**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?

7 November 2023

Dave and Harold have checked out summary document and manuscript idea, and “signed off”

Here are notes from meeting:

>> how does uncertainty for each trajectory category play into our picture?

-- vulnerable versus mismatched trajectories

turnover x dev --> should that be mismatched?

turnover/turnover is decline?

**make a figure that shows what proportion of areas fall in each category**

**--> see how this aligns with rupert and monica's // restructure, resilient, reassembly, replacement**

**composition x structure matrix**

conceptually; using a shorter timerperiod than is typically used in stand development, etc,

DB -- wonder if there is a way to focus on

gin up a version of Figure 3 under two different levels of fire disturbance

hybrid numerical modeling --> draw from a distribution, shift distribution for projections

-- only check at plot scale for lowest level

dave r2s are around 0.2-0.45

**db/mark harmon concept piece on mortality predicting uncertainty**

"how do you constrain the major sources of uncertainty to still be able to get at the major questions you're trying to answer"

every figure has a question, and it should pointedly answer that question

**local events matter --> changes in amount of variability matter**

"where are places we should worry lots; where are places where we don't need to worry"

-> if fire vs bda is teased out; we need a reality check on bda modeling

-> looking at bradford/bell paper; how do we condition scenarios to ask/answer different questions

So condensing all that :

* DB/HZ on board, think it’s a good idea and pretty well-developed, needs a bit more hammering
* Start by re-assessing change categories
  + *Compare with seidl/turner categories*
    - *Also what about RAD categories???*
  + *Maybe find some stand development literature that could be helpful?*
  + *Think/explore the turnover/vulnerable category*
    - *I might want to calculate the relative dominance of each species at T1, T2 and change – then see how that sits with categories*
  + *Make figure with area % in each category (smaller bins)*
* See how figure 3 (demographic scenarios) changes with future scenarios, think about whether spatialized predictions are necessary
  + Though they may increase impact/interpretation
  + But maybe the thing that’s most important is figuring where figure 3 categories are vulnerable or change?
  + Also make a version that has ABLA/PIEN on x/y, and separate plots for mort and regen
  + Add error

Does resilience imply a prior disturbance? Do I need to differentiate between disturbed and undisturbed plots?

11/17

NOTE: high ABLA fire mortality in areas with high PIEN insect mortality might indicate changes in fuel load? Though how would they differentiate insect mortaloity from subsequent fire?

IDEA:: go through other spp trajectories in ‘replacement’ category and look at what is taking place of spruce/fir forests