Processes that maintain species diversity in seedling communities are stronger in lower elevation forests

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Introduction

- Mechanisms that maintain diversity are critical for predicting species and ecosystem responses to environmental change
- Feedbacks on seedling survival can stabilize or destabilize tree populations, diversity, and ecosystem function, but are poorly understood
- Negative feedbacks of adults on survival of their own species' seedlings:
  - Maintains diversity by limiting locally abundant species and giving advantage to locally rare species
  - Generated by host-specific interactions with natural enemies/mutualists or intraspecific competition
- Positive feedbacks of adults on survival of their own species' seedlings:
  - Allows dominant species to exclude others, reduces species diversity
  - Generated by mycorrhizal fungal networks that increase nutrient uptake in the vicinity of a same-species (conspecific) neighbor

Research Question

- How do pairwise feedbacks in seedling communities change along gradients in temperature and climate associated with elevation?

Prediction

- We predicted that negative feedbacks will be stronger in warmer, wetter, more humid areas at lower elevations that favor pathogens, and that positive feedbacks would be stronger in harsher, colder, drier environments at higher elevations.

Fig. 1. 1-m^2 seedling plot in a humid, low-elevation valley-bottom forest.

Methods

- 372 1-m^2 seedling plots along 1,000 m elevation gradient at the HJ Andrews Experimental Forest (HJA) in the Oregon Cascade Mountains
- Each seedling in plots were identified to species & checked annually in 2019, 2020, and 2021.
- Feedbacks quantified as relative change in annual survival btw. seedlings growing under a same-species adult vs. adult of the other species (Fig. 2)
- Utilized long-term data on temperature and humidity across the elevational gradient
- Sampled soil for nutrient content and microbes across gradient (samples still being analyzed).

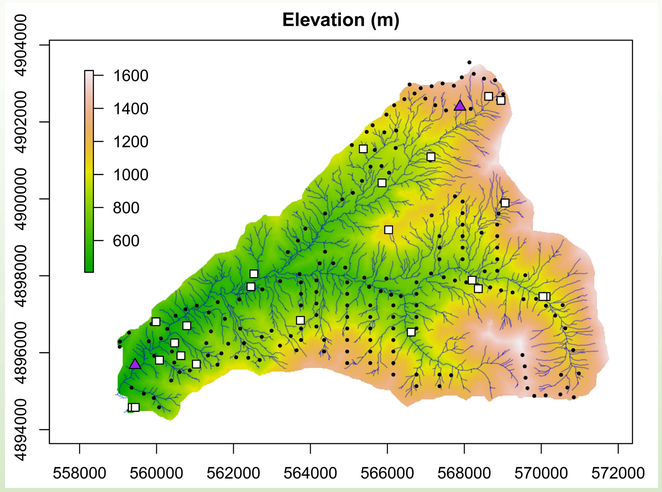
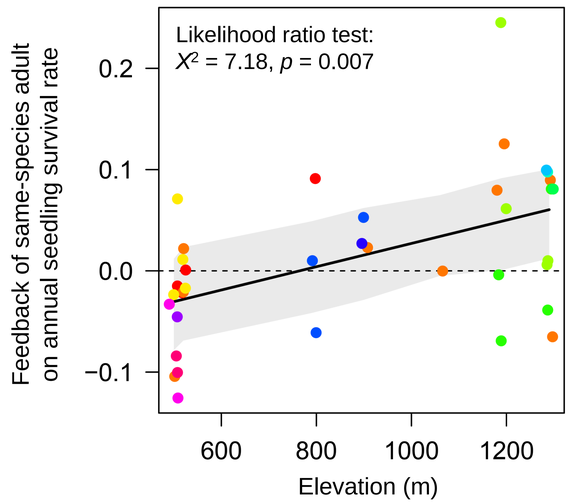


Fig. 3.(left) Topographic map of the HJA Experimental Forest. Locations of streams long-term plant & climate study plots are shown. X- and y-axes show UTM coordinates (m).

Results

Fig. 4. Feedbacks on seedling survival changed with elevation. Feedbacks were measured as the effect of a same-species adult on seedling survival relative to the effect of an adult of another species. Negative feedbacks reflect same-species suppression; positive feedbacks reflect same-species facilitation. Black line = mean effect, gray = 95% conf. interval (CI), different colors are different species pairs.



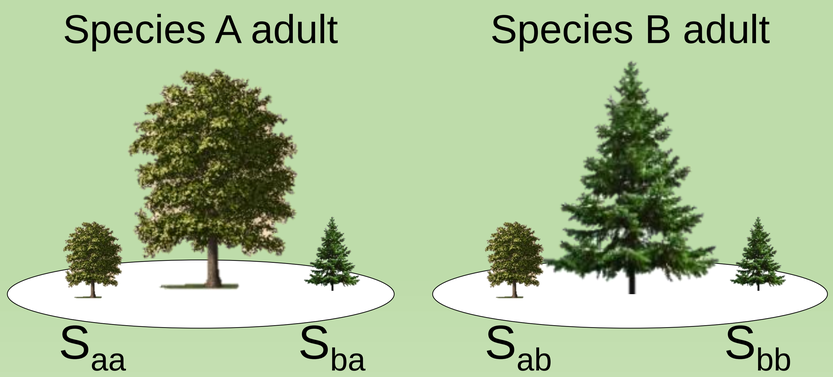


Fig. 2. How feedbacks on seedling survival are calculated. S_{aa} = Survival of seedlings of species A under adults of species A

$$\text{Feedback} = S_{aa} + S_{bb} - S_{ba} - S_{ab}$$

Fig. 5. Wildfires at the HJA Experimental Forest in Fall 2020

Conclusions

- Basic patterns of seedling survival with elevation:
  - No overall pattern in seedling mean survival with elevation
- Patterns in Feedbacks with elevation:
  - Feedbacks of adults on seedling survival were negative at low elevation and positive at higher elevations, matching predictions
  - Negative feedbacks associated with higher species diversity and more humid conditions at lower elevations.
  - Positive feedbacks associated with lower species diversity and drier/colder conditions at higher elevations.
  - We found increased seedling survival in areas away from adult tree species in general (canopy gaps), but effects were not as great as feedbacks

Implications & Future Directions

- As ecosystems are altered due to increased disturbance from climate change, understanding mechanisms that maintain species diversity via population feedbacks will help prevent loss of species
- Additional data will help us answer this question more fully, including data on soil chemistry and soil microorganisms (e.g. fungi) that may be responsible for the observed patterns in feedbacks with elevation.

HJ Andrews Experimental Forest in July 2021

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