IMPACT OF PRUNING INTENSITY ON GROWTH OF YOUNG LOBLOLLY PINE TREES: SOME EARLY RESULTS

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Abstract—In the spring of 2000, a designed experiment was established to study the effects of pruning intensity on the growth of loblolly pine (*Pinus taeda* L.) trees. Trees were planted at a 1.83 by 1.83 m square spacing in plots of eight rows with eight trees per row; the inner 36 trees constituted the measurement plot. Four blocks containing five treatment plots were established at each of two locations in the Virginia Piedmont. The five treatment plots included an unpruned control, and pruning treatments where 1/4 of the live crown was removed on all the trees, 1/2 of the live crown was removed on all the trees, 1/4 of the live crown was removed on 1/2 of the trees, and 1/2 of the live crown was removed on 1/2 the trees. Measurements at the time of treatment and one year after treatment for each tree included d.b.h., total height, height to base of live crown, crown width within and between the row. Results are presented that show the initial impact of pruning on tree growth. Additional measurements gathered over the life of the study will provide a more complete understanding of the effects of pruning on development of loblolly pine trees.

INTRODUCTION

Pruning affects wood quality of trees harvested from loblolly pine plantations (Gibson and others 2002). Pruning future crop trees during stand development removes limbs (both living and dead) that produce knots in wood products merchandized from harvested logs. Removing live branches may also affect the onset of the production of mature wood and thus change the density and strength properties of wood obtained from pruned trees. By improving wood quality, pruning has been shown to be profitable given certain economic assumptions (Huang and Kronrad 2004).

Pruning live limbs also affects tree growth and stand development. Valenti and Cao (1986) showed that pruning reduced stem taper resulting in more cylindrical trees with more volume per tree. Burton (1981) as well as others such as Labyak and Schumacher (1954) and Marts (1949) showed that pruning vigorous, live limbs causes a real and significant effect on stem form and subsequent diameter growth, at least for a period of time following pruning.

For the most part, past studies on the impact of pruning on tree form and growth have been conducted in stands without intensive silviculture. Today's plantations are being intensively managed using cultural practices that produce very rapid growth rates, thus allowing pruning treatments to be applied earlier in the rotation when trees are growing most rapidly. It is unclear what impact pruning will have on these intensively managed stands, and how they will grow and develop following treatments.

In order to examine the impact of pruning on loblolly pine trees growing in intensively managed plantations, a pruning study was established to examine the effect of pruning intensity on tree growth and stand development. In this paper we present some early results from this study.

DATA

In the spring of 2000, two study sites in the Piedmont of VA (Appomattox and Patrick Counties) were identified as being suitable for establishment of the study. Both sites were cutover areas, one of which was burned following harvest. At each site, four replications containing five future treatment plots were laid out and planted using genetically improved 1-0 loblolly pine seedlings. The five future treatments included (1) control (unpruned), (2) removing 25 percent of the live crown on all the trees, (3) removing 50 percent of the live crown on all the trees, (4) removing 25 percent of the live crown on half the trees, (5) removing 50 percent of the live crown on half the trees. Square treatment plots (eight rows with eight trees per row) were established; the interior thirty-six trees were measurement trees.

Herbicides were applied during the first two years after planting to control competing vegetation. Elemental nitrogen at 225 kg/ha and 22 kg/ha of elemental phosphorus were applied at age 2 to all plots. Annual measurements from age 2 included d.b.h., height to live crown, total height and two measures of crown width. Pruning treatments were applied at age 6. For treatments (4) and (5), the choice of which trees to prune was made systematically: tree 1 in row 1 was randomly determined to be pruned or not pruned and then every odd-numbered tree in the plot received the same treatment as tree 1. The even-numbered trees in the plot received the other treatment. Thus, following treatment, each tree in the plot was surrounded by four adjacent neighbors having the other treatment. Table 1 presents summary statistics by treatment at time of treatment (age 6).

ANALYSES

A model was specified to examine tree growth following treatment (from age 6 to age 7) and stem form using analysis of variance techniques:

$$G = b_0 + b_1 Loc_i + b_2 Rep_j + b_3 T_k + E_{ijk} \qquad (1)$$

where G is the periodic annual growth (PAI) of d.b.h, total height and average crown width between age 6 and 7, and also the height over d.b.h. ratio at age 7. Loc is the location effect (Appomattox or Patrick County, VA), Rep is the Replication effect, T is the treatment effect (control or one of the four pruning treatments) and E is the error term. All statistical tests were made at the α=0.05 significance level.

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Table 1—Before and after pruning statistics at time of pruning (age 6) for the four pruning treatment plots and the control plot

	Before pruning		After pruning	
	Mean	Std. dev.	Mean	Std. dev.
	-------------- Control ------------			
Dbh (cm)	8.40	1.74		
Height to live crown (m)	1.42	0.58		
Total height (m)	5.59	0.89		
Crown width (m) [a]	2.45	0.39		
	- Prune 25% of Live Crown on All the Trees -			
Dbh (cm)	8.10	1.89		
Height to live crown (m)	1.35	0.61	2.46	0.62
Total height (m)	5.51	0.94		
Crown width (m) [a]	2.47	0.39	2.24	0.39
	- Prune 50% of Live Crown on All the Trees -			
Dbh (cm)	8.31	1.88		
Height to live crown (m)	1.39	0.68	3.53	0.81
Total height (m)	5.62	1.04		
Crown width (m) [a]	2.46	0.42	1.85	0.42
	- Prune 25% of Live Crown on ½ the Trees -			
Dbh (cm)	8.18	1.92		
Height to live crown (m)	1.33	0.59	2.45	0.62
Total height (m)	5.43	0.93		
Crown width (m) [a]	2.45	0.42	2.27	0.37
	- Prune 50% of Live Crown on ½ the Trees -			
Dbh (cm)	7.88	1.89		
Height to live crown (m)	1.35	0.67	3.39	0.76
Total height (m)	5.42	0.99		
Crown width (m) [a]	2.36	0.44	1.80	0.43

[a] Average of within and between row crown widths

From age 6 to age 7, PAI for d.b.h. and average crown width were significantly different between the treatments. There was also a significant difference between treatments for the height over d.b.h. ratio at age 7. PAI for height, however, was not significantly different between the treatments (Table 2).

A second model was specified to examine the growth of the pruned trees (P) in the two plots where one-half the trees were pruned and the other half were unpruned:

$$G = b_0 + b_1 Loc_i + b_2 Rep_j + b_3 P_l(T)_k + E_{ijkl} \qquad (2)$$

where P is the group of trees pruned within treatment plot, T (the plots where 25 percent of the crown was pruned on half the trees or 50 percent of the crown was pruned on half the trees), and other variables are as previously defined. D.b.h., and mean crown width PAI from age 6 to age 7 were significantly different between the pruned and unpruned trees in these two treatment plots. Likewise, the mean height over d.b.h. ratio was significant. However, the mean total height PAI was not significant. Table 3 presents these results.

DISCUSSION AND CONCLUSIONS

The pruning treatments applied in this study range from light (removing 25 percent of the crown length on half the trees) to very severe (removing 50 percent of the crown length on all the trees). At age 6, the time of treatment, the plots had a closed canopy and crowns of adjacent trees were touching. Intraspecific competition had begun and crowns were beginning to recede. Removing 25 percent of the live crown length appeared to reduce crown mass, or volume, by about 30 percent on an individual tree basis, but still left the plot with a closed canopy. Removing 50 percent of the live crown length appeared to reduce crown mass by considerably more, perhaps on the order of 60 to 70 percent and greatly opened up the canopy of the plot. This was especially true on

Table 2—Periodic annual increment (standard deviation in parentheses) for dbh, total height and mean crown width; mean height over dbh ratio for the control and four pruned treatment plots (P value for F-test between treatment means)

Variable	Control	Prune 25% on all trees	Prune 50% on all trees	Prune 25% on half the trees	Prune 50% on half the trees	P value
PAI dbh (cm)	1.51(0.36)	1.41(0.36)	1.07(0.37)	1.46(0.37)	1.33(0.50)	<.0001
PAI total height (m)	1.23(0.30)	1.22(0.34)	1.20(0.28)	1.21(0.28)	1.20(0.26)	0.4960
PAI mean crown width (m)	0.13(0.25)	0.32(0.28)	0.60(0.32)	0.24(0.25)	0.41(0.32)	<.0001
Height over dbh ratio (m/cm)	0.70(0.10)	0.73(0.11)	0.74(0.10)	0.71(0.11)	0.74(0.11)	<.0001

Table 3—Periodic annual increment (standard deviation in parentheses) for dbh, total height and mean crown width; mean height over dbh ratio for the pruned and unpruned tree groups within the prune 25% of the live crown on half the trees and the prune 50% of the live crown on half the trees treatment plots (P value for F-test on the means between pruned and unpruned trees within treatment plots)

	Prune 25% on half the trees		Prune 50% on half the trees		
Variable	Unpruned trees	Pruned trees	Unpruned trees	Pruned trees	P value
PAI dbh (cm)	1.51(0.41)	1.41(0.33)	1.60(0.45)	1.06(0.39)	<.0001
PAI total height (m)	1.19(0.30)	1.22(0.25)	1.23(0.26)	1.16(0.26)	0.0778
PAI mean crown width (m)	0.18(0.23)	0.30(0.25)	0.26(0.24)	0.55(0.32)	<.0001
Height over dbh ratio (m/cm)	0.72(0.13)	0.70(0.09)	0.72(0.10)	0.76(0.12)	0.0096

the plot where 50 percent of the crown length was removed on all the trees. The trees appeared to respond to the pruning treatment as they would to a thinning, with greater rates of lateral crown expansion.

D.b.h. growth in the year following treatment was significantly less for the more intensively pruned plots. These findings suggest that pruned trees will allocate growth firstly to crown growth and secondly to diameter growth.

Interestingly, height growth was not significantly impacted by pruning. Even though a large portion of the crown was removed in the heavily pruned plots, resources were still adequate for achieving height growth that was not significantly different from the control. In a companion study (Amateis and Burkhart 2006) severe pruning at age 3 was found to significantly reduce height growth. Apparently, at this particular point in stand development, trees that have been severely pruned will still maintain normal height growth despite losing a large portion of their photosynthetic capacity.

Since height growth was maintained while diameter growth diminished, the height over d.b.h. ratio was slightly larger for the pruned plots. Thus, stem form has been altered by pruning even after only one year following treatment.

In the plots where half the trees were pruned and half were not pruned, results were similar. Within these plots, the mean height growth of the pruned trees was not significantly different from the unpruned trees, even though each pruned tree had four nearest neighbors that were unpruned. Diameter growth was significantly less for the pruned trees than for the unpruned trees, and thus the height over d.b.h ratio was larger for pruned than for unpruned trees within these plots.

If these early results persist they suggest that pruning all trees in a stand and even pruning some trees in a stand at an early age when height growth is vigorous may be viable treatments for improving wood quality and stem form.

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