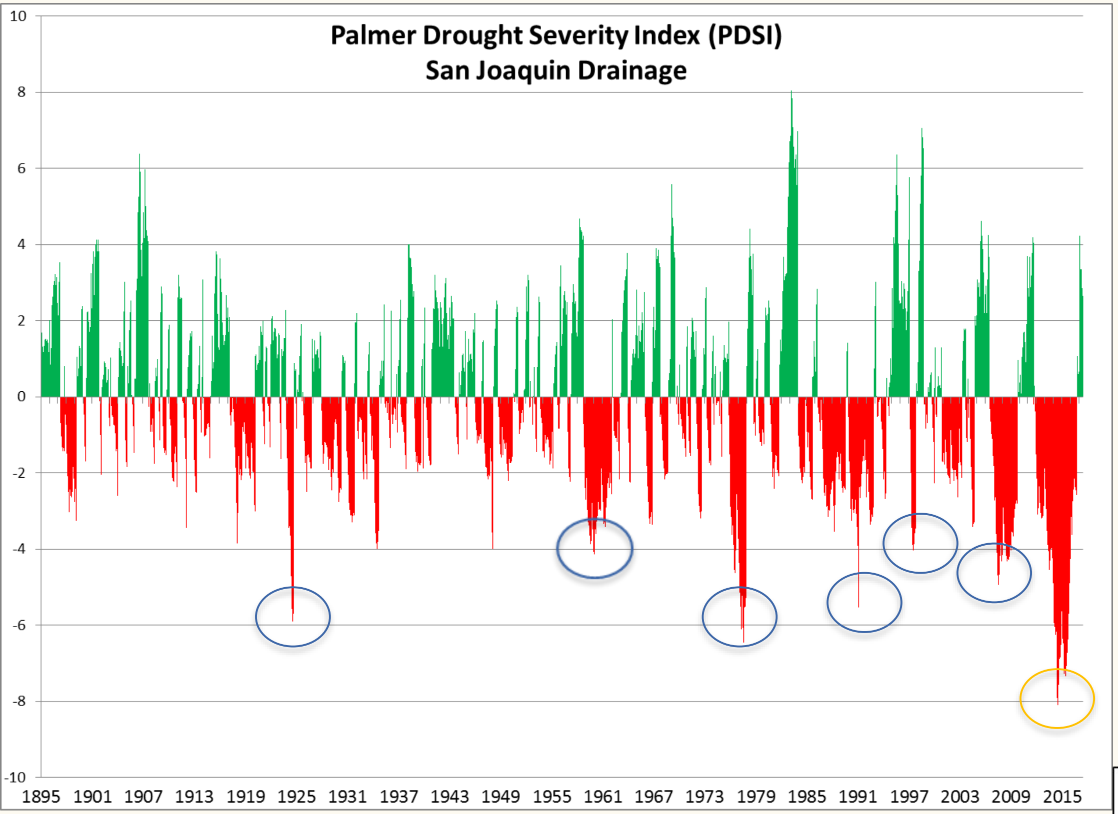
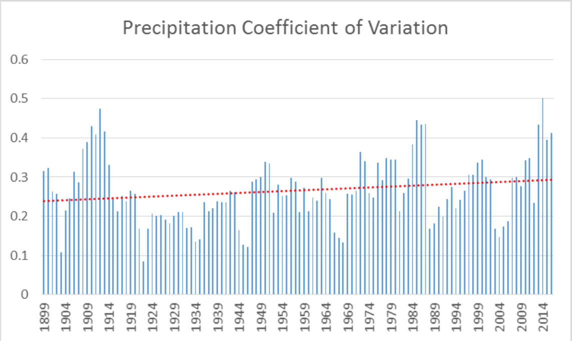
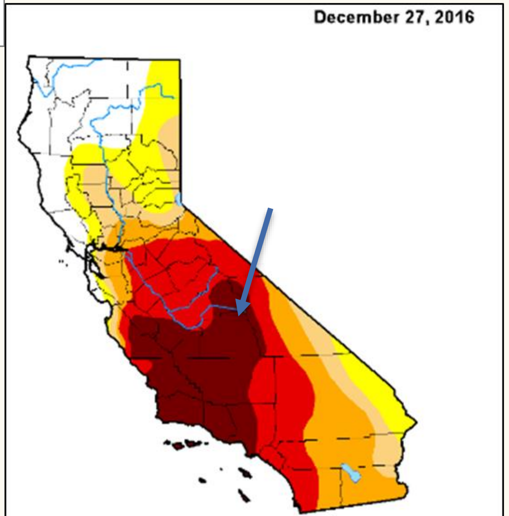
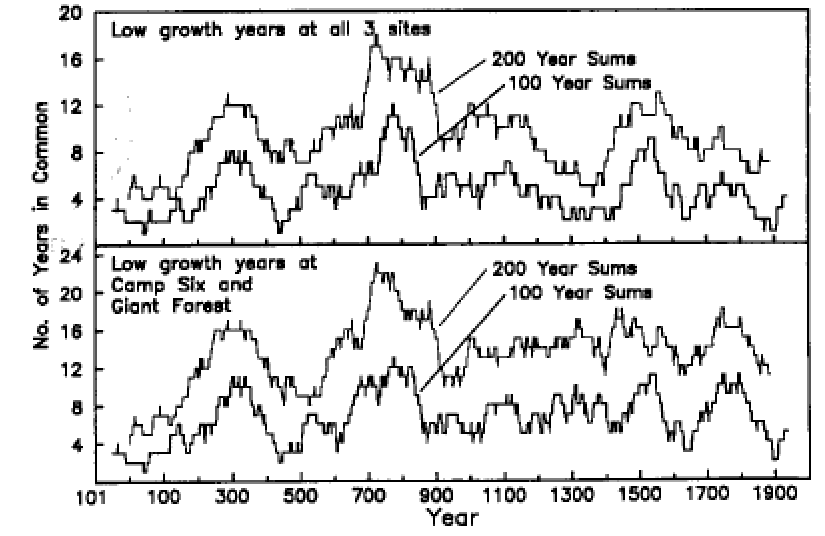


Management Context

- Drought is part of the Mediterranean climate (extreme droughts 12/100y period)
- The first part of the 20th century was an unusually wet period in the record (Hughes and Brown 1992)
- Management implications are for managers to increase tree resilience







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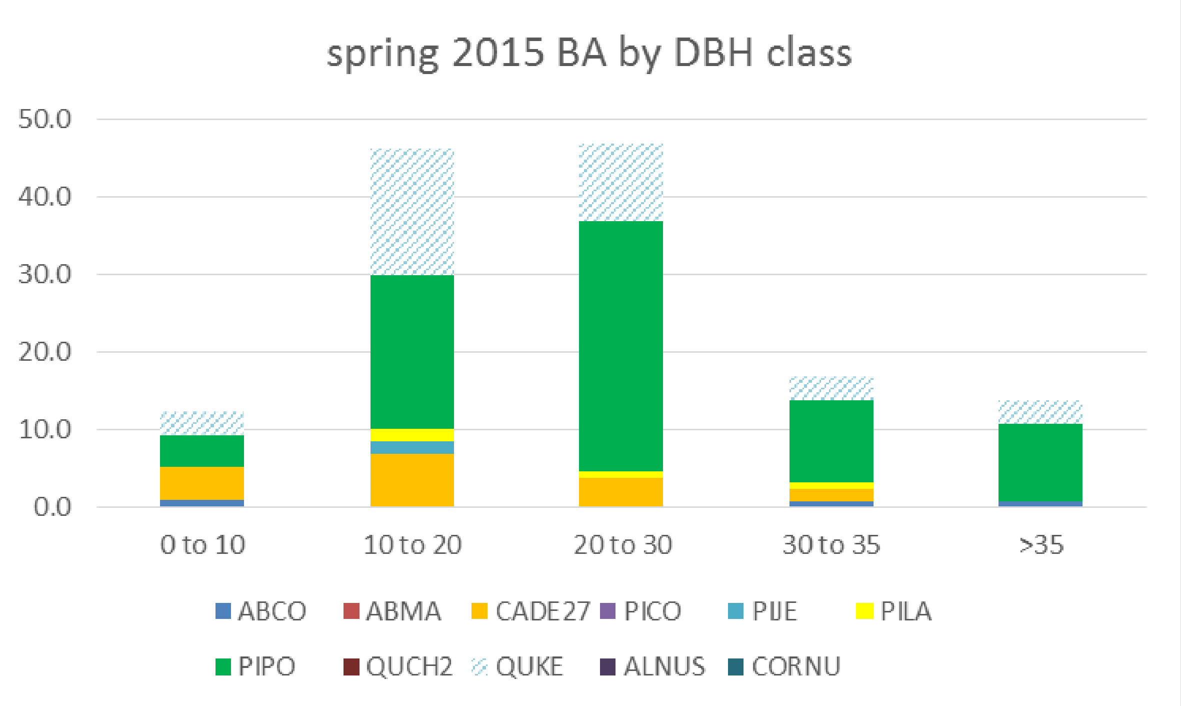
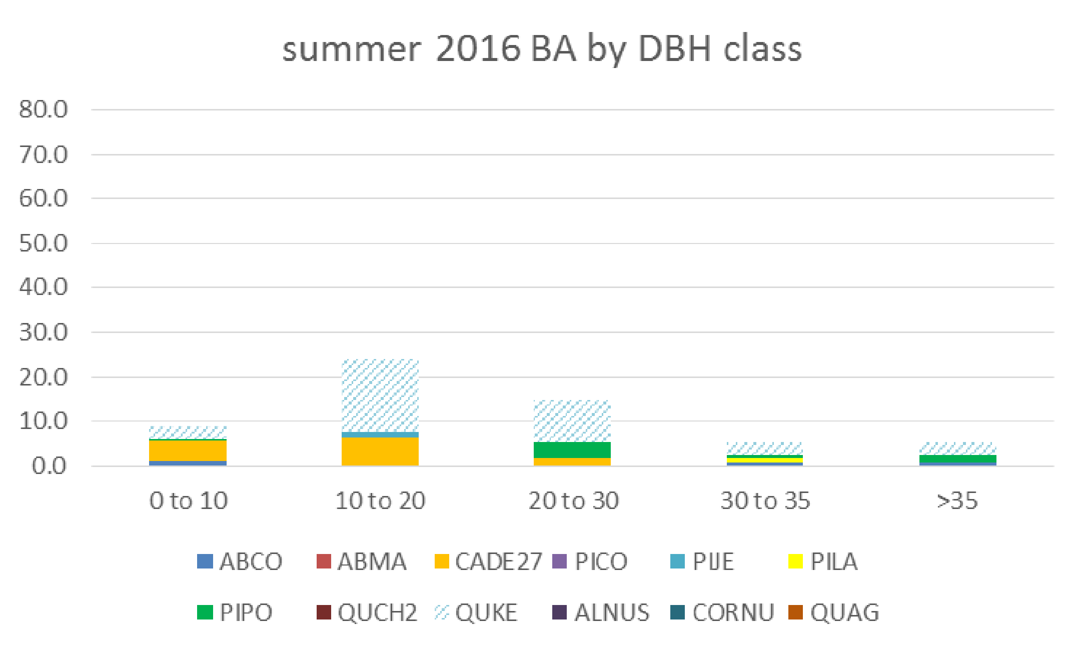


Low survivorship in ponderosa pine plots reflects the obvious change in forest structure and composition. Average ponderosa pine forest stands have less than 50 trees per acre over 10 inches DBH, with five trees per acre in pine species by 2016

Remaining forest structure and composition is dominated by white fir, black oak, and incense cedar

Only scattered large pines (>35") remain. Pine species are still found at every elevation it was found before the 4 year drought

Reforestation or thinning/fuel treatments are needed to set stands on a restoration trajectory



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Management note

- Live crown ratio can be manipulated by tree density or stocking
- Reduced forest densities will increase live crown ratios by providing more growing space (consider the difference between an open grown tree and a tree in a dense forest)
- However, thinning must occur prior to a threshold in live crown ratio – thinning past this threshold may not increase the live crown ratio (thinning when the crown is reduced to 30% lower probability that the tree will increase in crown ratio – especially true for DF and WF)

Management note

- Prior to the large beetle outbreak, the moderate/extreme drought effects in early 2015 – stand management that promoted large individual trees could have increased pine survivorship.

- However, in exceptional droughts representative of conditions in 2016 - variable structures that contain both large and small trees result in more survivors. Creating multi-aged stands may increase resilience and survivorship.

- During exceptional drought, prescriptions that have promoted openings for new trees or retain small trees are likely to recover soonest.

Management note

- Surviving understory trees (even suppressed pine) may provide opportunities to accelerate restoration of forest structure and composition (Barrett 1982)

- However, careful selection of understory trees with sufficient live crown (>30%) and potential for future growth have a higher probability for success..

- Increasing growth of understory survivors is complicated by the high volume of the dead overstory. Overstory removal greater than 15 MBF often results in the loss of the understory. This effect is lessened with mechanical harvest.
  - Average dead volume per acre for pine dominated stands is 21 MBF/A

Management note

- The dramatic loss of ponderosa pine and sugar pine creates conditions that limit the potential for natural pine regeneration
  - Few large trees or none
  - Unlike fires no bare mineral soil is created

- Reforestation efforts are necessary to create conditions for pine regeneration in many stands

- Consider - Planted or natural seedlings on R5 site class 3 at 18’ spacing remain open grown for ~40 years (without ingrowth).

Management Considerations

- Live crown ratio and tree size are important indicators of tree survivorship. These traits are a function of site and density
- Drought and subsequent insect attack are typical – extreme drought verses exceptional drought
- Take advantage of understories. Incense cedar is drought tolerant but not fire tolerant – implications for now IC dominated stands.
- Low pine survival and low basal creates opportunities for the rapid increase of shrubs and noxious weeds

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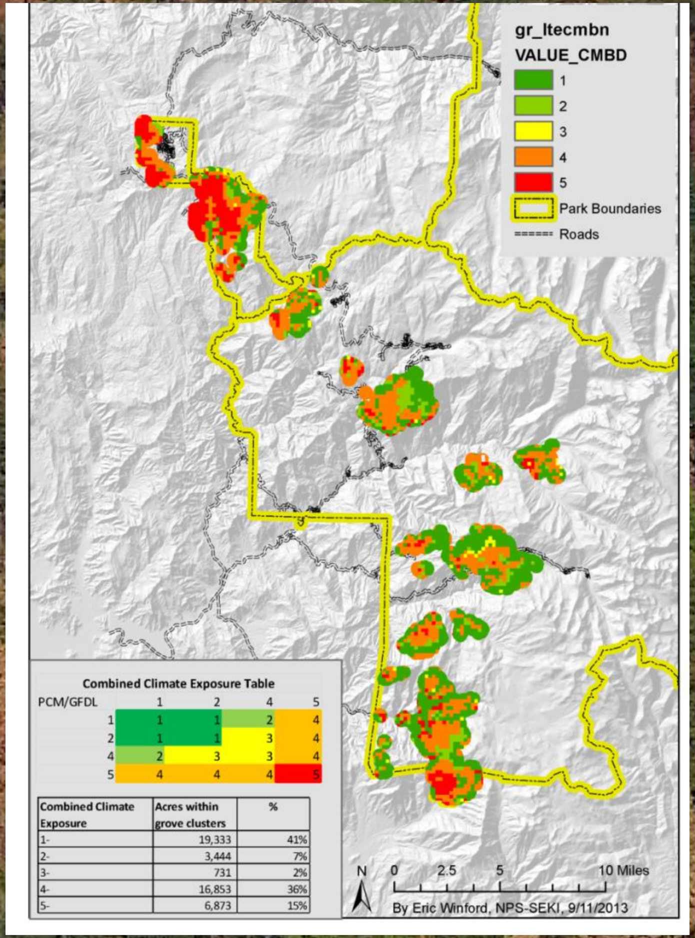
Which trees died? Why?

Insights for the future



Combined Climate Exposure Table

PCM/GFDL	1	2	4	5
1	1	1	2	4
2	1	1	3	4
4	2	3	3	4
5	4	4	4	5

Combined Climate Exposure	Acres within grove clusters	%
1-	19,333	41%
2-	3,444	7%
3-	731	2%
4-	16,853	36%
5-	6,873	15%

Adrian J. Das
Nathan L. Stephenson
Western Ecological Research Center
U.S. Department of Interior
U.S. Geological Survey

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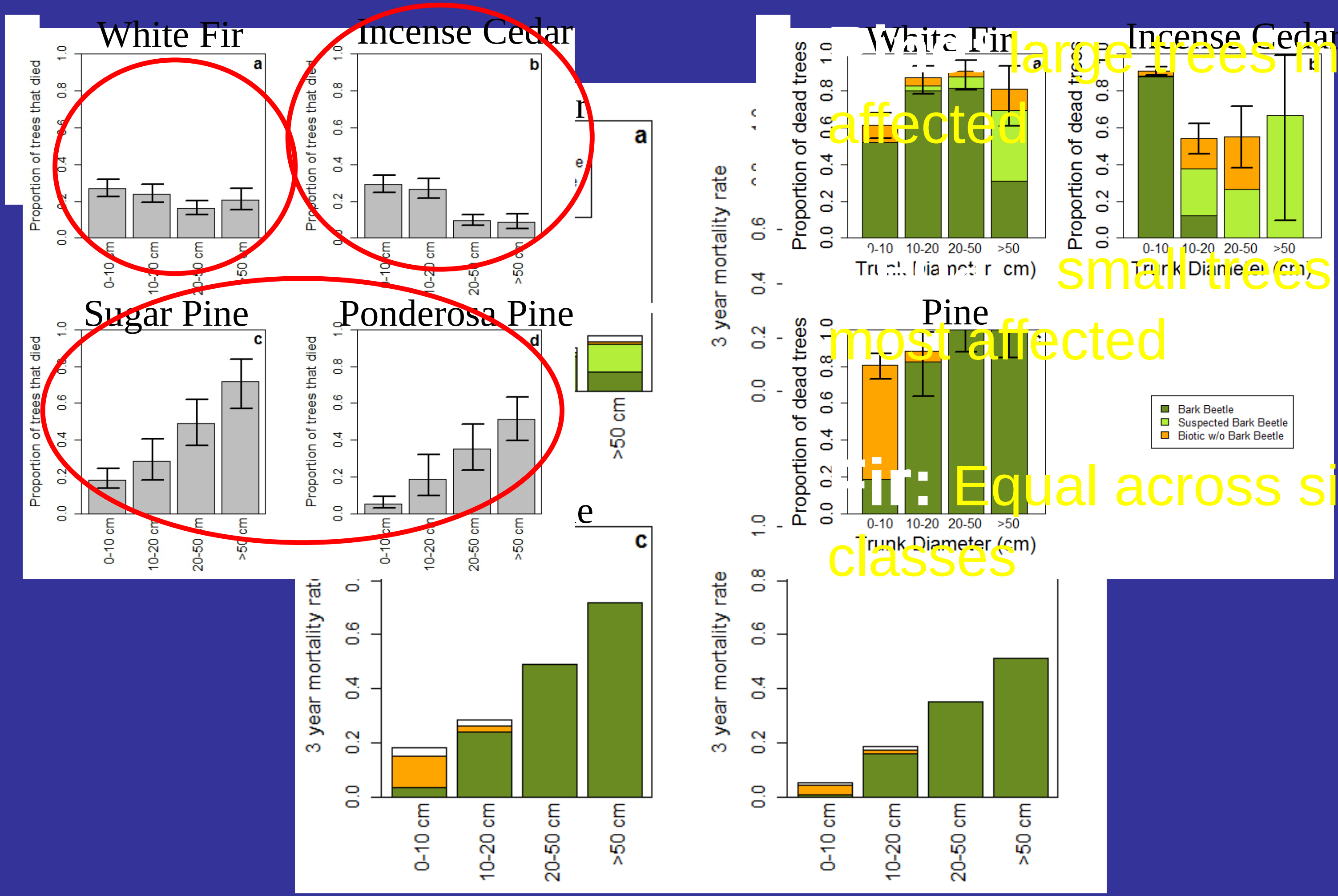
What died?

Bark Beetles

From What?

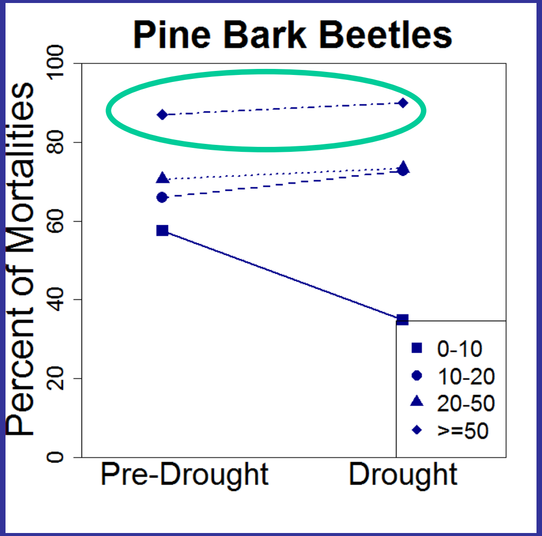


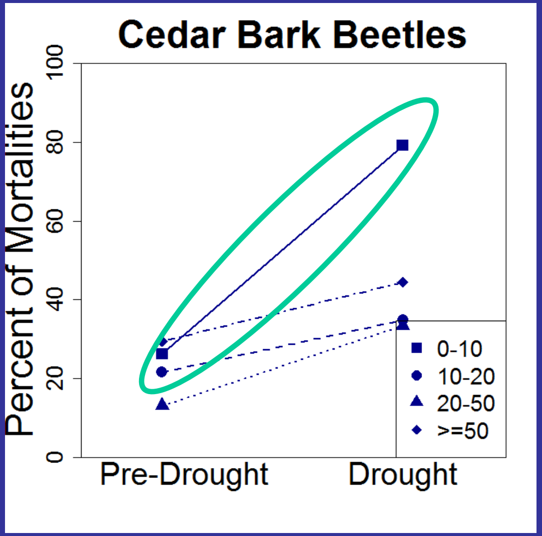
large trees most affected

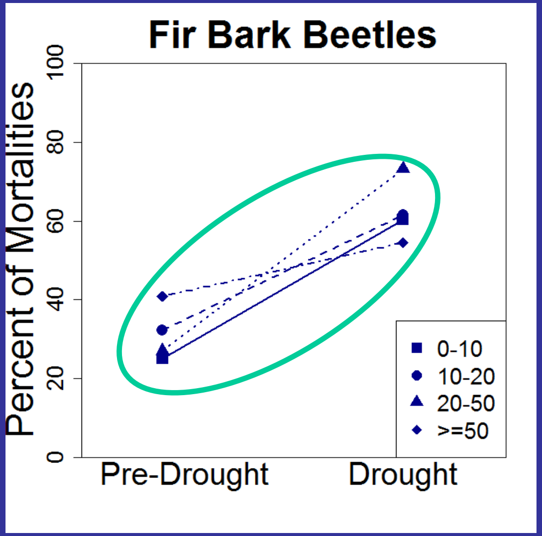
small trees most affected

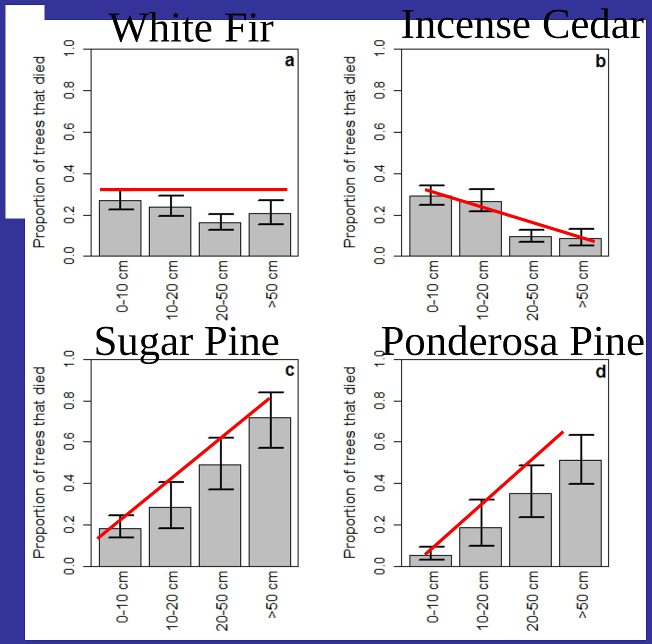
Fir: Equal across size classes

The Beetle is in the details.









- Pine Bark Beetles prefer large trees
- Cedar bark beetles prefer small trees
- Fir bark beetles combine to cover the size classes

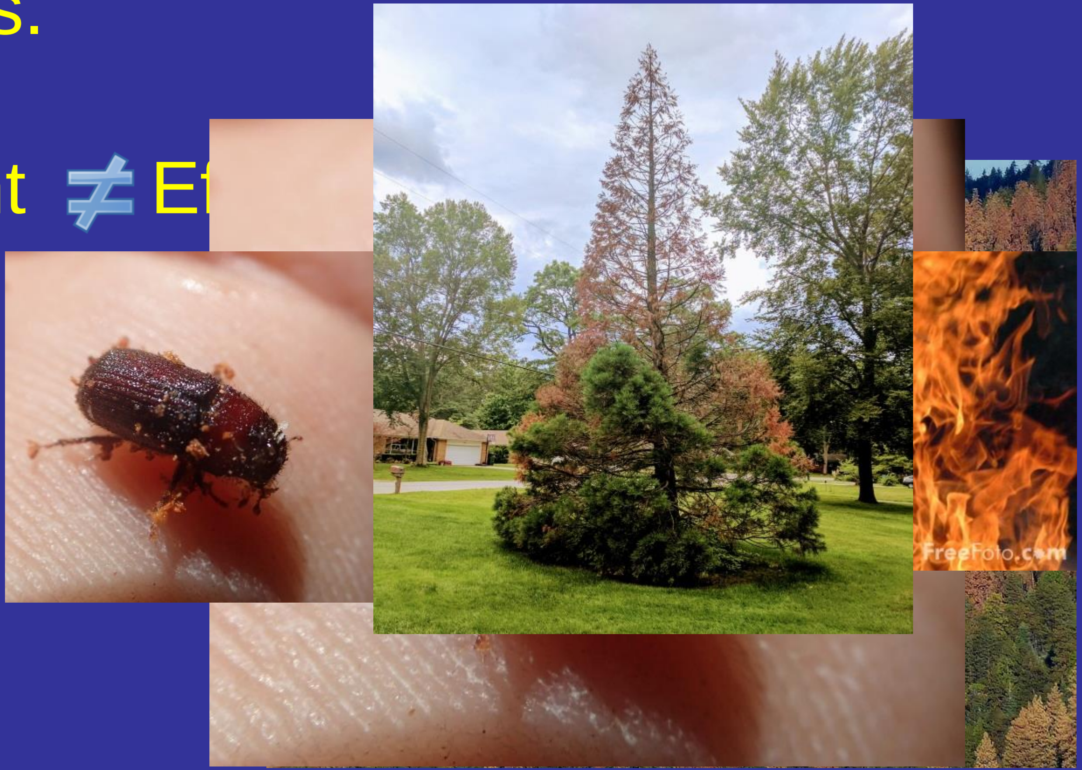
Management Considerations?

- Insects appear to be the filter through which drought mortality has occurred.

- Beware new threats: novel climate can lead to novel interactions.

- Effects of drought ≠ Ef

- It's still a forest.



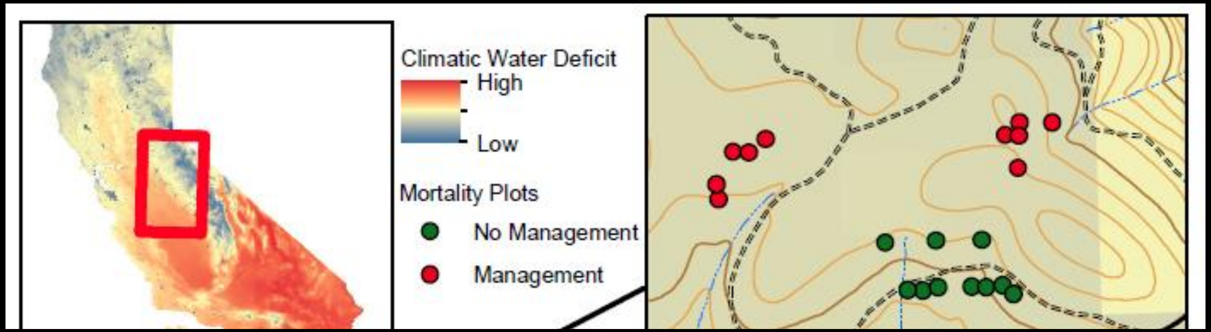

Density matters – forest thinning treatments reduce drought stress and tree mortality in the Sierra Nevada
Christina Restaino, UC Davis
Becky Estes, Shana Gross, Marc Meyer
Amarina Weunschel, Hugh Safford (US Forest Service)

Were treated forests more resistant to the recent bark beetle epidemic in the Sierra Nevada?

Actions to restore forests to more historical conditions (i.e. reduce stand density)

Yosemite National Park, Photo: Marc Meyer

Sierra National Forest, Photo: Marc Meyer



Eldorado NF – 46 plots

Stanislaus NF – 84 plots

Yosemite NP – 67 plots

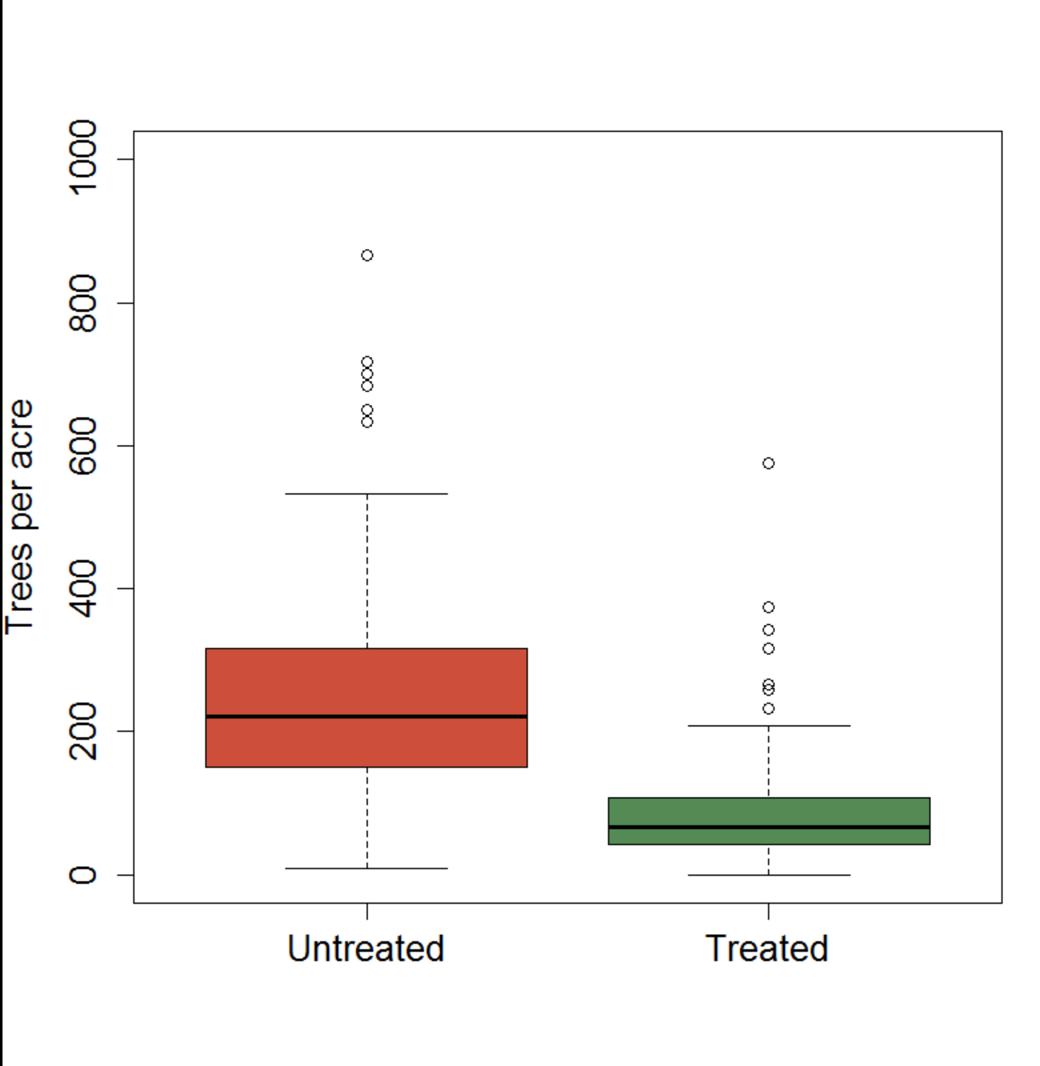
Sierra NF – 114 plots

Total = 311 plots

Untreated = 158

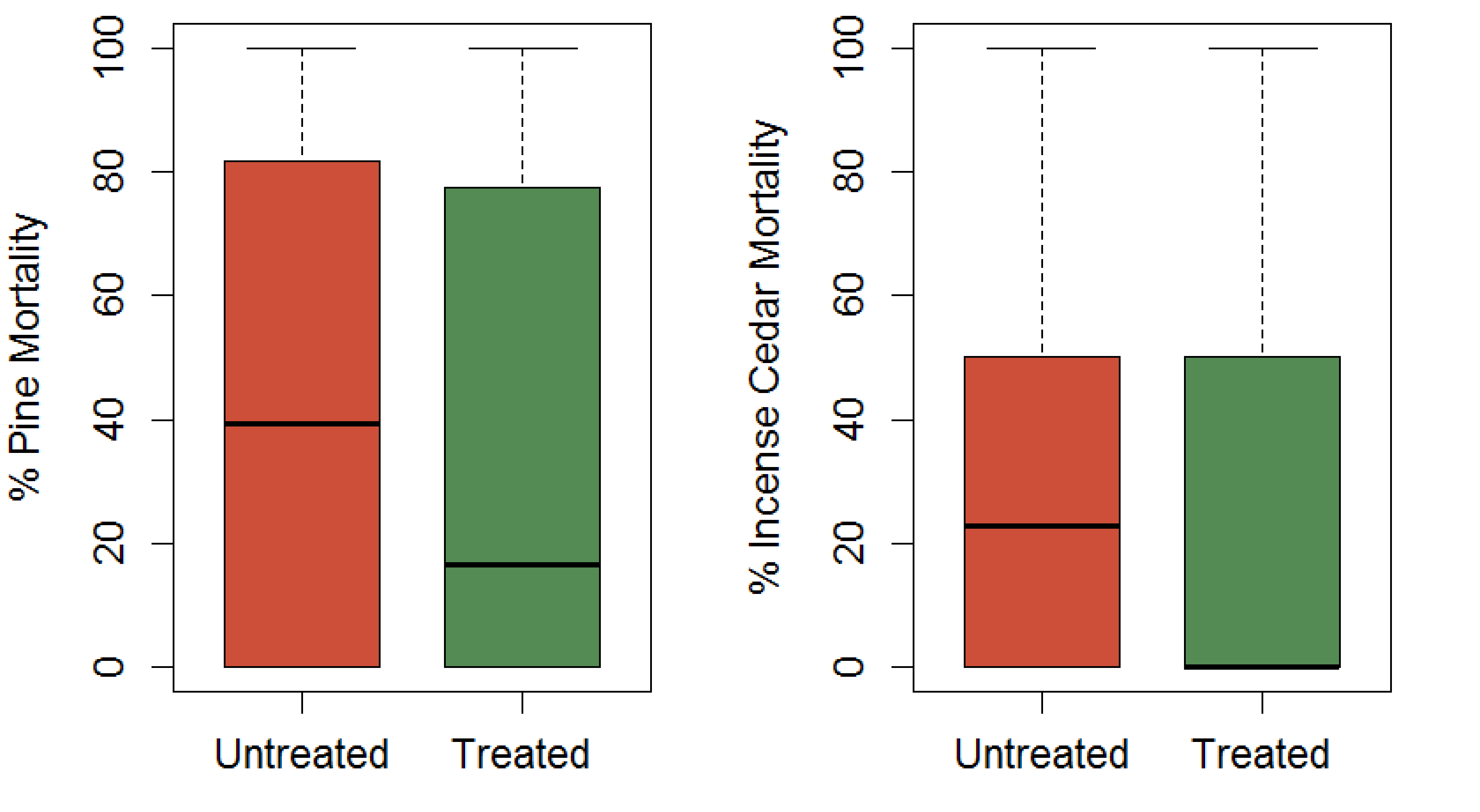
Treated = 153

Higher density (TPA) in untreated stands



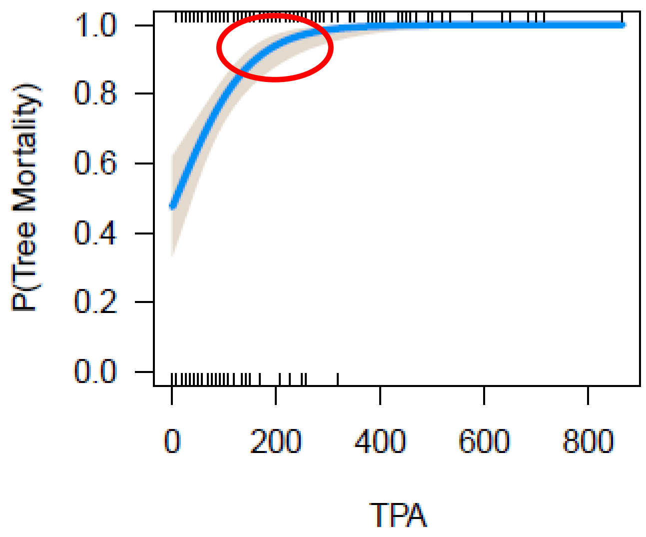
TPA = Trees per acre

Higher tree mortality in untreated units

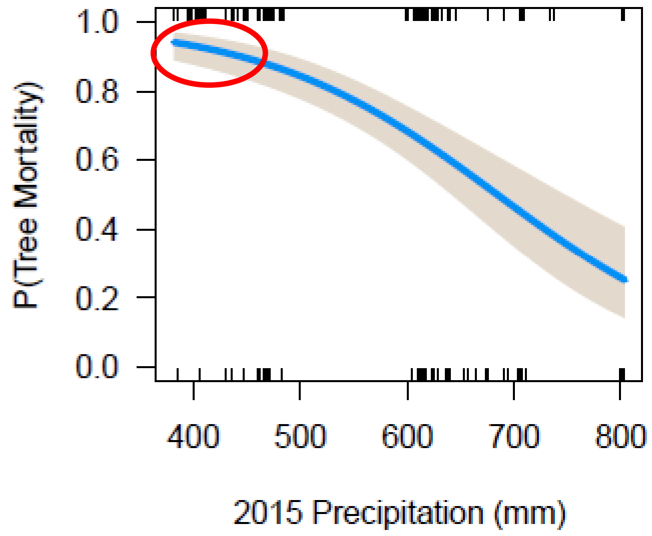


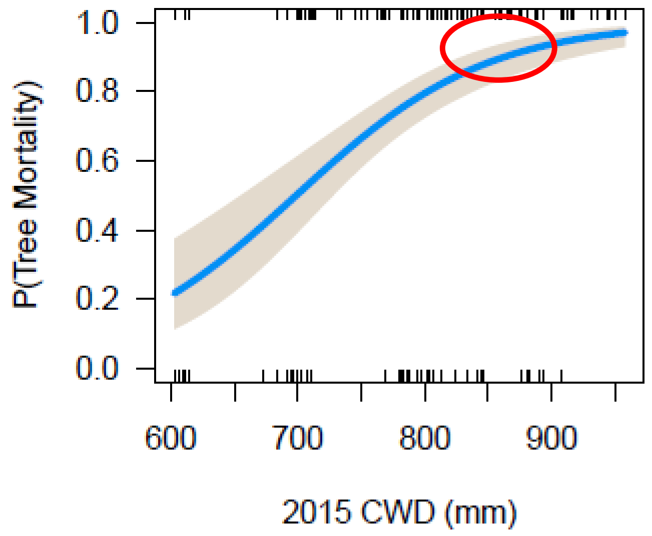
Higher TPA → Higher tree mortality

Logistic Regression

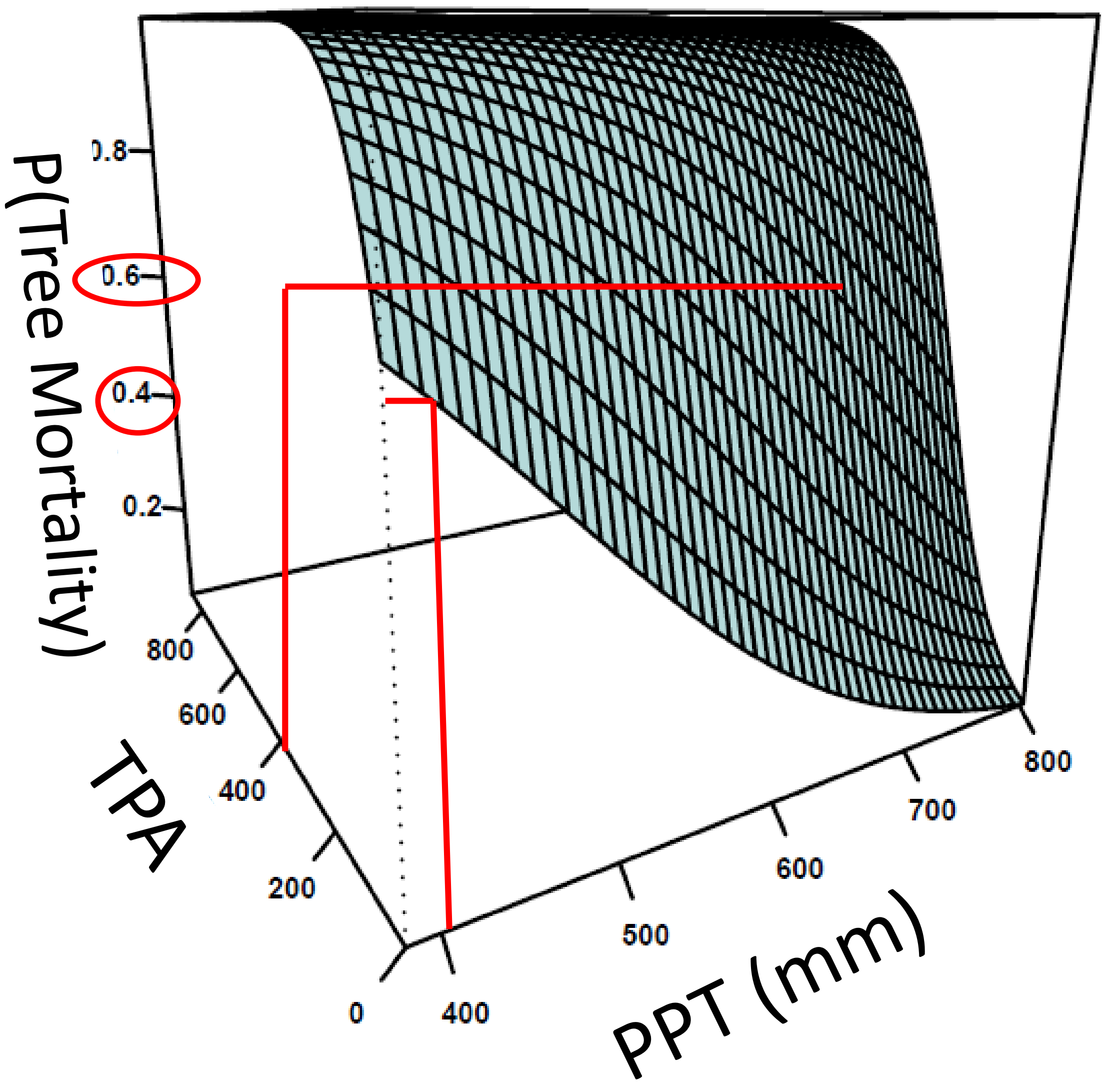


- 90% probability of tree mortality when TPA exceeds 200
- 90% probability of mortality when PPT = 400 mm and CWD = 850 mm





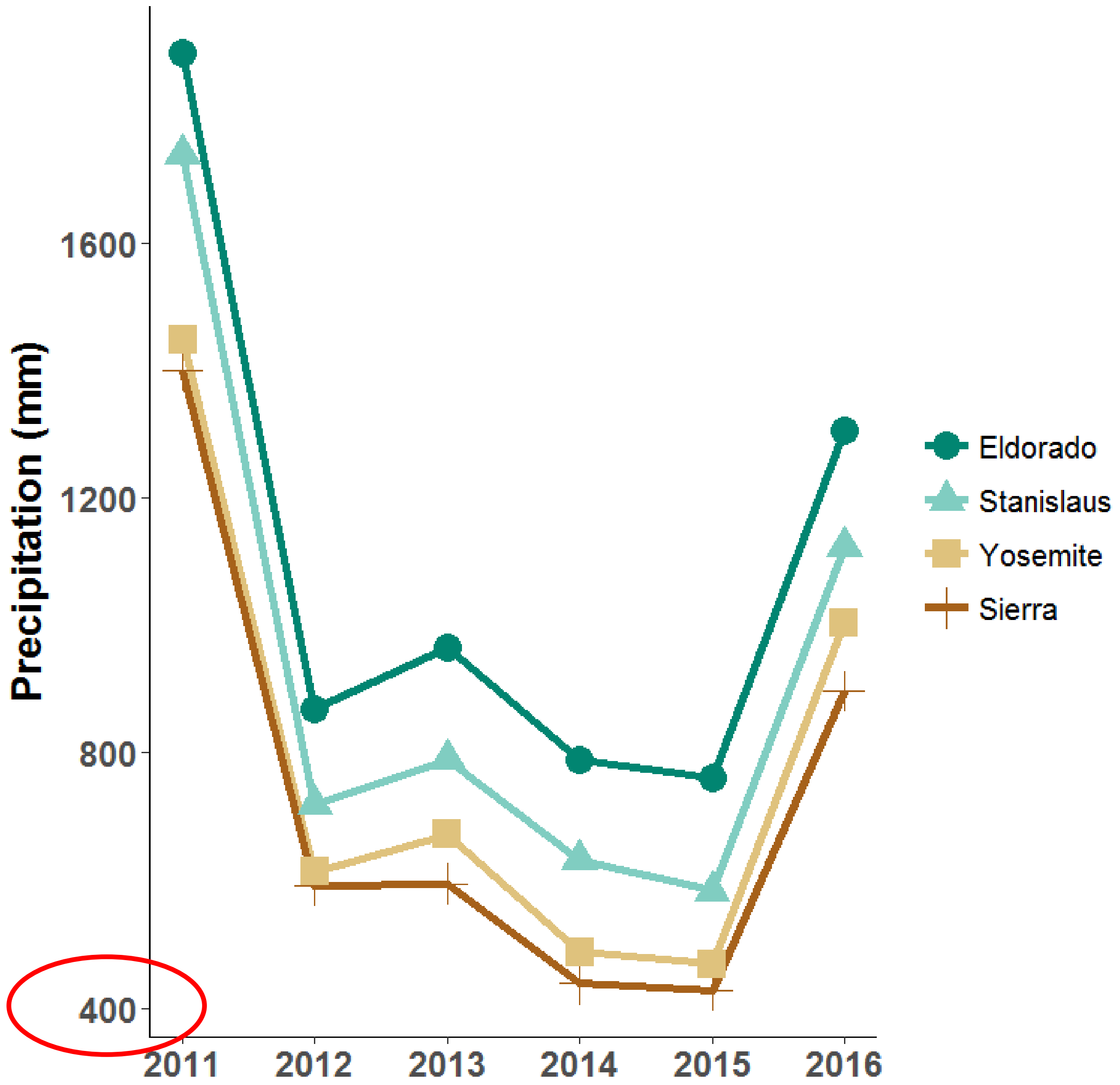
If water stress or density are too high…



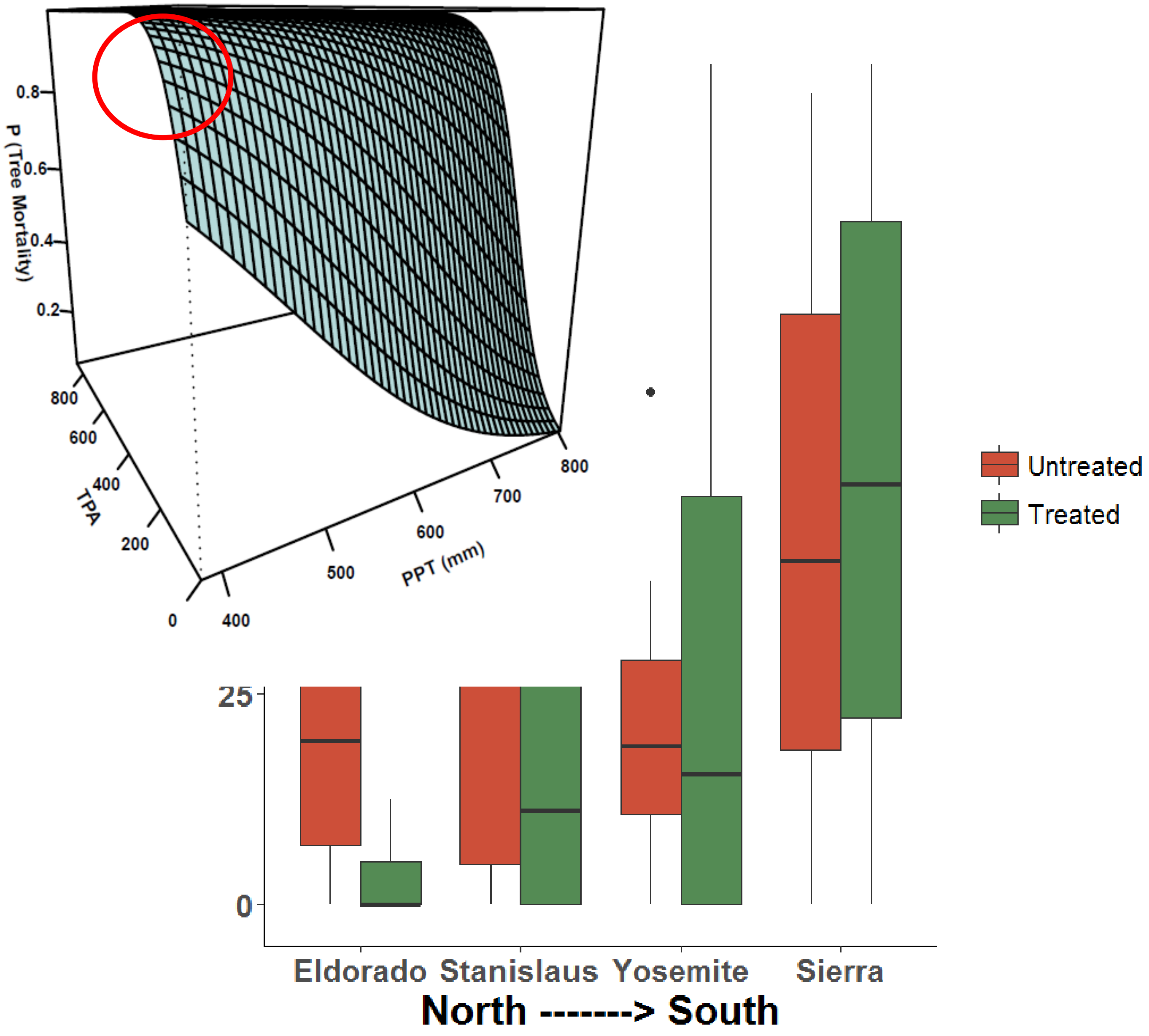
When PPT is at its lowest, probability of mortality is as high as 40% even when there is very low stand density.

Once TPA reaches 400, even with PPT levels as high as 700 mm, there is still a 60% probability of mortality.

Where has the precipitation been lowest?



Treatment effectiveness decreases as you move south



Summary

- High tree density → more mortality
- Low tree density → less mortality

- BUT, if water stress is too high density does not matter anymore. Likewise, if density is too high, increased moisture will not compensate for water demand in system.

- Gradient in treatment effectiveness from north to south

- Treatment only works below certain levels of water stress, but it does work!

Up Next

- Tree cores
- Complete re-measure of all plots
- Establish new sites on Sequoia and Tahoe
- Fuels transects
- Spatial heterogeneity measures

Acknowledgements:

Co-authors: Becky Estes, Shana Gross, Marc Meyer, Amarina Weunschel and Hugh Safford

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Is there a relationship between tree mortality and fire susceptibility?

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U.S. Geological Survey

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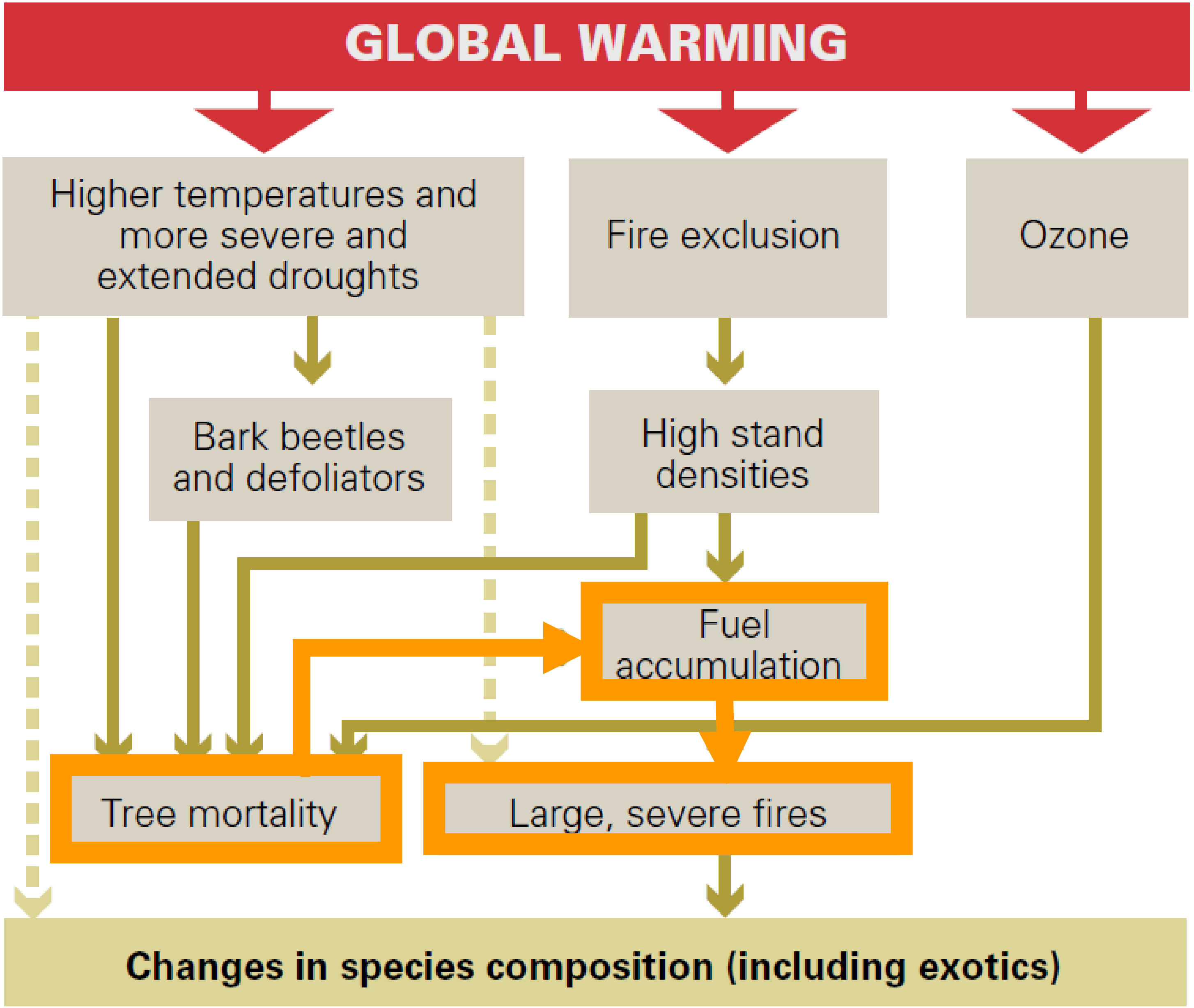
Photo credit: Carrie Vernon, NPS

Stress complex for Sierra Nevada and Southern California mixed-conifer forests



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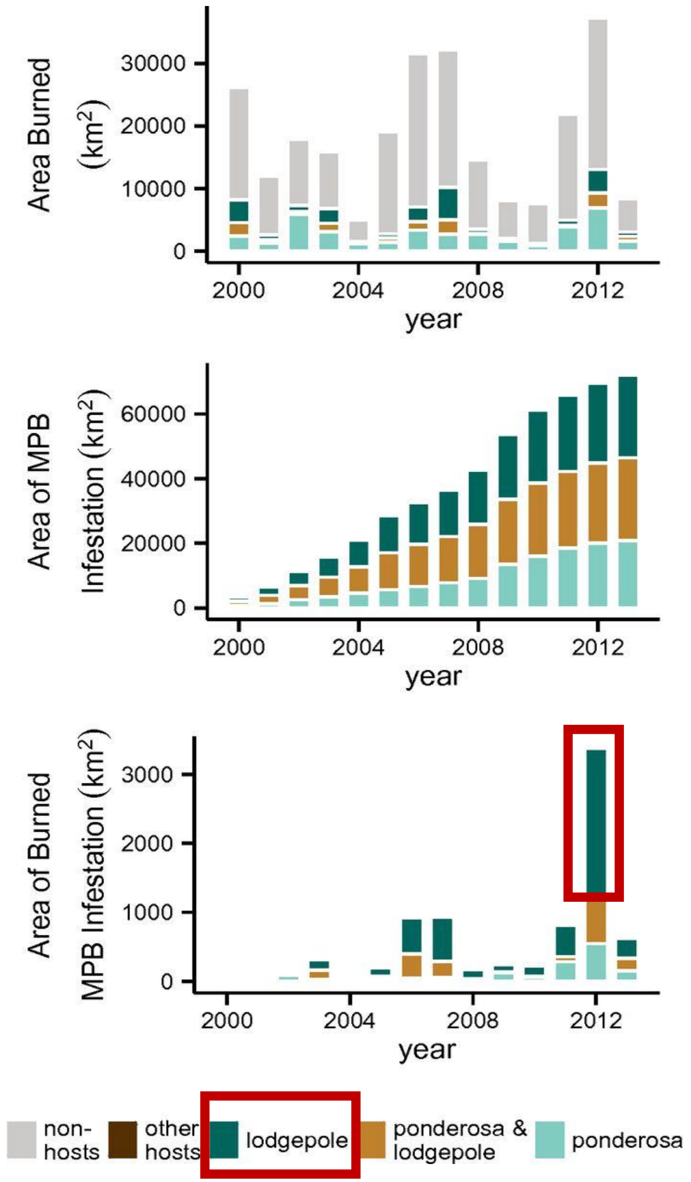
Littell *et al.* 2016 USFS GTR WO-93b

Major wildland fires in 2006, 2007, and 2012 that intersect MPB hosts and cumulative MBP infestation in 2000–2013 across the western United States.



Hart *et al. 2015 PNAS* 112:4375-4380

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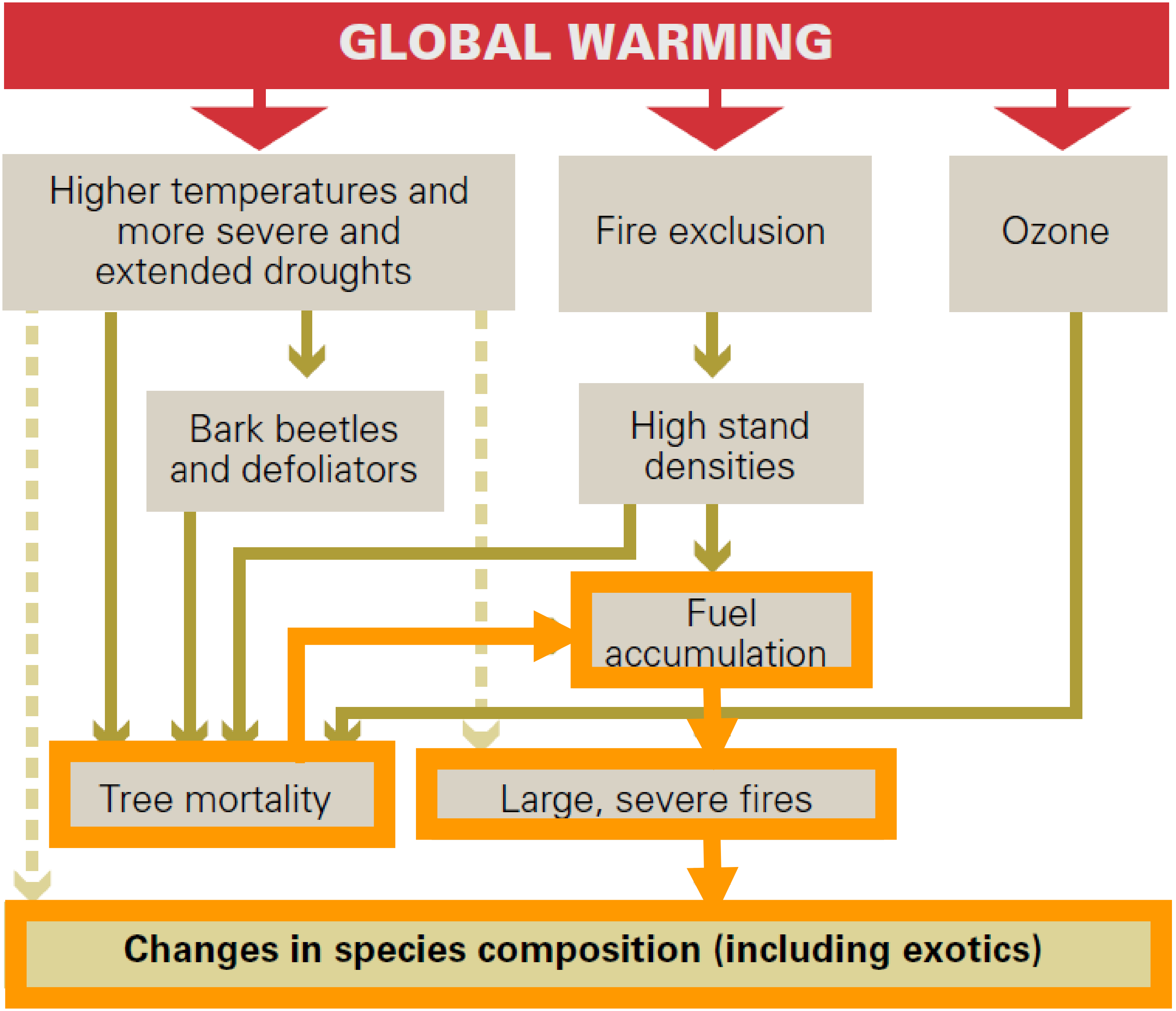
Stress complex for Sierra Nevada and Southern California mixed-conifer forests



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Littell *et al.* 2016 USFS GTR WO-93b

Reinforcement of fire-driven vegetation type conversions following Las Conchas fire, Jemez Mountains of New Mexico

2006 | **2014**

Ponderosa pine → Oak scrub

Ponderosa pine → Ruderal

Coop *et al.* 2016 *Ecol. Appl.* 26: 346–354

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

What to do?

Hazard tree removal

Increased use of forest thinning and prescribed burning

Wildland fire use

Barriers to implementation

Incentives, funding, site accessibility, processing infrastructure, air quality, limited burn windows

Rx treatments may not be sufficiently severe *(Higgins IJWF 2015)*

Hotter droughts may produce stresses that exceed potential management responses

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PRE-LUNCH SURVEY

https://www.surveymonkey.com/r/S9HVPKL

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