Oak Seedling Growth in Response to Canopy Thinning

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Introduction

Prior to Euro-American settlement, oaks (*Quercus)* were the dominant genus in many forests across North America (Dey, 2002). However, the dominance of oaks has declined greatly in many forests due to changing climatic conditions, changes in fire regimes, increased browsing, exotic pests and vegetation, and logging (Abrams, 1992). Further, in many forests where an oak component remains there is a trend for increasing dominance of shade-tolerant mesic species (e.g., sugar maple) and decreasing oak regeneration. Restoring oak dominance and promoting oak regeneration have become important goals for managers across a variety of forest types and locations. Several silvicultural practices have been shown to aid in the re-establishment of oak dominance by altering light environment and understory competition. For instance, mechanical thinning and removal of competitive understory plants have been shown to be effective methods in promoting native dominance (Grayson et al., 2012).

The principle goal of this project was to improve understanding of the relation between light environment and oak seedling success in a larger project focused on developing canopy thinning methods for promoting oak regeneration in urban natural areas. Prior to this research, study areas were manipulated to create increased canopy openness with two thinning intensities (20% and 10% basal area removal) and a control. We analyzed how canopy openness, light transmittance, and understory competition varied among treatments and how each affected oak seedling growth. We expected growth to be greatest with the most thinning; however, we also expected the negative effects of understory competition to be greatest in these locations. Specific goals of this study were to answer the following questions (1) how was the light environment affected by the thinning treatments? (2) how did the thinning treatments affect oak seedling growth? and (3) how was oak seedling growth related to light and understory competition?

Methods

Seedling measurements

- In 2011 red and white oak seedlings were planted on a 5 x 5m grid throughout the 6 treatment units studied here.
- For all living seedlings in each treatment unit we measured 2014 height growth, total height change (relative to height at planting), current total height, and diameter growth.

Instantaneous understory light measurements

- Canopy light attenuation was estimated by recording above canopy photosynthetically active radiation (PAR) and then dividing that by a understory PAR readings taken at 0.25m intervals between 2.5 and 0.5m.
- Above canopy PAR was recorded with a Li-Cor Quantum Sensor in an adjacent open field – understory was measured with a Decagon LP-80 Ceptometer.

Canopy cover measurements

- Canopy openness and total seasonal transmitted radiation were estimated using hemispherical photographs taken with a Sigma SD15 camera and Sigma fish-eye lens and analyzed with Gap Light Analyzer Version 2.

Results

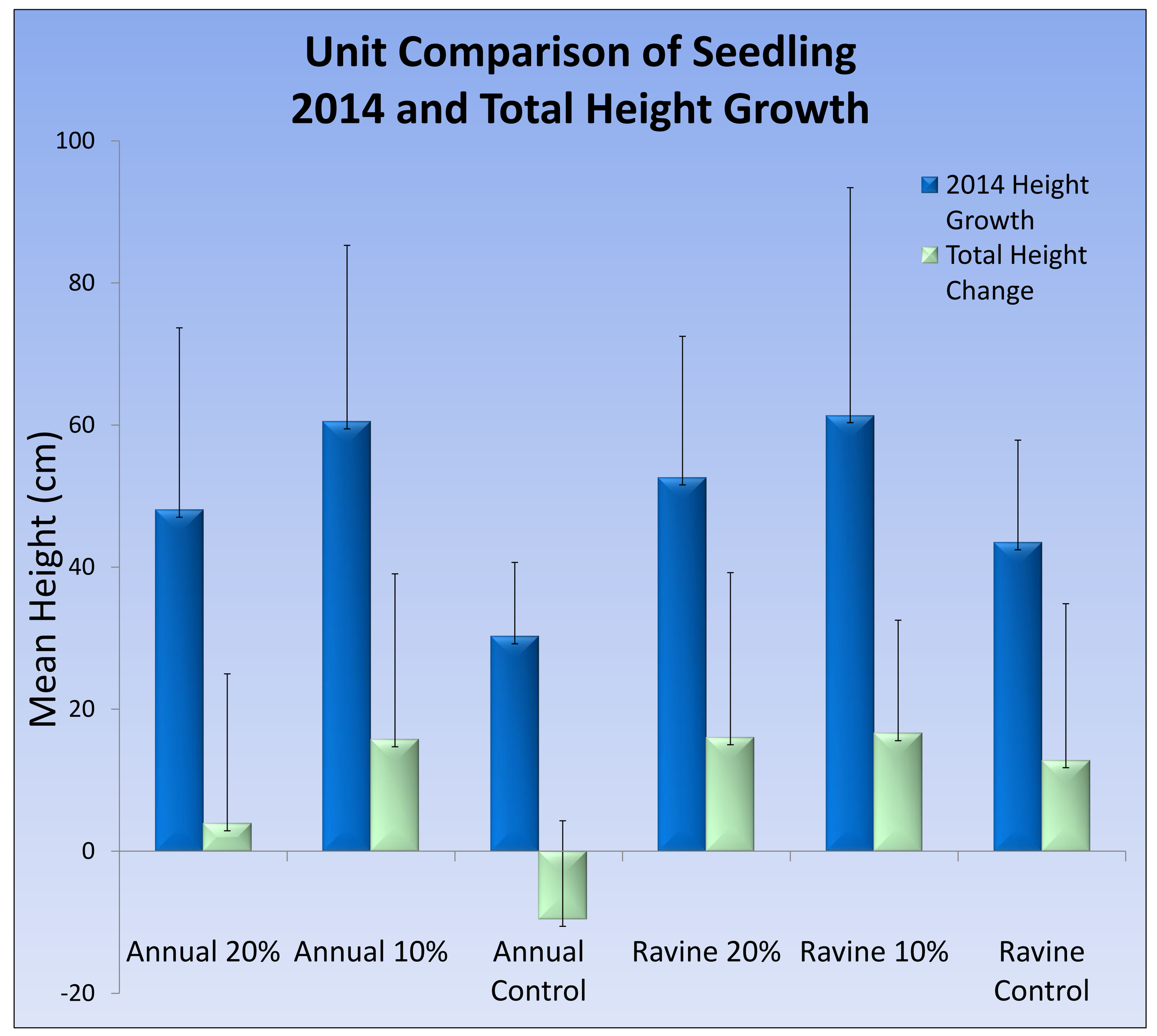

Fig. 1. Comparing total height growth and 2014 height growth across each treatment (20%, 10%, and Control).

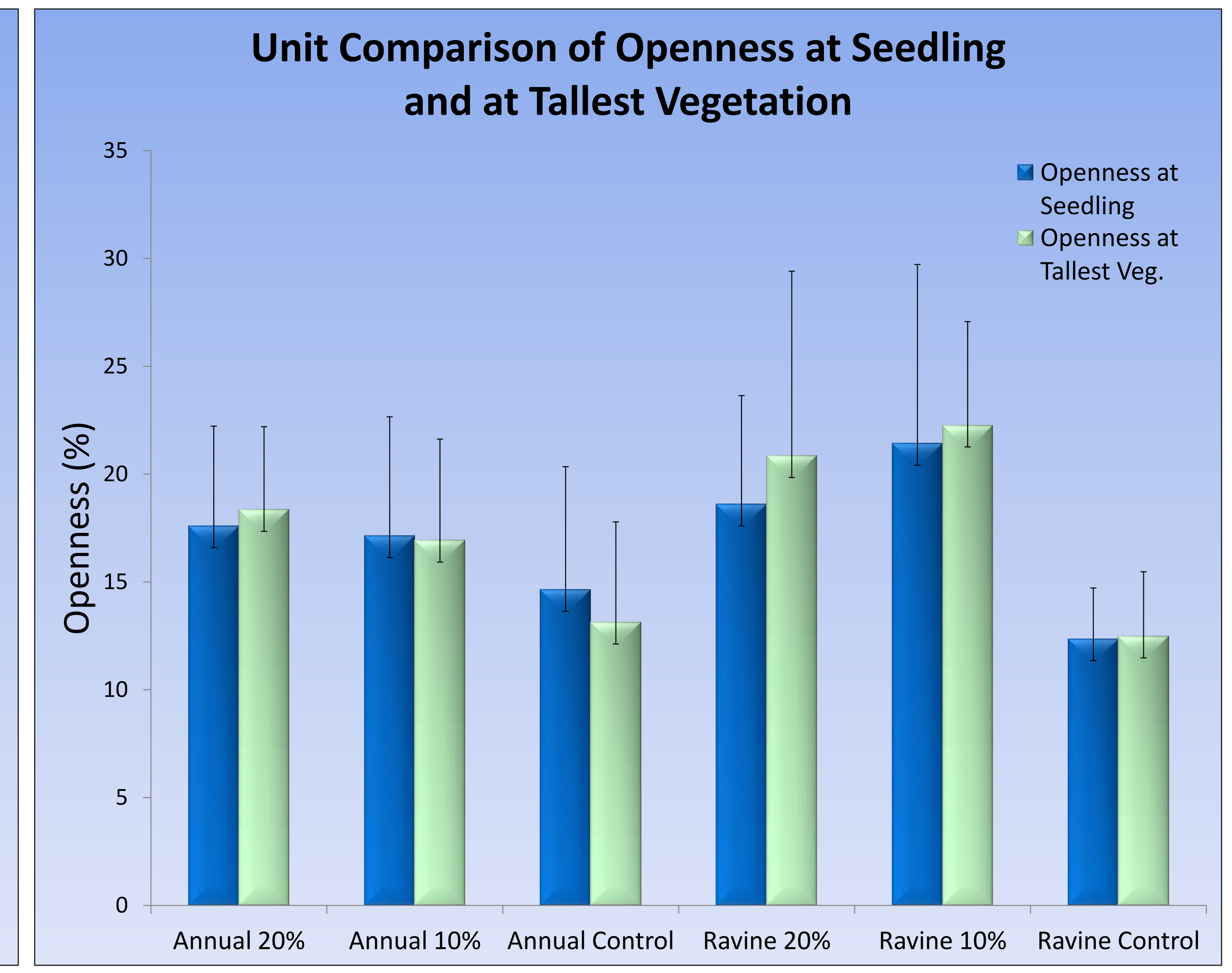

Fig. 2. Comparing openness (%) at the seedling level and tallest vegetation level across each treatment.

Unit Light Attenuation Curves

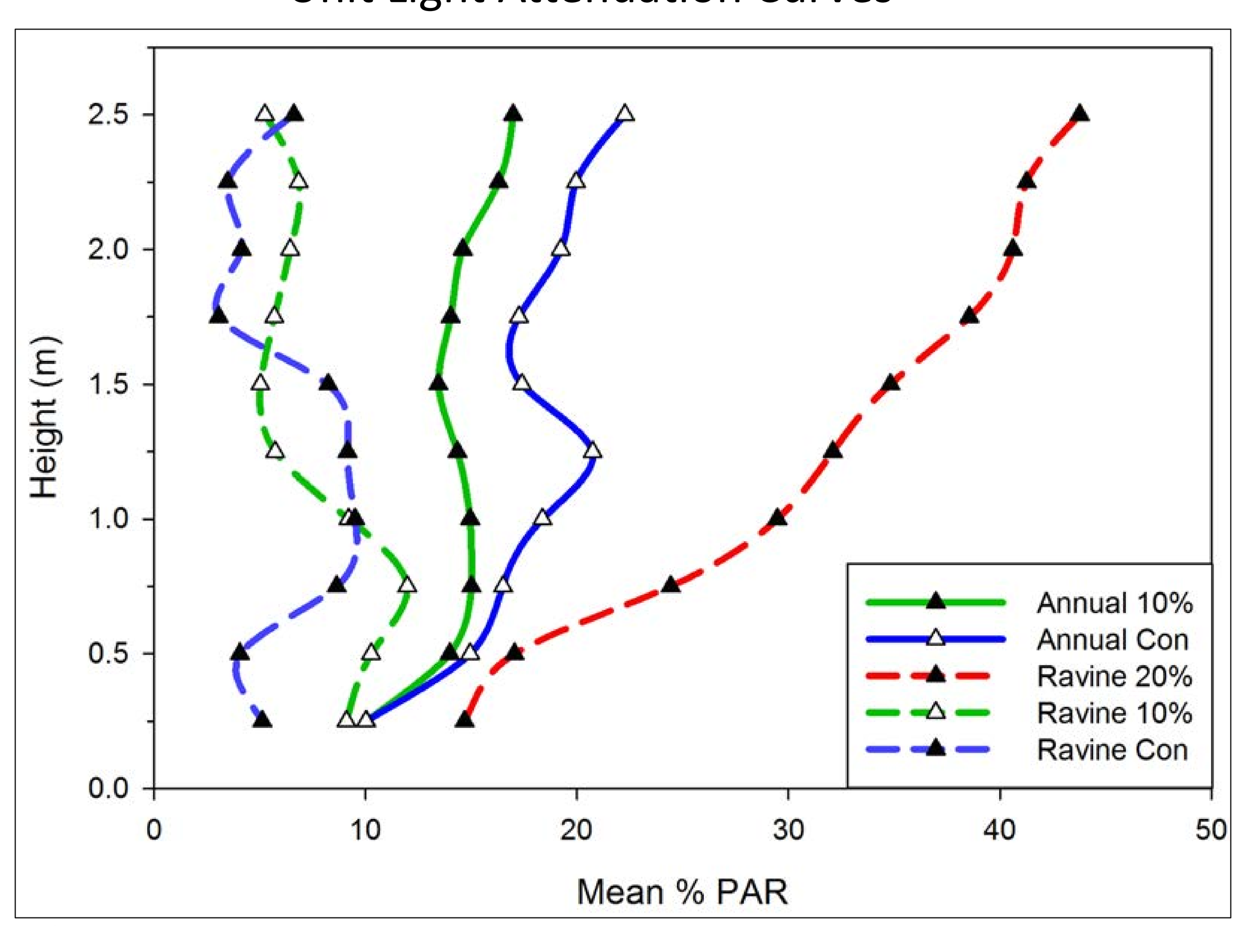

Fig. 3. Comparison of light Attenuation Curves for each unit .

Unit Comparison of 2014 Height Growth and Transmitted Radiation

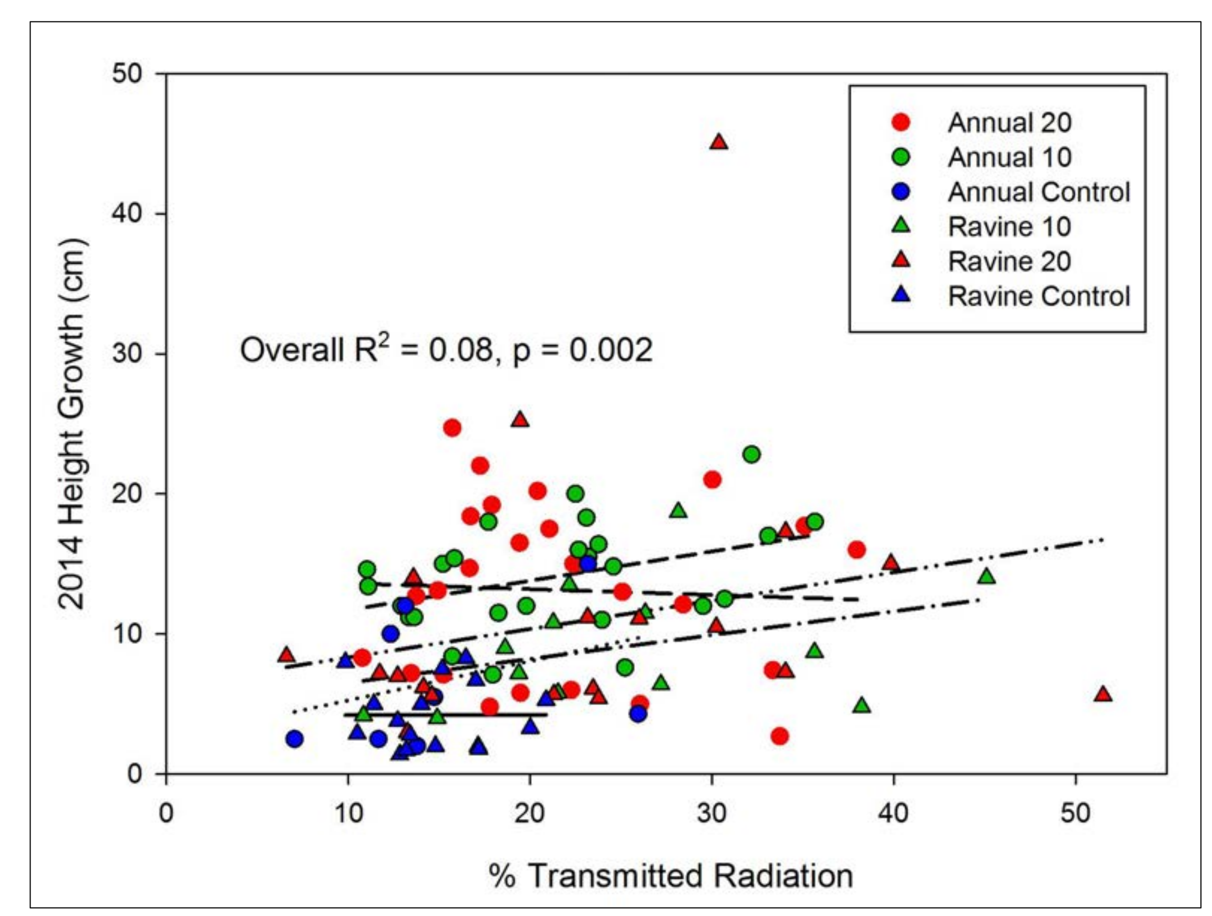

Fig. 4. Comparing the overall relationship between 2014 height growth and transmitted radiation (%).

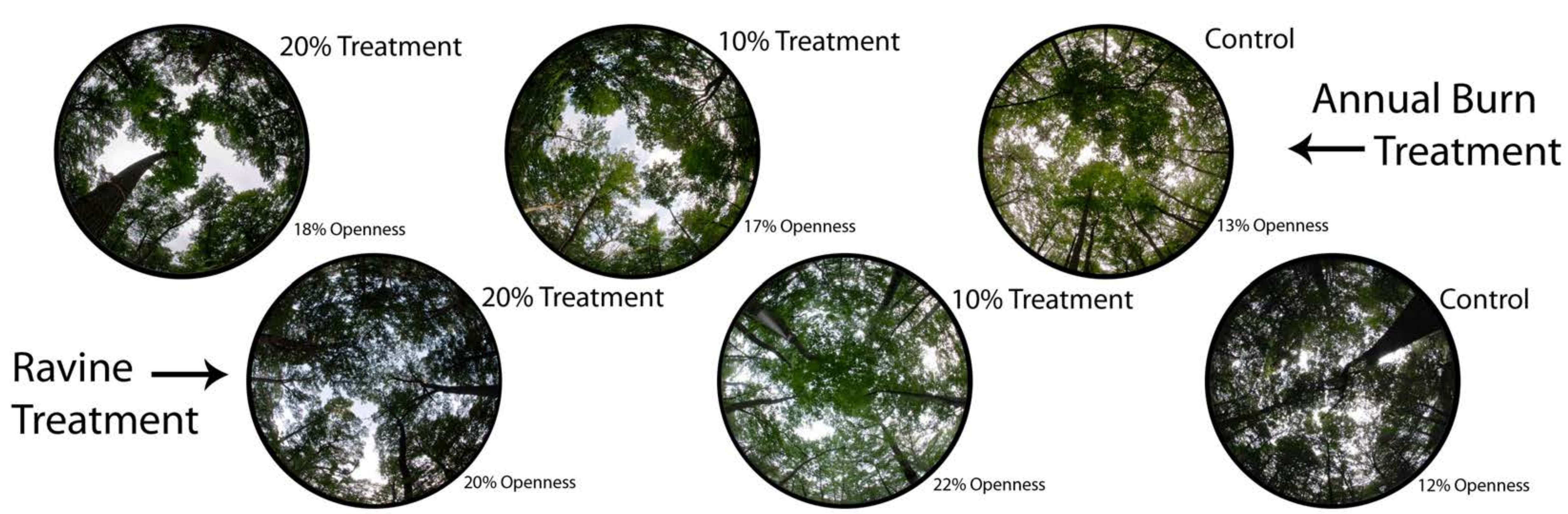

Fig. 5. Hemispherical photos taken at the height of the tallest vegetation, representing the average amount of canopy openness found in each treatment.

Results and Discussion

- Seedling growth (both total height change and 2014 growth) varied significantly among the thinning units (Fig. 1 – ANOVA 2014 Growth: $F_{5,107} = 6.45$, $p < 0.001$; Total Height Change: $F_{5,107} = 3.14$, $p = 0.011$), but growth only differed between the control and thinning treatments, not between the thinning intensities.
- Canopy openness was greater in the thinning treatments (Fig. 2 – ANOVA Seedling Openness: $F_{5,101} = 4.35$, $p = 0.001$; Tallest Veg Openness: $F_{5,101} = 8.13$, $p < 0.001$), but did not appear to differ between measurements taken above the tallest understory vegetation and directly above the seedling. Furthermore, there was also equivalent or greater canopy openness in the 10% treatment when compared to the 20% treatment area. A visual of the average canopy openness at each treatment is shown in Figure 5, these averages correlate to averages in Figure 2. This could partly explain the lack of difference between the treatment units.
- PAR was much greater at 2.5m in the 20% removal treatments (Fig. 3), but this light was quickly attenuated by the understory layer and there was no difference in radiation at 0.5m (approximately the average seedling height). This effect illustrates the importance of the understory layer, but it is difficult to separate out the specific effect of this layer. The impact of this understory layer is probably partly responsible for the lack of differences in growth between the thinning treatments. A useful next step could be to manipulate understory vegetation within the experiment to isolate the impact of understory competition.
- There was not a strong overall relationship between seedling growth and estimated transmitted radiation (Fig. 4). But the strength of this relationship differed among treatment units and was strongly positive for a few of the units.
- Future studies should aim to separate the effect of thinning versus understory competition on oak seedling regeneration. It is difficult to be sure how seedling growth is affected by the combined factors of canopy openness and understory competition. To be sure, this issue needs to be addressed in more depth to maximize the ecosystem services that oaks provide to their ecosystem. Continued research in forest trends will be essential given the current global climate change.

Literature cited

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Acknowledgements

A huge thank you to Rebecca Nelson for assisting in data collection and processing all of the hemispherical photographs. I'd also like to thank Christine Carrier for answering all my questions and helping out in the field. Lastly, I would like to thank The Morton Arboretum for making this research opportunity possible.