ANNUAL TOP PRUNING AS A CROWN MANAGEMENT TECHNIQUE IN A YOUNG LOBLOLLY PINE SEED ORCHARD TO REDUCE HEIGHT AND STILL PRODUCE FLOWERS

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Abstract.--Annual top pruning for five years in Westvaco's loblolly pine breeding clone bank, starting in the 2nd year after grafting, produced flat-topped trees that were 7.9 feet shorter than the unpruned control trees. Flower production per ramet was reduced an average of 30% from 1985 through 1987, but because overall productivity of orchards is low at a young age these losses are tolerable. Top pruning can be used as a crown management tool to produce more uniform orchards and to achieve a height reduction at a young unproductive age to extend the harvestable life of the more productive mature orchard. The flat-topped trees produced by annual top pruning, with all the flowers and cones at one height, may facilitate orchard operations such as supplemental mass pollination.

The use of top pruning as a crown management tool to keep trees shorter to make cones more accessible for collection and also to increase the number of potential flowering branches has been researched for years with inconsistent results. In Australia, top pruning radiata pine (Pinus radiata D. Don) trees either had no effect on cone production or increased cone production (Brown 1971, Matheson and Willcocks 1976, Hand and Griffin 1979). Copes (1973) reported 39% fewer flowers on Douglas—fir (Pseudotsuga menziesii (Mirb.) Franco) seed orchard trees top pruned annually. Coffen and Bordelon (1981) reported that trees in a western white pine (Pinus monticola Dougl.) breeding arboretum that had forked tops, starting 15 feet up the tree, caused by breakage produced more cones than straight single stem trees. Nienstaedt (1981) top pruned white spruce (Picea glauca (Moench) Voss) in Wisconsin and had 24% more cones on the pruned trees than the controls. Van Buijtenen and Brown (1962), and McLemore (1971) found that top pruning consistently reduced cone yields in loblolly pine (Pinus taeda L.). The studies basically conclude that heights can be controlled with top pruning but that the effect of top pruning on cone production is inconsistent depending on species, age and severity of pruning.

Hand and Griffin (1979) commented on the potential of top pruning in the new orchard concept proposed by Sweet and Krugman (1977). The Sweet/Krugman orchard concept calls for a series of single-clone hedged or top pruned orchards that rely on supplemental mass pollination to produce progeny with a

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specific genetic combination. Top-pruned trees of a uniform short height would also be easier to treat with flower initiating or pollen inhibiting chemicals. Applying pollen to flowers or insecticides to conelets and cones all in the top of the tree would be more efficient than treating flowers and cones scattered over a tall tree. Top pruning has not increased flowering in loblolly pine but what Ross and Pharis (1982) say about Douglas-fir can apply to loblolly pine: "Research aimed at determining the optimum tree size to begin treatment and the method and severity of pruning should be given the highest priority..."

METHODS

The study is located **in** Westvaco's breeding clone bank on the Jericho Unit in Charleston County, South Carolina. The area used for the study contains the plantation selections from Central Woodlands grafted in 1981 in 8-tree clonal rows at a 20- x 20-foot spacing. The selections were made in plantations in north Mississippi and west Tennessee, but monoterpene analysis of two clones indicated the seed may have come from stands in north central Georgia. Four consecutive trees per row were pruned in each row to give a block of pruned trees. Blocking eliminated the problem McLemore (1979) faced when he had to abandon his study after five years because randomly pruned trees were eventually overtopped by the unpruned trees. Hand and Griffin (1979) recommended block pruning as shading reduced the trees ability to respond to topping. Only clones that had at least three pruned and three unpruned ramets were used in the study. Data from 90 control trees and 90 pruned trees from 24 clones were used in this study.

The study deals with annual top pruning in a young developing seed orchard when height growth is high and seed production low. The top pruning treatment evolved with experience and observation. Top pruning began in 1982 during the second growing season after grafting. Total heights were measured before and after top pruning and at the end of the growing season. Total flower counts were made annually starting in the spring of 1984 when the first flowers were produced.

RESULTS AND DISCUSSION

Effects of Pruning on Height

In 1982, a light pruning was made on April 19 after the first flush had set a resting bud. The terminal and any side branches above a target height of 6.3 feet were removed from the pruned treatment trees. The target height was chosen to allow one-half foot of new growth after pruning. Any trees less than the target height were not pruned in order to give these trees a chance to catch up to the taller trees. The objective was to produce a more uniform orchard because small trees in an orchard generally stay small and are later removed because of size rather than genetic potential. Some ramets were grafted near 6.3 feet and these were pruned back to within one-half foot of their individual starting height. Table 1 shows that the first flush grew about the same length for both sets of trees. On the average only one-half foot of new growth was removed, but this is misleading because one-third of the trees were too short to prune. No additional pruning was done in 1982.

Table 1.--Five years of height growth and height reduction data due to annual top pruning

	YEAR									
	1982		1983		1984		1985		1986	
	Control	Pruned	Control	Pruned	Control	Pruned	Control	Pruned	Control	Pruned
	Average Height in Feet									
Starting Height	5.2	5.8	8.4	8.3	11.8	9.8	16.0	11.8	19.6	13.5
Growth of 1st Flush	+1.4	+1.5	+1.4	+1.3	+1.8	+1.8	-	-	-	-
Reduction in Height due to Pruning	0	-0.5	0	-0.9	-	-	-	-	-	-
Growth of 2nd Flush (or 1st plus 2nd)	-	-	+1.9	+1.5	+1.5	+1.5	+2.8	+3.0	+2.9	+3.0
Reduction in Height due to Pruning	-	-	0	-0.6	0	-2.0	0	-2.0	0	-2.0
Additional Growth	+1.8	+1.5	+.1	+.2	+.9	+.7	+.8	+.7	+.5	+.6
Total Growth	3.2	3.0	3.4	3.0	4.2	4.0	3.6	3.7	3.4	3.6
Total Growth after Pruning	3.2	2.5	3.4	1.5	4.2	2.0	3.6	1.7	3.4	1.6
Ending Height	8.4	8.3	11.8	9.8	16.0	11.8	19.6	13.5	23.0	15.1

The light pruning did have a slight effect on average total height as the pruned trees were one-tenth foot shorter than the controls at the end of the growing season.

In 1983, the pruned trees were pruned twice. The first pruning was done on April 19 using a target height of 8.8 feet that again allowed one-half foot of new growth. Twenty percent of the pruned trees had not reached the target height, but pruning was not as conservative as the first year and the target was reached. By the time the second flush set a resting bud the control trees had grown 1.9 feet and the pruned trees had grown 1.5 feet (Table 1). It was hoped that growth of the pruned trees would be much less since the cut ends had to produce buds before resuming new growth. Total heights are measured to the highest leader. What is being measured on the pruned trees are those leaders that were below the pruning height and continued to grow like unpruned trees. The target height for the second pruning was 9.5 feet and the pruned trees were topped on July 29. The control trees grew an average of 3.4 feet for the season. The pruned trees grew an average of 3.0 feet and 1.5 feet of that growth was removed during the two prunings. The pruned trees at 9.8 feet were 2 feet shorter than the control trees after two years of pruning and the crowns were beginning to have a flat-topped appearance.

In 1984, the trees began to produce flowers which influenced the pruning strategy. The first flush **in** 1984 grew 1.8 feet on both the control and pruned trees (Table 1). Previous top pruning had no effect on present growth. The first flush generally contributes more height growth to the tree than any of the other growth flushes during the year. Therefore, removal of the first flush would reduce height of the tree more than removal of any other flush. However, flowers are born on the terminal end of the first flush and any cutting of the first flush would remove flowers. The objective is to reduce height and increase flowering, not reduce flowering by cutting off flowers. The next best pruning strategy would be to remove the second flush as late as possible to remove as much growth as possible but early enough for the cut terminal to reset buds before flower primordia are produced for the next flower crop in August. By June 29 the second flush had set a resting bud on most trees and elongation of the third flush was just starting on some trees. Two feet of growth were removed which did remove some flowers from the tallest leaders. Again growth after pruning was similar for both the pruned and control trees due to uncut leaders on the pruned trees continuing to grow unchecked (Table 1). After three years the pruned trees were 11.8 feet tall and 4.2 feet shorter than the controls.

Two feet of growth were removed from the pruned trees after the second flush had set a resting bud in 1985 and 1986 (Table 1). Approximately one-half of the annual growth was removed by pruning. At the end of the 1986 growing season the pruned trees were 15.1 feet tall and 7.9 feet shorter than the controls after five years of top pruning.

Annual top pruning of loblolly pine, a species which expresses strong apical dominance, reduces total height (Table 2), but only by the amount of vegetation removed. There does not appear to be any residual effect as Copes (1973) reported in Douglas-fir, that is, pruning one year does not reduce

growth the next year. Table 1 shows that combined growth of the first and second flush the year after pruning on the pruned trees was equal to or greater than growth of the control trees from 1984 through 1986. Growth immediately after pruning was only slightly less on pruned trees because unpruned terminals just below the pruning height continued growth unchecked. In loblolly pine normal growth will resume when pruning is discontinued, only at a lower height; and pruning will have to be done annually to maintain control over height growth.

Table 2.--Average total height of pruned and control trees

Year	Age	Total Height (Ft)	
		Control	Pruned
1982	2	5.2	5.8
1983	3	8.4	8.3
1984	4	11.8	9.8
1985	5	16.0	11.8
1986	6	19.6	13.5
1987	7	23.0	15.1

Top Pruning Effect on Flower Production

Timing of the top pruning treatment is critical in determining the degree of flowering response (Hand and Griffin 1979). Top pruning of loblolly pine in two previous studies was done in the winter or early spring (van Buijtenen and Brown 1962, McLemore 1979). In both cases the cone crop was being removed either as flower primordia in the winter or corselets in the spring. The proper time to top prune loblolly pine is mid summer. Top pruning should be done above the first flush that bears the current conelet crop. The pruning should be done late enough in the growing season to remove the maximum amount of new growth but early enough so that the cut terminals can develop resting buds and develop flower primordia for the next flower crop. In this study pruning was done at the end of June when the second growth flush had set a resting bud and some trees showed beginning elongation of the third flush.

Flower production was clonal as expected (Byram, et al. 1986). Total flower counts per ramet varied from 0 to 427 on control trees and 0 to 309 on pruned trees in 1987. Only four pruned clones produced more flowers than their paired control trees. Basically, those clones that produced many cones or few cones on the control trees consistently produced many cones or few cones on the pruned trees (Figure 1). The pruned trees just produced fewer flowers than the control trees.

Despite pruning at the right time, pruning reduced flower production. Table 3 shows the average number of flowers produced by ramet from 1984 through 1987. In 1984, flower production was reduced nearly 50% but flower production was low. The control trees produced six cones per ramet versus three cones per ramet on the pruned trees. Assuming 97 trees per acre in a production orchard established at a 15— x 30—foot spacing and 250 cones per bushel, this would have been an insignificant loss of one bushel of cones per

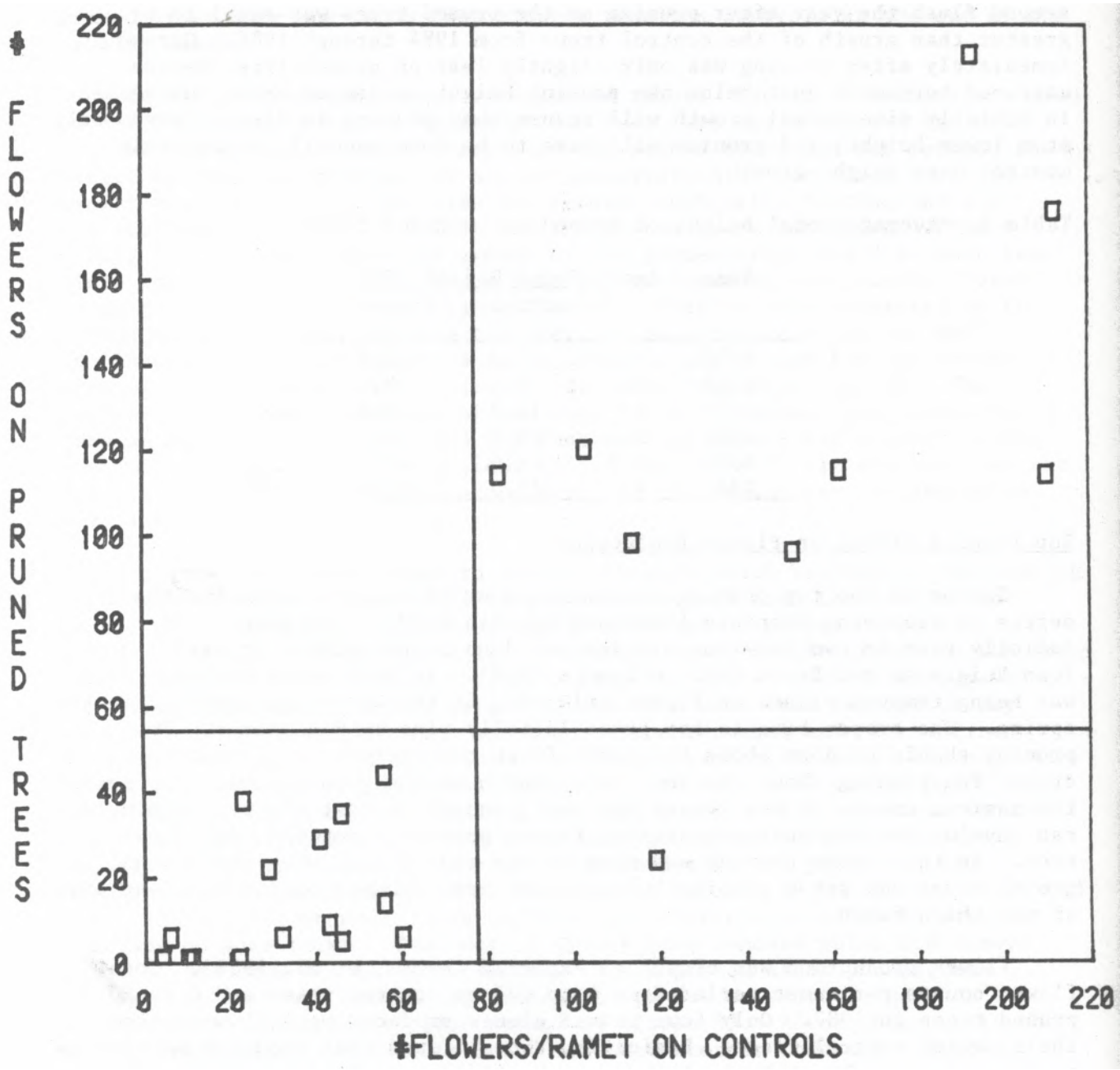

Figure 1.--Flower production per ramet by clone in the top-pruned and control treatments. Each of the 24 squares indicates a clone. The vertical and horizontal reference lines indicate the average number of flowers per ramet on all control ramets (77.5) and all pruned ramets (54.3). Productive clones were productive whether pruned or unpruned. Pruning reduced female flowering on all but four clones.

acre. The 30% loss in flower production in 1987, the best flower crop to date, would have amounted to a loss of 2250 cones per acre or nine bushels of cones per acre if all flowers had developed into cones. The harvest from the pruned trees would have been 21 bushels per acre if all flowers had made cones. If top pruning results in an orchard of uniform height and reduces the height of a mature orchard thereby extending its harvestable life, then some early production losses are tolerable.

Table 3.--Average # flowers per ramet on pruned and control trees

Year	Age	Flower Counts	
		Control	Pruned
1984	4	6.1	3.1
1985	5	37.8	26.8
1986	6	46.2	29.9
1987	7	77.5	54.3

The study will be pruned in 1987 to achieve an overall ten-foot reduction in height from six years of pruning. After 1987, some of the clones will be allowed to resume normal growth in order to determine if the reduction in flowering persists after top pruning stops and to determine if the ten-foot growth differential is maintained throughout the life of the orchard. The other clones will continue to be pruned annually to determine how long a top-pruned orchard can be maintained and what effect continued pruning will have on flower production. Orchard management in the top-pruned orchard would definitely be easier as all trees are the same height and flowers all occur at the same height.

CONCLUSIONS

Annual top pruning of young grafted loblolly pines in mid summer reduces height growth by the amount of growth that is removed. Growth immediately after pruning is not affected as unpruned terminals under the pruned height continue to grow unchecked. Growth the following year is also unaffected by pruning. Pruned trees are going to produce as much new growth as the control trees, but the new growth will start at a lower height due to pruning the previous year.

Annual top pruning reduced flower production an average of 30% in our test even when pruning was done in mid summer.

Top pruning can be used as a crown management techique to control height growth even though flower production is reduced depending on the seed orchard manager's objectives. If the objective is to give small ramets a chance to develop in a newly grafted orchard then top pruning the taller ramets for two or three years will accomplish this with a very minimal loss in production since the orchard is producing very few flowers. If the objective is to reduce height growth at a young age in order to reduce the height of mature trees to extend the harvestable life of an orchard, then pruning for six years after grafting will result in a ten foot reduction in height with a minimum reduction in flower production. If the objective is to produce a

hedged orchard, then annual pruning definitely keeps the flowers at a convenient working height but with a probable loss in flower production.

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