Water stress drives demographic shifts and the potential for type conversions in coastal California pine forests

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Abstract:
co-author: Brian Buma, University of Colorado - Denver Climate change-induced forest dieback is documented as a recent global phenomenon, with pervasive mortality having profound impacts on ecosystem services and natural forest functioning. The prolonged drought and scale of tree die-off in California from 2010-2016 (>145 million trees) was unprecedented in modern history. Morality of this magnitude can transform regional landscapes and have severe effects on forest function and ecosystem services. Ongoing drought and alteration of precipitation due to climate change will likely lead to continued mortality, which is most precarious for endemic species filling narrow yet essential ecosystem roles. Pinus radiata, an endemic to coastal California and Baja Mexico, is susceptible to non-native pine pitch canker and recently experienced widespread mortality following chronic drought stress. We used a 15-year dataset from permanent plot network to evaluate the 1) relative importance of exogenous vs. endogenous factors in shaping forest demography, 2) role of precipitation in the direction and magnitude of change, and 3) predicted impact of climate change on species persistence. Mortality peaked in during the 2014-2015 period of California's extended drought, with the greatest proportional mortality occurring in the small tree size class. Co-occurring Quercus agrifolia experienced negligible mortality over this same timeframe. For P. radiata, climatic water deficit was identified as the primary driver of mortality across all tree size classes ($p<0.001$). Small tree, sapling and seedling mortality were additionally influenced by the length of the frost-free period, with increasing mortality with increasing number of days ($p<0.001$). Pinus radiata recruitment was best explained by antecedent precipitation ($p<0.001$), while Q. agrifolia regeneration was driven by both antecedent and sampling year precipitation levels ($p<0.05$). Forest density was only influential in seedling mortality ($p<0.05$), and pine pitch canker incidence led to higher mortality in seedling and sapling size classes ($p<0.001$). The prevalence of disease significantly influenced demographic patterns over time, but, in all models, climate was the primary determinant of mortality and recruitment. Climate projections predict a decrease in annual precipitation and increase in the frost-free period, indicating a high likelihood for continued mortality and low recruitment for P. radiata into the future. Given the likelihood for ongoing decline of endemic P. radiata, management should focus on ongoing preservation of P. radiata stands in less impacted portions of the species' range as well as conservation of drought-adapted Q. agrifolia to support ongoing promotion and protection of forest ecosystems and associated ecosystem services.