**Subalpine fir – Engelmann spruce mortality analysis**

*Interactions between climate change and forest disturbance drive disassembly of subalpine forest communities*

*Climate – disturbance interactions break demographic mechanisms allowing tree species’ coexistence in subalpine forests of the western United States*

**Context**

Our subalpine fir status and trends paper suggested that the future trajectories of subalpine forest communities may depend on interspecific variation in responses to climate change, nondiscriminant forest disturbances (*e.g.,*fire), and host-specific forest disturbances (*e.g.,* biological disturbance agents, BDAs). This was supported in part by differences we found in the importance of major sources of mortality between regions where subalpine fir was in decline compared to other co-occurring species. The analyses described here dig into this suggestion by focusing on subalpine fir and Engelmann spruce, which co-occur across most of both species’ distributions and form a classic species association for western North American subalpine forests.

Prior work suggests that coexistence of subalpine fir and Engelmann spruce is maintained by certain demographic characteristics of each species and prevailing disturbance regimes. Specifically, coexistence depends on the higher survival of Engelmann spruce being balanced by faster growth and regeneration of subalpine fir, in the context of periodic disturbances providing canopy gaps in which spruce seedlings can outcompete the more prolific and shade-tolerant fir seedling (Shea 1985, also look up Andrus et al 2018). However, we also know that these species were not always as closely associated as they are today – during Pleistocene glaciations, the bulk of Engelmann spruce refugia were in southern interior highlands (AZ mountains, NM plateau, CO plateau), whereas subalpine fir populations were more widely distributed across northern interior basins and coastal refugia (Roberts & Hamann 2015). The questions are then whether the current association between these two species and widespread distribution of spruce-fir subalpine forests depends on current climate and disturbance regimes, and whether projected future changes in either or both will lead to the dissolution of that association.

Preliminary analyses built off of our previous subalpine fir work indicate that these two species have matching population trajectories across XX % of the forest area they occupy, and opposite population trajectories across the remaining XX%.

What’s driving these mismatched trajectories, and do they suggest a breakdown of this classic species association?

Building off of mortality estimates and community trajectory work from ABLA status/trends paper by focusing on classic species association to dig down on mortality drivers

Major questions would be – Are there interspecific differences in species’ responses that will alter future community compositions? Or something along those lines (*dig back into abla discussion to find language*).

Other research context – large-scale Anderegg paper, but different in that we’re modeling effects on overall mortality, not depending on causal agents; also different in that we’re explicitly considering species associations in community context. Also approach modeling e.g., insect mortality separately from others confounds proximate with contributing mortality sources.

**Analyses**

Using generalized linear mixed models to quantify the effect of tree-level, stand-level, and landscape-level factors on individual probability of survival and probability of regeneration for subalpine fir and Engelmann spruce in forests where they co-occur.

Using a generalized linear mixed model to quantify the effects of species identity, tree size and condition, stand density, climate anomalies, and disturbance context on individual probability of survival over a ten-year remeasurement period. List out predictors (*i.e.,* how they build off of ABLA status/trends analyses) and potential extensions (*e.g.,* moving to a Bayesian framework to get uncertainty estimates for random effects, adding in regeneration or recruitment analysis).

**Preliminary results**

Sign switches in effect of warming

Importance of tree size; warming worse for large trees

Differences between species; what are the implications for future community-level trajectories and associations?

**Prospective**

**Chart

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