# Approaches to increase the utility of tree regeneration inventories: Characterizing drivers of sapling recruitment and seedling survival

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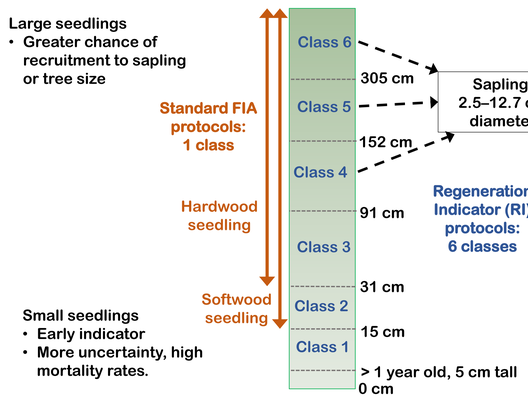
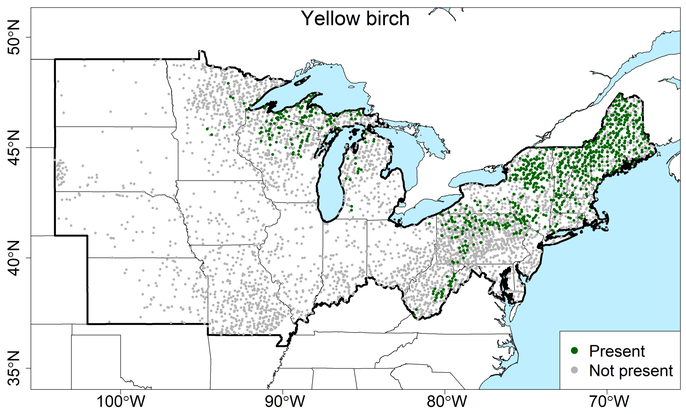
Accurately interpreting tree regeneration patterns to assess how forests are changing is increasingly important in the context of global change drivers such as climate change and shifting disturbance regimes. Tree seedling growth and development is controlled by a set of environmental filters such as climate, competition and substrate whose effects may vary in strength and even direction depending on seedling size. We are developing approaches to use seedling size class tallies from forest inventory plots to characterize influences on seedling survival and to better predict future forest composition from observed tree regeneration patterns.




The six seedling height classes tallied under the detailed RI protocols compared with the single size class normally used for FIA plots.

## Tree regeneration data

Since 2012, the USDA Forest Service Forest Inventory and Analysis (FIA) program has conducted tree regeneration surveys using six seedling height classes instead of the traditional single size class for a subset of its field plots across the northeastern US. Because FIA plots are remeasured at 5–7-year intervals, plot remeasurements are just now becoming available from this "Regeneration Indicator" (RI) dataset (McWilliams et al. 2015). FIA plots contains four circular subplots (168 $m^2$) in which trees are measured, each with a microplot (13.5 $m^2$) in which seedlings and saplings are measured. Data on understory vegetation and ground cover, terrain and substrate characteristics, and more are also collected.

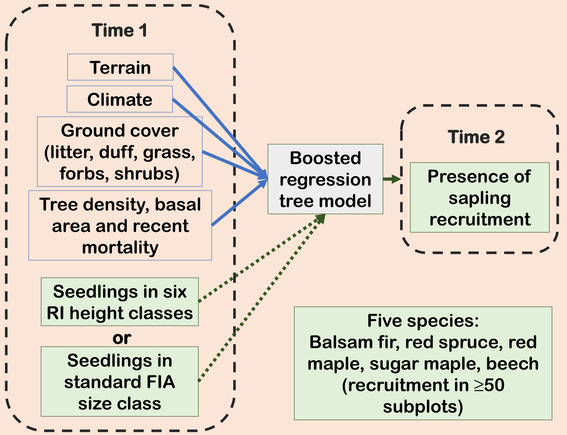


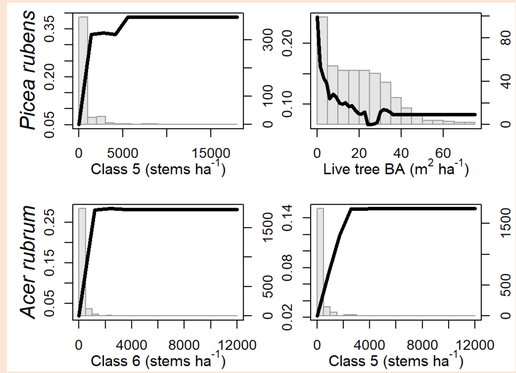

RI plot locations across the Northeast, showing plots where yellow birch was present as an example.

## Approach: Predicting sapling recruitment

A key goal of surveying tree regeneration is to predict how patterns of seedling abundance will translate into sapling and eventually tree recruitment down the road. We created models to predict sapling recruitment in subplot remeasurements from seedling abundance in the prior measurement and other stand and site-level factors.

Questions:
- Does using seedling height classes improve predictions of sapling recruitment?
- How does influence on recruitment vary by height class?
- How does seedling abundance interact with other factors to determine recruitment?




Influence on sapling recruitment likelihood (y-axis) for the two most important variables in the red spruce and red maple models. BA is basal area. Bars show the distribution of each variable among the RI subplots.

## Findings

- Use of the six height classes improved models for all species
- Tallest seedlings (Class 5 and 6) were the best predictors of sapling recruitment across species
- Shorter seedlings (Classes 1-4) were omitted from most models
- Other influences are also important: tree basal area/density, harvesting, ground cover, climate

## Approach: Seedling survival by size class

The influence of factors like climate and competition is likely to change as seedlings grow, but how these influences change by size class is not well-understood. We are developing a method to characterize influences on seedling abundance and survival across successive size classes using ratios of seedling abundance.




Workflow for using tree regeneration tallies by size class from forest inventory data to examine the effect of a given variable on abundance by size class and relative survival rates based on ratios between size classes




Effects of shrub cover on survival, as inferred from ratios of abundance, across seedling size classes for 10 common tree species.

High shrub cover had a generally positive effect on survival of small seedlings (< 1 m tall) but a negative effect on tall seedlings. This shift from facilitation to competition may be related to herbivory.

## Conclusions

We found that tallies of seedlings > 1.5 m tall are important for predicting near-term sapling recruitment, and that the common practice of lumping seedlings into a single size class may hamper our ability to predict future forest composition from tree regeneration surveys.

Our analysis of seedling survival across size classes suggests that shifts in strength and directionality of key influences on survival as seedlings grow are common. These complex and sometimes opposing influences on seedling survival are important to understand when predicting and managing for successful tree recruitment and future canopy tree composition.

In future work, we plan to use these methods to assess how abundance of key tree species may shift across the Northeast as climate, vegetation and management strategies change.

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References

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