Field Note

Ten-Year Performance of Eastern White Pine under a Crop Tree Release Regime on an Outwash Site

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ABSTRACT: *A young stand of eastern white pine aged 38–40 years received a crop tree release cutting reducing stocking to 100 trees/ac. This stocking level reflects the number of stems per acre that would be contained in a well-stocked mature stand at final harvest (20-in. quadratic mean stand diameter). The stand then was monitored for growth and value change. Stems that grew from poletimber to sawtimber size had the greatest rates of annual value change. They also showed the greatest return per square-foot of crown area used. Careful early thinning that removes sawtimber and releases good-quality poletimber capable of vigorous growth can substantially increase stand earnings if markets are available. North. J. Appl. For. 22(2):139–142.*

Key Words: Early thinning, rate of return, crop tree release, optimal stocking.

Crop tree release (CTR) is a silvicultural application used for intermediate cuttings in forest stands. This application allocates the most growing space to the most desirable trees, often those stems that will be maintained within the stand for the entire rotation making up the "final stocking." More space is justified for the "crop trees" because they are usually the highest-quality stems that can grow quickly and produce the greatest financial return to the landowner.

Although much work has been done recently with eastern hardwood species (Perkey et al. 1993), little information appears to be available about eastern white pine (*Pinus strobus*) under such a regime. One study by Page and Smith (1994) working with low stocking densities of white pine reported very favorable rates of return on pruned stems even over very long periods (as much as 62 years after pruning). Still, there seems to be little available about individual tree performance of white pine.

Methods

To study the performance of white pine under a crop tree release regime, a 2-ac, even-aged pure stand approximately 38–40 years old was chosen at Mast Yard State Forest, Hopkinton, New Hampshire. The site is glacio-fluvial, river terrace, stratified outwash sand, which tends to be nutrient poor and droughty. The USDA Natural Resources Conservation Service (NRCS) mapped the soil series as Croghan, moderately well-drained, fine sandy loam. The site index measurements for the stand averaged 75 at base age 50. The stand appeared to be naturally regenerated, possibly the result of abandoned agricultural practices.

We determined that 100 crop trees per acre would stock a mature stand at final harvest by locating the point halfway between the A- and B-lines of the stocking guide at 20-in quadratic mean stand diameter (QMD) (Lancaster and Leak 1978). Prior to the crop tree release, the stand contained about 1,289 trees/ac, a basal area of 310 ft^2/ac, and a QMD of 6.6 in. A forester marked the crop trees and a logger cut all unmarked stems. The cutting operation yielded stumpage revenue to the State from the sale of logs and biomass chips.

Three circular plots each measuring 0.1 ac were established after the cutting. The crop trees were numbered and breast height was marked on each stem. Diameter at breast height was measured with a diameter tape. The residual stand contained 100 trees/ac, a basal area of 69.3 ft^2/ac, and QMD of 11.3 in. The relative density was 28.3.

Merchantable stem heights were estimated using a tape and clinometer and rounded to the nearest ½-log with height terminating at an 8-in. top or at a major stem defect with no sawtimber above. The board foot volume of each butt log was estimated by applying Girard Form Class (80) taper estimates to calculate the small-end diameter inside bark (dib); dib was rounded to the nearest inch, and the International ¼-in rule was used to calculate the volume.

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The remaining merchantable height received a standard taper of ½-inch in diameter for each 4-ft log section. Based on this taper, the board-foot volume was calculated for each log above the butt log using the same volume equation. We felt that this method yielded a volume closer to the actual volume obtained by harvesting the stems and scaling them at the mill.

Log value was calculated using log specifications and prices from a local mill. An operating cost of $120/MBF was deducted for harvesting and trucking costs (Sarah Smith, University of New Hampshire, personal communication, June 2003). Some low-quality logs with board-foot volume had negative stumpage values. In this case and for nonsawtimber stems, a stumpage rate of $0.75/ton for biomass chips (UNH Cooperative Extension) was assigned. Stem weights were calculated using tables in USDA (1984).

Results

After 10 years, the mean QMD increased from 11.3 to 13.6 in., a change of 2.3 in. Basal area per acre increased from 69.3 ft^2/ac to 94.5ft^2/ac, an increase of 25.2 ft^2/ac. The board foot volume per acre increased from 4,850 to 12,766, a change of 7,916 bf/ac (International ¼-in). Stumpage values increased from $409/ac to $1,285/ac, a gain of $876. The annual percentage change (APC) for board-foot, basal area, and stumpage value growth were 10.2, 3.2, and 12.1%, respectively. Mortality over the 10-year period was less than 7%.

All but two of the surviving trees in the study plots had a real annual percentage change for dollar value growth in excess of 6% (Table 1). Eleven of the 30 study trees had real annual percentage change rates of 30% or more. All 11 of these trees were poletimber at the beginning of the growth period and sawtimber at its conclusion. Due to this ingrowth into a higher value class as well as taper changes that increased the proportion of sawtimber by log height, large average annual percentage changes were observed.

Figure 1 shows the relationship between initial dbh and 10-year gain in value. Regression analysis shows a highly significant difference between dbh and earnings ($R^2 = 0.40$, $P = 0.0003$). Figure 2 shows the relationship between crown projection area (CPA) and the dollar value growth per square foot of CPA. Regression analysis shows that smaller stems had smaller CPAs yet were using the available crown space more efficiently and that the difference was significant ($R^2 = 0.16$, $P = 0.03$).

Discussion

When thinning a stand to optimize financial return, Klemperer (1996) suggests removing all stems growing below the determined minimal acceptable rate of return (MAR). This rate is different for various landowners based on their

Table 1. Dbh, merchantable height, volume, and stumpage value with annual rates of change at the beginning and conclusion of the 10-year study period by tree.

	Dbh (in.)		Height (16 ft logs)		Board feet			Stumpage value (2002 dollars)		
Tree no.	1991	2001	1991	2001	1991	2001	Annual volume Δ (%)	1991	2001	Annual value Δ (%)
1	12.9	15.2	1.5	1.5	80	125	1.1	8.53	16.28	6.68
2	11.0	12.2	1.0	2.5	40	130	7.9	2.80	9.10	12.51
3	7.8	9.2	0.0	0.5	0	15	32.2[a]	0.26	0.33	2.41
4	9.1	11.7	0.0	3.0	0	155	60.6[a]	0.33	10.85	41.81
5	12.3	15.3	2.0	3.0	105	200	4.6	7.35	23.10	12.13
6	11.5	12.0	1.0	2.0	50	90	4.7	3.50	6.30	6.05
7	13.4	15.7	2.0	2.5	120	175	2.1	12.00	21.35	5.93
8	12.3	Dead	2.0		105			7.35		
9	15.8	18.1	2.5	3.0	160	295	1.4	17.38	44.60	9.88
10	12.8	15.3	1.5	2.0	80	160	3.7	8.53	20.30	9.06
11	9.4	12.6	0.5	2.0	15	105	22.9	0.33[b]	10.28	41.04
12	10.0	13.1	0.5	2.5	20	130	23.6	0.11[b]	12.03	59.91
13	11.5	14.5	1.0	1.5	50	100	7.0	3.50	10.60	11.72
14	7.6	9.8	0.0	1.0	0	40	41.7[a]	0.26	2.80	26.83
15	12.6	15.4	2.0	3.0	105	200	4.3	10.28	23.10	8.43
16	12.1	14.9	2.0	3.0	90	200	4.3	6.30	23.10	13.87
17	12.1	14.6	1.5	2.0	65	130	3.8	4.55	12.70	10.81
18	11.1	13.8	1.0	2.5	50	145	10.9	3.50	13.75	14.66
19	10.8	14.3	0.0	2.5	0	145	66.2[a]	0.50	13.75	39.29
20	10.4	11.8	0.0	2.0	0	90	56.3[a]	0.41	6.30	31.42
21	10.4	14.2	0.0	2.5	0	145	66.0[a]	0.41	13.75	42.09
22	8.6	12.6	0.5	2.5	15	130	28.9	0.37[b]	12.03	41.65
23	11.5	13.8	0.5	1.5	20	95	15.6	0.83[b]	10.25	28.58
24	10.8	13.8	1.0	2.5	50	160	11.5	3.50	14.80	15.51
25	11.3	14.8	1.5	3.0	65	185	8.7	4.55	16.55	13.78
26	9.6	12.0	0.0	2.0	0	90	56.9[a]	0.41	6.30	31.42
27	9.4	11.8	0.5	2.5	15	130	23.0	0.33[b]	9.10	39.33
28	11.6	13.8	0.5	2.5	20	160	19.9	0.61[b]	14.80	37.56
29	8.9	11.6	0.0	2.5	0	105	58.3[a]	0.33	7.35	36.39
30	14.9	Dead	2.0		135			13.73		

[a] 1991 pulpwood trees containing no board foot volume in 1991 were assumed to contain 1 board foot to calculate an annual rate of change.
[b] Sawtimber trees containing negative stumpage value were converted to pulpwood stumpage prices.

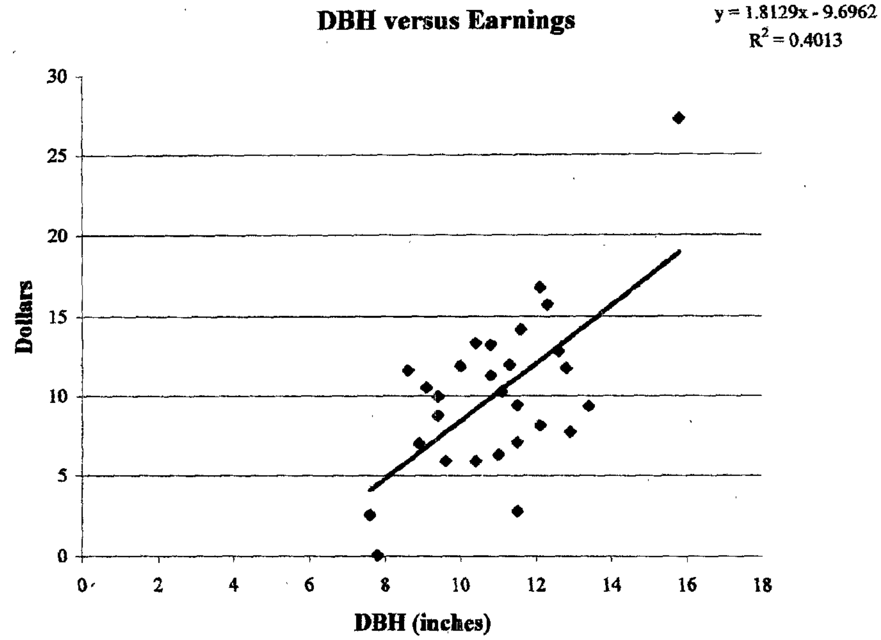

Figure 1. A scatter plot showing the relationship between initial dbh (inches) and earnings in 2001 $US.

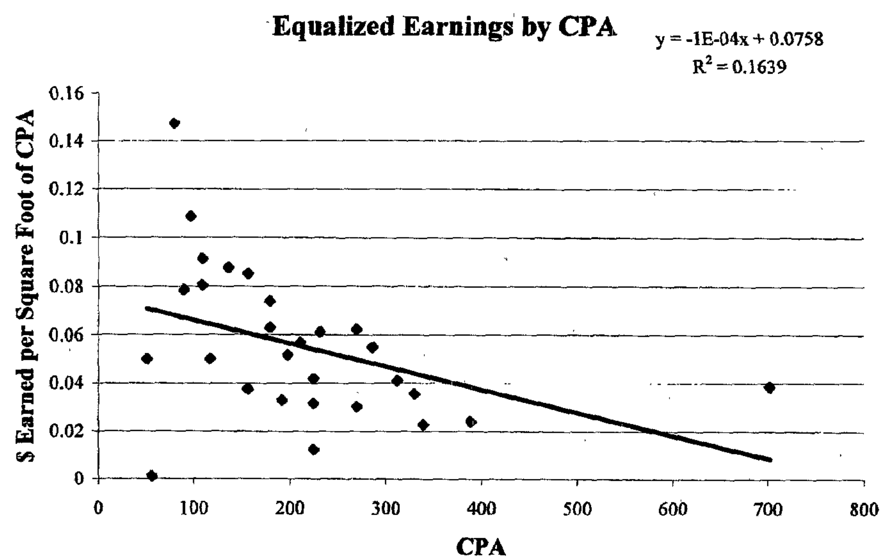

Figure 2. Earnings per square foot of crown space used by each tree.

best investment options. During this growth period, the Fox Research Forest was earning about 7.4% on money market funds. This was roughly a 5% real rate of return. If the stand in this study was subject to this MAR, then most stems growing in value at less than 5% (real) annually should have been harvested.

However, when trees are thinned, some stems that were increasing in value at less than 5% annually prior to cutting may surpass 5% after the cutting due to increased growing space, so not all trees earning less than 5% initially should be harvested. Also, tree value jumped when a tree grew into a new value class, e.g., from poletimber into sawtimber (Table 1). Only one tree (tree 3) was growing at less than 5% annually. In fact, the trees that achieved the greatest annual value change were the trees that had the smallest diameter and presumably the slowest growth rates prior to cutting based on their size.

We looked at how the stand might have performed if the same basal area (69.3 ft^2/ac) was left entirely in good-quality 9-in. poletimber or entirely in larger sawtimber-sized trees. We averaged the value growth of all five 9-in. trees (8.6–9.4 in) and multiplied it by 157, the number of 9-in.

stems required for 69.3 ft^2/ac basal area. The earnings averaged $9.58/tree multiplied by 157 trees/ac, yielding $1505/ac. Likewise, we averaged the earnings of the 11 largest-diameter surviving trees (11.5–15.8 in) and multiplied that by 78, the number of trees required for 69.3 ft^2/ac basal area. The large trees earned an average of $12.15 multiplied by 78 trees/ac, yielding $948/ac. The stand actually earned $876/ac as harvested, including the two dead trees. We could have earned more (about an additional $629) during the growth period by harvesting the larger stems and leaving more 9-in. good-quality co-dominants to grow. Figure 2 supports this point by showing that although trees with a smaller dbh had less growth than large trees, the smaller dbh trees generally grew more per square foot of crown space used.

If earnings from the invested early harvest revenues are considered, the total earnings are even better for retaining the 9-in. codominants. Biomass is a low-value product that yields small stumpage revenues. If a greater proportion of sawlogs were harvested in 1991, the invested principle would have been much larger. This would have earned more dollars as a money market investment combined with greater stand earnings.

However, Figures 1 and 2 each show an outlier, which in each case is tree 9. This tree grew into the highest-value class during the 10-year growth period. This tree exhibits an important characteristic that a forester must consider when choosing trees to harvest. Tree performance is based on the ability of a tree to change from one value class to a higher one. This tree did not have tremendous growth compared to others in the stand. However, it did change from a moderate value class to a high value class because the butt log scaling diameter reached the most valuable size (14 in.). Consequently, although releasing poletimber crop trees will help optimize the value growth of the stand, other crop trees capable of quickly changing value classes must be considered as well.

The practice of thinning heavily from below early in the life of a stand may remove many stems with the greatest potential for growth in value. This stand was even-aged, and the smaller, better-performing crop trees after release were co-dominants in most cases. Foresters should not misconstrue our results as justification for high grading. The practice of removing larger dominants to release smaller co-dominants is termed "selection thinning" by Smith (1962). Released co-dominants should be vigorous enough to respond both in volume growth and value growth.

In southern New Hampshire timber markets, white pine value classes culminate when logs are 16-ft, 14-in. scaling diameter, and contain few small or no knots. This would be equivalent to an 18-in. dbh butt log. At the time this study was initiated, we used 20-in. dbh as our optimum butt log size because field foresters generally accept it as the point of financial maturity. In retrospect, 18-in. dbh would have permitted us to retain about 25 more crop trees/ac. More research is needed to determine whether retaining those 25 more trees would have increased the value growth of the stand.

Based on this study, we suggest that more high-quality poletimber should be retained to grow into sawtimber and more sawtimber should be harvested during the first cutting in similar stands to one observed in this field note.

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