**21 august 23**

**Mortality & Vulnerability modeling paper**

The central question for this set of analyses is something along the lines of

*How are changing climate and disturbance regimes impacting tree mortality rates? Which trees are at highest risk, and where are they?*

Or something like that. It can be refined and opened up more.

This analysis grew out of subalpine fir status and trends analyses, and attempt to model disturbance footprint impacts on overall mortality.

As presented at FIA and MtnClimate 2022; I built a hierarchical individual-based mortality model, a GLMM, that used predictors from three different levels of organization:

**Tree-level**

Tree size at T1

Tree species

Crown vigor?

**Plot-level**

Recent MAT/PPT anomalies

Stand density

Other structural aspects?

**Landscape-level**

Landscape fire footprint

Landscape insect footprint

Landscape disease footprint

Because most of the predictive information really comes in at the higher level of organization, those are the levels that most inference is going to end up being made.

I need to think through the multi-species framework; the contingency table that we put together for subalpine fir, and how that plays into this analysis.

Initial results seem to suggest that, for subalpine fir and Engelmann spruce, the effect that climate has on individual probability of survival changes sign depending on the disturbance context; in low-no disturbance scenarios, warming increases the base probability of survival across all tree sizes. However, as disturbance accumulates on the landscape, that relationship flips such that warming is associated with more mortality.

Climate alone cannot predict tree population trajectory; it depends on disturbance; even the direction of the climate effect depends on the disturbance context.

Analysis structural thoughts:

* What’s the justification for focusing on specific species? And how does this play into the multi-species context?
* What would it look like to lump by forest type instead of by species?
* Is there a way to avoid the SFTS problem? Perhaps by dividing into smaller geographic units; this is unsatisfying for several reasons; one, arbitrariness; two, fit separate models or random slopes across ecoregions or so?; three, assumptions about biological scale that SFTS breaks down…
* In comparison to that recent anderreg paper…
  + Individual-based model vs. condition-based model
  + They modeled different mortality types; not the impact of disturbances, etc, on overall mortality
    - This is a major difference in the kinds of inference that are made; need to think this through?
    - Anderregg assessed the climate predictors of insect mortality; I’m assessing how insects and climate together impact overall mortality
      * So advantage of my approach is grabbing unclassified mortality and using it as additional information
* That “Darcy’s Law” paper (McDowell & Allen 2015) gives a really solid justification for looking at the impact of warming on mortality of trees of differing sizes; could make a whole analysis asking how big the mismatch between physiological predictions and observations is…
  + Could I just manipulate those equations to get a % diff in expected mortality by tree size (they only focus on height)
* I should consider adding tree height into mortality models

Analysis idea:

* See what mortality model does when splitting by plots with disturbance codes or not; does sign of warming relationship change? Are relationships the same? Importance of including disturbed forests in our models and analyses!

\*\* let’s build some hypotheses \*\*

Based on DarcyLaw paper…

Based on McDowell demo review…

Based on my own previous work…

Whiteboard time?