Climate and competition explain regional forest mortality patterns under extreme drought

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Research question

What explains spatial variation in tree mortality throughout California?

- Average aridity?
- Stand density (competition)?
Aerial mortality monitoring in California

U.S. Forest Service
Region 5 Aerial Detection Monitoring
Dead trees km\(^{-2}\)
Dead trees km$^{-2}$

- > 400
- 0
Dead trees km$^{-2}$

- > 400
- 0
Dead trees km\(^{-2}\)

- > 400
- 0
Dead trees km\(^{-2}\)

- > 400
- 0
Long-term average climatic water deficit (CWD)
“Hurdle model” structure

- Explain *probability of observing any mortality* in a given grid cell. Then...

- Explain *mortality amount* for grid cells that had at least some mortality
Mortality probability

Mean annual climatic water deficit (mm)

Drought onset

Mortality amount
Mortality probability

Mean annual climatic water deficit (mm)

Drought onset

Mortality amount
Simultaneous effects of aridity and competition

Observed mortality (2015)

Predicted mortality (2015)
2015

Observed Mortality

Predicted Mortality
Summary

• Greater mortality in hotter/drier sites
• Greater mortality in denser stands
• Aridity—density interaction
• Longer mortality lag in cooler, wetter areas

Management implications

• Fire suppression is likely increasing drought vulnerability
• Thinning and/or burning may reduce drought vulnerability
  • Also supported by Van Mangtem et al. 2016, Bradford et al. 2017
• Greatest benefit likely in the driest and densest areas
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