BASAL AREA OR STOCKING PERCENT: WHICH WORKS BEST IN CONTROLLING DENSITY IN NATURAL SHORTLEAF PINE STANDS

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ABSTRACT

Results from a shortleaf pine thinning study in Missouri show that continually thinning a stand to the same basal area will eventually create an understocked stand and reduce yields. Using stocking percent to control thinning intensity allows basal area to increase as stands get older. The best yield should occur when shortleaf pine is repeatedly thinned to 60 percent stocking, the minimum that will fully utilize a site.

INTRODUCTION

There are many trees per acre in fully stocked natural shortleaf pine stands. Each tree has a minimum amount of growing space available to it, individual trees grow slowly, some trees are crowded out and die. When we reduce density, each remaining tree has more room to grow, trees grow faster, and fewer die. If we reduce density further, we reach the point of full-site utilization--where each tree has all the growing space it can use but no more. If we reduce density below this point, diameter growth will be at its maximum, but growing space will be wasted, the yield of products reduced, and a vigorous understory will begin to develop in response to the excess growing space. The question then is, at what density should we maintain a stand to realize optimum growth and product yield?

BASAL AREA VS. STOCKING PERCENT

Controlling density really means controlling growing space so that each tree left in the stand has enough room to grow well. How can we accomplish this most efficiently? Traditionally we have used basal area to control thinning intensity, but basal area alone is not a good measure of stocking or relative density. We also need to know something about the age or average tree size to estimate what the residual basal area should be at that particular point in the life of the stand. The general development of even-aged stands shows that basal area increases rapidly when the stand is young. It then decreases and finally levels off or declines as mortality increases because of overcrowding. If we continually thin a stand to the same basal area level, we do not allow this natural pattern to occur and we soon have an understocked stand.

How can we avoid creating an understocked stand? One way is to let the residual basal area level increase each time the stand is thinned. This will work but requires several site- and age-specific basal areas.

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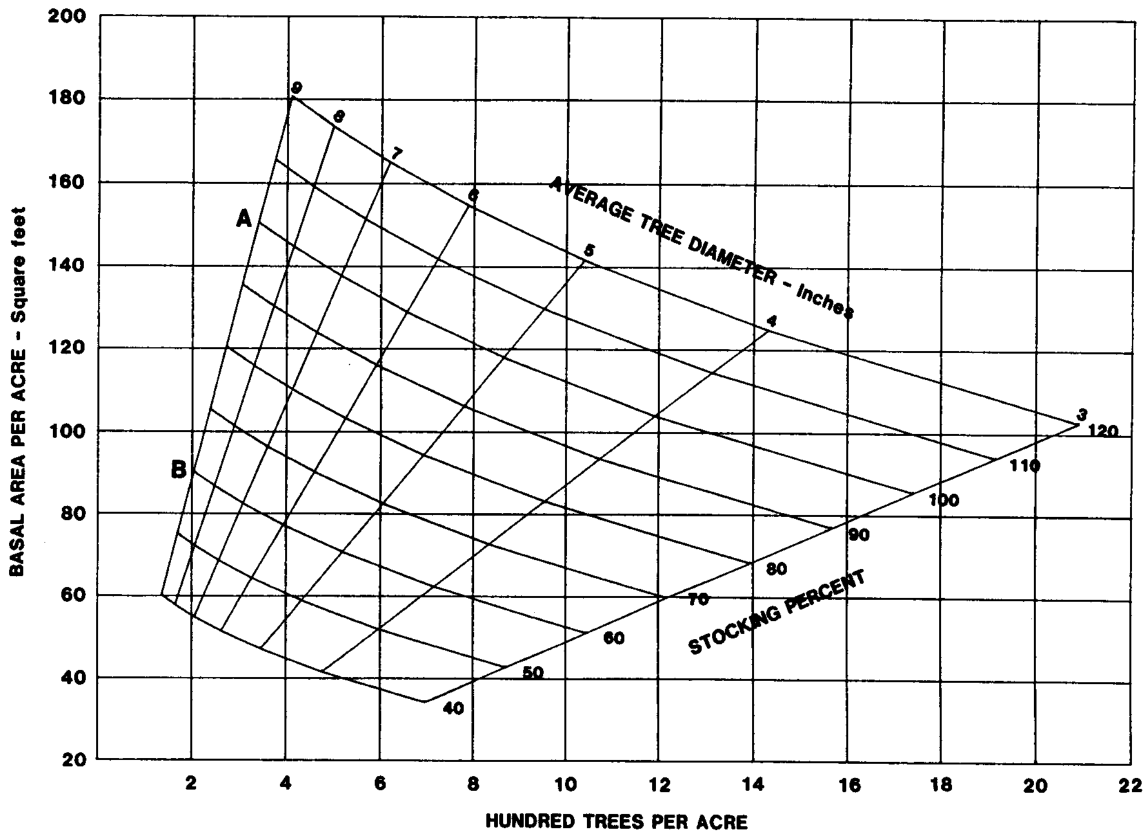
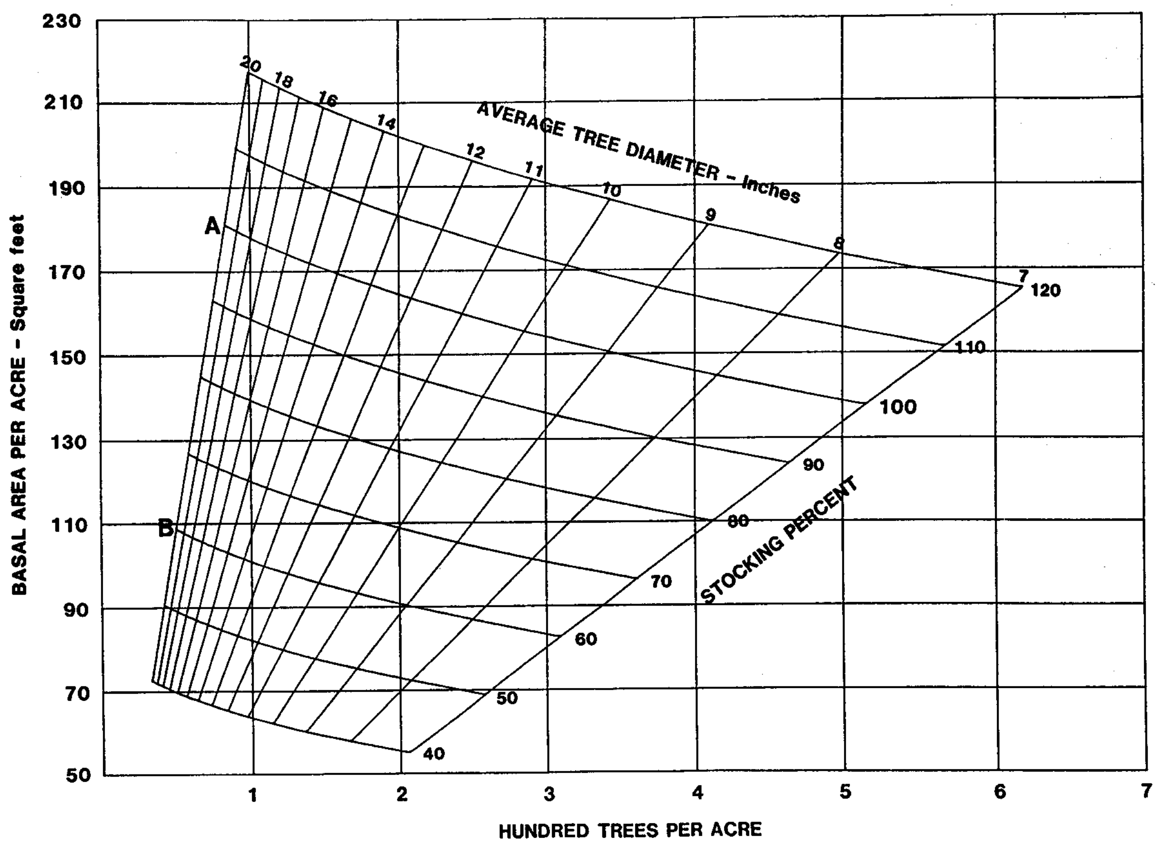


Figure 1. Relation of basal area, number of trees, and average tree uniformity. The area between Curves A and B indicates the range of diameter is the diameter of the tree of average basal area.

A better way to control thinning intensity is to use stocking percent and a stocking chart (Figure 1) developed by Rogers (1983). Stocking percent is an expression of the amount of growing space required by trees of various sizes. The line labeled B on the chart is the stocking at which each tree has the maximum amount of growing space it can use, and is the minimum stocking required for full-site utilization. The A line is the stocking at which each tree has just enough growing space to stay alive. Between the A and B levels, a stand is considered to be fully stocked because it can fully utilize the growing space.

If we maintain a stand at a constant stocking percent, basal area will increase as the stand gets older and average tree size increases. Stocking percent is also independent of site quality and stand age. This means that a tree of a given size needs the same amount of growing space regardless of how old it is or where it is growing. Trees on good sites will grow faster because the same amount of growing space on a good site contains more of the factors necessary for growth than on a poor site. Thus we need only specify one residual stocking percent, and we can continually thin a stand to that level and still maintain a fully stocked stand.



diameter to stocking percent for shortleaf pine stands of average stocking where trees can fully utilize the growing space. Average tree

The results from a shortleaf pine thinning study in Missouri illustrate how this species responds when thinning intensity is controlled by basal area alone.

THE STUDY

The stand in which the study was installed originated after the harvest of an oak-pine stand. The area burned periodically until the USDA Forest Service acquired it in 1933 and has not burned since.

Information about initial stand establishment and composition is not available. However, we do know that when the stand was 15 years old, the remaining overstory trees were cut or killed, small competing hardwoods were cut, and the pine was reduced from about 1,100 to about 600 trees per acre. When the study was begun, the stand was 30 years old, averaged 570 shortleaf pine trees, and 130 square feet of basal area per acre. Average diameter was 6.6 inches d.b.h. The stand also contained about 3,700 hardwoods per acre, mostly in the understory, that comprised 14 square feet of basal area.

Four density levels were created by thinning--50, 70, 90, and 110 square feet of basal area per acre. An unthinned treatment was left as a check. The thinning method used can best be described as a "free" thinning, in which trees from all crown classes are free to be removed. Generally the smaller, less vigorous trees were removed first, but better trees were also removed to attain uniform spacing. Since the study began, the plots have been thinned three times at 10-year intervals, always to the same basal area level. Any hardwoods in the overstory were cut and the understory hardwoods were controlled with herbicides.

RESULTS

The data have not been subjected to rigorous statistical analysis. Rather, I have used unadjusted plot averages to show a general pattern of stand development when shortleaf pine is thinned to constant basal area levels.

Stocking percent ranged from 88 to 111 percent before any of the plots were thinned the first time (Table 1). After the first thinning, stocking percent of the 50 and 70 level plots was less than needed for full-site utilization, and this understocked condition became worse with each subsequent thinning. The 90 level plots were close to the minimum for full-site utilization after each thinning; the 110 level plots were overstocked. However, stocking percent at all levels was lower after the second and third thinnings than it was after each previous thinning.

Table 1. Stocking percent before and after thinning shortleaf pine to constant residual basal area levels.

		Residual Basal Area Level [1]				
Age		50	70	90	110	Un-thinned
		- - - - - Stocking Percent - - - - - -				
30	Before	88	111	104	95	116
	After	37	49	64	79	116
40	Before	56	71	84	97	131
	After	31	45	60	74	131
50	Before	42	62	77	94	134
	After	31	43	58	70	134
60		35	48	67	78	118

[1] Square feet per acre.

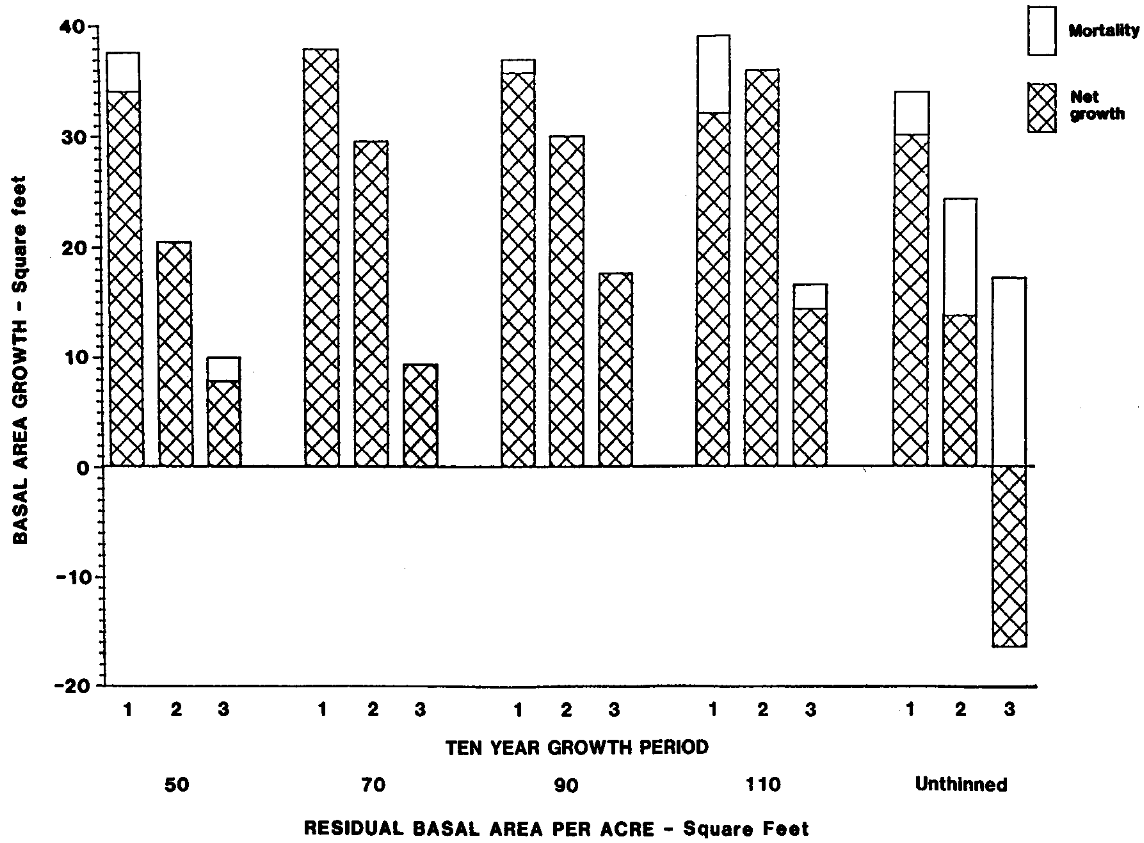


Figure 2. Basal area growth per acre of shortleaf pine thinned to constant basal area levels.

After the first thinning, net basal area growth was greatest at the 70 level (Figure 2). Growth at the other levels fell in the order 90>50>110>unthinned. However, the differences in basal area growth among residual density levels were small and of no practical significance. The amount of growth at the 50 and 70 levels demonstrates the ability of young shortleaf pine stands to recover from an understocked condition if enough trees are present to provide at least 60 pecent stocking at some future age. This ability to recover has also been demonstrated for upland central hardwoods (Gingrich 1967).

Net basal area growth after the second thinning was much lower at the 50 and unthinned levels because of understocking at the 50 level and increased mortality on the unthinned plots. Growth was greatest at the 110 level and about equal at the 70 and 90 levels. Although the residual stocking percent at the 70 level was only 45, enough trees were left to regain full stocking in 10 years, and the stand was still growing fast. Why growth was higher at the 110 level than at the 90 level is not clear. However, the residual stocking percent at both levels was within the range of full stocking (Table 1). Thus, even though net growth at the 90 level could be expected to be higher than at the 110 level, the stocking at the 110 level was low enough to prevent mortality that would result from overcrowding.

During the 10 years after the third thinning, net basal area growth was much reduced from what it was after the first and second thinnings. This reduction occurred because the stands had reached the age--50 years--when in the absence of thinning, basal area per acre was leveling off and net basal area growth was starting to decline. Greatest net basal area growth during this period was at the 90 level, but only slightly more than at the 110 level. At all other levels growth was significantly lower.

The best total net basal area growth from age 30 to 60 was 84 square feet per acre at the 90 level. This was only 1.5 square feet better than at the 110 level, but much better than the 77, 62.5, and 27.5 square feet per acre at the 70, 50, and unthinned levels, respectively. Residual stocking percents after each thinning were closer to the 60 percent minimum for full-site utilization at the 90 level than at any other level. Thus we would expect growth to be greatest at this level.

Net merchantable cubic foot and board foot volume growth followed patterns very similar to basal area growth (Figure 3). The growth after thinning was not consistently greatest at any residual density level for all growth periods. Growth was better at the 90 and 110 levels than at the other levels. The lower growth at the 50 and 70 levels is the result of understocking; the lower growth at the unthinned level stems from overstocking. The difference in total growth between the 90 and 110 levels occurred during the period from age 41 to 50. The reasons for this are not apparent, but as with basal area growth, the lack of any mortality at the 110 level probably contributed to better growth than we expected.

Although not identified separately, ingrowth contributed to total net growth of both cubic and board feet at all density levels after the first thinning. After the second thinning at age 40, no trees were smaller than the 5-inch minimum diameter for cubic foot volume except on the unthinned plots (Figure 4). Board foot volume ingrowth was significant only at the 110 and unthinned levels. After the third thinning at age 50, no trees below the 7-inch minimum for board foot volume were left except on the unthinned plots. Both cubic and board foot volume growth were much lower after the third thinning than after either the first or second thinning.

The volume yields at age 30 are the result of natural stand development except for the thinning at age 15 (Figure 5). The effect of this early thinning cannot be determined because no records were kept. Thus we do not know if the trees removed contained any merchantable volume or what the residual basal area was. Standing merchantable volume at age 30 differed significantly. The 50 level had the lowest cubic and board foot volumes, the 90 level had the highest board foot volume, and the unthinned level had the highest cubic foot volume.

The highest net cubic or board foot yield, like volume growth, did not occur consistently at any one residual basal area level in all growth periods (Figure 5). It was apparent by age 50 that the 50 level plots were falling behind because they were understocked. By age 60, yield on the 70 level plots was significantly less than that on the 90, 110, and unthinned plots. The third thinning to 70 square feet at age 50 had reduced the stocking too much for these plots to reach 60 percent stocking by age 60

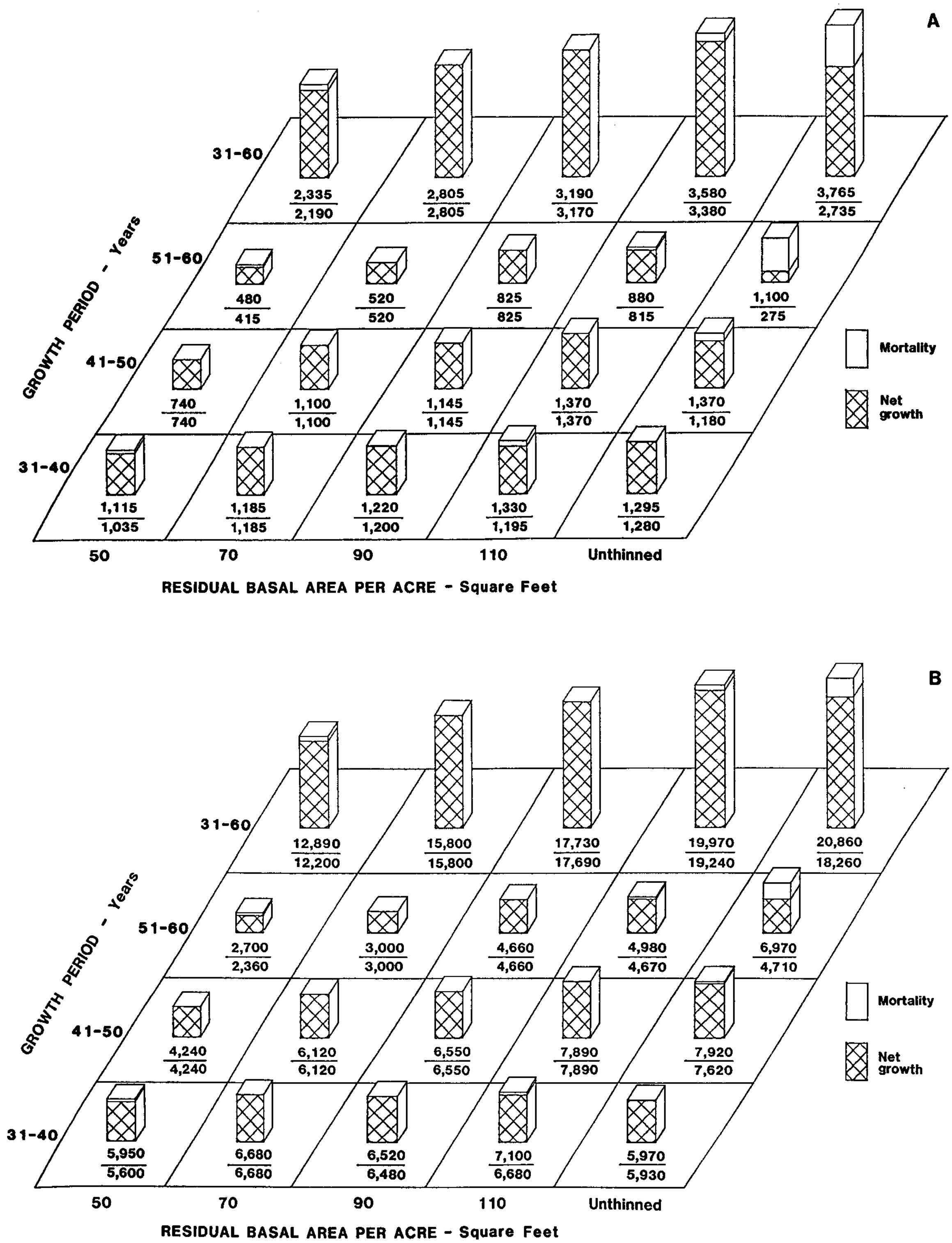


Figure 3. Volume growth per acre of shortleaf pine thinned to constant basal area levels. (A) Cubic feet less bark in trees 5 inches d.b.h. and larger to a 3-inch top I.B. (B) Board feet Int. 1/4-inch rule in trees 7 inches d.b.h. and larger to a 5-inch top I.B.

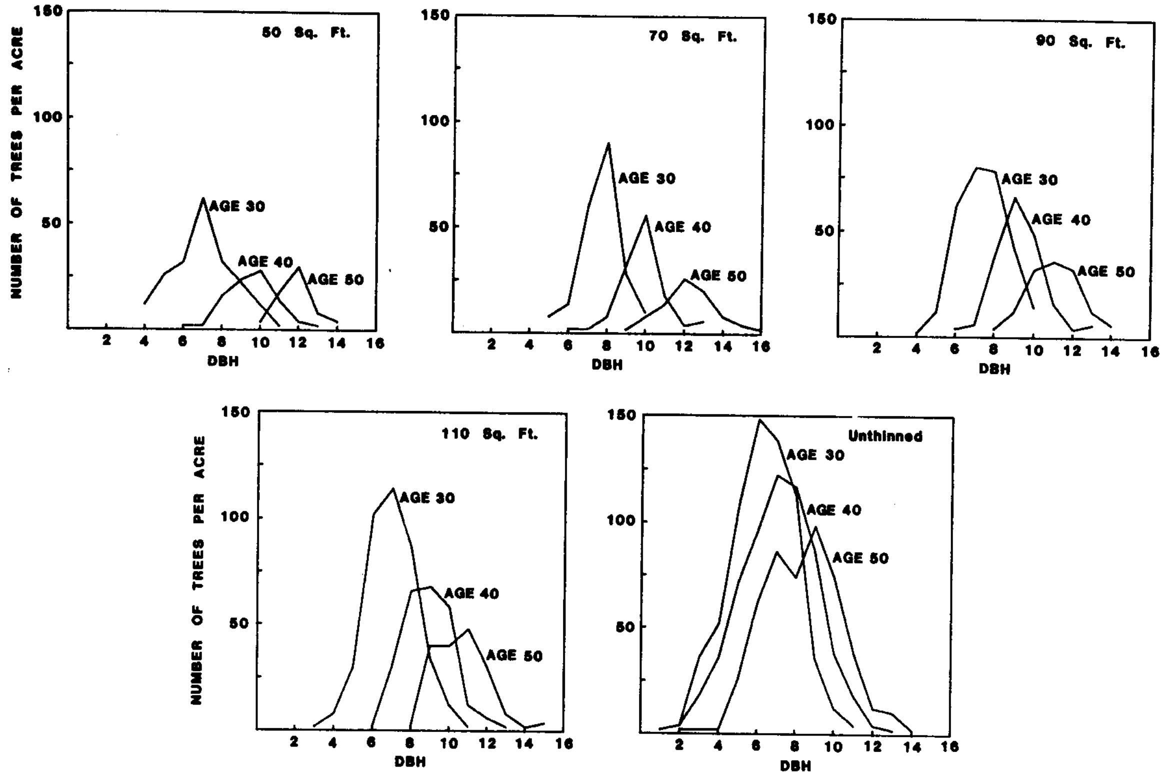
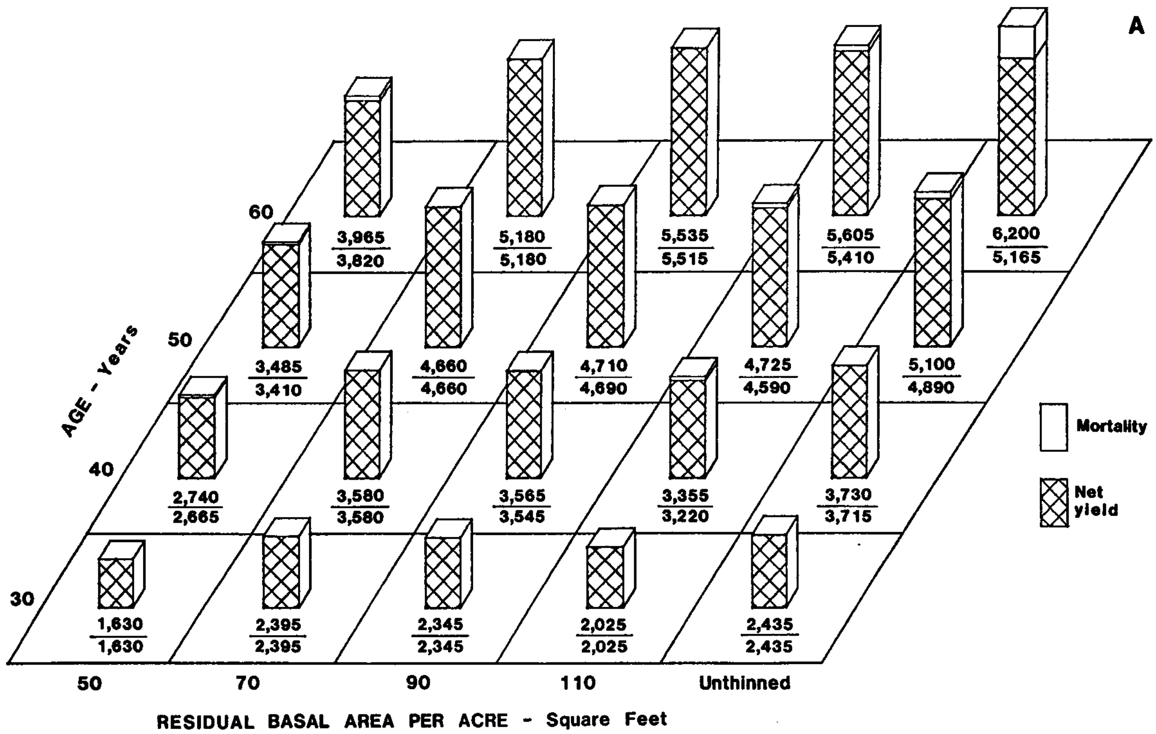


Figure 4. Diameter distribution of shortleaf pine after thinning to constant basal area levels at ages 30, 40, and 50.

and they like the 50 level plots are understocked. Yields at the 90 and 110 levels were about equal at age 60. Both of these levels are within the range of full stocking on the chart, and we would expect their yields to be similar. However, another thinning to 90 square feet would likely put these plots in an understocked condition also. Although net yield on the unthinned plots was about the same as it was at the 90 and 110 levels, mortality is increasing and further declines in net yield can be expected.

The harvested yield is important because most of the trees removed at age 30 were sold, and at ages 40 and 50 all trees removed were sold. The products cut were posts, poles, and saw logs. More volume has been harvested from the 70 level plots than from any other level (Figure 6). However, during the third thinning the most volume was harvested from the 110 level plots.

At age 60 the average tree diameter--diameter of the tree of average basal area--was largest on the 50 level plots and smallest on the unthinned plots (Table 2). This trend was expected because the growing space available to each tree decreased with increasing residual basal area. And, even though the trees are larger on the 50 level plots, yield is reduced because not enough trees are left to fully utilize the site.



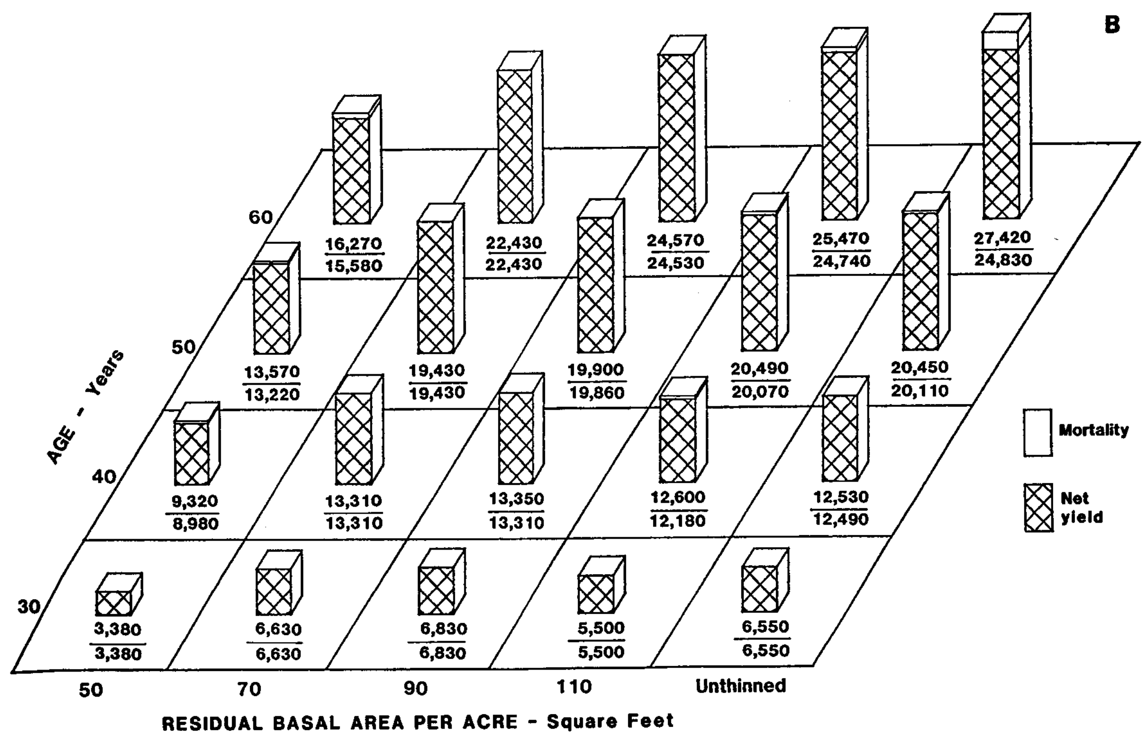


Figure 5. Yield per acre of shortleaf pine stands thinned to constant basal area levels. (A) Cubic feet. (B) Board feet.

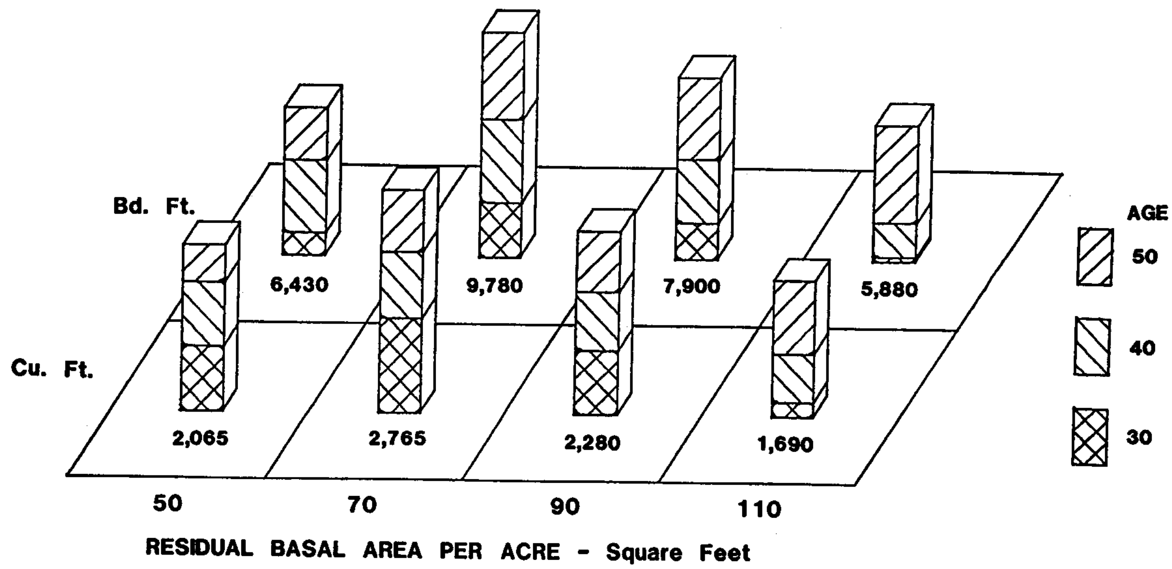


Figure 6. Volume harvested from shortleaf pine stands thinned to constant basal area levels.

Table 2. Average stand diameter [1] of shortleaf pine before thinning to constant residual basal area levels.

Age	Residual Basal Area 50	70	90	110	Un-thinned
	- - - - - - - - - - - Inches	- - - - - - - - - - -			
30	6.5	6.4	6.7	6.5	6.5
40	9.8	9.4	9.1	8.2	7.5
50	12.5	11.8	11.2	10.0	8.5
60	14.5	13.5	12.2	11.6	9.7

[1] Diameter of the tree of average basal area.

IN CONCLUSION

At what density then should shortleaf pine stands be maintained to produce maximum yield? We cannot answer this question from the results of this study. The optimum density appears to be between 70 and 110 square feet of residual basal area, but we can't tell where or how much we should let residual basal area increase at each thinning. Burton (1980) found the highest yields of shortleaf pine-loblolly pine stands on plots first thinned to 70 square feet of basal area per acre at age 20, and the residual basal area allowed to increase 5 square feet at each subsequent thinning at 5-year intervals. Because no other increasing level was included, Burton's results do not necessarily provide a definitive answer to the best possible thinning regime either.

We can use stocking percent to control density and avoid this dilemma. If we thin to a constant stocking percent each time, basal area will increase and the stand will develop naturally but at a different rate than unthinned stands. Because 60 percent stocking is the lowest stocking that will fully utilize the site, maintaining stands at this level should result in maximum yield. The one exception is the first thinning in stands 10 to 15 years old. Because these young stands grow rapidly, they can probably be thinned to 50 percent stocking the first time. Thereafter they should be thinned to 60 percent stocking. I know of no research studies that have used stocking percent to control shortleaf pine density, so it is uncertain whether or not 60 percent stocking is the best level. However, density studies in oaks have shown that net volume yields are greatest in plots maintained at 50 to 60 percent stocking (Dale 1968).

Stocking percent is easy to use. The data needed are basal area and number of trees per acre. Basal area is easily determined from a number of angle gauge or wedge prism sample points. Number of trees is best determined by counting the trees on a fixed radius plot using the angle gauge point as the plot center. Stocking percent is then determined from the chart (Figure 1).

To illustrate how stocking percent is used, assume that a cruise of a shortleaf pine stand shows it to have 150 square feet of basal area and 400 trees per acre. Then:

1. Find the point on the chart (Figure 7) where number of trees per acre intersects the basal area per acre line.

2. This point shows the stocking percent (103) and average tree diameter (8.3) for the stand.

3. From this point follow down to the 60 percent stocking line, keeping parallel to the next lowest average diameter line.

4. Then, find the basal area per acre (89) that corresponds to 60 percent stocking.

5. Thin the stand to 89 square feet of basal area.

Even-aged shortleaf pine stands should generally be thinned from below because the larger trees being the same age as the smaller trees, have larger crowns, higher vigor, and greater growth potential. Some larger trees will have to be removed to maintain uniform spacing.

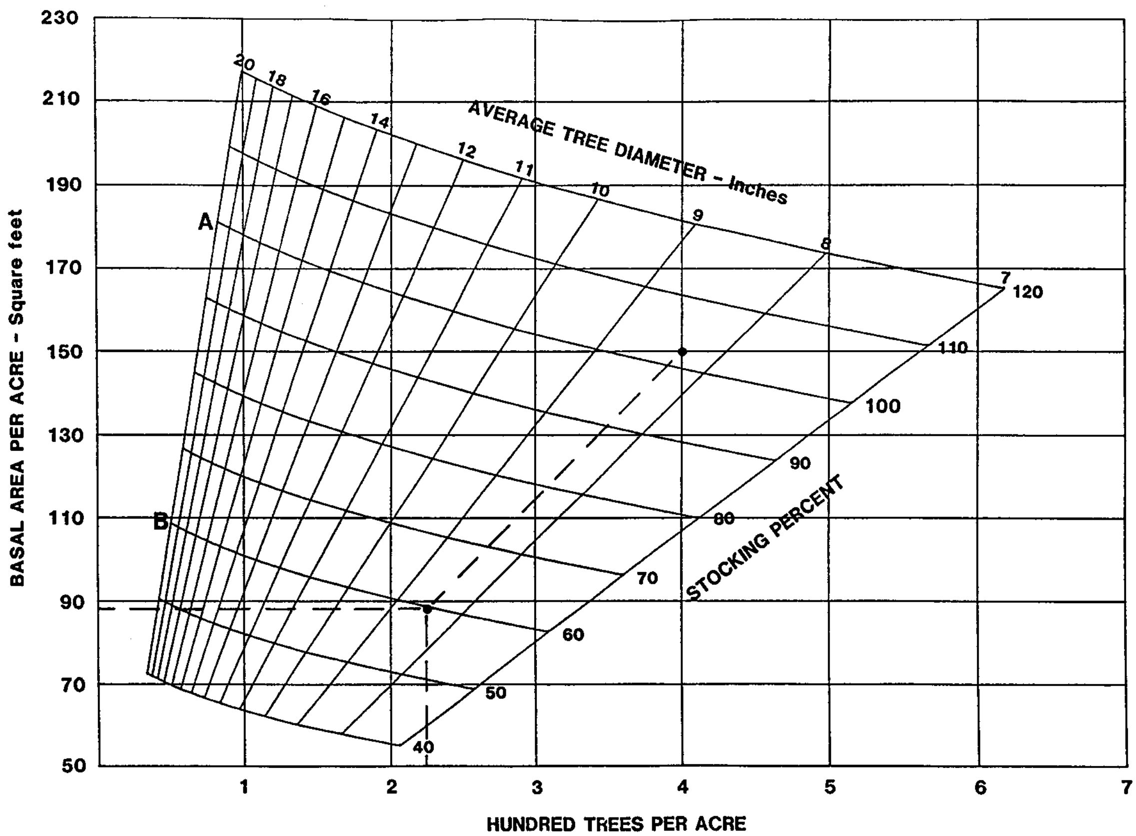


Figure 7. An example of how to determine stocking percent and residual basal area for a specific shortleaf pine stand.

Thinning shortleaf pine stands at regular intervals will help keep them healthy and vigorous, thus enabling them to better withstand insect and disease attacks. Thinning is probably the single most important factor in minimizing losses to the southern pine beetle (Nebeker et al. 1985). Infestations most often occur in dense stands where trees are most apt to be under stress and less vigorous than trees in more lightly stocked stands. However, a carelessly executed thinning operation may increase attacks by the black turpentine beetle because of its attraction to fresh wounds as well as freshly cut stumps.

Density control in natural shortleaf pine stands can help landowners and managers meet their objectives. If those objectives are to produce maximum yields of sawtimber, density control will help attain those yields in the shortest possible time. A market for cordwood or posts makes thinnings to attain sawtimber objectives even more economically attractive. If cordwood is the major objective, controlling density may not be beneficial particularly if the anticipated rotation is about 40 years or less.

Density control in natural shortleaf pine stands is an excellent practice. Stocking percent is biologically sound, easy to use, and I recommend that it be adopted as the standard for controlling thinning intensity.

REFERENCES

Burton, J. D. 1980. Growth and yield in managed natural stands of loblolly and shortleaf pine in the West Gulf Coastal Plain. USDA Forest Service, Southern Forest Experiment Station, New Orleans, LA. Res. Pap. SO-159. 23 p.

Dale, Martin E. 1968. Growth response from thinning young even-aged white oak stands. USDA Forest Service, Northeastern Forest Experiment Station, Upper Darby, PA. Res. Pap. NE-112. 19 p.

Gingrich, Samuel F. 1967. Measuring and evaluating stocking and stand density in upland hardwood forests in the Central States. For. Sci. 13:38-53.

Nebeker, T. E., Hodges, J. D., Karr, B. K., and Moehring, D. M. 1985. Thinning practices in southern pines--with pest management recommendations. USDA Forest Service Tech. Bull. 1703. 36 p.

Rogers, Robert. 1983. Guides for thinning shortleaf pine. In Proceedings, Second Biennial Southern Silvicultural Research Conference. Atlanta, GA (November 4-5, 1982). USDA Forest Service, Southeastern Forest Experiment Station, Asheville, NC. Gen. Tech. Rep. SE-24. p. 217-225.

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