The Effects of Land-Use History and Natural Disturbance on Changes in Tree Species Composition

Sasha Petrycki, Victoria Williams, Andrew LaVoie, Rhine Singleton, Ph.D., and Catherine Koning, Ph.D.
Department of Environmental Science, Franklin Pierce University, Rindge, NH

Introduction

Numerous studies have documented how different land-use histories can have long term impacts on forest vegetation; much of this work is summarized the book *Forests in Time* which focuses on research conducted in central New England (Foster & Aber, 2004). We investigated whether land-use history can affect changes in tree species composition and recruitment into the forest canopy. Our study took place on the Franklin Pierce University Campus in Rindge, NH in forests located on former pasture and forests located on formerly cultivated land.

Research Questions:

- Is there a significant difference in tree density, tree mortality, tree recruitment, or basal area between the two forest types (former pasture vs. formerly cultivated land)?
- Does land-use history affect whether tree species composition is changing?
- Is there any evidence that factors other than land-use history are affecting recruitment of new trees into the forest canopy?

Methods

Our study took place in eighteen 20 m x 20 m plots originally established in 2003. Nine plots are located in former pastures and nine are located in formerly cultivated land. All forests are approximately 100 years old. When the plots were originally established, all trees greater than 10 cm dbh were tagged, identified, and diameter was recorded.

In September and October of 2016, we

- Recorded the diameter of all the trees that were previously tagged.
- Noted all trees that had died.
- Recorded and tagged all new trees that had reached the 10 cm dbh size class.
- Using Microsoft Excel, we conducted our statistical analyses for this study, including t-tests, relative abundance graphs and corresponding chi-square analyses, and scatterplots and corresponding regression analyses.

Figure 1. Map showing the location of the Franklin Pierce University campus in Rindge, NH and an enlargement of the study area. Red dots mark forest plots on former pasture; white dots mark forest plots on formerly cultivated sites (screenshot from Google Earth).

Work Cited: Foster, D. R. and J. D. Aber. 2004. *Forests in Time*. Yale University Press, New Haven, CT.

Results

- T-tests showed that there were no significant differences in tree density, tree mortality, recruitment and basal area between former pastures and formerly cultivated sites.
- There was no significant change in forest tree species composition between 2003 and 2016 in former pastures (Figure 2; $\chi 2 = 7.34$, df = 14, p = 0.92).
- There was a significant change in forest tree species composition between 2003 and 2016 in formerly cultivated sites (Figure 3; $\chi 2 = 113.73$, df = 12, p = 1.09×10^{-18}).
- In the former pasture site that was heavily damaged by the 2008 ice storm, Figure 4 suggests a change in tree species composition between 2003 and 2016; chi-square analysis revealed this change is near statistical significance ($\chi 2 = 11.66$, df = 6, p = 0.069).

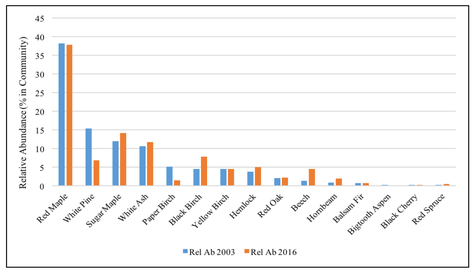

Figure 2. Relative abundance of tree canopy species in 2003 and 2016 in the former pasture sites.

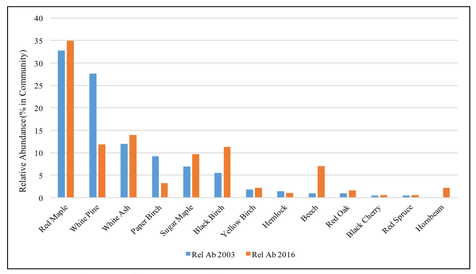

Figure 3. Relative abundance of tree canopy species in 2003 and 2016 in the formerly cultivated sites.

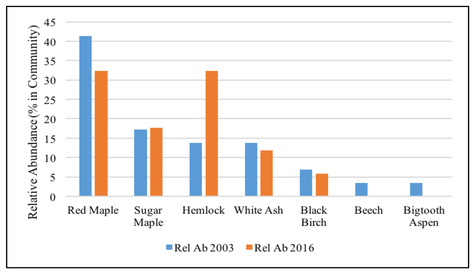

Figure 4. Relative abundance of tree canopy species in 2003 and 2016 in the former pasture site that was heavily affected by the 2008 ice storm.

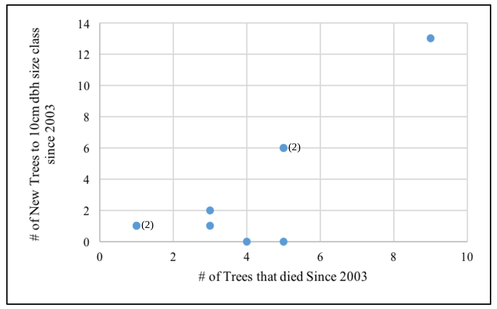

Figure 5. Recruitment of trees over 10cm dbh vs. mortality of trees since 2003 in the former pasture sites ($R^2 = 0.65$, df = 8, p = 0.0086).

Figure 6. Photo of site damaged by 2008 ice storm.

Discussion

In this study there were noticeable changes in tree species composition related to land-use history. We found that former pastures and formerly cultivated sites differ in the recruitment of species. Unlike cultivated sites, pastured sites likely maintained at least some forest plant legacies (such as roots, stumps, seeds, seedlings, and saplings), so it may have been easier for the forest to recover in these sites. By contrast, formerly cultivated sites rely on seed dispersal for forest plant colonization and therefore may experience more extreme changes between successional stages than former pastures. For example, in our cultivated sites, there was a large decline in shade intolerant white pine which had previously dominated as one of the first tree species recruited. In addition, the population of beech trees increased dramatically in these sites indicating that shade tolerant species are beginning to grow into the canopy.

One of our forest plots on former pasture experienced heavy damage from the 2008 ice storm which created many new gaps in the canopy. These gaps likely explain the recruitment of seven shade tolerant eastern hemlock into the 10 cm dbh size class; these individuals had been growing slowly in the understory prior to the ice storm.

Our results demonstrate how human land-use history and natural disturbance can affect recruitment into the canopy and influence changes in tree species composition.