Looking beyond the mean:
Drivers of variability in postfire stand development of Rocky Mountain conifers

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Drivers of historical variation can help us anticipate future landscape patterns

- Fires shape landscape mosaics of stand age and structure for decades to centuries
- Variation in early postfire regeneration and abiotic conditions foster convergent or divergent stand structural trajectories
- Climate is changing and fire activity is increasing in the Greater Yellowstone Ecosystem (GYE) (Westerling et al. 2011)
- Individual-based models contribute to system-level understanding (Grimm et al. 2017) and process-based models are needed to anticipate ecosystem responses to novel environmental drivers (Gustafson 2013)

Question

- Over 300 years of postfire stand development, how does variation in biotic versus abiotic conditions influence same-aged, among-stand structural variability for the four widespread conifer species in the GYE?

Methods: Field data

- Parameterized individual-based process model **iLand** (Seidl et al. 2012) for four GYE conifers
- Initialized iLand with field data on wide range of postfire regeneration, climate, and soil conditions

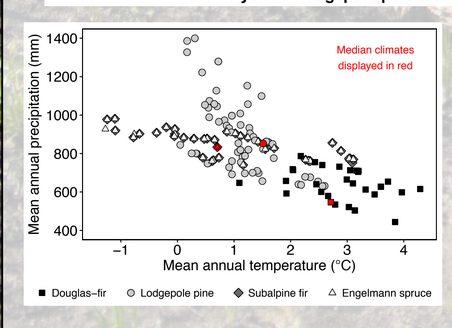

Figure 1 (above): Lodgepole pine ranged in early regeneration density from 33 to >300,000 stems ha^{-1} (adapted from Turner et al. 2016). All other species had <14,000 stems ha^{-1}.

Figure 2 (left): For each species, stands spanned a range of >2.5 °C in mean temperature and >200 mm in annual precipitation.

Methods: Simulation experiment

- Simulated monospecific stand development in 2x2 factorial experiment for 300 years with no additional disturbance, *n* = 20 replicates of each
- Calculated coefficient of variation (CV) for among-stand tree density and basal area

Abiotic conditions \ Postfire regeneration density	Among-stand variation	No among-stand variation
Among-stand variation	*All vary*	*Abiotic varies*
No among-stand variation	*Regeneration varies*	*None vary*

Table 1: Factorial design in which simulated stands either varied within observed ranges (among-stand variation) or were assigned a median condition (no among-stand variation). Lines and colors are used in Figures 3 and 4.

Variation in postfire regeneration drives early among-stand variability, but abiotic variation maintains late-seral variability

- Mean CVs were initially similar when early regeneration density and abiotic conditions both varied ( ) and when only regeneration density varied ( )
- When only abiotic conditions varied ( ), mean CVs increased or persisted at a higher value over time

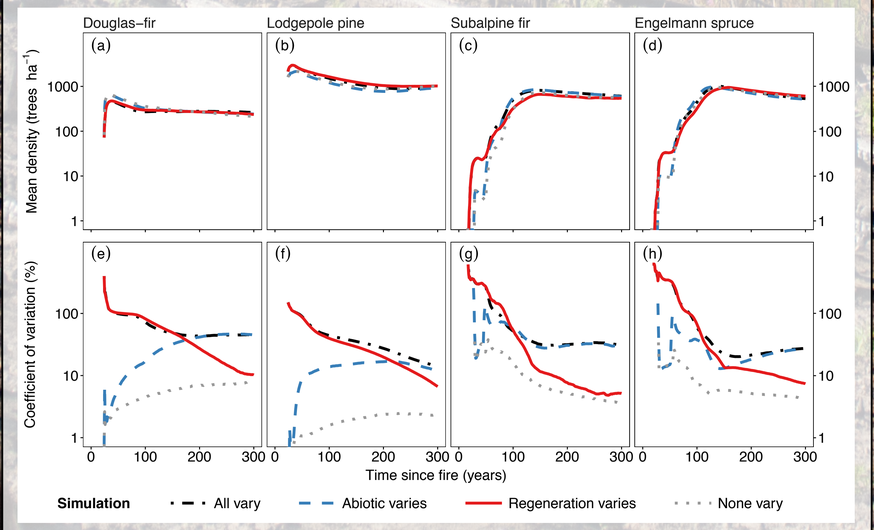

Figure 3. (a-h) Mean stand densities and mean among-stand density CVs over 300 years of postfire stand development for 4 simulation scenarios (*n* = 20 replicates each). All metrics were calculated for trees >4m in height. Y-axes are on log10 scales for easier comparison over time and among simulations.

Early postfire regeneration dictated variability in among-stand densities for >90 yrs and up to 217 yrs postfire for lodgepole pine

- Species and structural metrics differed in when biotic versus abiotic conditions were the most important driver of variability

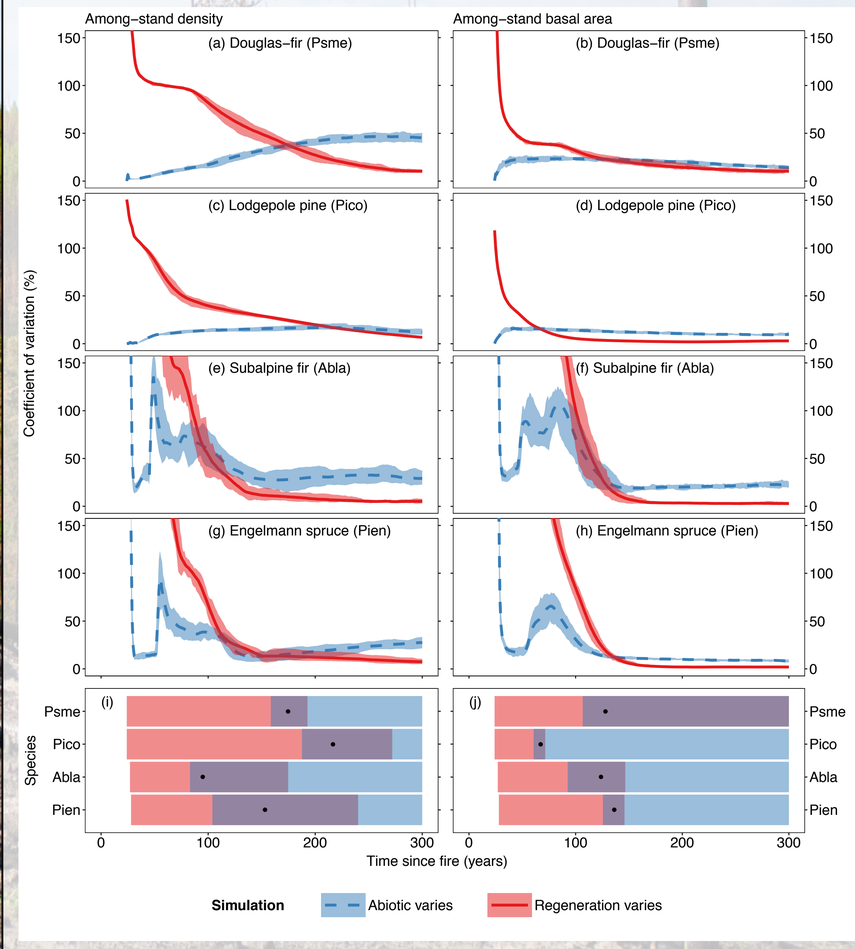

Figure 4. (a-h) Ranges of CVs (min to max) across 20 replicates each of *Abiotic* and *Regeneration varies* scenarios. **(i-j)** Timeline plots for all species, showing years when *Regeneration* CVs > *Abiotic* CVs (red), when *Regeneration* and *Abiotic* CV ranges overlapped (purple), and when *Abiotic* CVs > *Regeneration* CVs (blue). Bars start after trees >4 m height are present. Points show point of intersection of mean CVs. Psme = Douglas-fir, Pico = lodgepole pine, Abla = subalpine fir, and Pien = Engelmann spruce.

Discussion

- Patterns of early postfire regeneration establish long-term trajectories of landscape variability in stand structure
- Differences in species traits (e.g., serotiny, shade tolerance) and growth rates are reflected in among-stand variability
- As fire activity increases the extent of young forest, mean estimates of stand structure will not be sufficient to anticipate carbon storage, wildlife habitat, or the spread of future disturbances across forested landscapes

Acknowledgements

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