To plant or not to plant? Results from a century-long forest planting experiment

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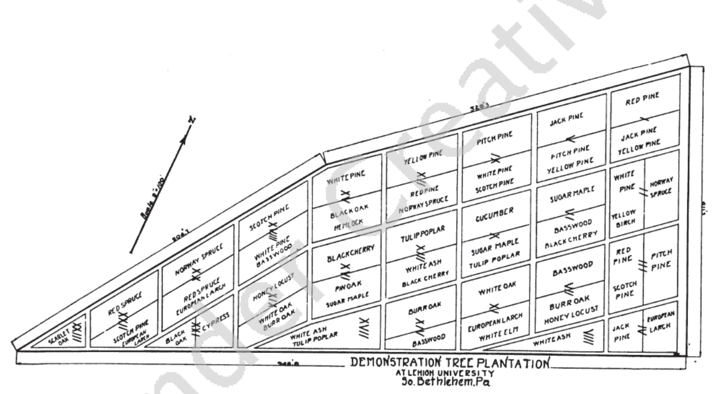
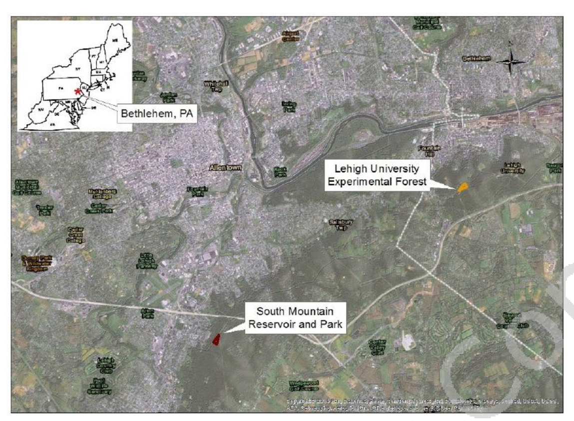
The Lehigh University Experimental Forest

The Lehigh University Experimental Forest (LUEF) is a unique 5.5-ha forest in eastern Pennsylvania that was densely planted with 22 species of evergreen and deciduous tree seedlings in 1915. The trees were arranged in 43 distinct monospecific or bispecific plots, which were then left unmanaged for approximately a century. In this study, the community composition and recruitment history of the LUEF were compared to a nearby non-planted control site in order to contrast the effects of planting versus natural succession alone.



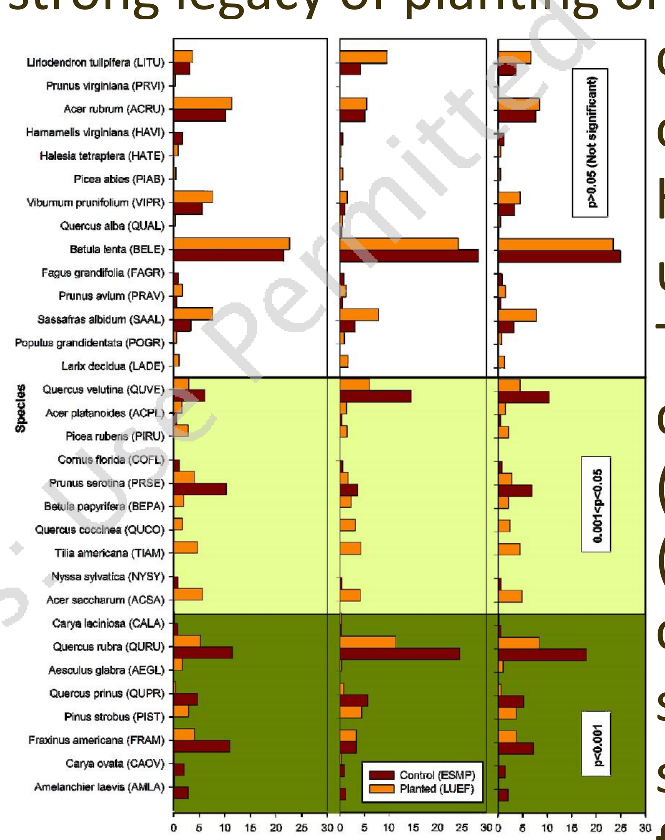
1915 sketch of Lehigh University Experimental forest, with mono- and bispecific plots specified (Emery 1915).



Site locations of the experimental forest (LUEF) and the control site (Emmaus South Mountain Reservoir and Park).

Questions addressed in this study

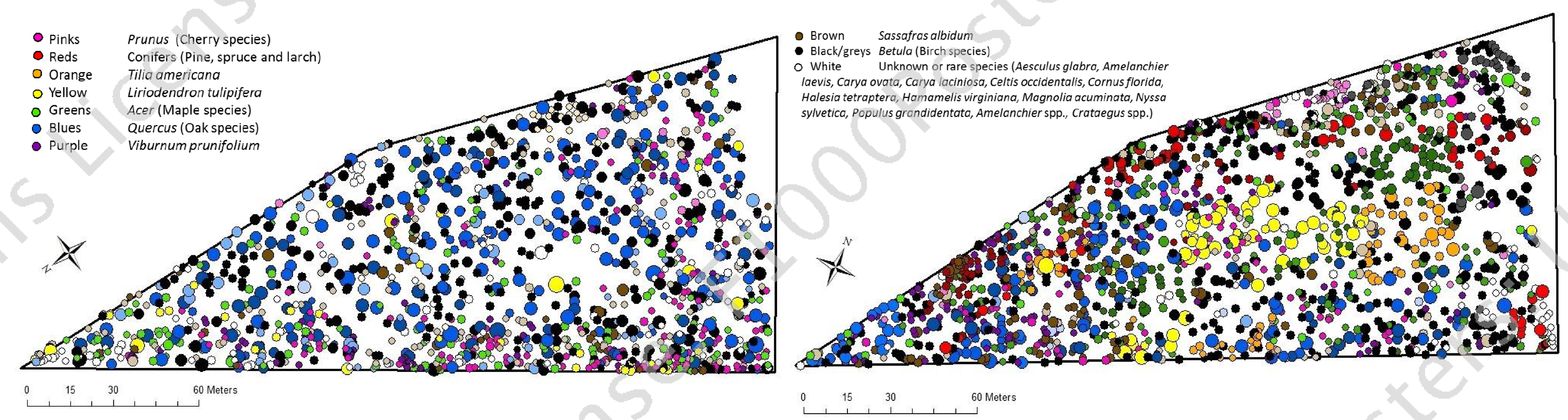
1. Forest composition. *Does a planted forest have greater species richness and evenness than a forest that developed through natural succession? After a century, is community composition similar in both forests?* Results from surveys of both forests show a strong legacy of planting on the community composition and structure of the forest, even after a hundred years of unmanaged succession. Though both forests are dominated by black birch (*Betula lenta* L.) and oak (*Quercus* spp.), composition varied significantly between sites, and the planted forest had greater species richness and evenness.



Community composition in the two forests, with species arranged from those most significantly different between the two forests toward the bottom and not significantly different on the top.

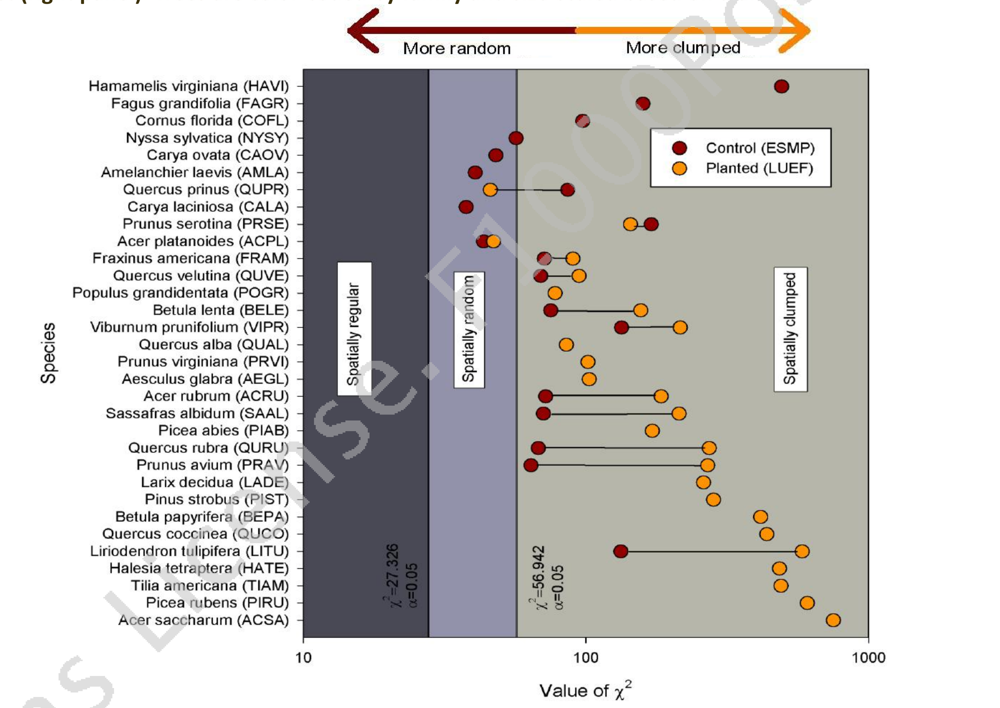
2. Forest density, diameter, and total tree biomass. *Does planting impact the long-term density or size of trees? Are there differences in overall biomass between the two forests?* The average bootstrapped density of trees was significantly higher in the planted forest than the control (782±19 trees/ha vs. 651±19trees/ha), and mean tree diameter was not significantly different overall. Total tree biomass, calculated with the formula $BM = a + \left(\frac{b*(DBH^c)}{DBH^c+d}\right)$ (Jenkins 2004) was greater in the planted forest, mainly due to significantly higher tree density in the LUEF.

3. Spatial distribution*. Is there a difference in spatial distribution (random, clumped, regular pattern) of tree species between the two forests?*

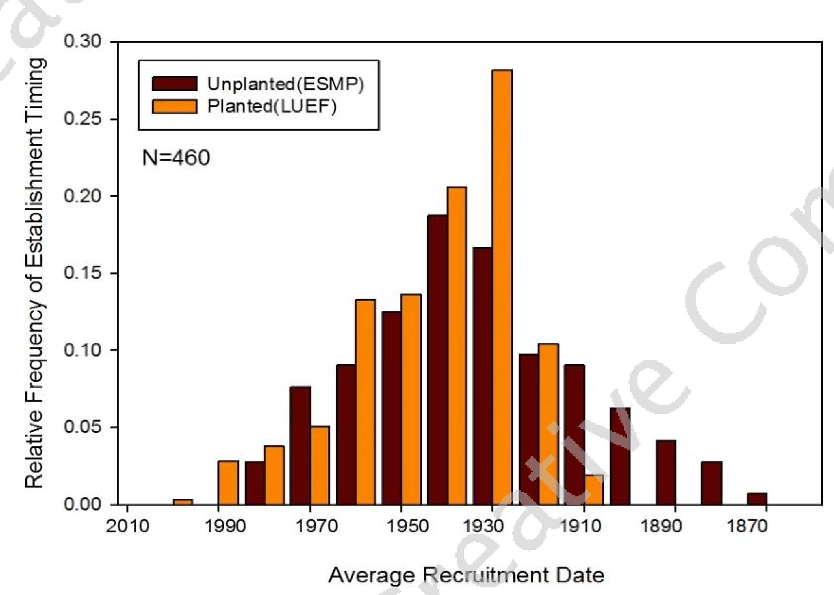


Distribution of trees in the unplanted forest (left panel) and the planted forest (right panel). Trees are color-coded by family and size-scaled based on diameter.

All trees with a measurable DBH were spatially mapped in ESRI ArcMap 10.1, and placed along a gradient of randomness of distribution via a chi-squared test. Trees in the planted forest tended to have a clumped spatial distribution pattern whereas species in the unplanted forest tended to be more randomly distributed.



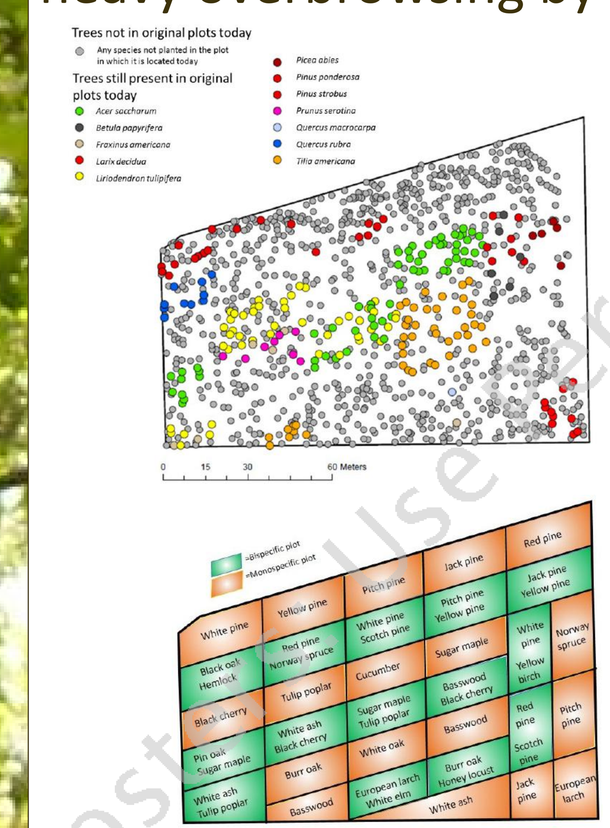
Log-scale representation of the spatial distribution of trees in both forests. Species falling within the upper and lower critical X^2 value (middle grey bar) are randomly dispersed, and higher values represent trees in a clumped distribution. Lines connect the same species to contrast planted and unplanted forests.



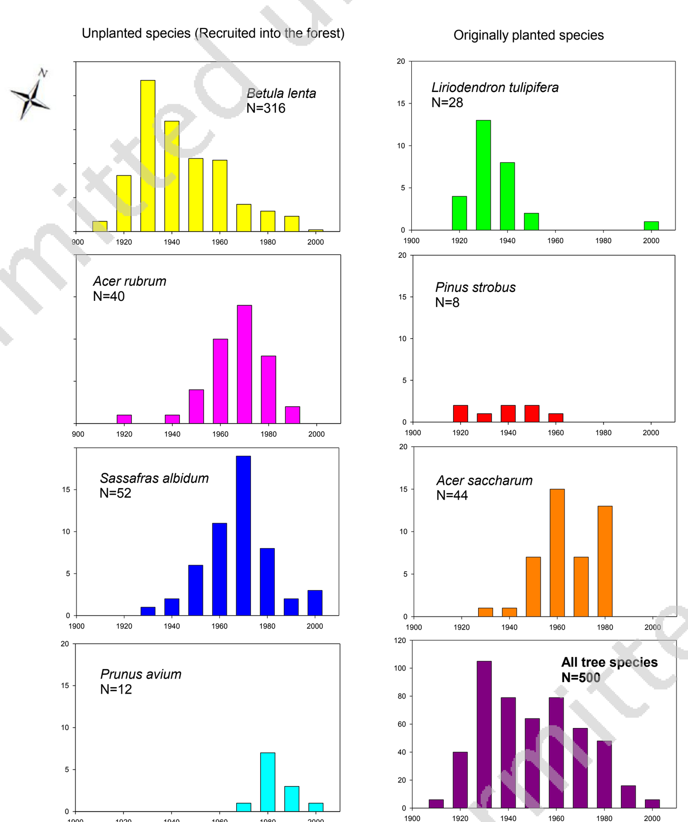
Histogram of relative frequency of cored *Betula lenta* that recruited in each decade in the planted and unplanted forest.

4. Spatiotemporal recruitment patterns*. Do spatiotemporal patterns of tree recruitment differ in the two forests?* Peaks in recruitment of *Betula lenta* L. obtained from tree ring counts of 460 cored trees occurred synchronously during the 1930s and 1940s in both forests, although there was spatial variability in recruitment patterns. Based on a Moran's I test, black birches tended to recruit more spatially randomly in the control forest (unplanted), suggesting possible effects of planting on gap dynamics.

5. Planting strategy. *Did planting strategy (bispecific versus monospecific planting) affect the success of originally planted trees? How did initial community composition influence subsequent establishment?* Within the LUEF, there was great variability in recruitment success of originally planted species, but a few species (e.g. tulip poplar, American basswood) were particularly successful at maintaining dominance within their original plots. Spatiotemporal patterns of recruitment of trees within the LUEF were species-specific, yet all species cored show depressed recruitment in the past few decades, likely due to heavy overbrowsing by white-tailed deer.



Planted tree species still present today within the plots in which they were planted (top). Trees that are present today but were not originally planted in their current plot are colored grey. Original plot planting arrangement (bottom).



Recruitment histograms for cored species in the planted forest (LUEF). Species-specific patterns are apparent among unplanted species (left column) and originally planted species (right column).

The legacy of planting

The results of this comparative ecological study highlight the need for careful consideration in choosing forest management strategies, as planting decisions leave century-long legacies on composition, biomass, spatial structure, gap dynamics, and recruitment patterns of secondary forest communities. Especially in shifting climate regimes, the unique character of forests like the LUEF will likely play a vital role in carbon sequestration, biodiversity conservation, resistance to invasive species, and nutrient cycling.

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