



NUTRITIONAL IMPACTS ON INVASIVE BEECH SCALE QUANTIFICATION IN BEECH BARK DISEASE AFTERMATH FORESTS

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INTRODUCTION

- Beech bark disease (BBD) invaded North America over a century ago but the pathosystem is still not well understood.
- BBD occurs when beech scale insects, *Cryptococcus fagisuga* (invasive) and *Xylococcus betulae* (native), attack American beech (*Fagus grandifolia*) and feed on the inner bark making the tree susceptible to fungal infections, primarily by *Neonectria ditissima* and *N. faginata*, which cause cankers that kill the tree.
- Three stages of BBD: the Advancing Front, the Killing Front, and the Aftermath Forest (Houston 1975).
- Counting and monitoring scale using digital photography is effective in quantifying population density (Wainhouse 1980; Gardner 2005; Teale et al. 2009; Koch et al. 2010; Wieferich et al. 2013).

Objectives:

- Quantify invasive beech scale *C. fagisuga* in an aftermath forest
- Determine if nutrient additions affect invasive scale coverage
- Improve previously used methods to quantify scale

STUDY SITE

- Research was conducted in an aftermath forest in the White Mountain National Forest in New Hampshire, USA, in Bartlett Experimental Forest, taking advantage of an existing study of Multiple Element Limitation in Northern Hardwood Ecosystems with treatment plots of N, P, N+P, Ca, and untreated controls across three forest stand age classes:

MELNHE Project in Bartlett Experimental Forest						
Stand Age (years)						
Stand Names	Young (28-38)		Mid-Age (40-43)		Old (128-136)	
Stand Names	C2	C3	C4	C6	C7	C8
Treatments	Con N P N+P	Con N P N+P	Con N P N+P	Con N P N+P Ca	Con N P N+P	Con N P N+P Ca

METHODS

- Five beech trees per plot were selected for imaging, totally 20-25 trees per stand. Trees were selected to be as far apart from each other as possible, ideally 20m, to reduce the chance of sampling genetically identical individuals (A).
- In July and August 2017, photos of tree bark were taken from the four cardinal directions at each of two heights, 0.5 m and 1.5 m above the ground (B).
- Images were cropped to 5x10cm using Image-J software and then a grid was superimposed onto the image in GIMP. Scale wax masses were tallied when present at a gridline intersection (C).
- Linear regressions and pairwise comparisons were examined in R with stand age, stand elevation, photo aspect, tree diameter, and treatment as predictor variables and scale density as a response.



A) Scale wax masses on a tree afflicted by BBD



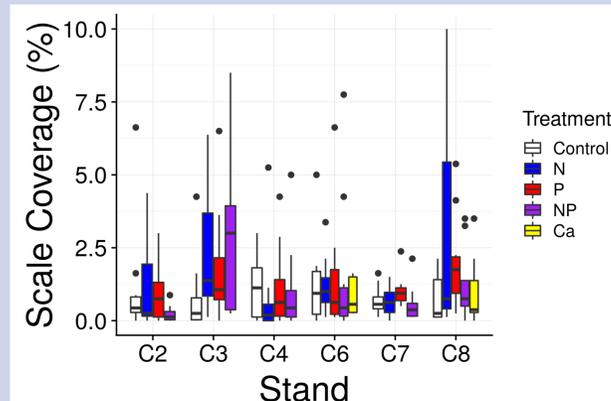
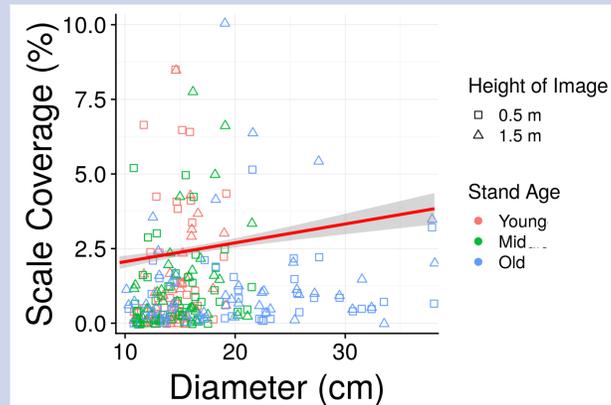
B) Frames painted on beech for photo analysis



C) Cropped image with superimposed grid

RESULTS

- Mean scale coverage per tree (%) varied significantly with DBH ($p < 0.001$, $b=0.23$), elevation ($p < 0.01$, $b=0.002$) and the interaction of age and DBH ($p < 0.01$) at $\alpha = 0.05$.
- Mean scale coverage per tree did not vary greatly by stand age ($p = 0.10$; Young = 1.4%, Mid = 1.1%, Old = 1.2%) or treatment ($p = 0.08$; Con = 0.96%, N = 1.5%, P = 1.4%, NP = 1.2%, Ca = 0.9%).
- Image height ($p = 0.74$) and photo aspect ($p = 0.36$) were not significant predictors; Aspect was removed from the model.



DISCUSSION AND CONCLUSION

- While treatment was not a significant predictor of scale density at $\alpha = 0.05$ ($p = 0.08$), nitrogen fertilized plots had higher scale densities than those in control plots at $\alpha = 0.1$ ($p = 0.056$).
- We expected scale to be significantly higher on larger DBH trees, at lower image heights, with age, and in N and N+P plots. We were surprised to find a lack of significance across nutrient plots and image height.
- Previous scale analysis used multi-stage sampling methods including direct counts (30+ min/sample) and stratified random samples in photos (~10 min/sample) (Teale et al., and Wieferich, Hayes, and McCullough 2013). Our modified point sampling method was 2-5 times faster per sample than random sampling.

ACKNOWLEDGEMENTS

Thank you to Ruth Yanai for research methods guidance and Sara Wasserman for her work with image analysis. Additional thanks to field crew members of Summer 2017!