ELEVATIONAL DISTRIBUTIONS OF TREE SPECIES: CLIMATE, LAND MANAGEMENT HISTORY, OR SOILS?

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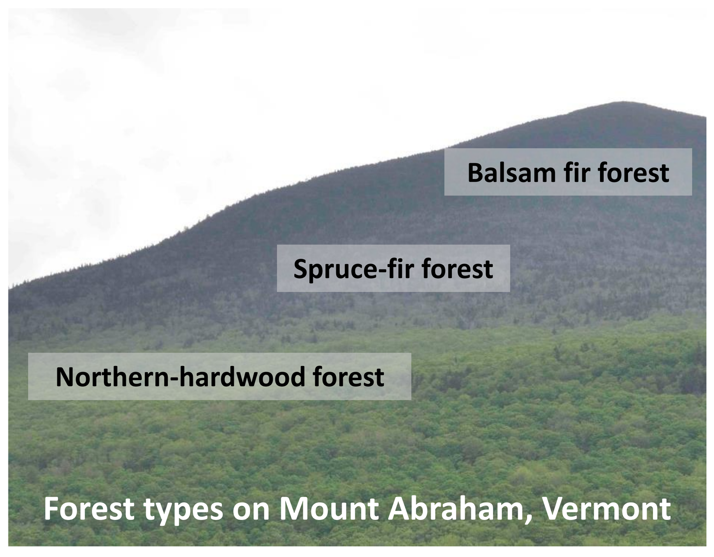
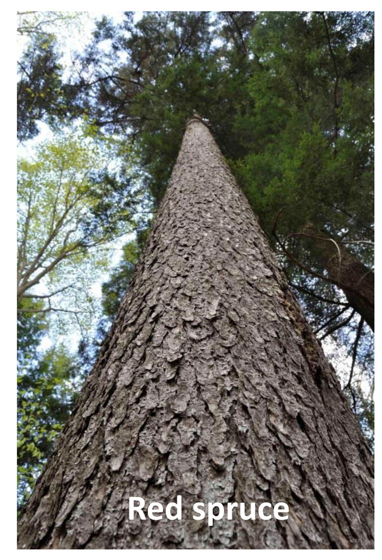
INTRODUCTION

- Mountain spruce-fir forests are expected to be vulnerable to climate change[1,2].
- We studied the influence of climate, past land management, and soils on tree species distributions in the northeastern United States .
- **Hypothesis**: climate, not land management history or soils, is the main determinant of tree species life stage distributions.





METHODS

Field

- 76 vegetation plots were established across elevational gradients on 11 mountains in the northeast (Figure 1).
- Tree population sampling included 15 point-quarter estimates per plot of basal area and density of all trees ≥2.54cm diameter at breast height (DBH).
- iButton temperature sensors logged temperature every 2 hours for ~1 year
- Soils depths were measured at points 1, 5, 10, and 15.

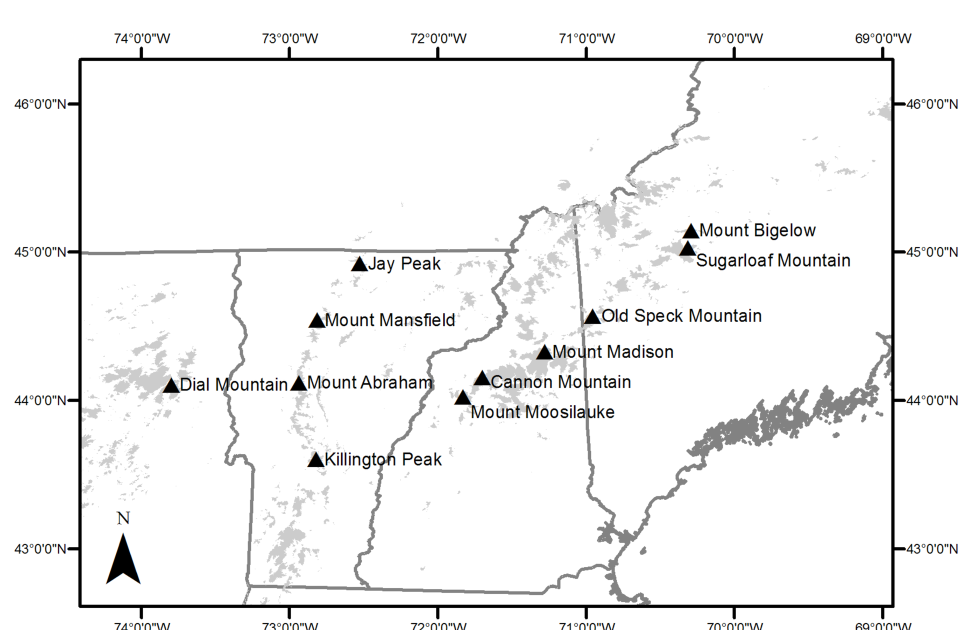


Figure 1: Eleven mountains sampled in northeastern US (elevations above 700m highlighted in grey) and iButton temperature sensor in protective case.

Analysis

- We built generalized linear models of species importance value (average of relative frequency, relative basal area, and relative density) with a suite of variables (Table 3).
- To determine the amount of variation explained by each variable class (climate, forest management history, and soils) by species, size class (mature: >10.15cm DBH or sapling: 2.54 – 10.15cm DBH), and living or dead we built full models including all variables (no interactions) as well as alternate models that do not include the variable class of interest.
- We then compare the additional deviance explained by the full model to each reduced model. This yields the amount of extra information a variable class can explain beyond all other variables.

Table 1. Variable descriptions for models of tree species importance value on 11 mountains throughout the northeastern United States. Variables were added or removed from models by variable class.

Variable class	Variables included	Description
Climate	GDD	Growing degree days (˚C) 2013, calculated from iButtons
	GDD^2	Allows unimodal climate response
Land management history	Cut stumps	Frequency of cut stumps (>10.15cm DBH; out of 15 subplots)
	Lack of large logs	Frequency of not encountering a log (>10.15cm DBH; out of 15 subplots)
Soils	Slope	Average of 4 slope measurements
	Soil depth	Average of 4 soil depth measurements
	Soil depth variation	Standard deviation of 4 soil depth measurements

References
1. Beckage B, et al. (2008) A rapid upward shift of a forest ecotone during 40 years of warming in the Green Mountains of Vermont. Proc Natl Acad Sci 105(11):4197.
2. Iverson L, Prasad A, Matthews S (2008) Modeling potential climate change impacts on the trees of the northeastern United States. Mitig Adapt Strateg Glob Change 13(5-6):487–516.

RESULTS

- Full models explained between 80 and 12% of the variability in species importance value (Figure 2).

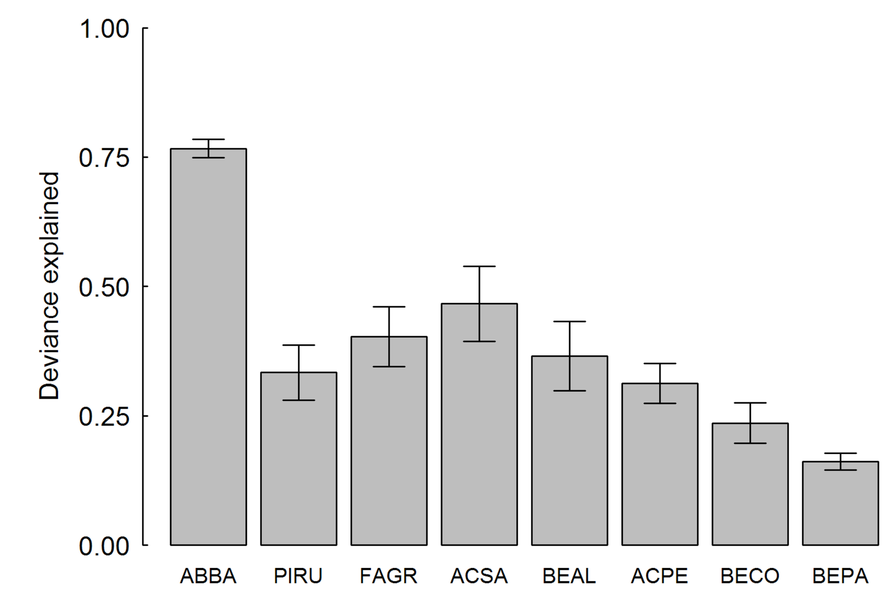
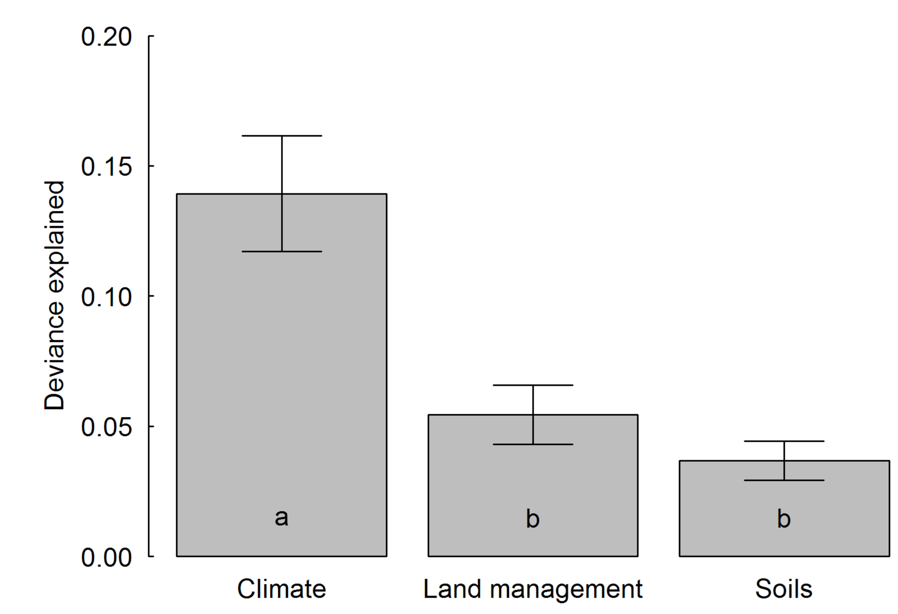


Figure 2. Average total deviance explained by full models of species importance values as a function of climate, land management history, and soil variables. Each average was calculated from four models for each species (mature-living, mature-dead, sapling-living, sapling-dead). One standard error reported.

- The proportion of deviance explained in models of living tree importance value as a function of climate, land management history, and soils significantly differ by variable class ($F = 12.94$, $p = 0.0256$) but did not differ by size class ($F = 0.0046$, $p = 0.9462$). Climate explained significantly more deviance than both land management history and soils (Figure 3).

Figure 3. Average proportion of deviance explained by each variable class in a model of species importance value (see Methods) by climate, land management history, and soil variables. Each bar is the average of living mature and sapling tree models from the 8 most common tree species (n =16 per bar). Significant differences shown by bars that do not share a letter. Significance determined using Tukey's HSD. Error bars are one standard error.



- Analysis of the species level models of IV and each variable class show that while climate is a main predictor of most species distributions, land management history and soils both contribute significantly to some of the models (Figure 4).

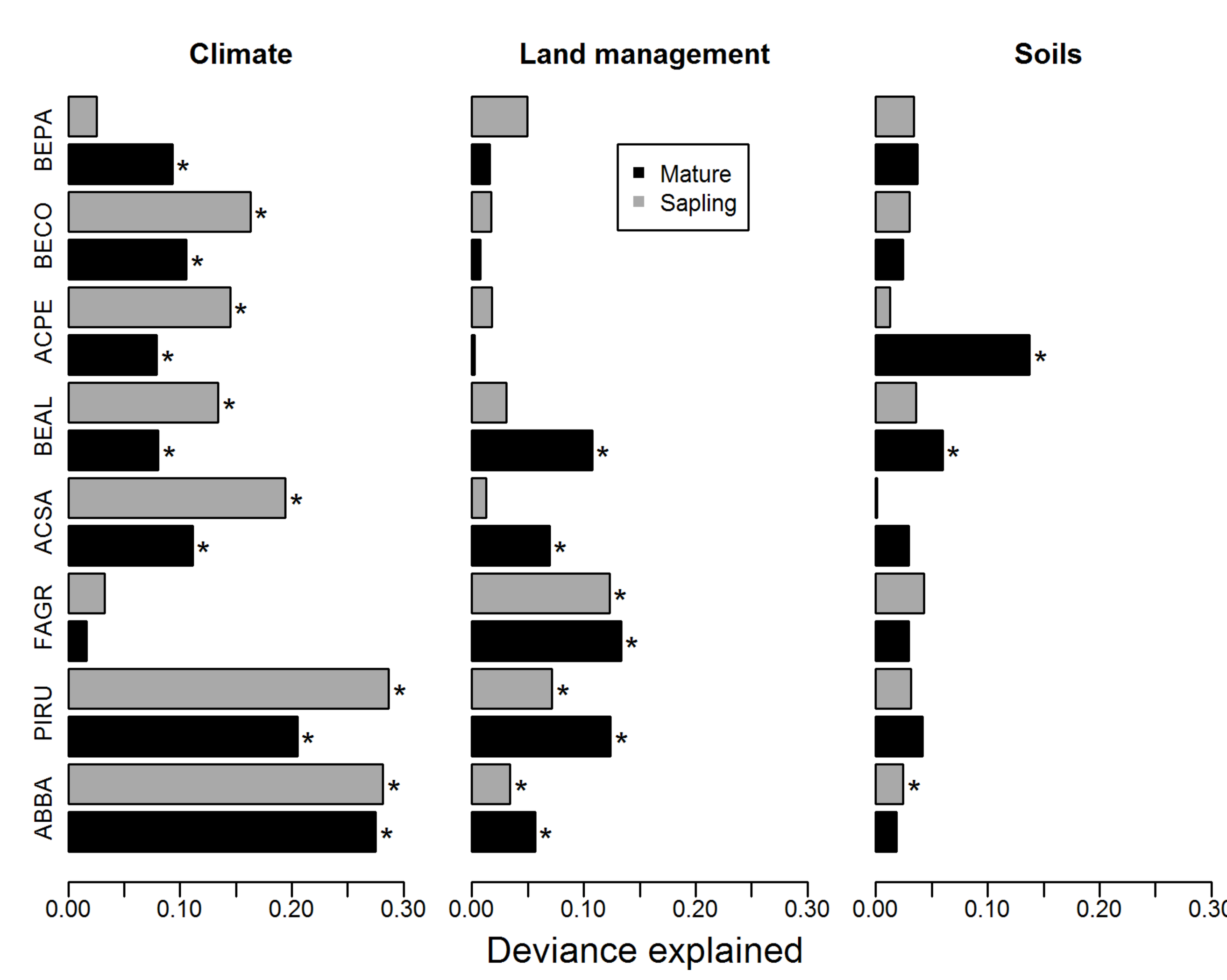


Figure 4. Proportion of deviance explained in models of importance value as a function of climate, land management, and soil variables for mature and sapling trees of the 8 most common tree species. Significance at alpha = 0.05 (*) determined by likelihood ratio tests of full model against reduced model without the variable class of interest included.

BEPA = *Betula papyrifera*, BECO = *Betula cordifolia*, ACPE = *Acer Pensylvanicum*, BEAL = *Betula Allegheniensis*, ACSA = *Acer saccharum*, FAGRA = *Fagus grandifolia*, PIRU = *Picea rubens*, ABBA = *Abies balsamea*

CONCLUSIONS

- Climate is a main determinant of species distributions though land management and soils play important roles for some species.
- Most species are likely to be sensitive to future climate changes but some responses may be moderated by other factors.
- These results can help land managers better anticipate future responses to climate change in northeastern mountain forests.

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Check out my website!
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