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Impact of Thinning Immature White Pine Stands on Growth and Timber Value in Grayson County Virginia

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Introduction

Eastern white pine (*Pinus strobus*) is a widespread and economically significant timber species found throughout the northeastern United States. In Virginia, white pine is often most productive in open, sunny forest spaces and has the potential to reach a marketable size in the span of 20-30 years after planting. White pine is also the third most common pine in Virginia, after loblolly pine (*Pinus taeda*) and Virginia pine (*Pinus virginiana*) (VDOF 2021). Though pine forests, in general, make up only about 20% of all forest cover in Virginia, they provide a disproportionate 45% of all annual harvest volume in the state (VDOF 2021) due to their fast-growing and productive nature.

In Virginia, pine plantings are a popular choice for forest landowners as a method of income creation. White pine stands are capable of producing a variety of forest products, including not only quality sawtimber, but also wood chips, fuel pellets, pulpwood for paper, and “pine tips” for use in holiday wreaths and greenery (VDOF 2021). A variety of management plans and techniques are used for these plantations. Many landowners see pine plantations as a low-maintenance source of passive income for the future, while others may take a more active role in management and use a variety of silvicultural techniques in hopes of increasing the return on their investment.

Typical silvicultural techniques used in pine plantations include site preparation and planting for stand establishment, and commercial/pre-commercial thinnings followed by a final harvest. Thinnings are an intermediate treatment that may take place several years or decades after planting occurs. Thinnings target the removal of weak or overtopped trees from the stand. This lessens competition for the residual pines, allowing for an increase in available sunlight and other resources increasing the diameter and corresponding value of timber at the final harvest (VDOF 2021).

Figure 1. An eastern white pine tree at age 40 located within the designated observation area at Matthews State Forest in Grayson County.

Pre-commercial thinnings occur when trees are harvested at a size insufficient to be sold at market. Conversely, commercial thinning occurs when trees thinned from a stand are large enough to be sold. Commercial thinnings generate revenue for the landowners while a precommercial thinning requires an investment by the landowner to improve the quality of the future timber produced by the stand. The timing and extent of thinning is an important factor to be considered in order to lower the overall investment costs for the plantation and result in a greater total profit. Historically, planted Eastern white pine stands within the study area of Grayson County (and much of the surrounding region of southwestern VA) are not prone to any type of commercial or precommercial thinning. This is primarily due to the lack of local markets for small diameter white pine stems, and otherwise high initial costs for what may be perceived by landowners as a low financial return on investment. Additionally, Eastern white pine tends to avoid "stagnating" in its rate of growth when not regularly thinned, unlike other common commercially-planted species of pine.

In this case study, two Virginia Tech undergraduate students evaluated a mechanically planted and pre-commercially thinned eastern white pine stand located on the Matthews State Forest in Grayson County during the summer of 2022. The site was cleared and planted in 1982, and later underwent a partial, precommercial thinning treatment in 1997, dividing the area into "thinned" and "unthinned" stands. The purpose of this case study was to determine if the precommercial thinning treatment itself resulted in a significant benefit to the stand, through improved tree vigor, overall timber value, or both.

Methods

The combined area of the study site was approximately 1.1 acres, with the thinned portion of the stand equaling 0.21 acres, and the unthinned portion making up the remaining 0.89 acres. Eastern white pine dominated the stand, with only a few additional species such as sweet cherry (*Prunus avium*) and scarlet oak (*Quercus coccinea*) located along the stand edges. A permanent inventory plot was established in both the thinned and unthinned stands. Two previous inventories used this same permanent plot center to conduct an inventory in 2010 and 2017. The previous inventories provided boundaries and a location to conduct fixed radius sample plots within each stand.

Explicitly delineating the borders between thinned and unthinned stands was important for accurate data collection. In order to create a clear and defined boundary, red flagging was used to mark shared borders and stand edges, and the perimeter was measured using a handheld Bad Elf© GPS device. The GPS allowed for creation of a map of the entire stand, as well as for calculations to be made on a per-acre basis. Since this study began in 1997, all treatments were already performed, and only data collection occurred in 2022.

Figure 2. GPS track of the entire white pine stand, with the thinned portion represented in red, and the unthinned portion in blue.

Data on each portion of the pine stand were collected using two different inventory methods: a 1/10th acre fixed radius plot, and a comprehensive inventory of the entire stand. The plot center used in each fixed radius plot was the same for each survey that had previously been conducted (once in 2010 and once in 2017). The data obtained from each fixed radius plot was also included within the comprehensive stand inventory for its corresponding portion of the stand (thinned or unthinned).

Data collected from each tree included total height, merchantable height, diameter at breast height (DBH, 4.5 ft), and product class (pulpwood or sawtimber) based on both diameter and stem form. Height measurements were conducted using a Nikon Forestry Pro II laser range finder, with measurements for merchantable height taken to a 6-inch top on each tree.

Trees were marked after being measured to avoid repeat counting within each stand. The trees in the fixed radius plots of each stand were marked with a spot of blue spray paint to signify that it had been counted. The trees in the full inventory were marked with a hollow circle that indicated it had been counted, but to also differentiate it from the fixed radius plot.

Basal area for each stand was calculated in Excel using data from measured diameters. A net present value estimation was conducted from the thinned stand's per-acre timber value, in order to observe the treatment's return on investment at the time of each conducted inventory.

Results and Discussion

Of the two fixed-radius plots sampled within the white pine stand (one in the thinned section and one in the unthinned), the plot located within the thinned stand generally had greater growth and productivity. Pine trees within the thinned stand were on average 3.1 inches larger in DBH, 8.6 feet taller in merchantable height, and provided approximately 24 more square feet of basal area per acre than their counterparts in the unthinned stand. The thinned fixed-radius plot had an average total of 10,760 more board feet (BF) per acre than those in the unthinned plot: 40,890 BF to 30,200 BF (Figure 6).

The unthinned white pine plot was found to have a larger count of trees per acre, or TPA (260 TPA to the thinned plot's 180 TPA) - as expected for a stand which had not had an additional source of mortality introduced through silvicultural thinning (Figure 7).

As mentioned previously, three total stand inventories had been conducted at the study site - over a period of 12 years. Between the years of 2017 and 2022, a significant amount of pine mortality was observed in both the thinned and unthinned stands. The root cause of this pine mortality remains unknown, though evidence supports the hypothesis that it was caused by a combination of Ips pine-boring beetles (*Ips pini*) and a detrimental insect-fungus complex (*Caliciopsis pinea* and *Matsucoccus macrociatrices*). Mortality is expected in eastern white pine stands since the species is known as "self thinning", however an unexpected amount of decline was observed in the thinned pine stand which provided evidence that external factors were at play. In 2010, 23 total trees were recorded in the thinned pine fixed-radius plot, and 53 in that of the unthinned (Figure 7). In 2017, no tree mortality was recorded in the thinned pine fixed-radius plot, and 34% mortality was recorded in the unthinned stand - resulting in a remaining 34 trees in the plot. In 2022, 28% stand mortality was noted in the thinned pine plot (resulting in a remaining 18 trees), and 26% pine mortality noted in the unthinned pine plot. Due to this significant and unexpected level of mortality observed throughout the years, we have provided an additional estimate representing a scenario in which no additional tree mortality took place from 2017 - 2022 (Figure 6).

Figure 3. Stand of unthinned white pine trees, marked with blue paint to prevent repeat counting.

Analysis of data for the entire thinned and unthinned white pine stands showed that trees in the thinned white pine stand were on average 1.6 inches larger in DBH, 10.4 feet taller in merchantable height, and had approximately 15.4 more square feet of basal area per acre than trees within the unthinned stand. The estimated board feet per acre for the two stands in their entirety (Figure 6) was similar to their respective permanent fixed-radius plots. The thinned stand had an average of 40,890 BF per acre compared to the unthinned stand's 32,329 BF -

resulting in an increase of approximately 8,561 BF from the thinned stand.

These data indicate that silvicultural thinning may result in the production of eastern white pine stands which produce higher volume per acre compared to unthinned stands (Figure 6). Trees found within the thinned portion of the stand had a higher average DBH, merchantable height, and basal area than trees within the unthinned stand - factors that result in more valuable trees for use in sawtimber and pulpwood production. Using current white pine stumpage price estimates for 2022 (approximately $165 per thousand BF), the timber in the thinned stand held an average value of $6,758 per acre, while the timber in the unthinned stand held an average value of $4,983 per acre. This estimate suggests an approximately $1,775 increase in per-acre timber value resulting from the thinning treatment, though initial treatment costs and possible mortality effects must first be recognized and accounted for.

When estimating the profitability of the two measured pine stands, it becomes evident that the thinned pine stand became rapidly more valuable than the unthinned stand several years after the treatment occurred (Figure 8). In 2010, the pre-commercially thinned stand was found to have a value that was $1,437 greater than the unthinned stand. This trend continued with the thinned stand averaging $3,741 more in 2017. In 2022, as mentioned earlier, stand mortality greatly increased . As a result, the estimated value of the thinned stand continued to increase, but only to a price approximately $1,775 more than that of the unthinned stand. When using the hypothetical estimate of zero pine mortality from 2017-2022, the thinned pine stand is estimated to be worth $2,097 more per acre than the unthinned stand. On average, excluding the estimated stand values, the average value per acre of the thinned pine stand is equivalent to 1.6 times greater than the unthinned pine stand over the three observation periods.

The net present value estimation for the pre-commercially thinned stand began with an initial cost of $400 per-acre, accounting for typical labor costs and expenses incurred by the thinning treatment. The per-acre value of the thinned timber was discounted using an annual rate of 5% in order to calculate a return on investment.

The completed graph (Figure 9) displays an interesting view of the net benefits of thinning over the 25-year period. The thinning treatment was found to result in a positive net present value and net increase in value over the unthinned timber until the final sampling period. While thinning led to a moderate increase in net present value for timber at 13 and 25 years after thinning, the NPV was substantially greater at 20 years post-thinning. In 2017, the estimated NPV per acre for a thinned stand of white pine was over $2,500 greater per acre than for a stand of unthinned white pine. This data suggest that the benefits incurred from the thinning process may be maximized at around twenty years after the treatment occurs.

Figure 4. Bark of standing dead white pine tree, with evidence of bark beetle activity.

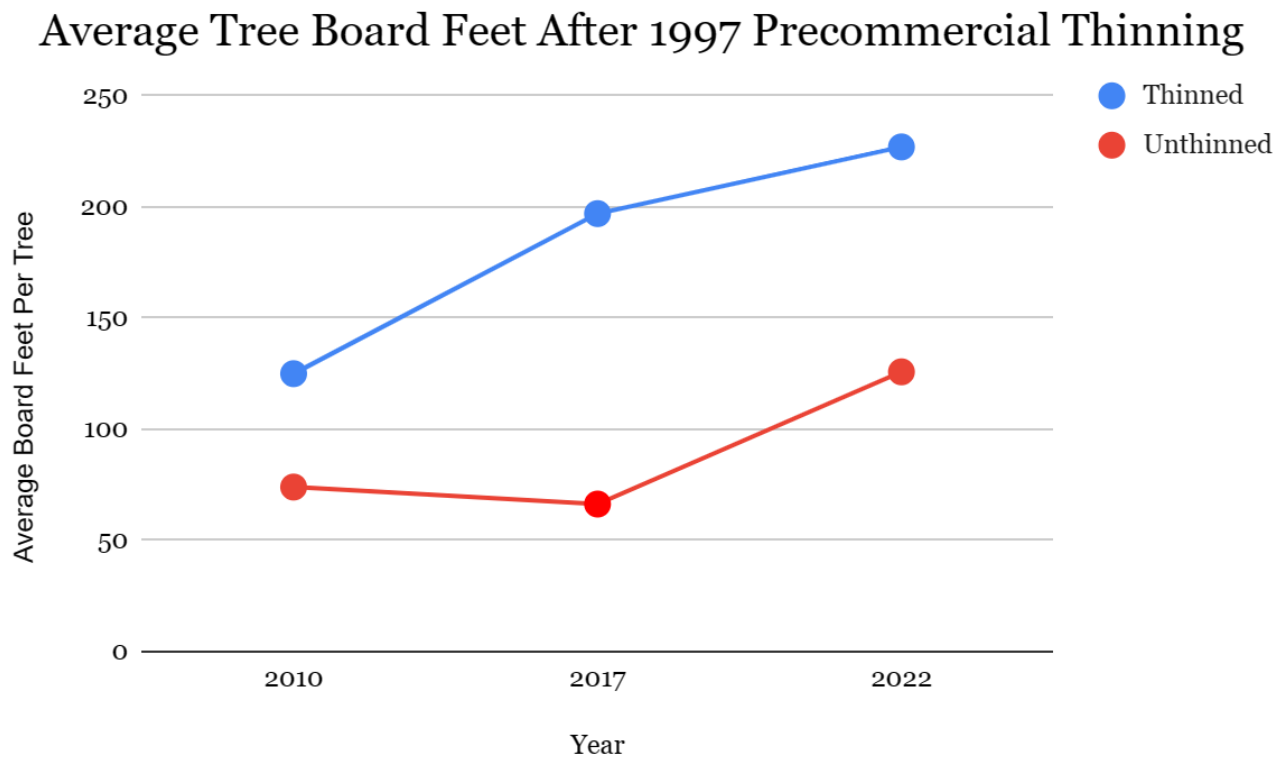

Figure 5. Estimated average board feet produced per tree for both thinned and unthinned white pine stands.

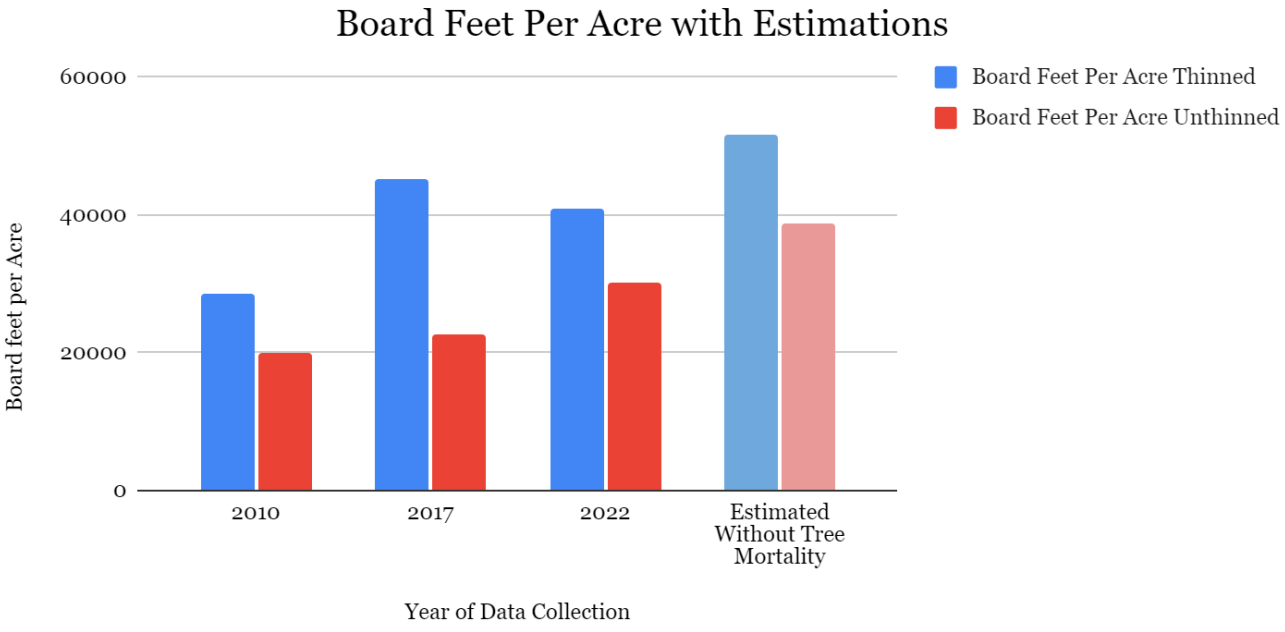

Figure 6. Comparison of board feet per acre for thinned and unthinned white pine stands. The final column represents an estimation of board feet per acre if no pine mortality had occurred from 2017-2022 using the average DBH of the stand at that time period multiplied by the number of individuals lost.

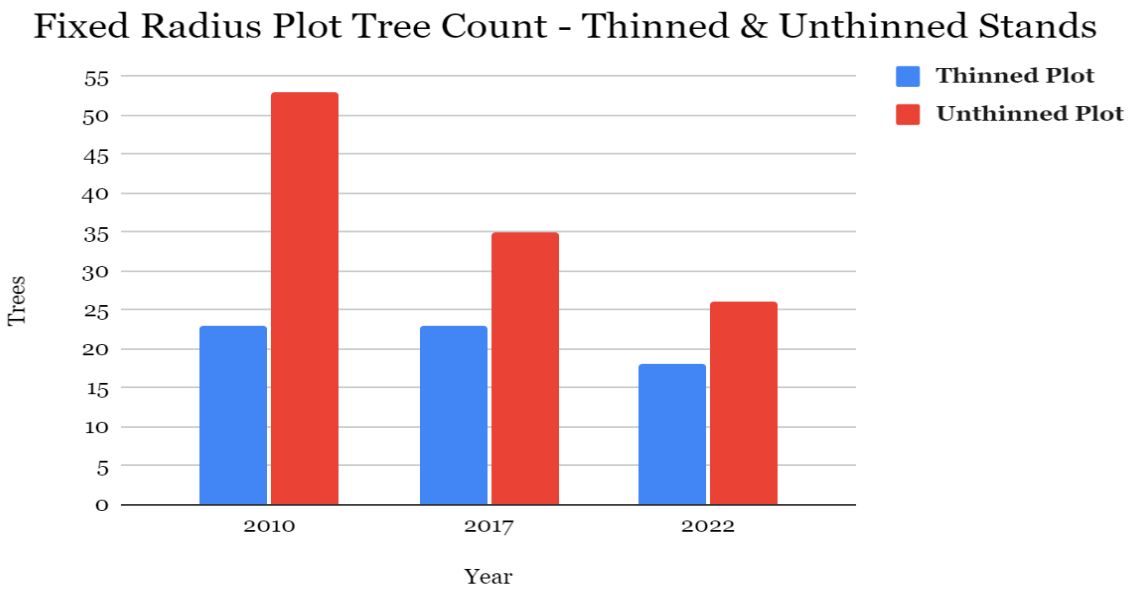

Figure 7. Total count of surviving white pine trees within the two permanent, tenth-acre plots, as observed by inventory year. A significant amount of pine mortality was found to have occurred for both stands from 2017 - 2022.

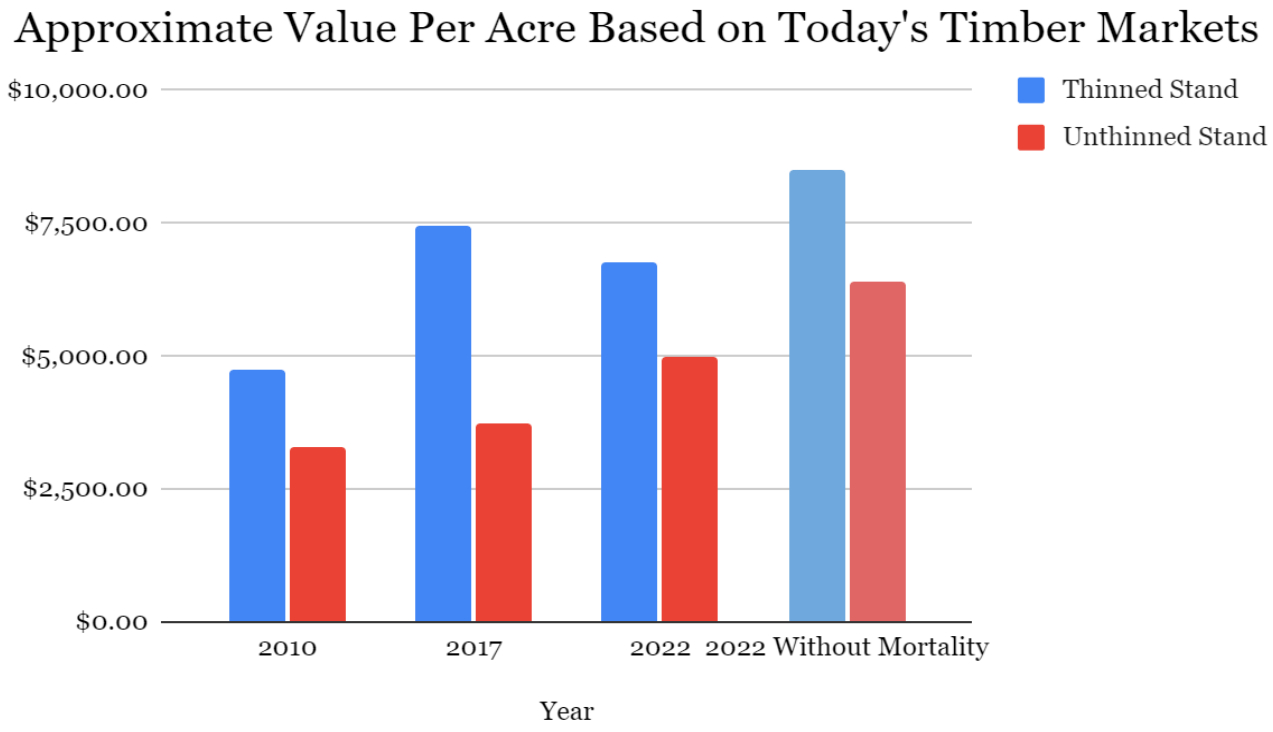

Figure 8. Average per-acre stumpage value of pine sawtimber present within the thinned and unthinned pine stands, as observed by inventory year. The final column represents an estimate for a scenario in which no pine mortality occurred from 2017 to 2022. Estimations were based on a current 2022 stumpage price for white pine sawtimber: approximately $165 per thousand board feet.

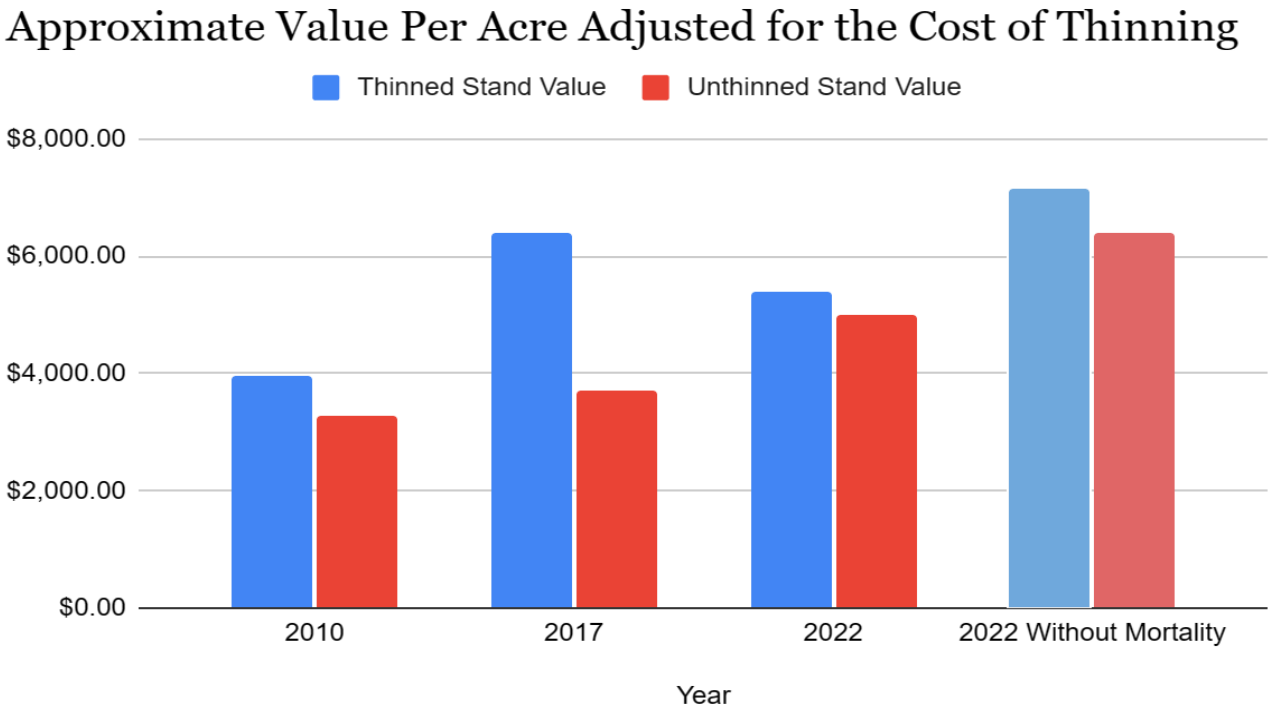

Figure 9. The estimated value per acre of both stands adjusted for the cost of site preparation. The cost of the initial thinning was adjusted to reflect the present cost of thinning for each year, and subtracted to generate an estimate of net present value for each sampling year.

Conclusions

Our results are consistent with both of the previously conducted inventories of the permanent plots in this white pine stand. The observed data supports the conclusion that thinned stands of white pine tend to be more productive and hold greater timber value than stands that are left unthinned (Figure 9). On average, trees present within the stand that had undergone thinning achieved a larger merchantable height, DBH and total board foot production than their unthinned counterparts (Figure 5).

NPV analysis of the benefits received from conducting a thinning indicates that pre-commercial thinning provides a significant benefit in per-acre value when utilized - even when accounting for treatment costs and discounting for time. Landowners should also consider factors such as potential mortality when determining how long they wish to delay their timber harvests for maximum financial gain. As thinning of Eastern white pine stands increases overall tree vigor and reduces crowding (which may lead to harmful impacts such as an increased spread of insects or disease), landowners should hold these factors in consideration for their management plan. This may especially be the case as harmful pathogens increase in range and prevalence throughout southeastern pine stands, and in the context of ever-changing global and regional climate systems. Due to these concerns, thinning may increase in popularity as a method of ensuring the health of planted white pine stands over a sustained period of time.

It should be noted that these results are from a series of repeated case studies localized to a single set of pine stands located in the Matthews State Forest of Galax, Virginia. As such, they do not apply to all situations and different results may be obtained from a replicated designed experiment. These repeated case studies do show correlations between thinning and increased board feet per acre, height, and DBH. These increased volumes increased the total NPV of the thinned stand when compared to the unthinned stand. The results of the data collected during this 25-year time period after thinning allow for greater insight into the dynamics of thinning pine and increased board feet per acre.

References

Virginia Department of Forestry (VDOF). 2021. Pine Management. Available online at https://dof.virginia.gov/forest-management-health/learn-about-forest-management-health/pine-management/. Accessed 8/3/2022.

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