Management of Bottomland Forests: Proceedings, Seventh Annual Forestry Symposium, April 10-11, 1958

School of Forestry and The General Extension Division, Louisiana State University, Baton Rouge, Louisiana
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One acre out of every 5 that Southern foresters manage is in the bottoms. One board foot out of every 4 you mark is in bottomland species. You cannot escape these hardwoods, even if your principal job is managing pine. To improve the management of the vast bottomland resource is an important goal for southern forestry. Hence this Symposium.

Across the South, the bottomland hardwood types total almost 37 million acres. This area supports 94 billion board feet (International 1/4-inch rule), in trees 11.0 inches d.b.h. and larger (table 1). A little less than half of this volume is in trees 18 inches in d.b.h. and larger—the sizes that contain the quality of lumber desired for most manufacturing purposes. The volume in trees below 18 inches is the growing stock which will provide for the future.

Area

Although the total acreage in these types seems to remain fairly stable, shifts are occurring within the bottoms. In much of the Mississippi River bottomlands, clearing for agriculture continues to gnaw away at the forest. In the Louisiana part of the Delta, for example, a net of 450 thousand acres of forest was converted to crop land between 1934 and 1954—the reduction equaled 1/2 of 1 percent each year. During the past 10 years in the Mississippi part of the Delta the net reduction has been almost 1 percent each year.

Counteracting increases are found in many if not most of the other riverbottoms in the South. Sure, dams are built and reservoirs reduce the area. So does a certain amount of land clearing for agriculture or pasture in these areas. But as small farm operations dwindle and disappear, fields here and there go back to forest. No doubt each of you have a few that plague you with regeneration problems. All together, these additions appear to at least equal the losses.

Whether this situation will continue very far into the future is problematical. Certainly the increasing population must be fed. There is little question in my mind that forest area in the floodplain of the Mississippi River will trend downward for some years. The forests of the Delta are being driven back to areas where flooding, poor drainage, and unfavorable soils preclude agricultural use. On the other hand—since mechanized agriculture requires large fields—small fields in the minor bottoms are likely to continue to revert to forest in sufficient number to maintain present area.

The still unknown quantity, discounting dam building, may be greatly increased development of improved pasture in these smaller bottoms. This I believe is coming, although I do not look for it to tip the balance for
Table 1.—Sawtimber volume on bottomland hardwood types in the South, by State

<table>
<thead>
<tr>
<th>State</th>
<th>Year of survey</th>
<th>Billion board feet</th>
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<tbody>
<tr>
<td>Alabama</td>
<td>1953</td>
<td>7.2</td>
</tr>
<tr>
<td>Arkansas</td>
<td>1951</td>
<td>10.3</td>
</tr>
<tr>
<td>Florida</td>
<td>1949</td>
<td>5.1</td>
</tr>
<tr>
<td>Georgia</td>
<td>1953</td>
<td>10.1</td>
</tr>
<tr>
<td>Louisiana</td>
<td>1954</td>
<td>20.6</td>
</tr>
<tr>
<td>Mississippi</td>
<td>1948</td>
<td>8.5</td>
</tr>
<tr>
<td>North Carolina</td>
<td>1955</td>
<td>11.7</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>1956</td>
<td>.6</td>
</tr>
<tr>
<td>South Carolina</td>
<td>1947</td>
<td>10.7</td>
</tr>
<tr>
<td>Tennessee</td>
<td>1950</td>
<td>2.0</td>
</tr>
<tr>
<td>Texas</td>
<td>1955</td>
<td>4.0</td>
</tr>
<tr>
<td>Virginia</td>
<td>1957</td>
<td>3.4</td>
</tr>
<tr>
<td><strong>Total South</strong></td>
<td></td>
<td><strong>94.2</strong></td>
</tr>
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</table>

1 International 1/4-inch rule.
some years. How many? Your guess is as good as mine—I’ll say 15 to 20 years. By 1975 the pressure for food and meat to supply a much larger population seems likely to meet head on the pressure for high-quality hardwood. If at that time people are willing to pay a high enough price to grow hardwoods for furniture of the kind one likes to touch and admire, the hardwood types may keep their place in the sun. And if I do not remind you, I am sure John Putnam will: It takes more than a few decades to grow large, high-quality hardwoods. We should have started yesterday to bridge tomorrow’s gap.

Volume

Volumes on the average acre of bottomland hardwoods have been and still are well above the average of all forest land in the South. Forest types other than bottomland (the pine, pine-hardwood, and upland hardwood) averaged 1,700 board feet per acre in 1953. Bottomland types averaged 2,500 board feet per acre. But as many of you are aware, cutting has been heavy. The average volume per acre, and with it—quality, is decreasing. In the bottomlands over the whole State of Mississippi, for example, there has been a sharp drop during the last 10 years—from 2,500 to 1,750 board feet per acre. Total volume in the bottoms has dropped almost a quarter, and a net increase in total area, caused by old field additions, has amplified the disparity.

The southern part of the Louisiana Delta is one of the few places where average volume per acre has increased significantly. It rose from 2,650 board feet to 3,460 board feet between 1934 and 1954.

This, I expect, is much more the result of very tough logging conditions than of forest management. The stands have been left to grow until volume and quality will again justify economic operation.

Forest managers are faced with the job of stopping and reversing the trend toward lighter stocking. Short of refraining from cutting, one of the best ways to stimulate growth in bottoms is to control cull trees. As in most of our southern stands, about 1 in every 4 or 5 trees is an outright cull. Many of these are of large size and occupy considerable space. Their control would increase the effective growing space by 1/4 to 1/3, thereby increasing the growth of the residual stand, and improving the chances for regeneration.

Absolute control of fire is necessary for the regeneration of hardwoods and to prevent the progressive deterioration of larger trees from rots that enter through fire scars. More than two-thirds of the cull in merchantable hardwoods is attributable to previous fire damage. And most cull trees are cull because of fire. Complete fire control will materially further your efforts to improve stocking.

The increasing demand for hardwood fiber products, which permit economical utilization of small hardwoods as well as larger ones not suitable for factory lumber or veneer, will surely stimulate and facilitate management of bottomland hardwoods. In the Delta region alone, for example, the cut of
hardwood pulpwood zoomed from 52 thousand cords in 1949 to 256 thousand cords in 1956. Further increases appear certain in the near future. A new hardwood pulp mill is already under construction at St. Francisville, Louisiana, and only a few weeks ago it was announced that another may be built at Donaldsonville. The growing market for hardwood pulp will enable more and more forest managers to thin their stands and make improvement cuttings without reducing the inventory for more exacting products. Somewhere along the line, however, the clear-cutting-for-pulpwood controversy between the lumber and veneer men and the pulpwood producers must be resolved to the satisfaction of both.

Growth and Cut

We have not made separate growth calculations for the bottomland hardwood types and I can only give you my considered judgment. The average annual growth rate for all bottomland stands appears to lie between 5 and 6 percent. This rate is on 2,500 board feet per acre, so that annual growth per acre is about 140 board feet. All other types have a rate of some 7 percent, but on their low stocking of 1,700 board feet, growth is perhaps 120 board feet per acre. Total growth in the Southern bottomland areas probably exceeded 5 billion board feet in 1952.

Timber cut is another item which we are unable to separate out for the bottomlands. The differentiation may be important to you or me, but it is not important to the severance tax collector. It is safe to say, however, that well over half—probably 60 to 65 percent—of the hardwood cut in the South comes from the bottomlands. On this basis, these types supplied almost 5 billion board feet for all uses, industrial and domestic, in 1952.

That the estimates of total growth and cut in the bottoms are so nearly in balance is no grounds for complacency. There is a great disparity in size and quality between cut and growth. Market conditions have sometimes changed over night. Current indications of dwindling quality and average volume per acre, and future losses to be expected in area, give advance warning of trouble. You are faced with a complexity of problems—not the least of which is the removal of cull trees. If you can lick cull trees and fire as well as has been done in pine, you are well on the road to success.
DIRECT SEEDING OF CHERRYBARK RED OAK

Robert H. Clark

The long wait for the recovery of some of our poorly stocked bottomland to the point where more desirable hardwoods are once again a part of our hardwood composition, prompted the trial seeding of acorns as one possible phase in creating the change.

Cherrybark red oak (Quercus pagodaefolia) was chosen as the species for direct seeding. A site along the west outer edge of the Saline River bottoms was selected for seeding. Although the site is subject to heavy spring overflows, the area is well drained. Plantings were concentrated on the high ground between one or more parallel sloughs. The overstory consisted of scattered, poorly formed, mature gums, water and pin oaks. The understory consisted of holly, bluebeech and ironwood of pole and sapling size that could be classified as occupying 90% of a total crown canopy. The vegetation under this heavy crown cover was very sparse and many spots were practically devoid of any type of vegetation. A release of this heavy undesirable canopy was scheduled on these areas following the direct seeding of acorns.

The seedings were separated into three separate areas totaling 7.5 acres. Areas 1 and 2 were each 3 acres in size. Area 3, 1.5 acres, was fenced for the exclusion of both cattle and hogs.

Acorns were collected for the above three small planting areas on November 1, 1951, and planted on November 8, 1951. Planting spots were prepared by a twist of a standard planting bar, which made a shallow hole in which two acorns were deposited and covered with a kick of the foot. They were planted approximately two inches deep. Spacing in plot #1 was 12'x12', in plot #2 8'x8', and in plot #3, the fenced area, 12'x12'. The time required to plant the closer spacing of 8'x8' was almost double that of the 12'x12' spacing, the latter requiring approximately 2 man-hours per acre. As the acorns were planted, stakes were set at seed spots diagonally across each planting area for the purpose of future germination checks.

In addition to seed spots in the fenced area, three 10-foot-square plots were established in which 100 acorns were broadcast with no covering.

Observations in chronological order were recorded as follows:

February 19, 1952: Area received first complete overflow from Saline River.
March 24, 1952: Area free of Saline River overflow.
April 8, 1952: The last complete overflow.
June 2, 1952: The last check that showed no germination.
June 18, 1952: The first check that showed germination. The germination determined by the number of plants at each stake seed spot for the three areas, was recorded as follows:
Area #1: Six single plants were found with two plants at one stake from the 68 acorns planted, giving a germination of 11.8%.

Area #2: Eight plants were found out of a total of 94 acorns for a germination of 8.5%.

Area #3: (Fenced) One plant was found out of 30 acorns for a germination of 3.3%.

The June 18th check on the three areas gave a total of 17 plants germinating from the seeding of 192 acorns, for an average germination of 8.9%.

No germination was noted in the three 10-foot-square seed spots in the fenced area. It was also observed that the vegetation under the ironwood and bluebeech was still dormant compared to the greening of vegetation in openings adjoining the planted area. Also, June 18th was the 26th consecutive day of no precipitation which was the start of the 1952 drought. Even at this early date, June 18, 1952, a statement was recorded that the soil was dry, hard, and cracked open.

July, 1952: Cull timber removal was completed on the three areas by a combination job of girdling trees 8" and up and the use of Ammatite in cups on stems 8" and smaller to a 2" stem. The cups were placed one foot or lower above ground.

No other check was made of the planting during the rest of the 1952 season.

November 6, 1953: Following the second growing season, a check on the survival at each numbered stake gave the following results:

Area #1: Three plants were found at stakes not found in 1952. Also, two of the plants that germinated in 1952 were lost in 1953. Adding the three plants found in 1953 to those first germinated in 1952, brought the total germination to 10 plants out of 68 acorns or 14.7% germination.

Area #2: Six plants were at stake not found in 1952. These added to the germination in 1952 gave a total number of 13 plants out of 94 acorns for a combined germination of 13.8%. Three plants that were found at stakes in 1952 were missing in 1953.

Area #3: (Fenced area) Three plants were found at stakes not found in 1952 and the one plant germinated in 1952 was missing in 1953. The total germination was 4 plants out of 30 acorns for a combined germination of 13.3%. No plants were found in any of the three broadcast plots.

February 19, 1958: These 3 areas were checked this February in order to make some general observation of the present conditions. The cull timber removal eliminated the dense overhead canopy of ironwood,
bluebeech, and other miscellaneous cull species. These openings provided a succulent growth of grass which was and still is ideal for cattle grazing. Heavy grazing by cattle did result in severe losses and we might say that we are no further along than when we started. It was estimated that we now have a 2.5% survival of the original plantings.

The condition within the fenced area was considerably different. Small patches of tall grass are present as well as small clumps of brush and briers. Pin oak and water oak seedlings are also present. Unfortunately, no cherrybark seedlings were identified at the existing staked spots, but three were found in the area averaging 2 1/2 feet in height that we claim resulted from seeding.

A second planting just north of the original planting was made in the winter of 1953. The site was identical to the original planted area. The acorns were gathered November 5, 1953, and planted on November 11, 1953. The area received cull timber removal in July, 1952, preceding the planting.

A new planting tool was used which permitted acorns to be planted at a depth of only one inch. One might describe the planting tool as a reversed-L long handle dibble. This method was much faster and consequently was done at a much lower cost. Only one acorn was placed in each spot; seed spots were spaced 12 feet apart. Stakes were placed at seed spots diagonally across the area immediately following the seeding operation in the same manner as in our first planting.

Interesting observations during the following 1954 growing season are listed in chronological order:

April 23, 1954: First date that germination was noticed - 16 plants out of 44 acorns for a germination per cent of 36.4%. It is interesting to note the difference in time of germination with that of the first seeding, which was not recorded until June 18, 1952.

April 7-May 10: Saline River overflowed. Plants and acorns completely covered by overflow.

May 11, 1954: Plants out of water.

May 15, 1954: Twenty-six plants out of 44 acorns for a germination per cent of 59.1%. Plants looked bad, some leaves withered and brown.

May 28, 1954: Twenty-nine plants out of 44 acorns for a germination per cent of 65.9%.

June 11, 1954: Thirty-three plants out of 44 acorns for a germination per cent of 75%.
February 20, 1958: One plant out of 44 acorns for a survival per cent of 2.27%.

The successful germination of our first two tries brought about the third cherrybark acorn planting. In 1955 acorns were collected immediately behind logging operations during the first two weeks in November. Approximately 55 gallons of seed were collected of which 50 gallons were used for direct seeding and the remaining 5 gallons were sent to the State Nursery for planting.

As the acorns were collected, they were placed in cold storage for approximately 30 days. Seeding was completed on 211 acres of bottomland by the last week of December 1955. The area selected had received cull timber removal prior to seeding and was similar in site and stand composition as that of the 1951 and 1953 areas. The new 3/4" reversed L dibble tool was used to plant one acorn at each spot.

The cost of labor ranged from a high of 1.6 man-days to a low of 0.4 man-days per acre for an average of 0.5 man-days per acre. Spacing of seed spots averaged approximately 8'x8'. The man-hour requirement included travel time of 1 hour for an 8-hour working day.

Only one area was staked for a germination check. The 1956 fall check gave 3 plants out of 39 acorns, for a germination per cent of 7.7%. A check made after the second growing season in the fall of 1957 was completely negative which included the loss of the 3 plants found in 1956.

A quick conclusion might have been that the storage of acorns over a period of 30 days might have accounted for the low germination. However, the germination of the same acorns planted at the State Nursery was excellent.

General observations were also made on the remaining 1955 seeding areas which gave the same poor results. It was certainly disappointing in comparison to the 1951 seedings which led us to believe that we had found a method of converting cull bottomlands to a hardwood stand that would eventually consist of the highly desirable species of cherrybark oak.

In each case the removal of the dense canopy created a succulent growth of grasses, which was ideal for the illegal open range policy of Arkansas. This heavy concentration of grazing, plus the severe drought which prevailed after each seeding certainly were the main contributing factors for the yearly loss of each established planting to the present 2%.

**Summary and Conclusion**

1. The germination of the acorns, particularly in the first two plantings, was surprisingly high. It was evident that the highest overall per cent of germination occurred on the areas where large openings were made in the overstory prior to seeding.
2. The fact that germination occurred over a period of three months during the growing period indicated that cherrybark acorns may remain dormant and still have the ability to germinate.

3. It appeared that the second seeding, which was at an average depth of 1", gave a greater and quicker germination than those seeded at an average depth of 2".

4. The ability of young plants to withstand complete submergence from one to four days was somewhat of a surprise.

5. Although after 4 to 6 growing seasons our direct seeding was not a huge success, it is our opinion that direct seeding of acorns still has possibilities when we consider the fact that our plantings were made during severe drought conditions and that heavy grazing was also a major cause of failure to seedlings that became well-established during the first and second growing seasons.

DISCUSSION

The overstory hardwoods girdled were chiefly bluebeech, ironwood, and holly, which are absolutely worthless in this area at the present time. One of the problems, especially in the fenced area, is quantity of debris when one girdles such a terrific number of stems. Our problem is not one of getting reproduction, but of getting what we want when we want it. We think that we planted the acorns deeply enough so that the low germination obtained was not a result of their being washed out. We ran no germination tests on the acorns except some cutting tests following separation by flotation. Some of the floaters looked good when cut open and some of the sinkers didn't look good. The acorns sowed in the nursery gave about 70% plantable seedlings. Although we opened up large areas by cull-tree removal, it still wasn't enough to take care of the influx of cattle. We think the damage from grazing was partly due to compaction and partly due to the actual eating and trampling of the seeds and seedlings. There has been no apparent damage from coons and squirrels.
PLANTING COTTONWOOD CUTTINGS

Hal Moore

The planting of cottonwood cuttings is a broad subject. On the surface it may seem like a rather simple and easy task; but let me assure you from the beginning that it isn't. It is probably some of the most time consuming and expensive planting being done today. However, it is well worth the time, energy, and capital outlay which it requires. With a fair amount of success an investment in this type planting will yield a return of 7% compound interest annually. This may not sound very high; but when I say that I am investing more than $50 per acre and that I expect to harvest between $430 and $650 per acre within 30 years you will consider it very high indeed.

I would like to show you our cost figures and the figures of our estimated returns.

**ACTUAL COSTS AND ESTIMATED RETURNS**

<table>
<thead>
<tr>
<th>PLANTING COTTONWOOD CUTTINGS</th>
<th>PER ACRE</th>
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<tbody>
<tr>
<td></td>
<td>COSTS</td>
</tr>
<tr>
<td>Land Clearing:</td>
<td></td>
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<tr>
<td>Bulldozing</td>
<td>$18.80</td>
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<tr>
<td>Clean-up of Debris</td>
<td>1.75</td>
</tr>
<tr>
<td>Discing</td>
<td>2.63</td>
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<tr>
<td></td>
<td>$23.18</td>
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<td></td>
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<tr>
<td>Planting:</td>
<td></td>
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<tr>
<td>Sub-soil &amp; row marking</td>
<td>$2.80</td>
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<tr>
<td>Cost of Planting Stock</td>
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<td>Actual Planting</td>
<td>3.25</td>
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<td></td>
<td>$13.80</td>
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<tr>
<td>Cultivation:</td>
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<tr>
<td>4 Cross Discings</td>
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<td></td>
<td>$6.40</td>
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<tr>
<td>Total All Costs</td>
<td>$43.38</td>
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Allowing for 20%
Failure from fire etc.
Each successful acre will cost $54.20
Briefly these are the steps taken in planting cottonwood cuttings:

- Clear land if not already cleared.
- Disc thoroughly with heavy disc.
- Subsoil rows 10' apart.
- Cross mark rows 10' apart.
- Prepare cutting 20" long. The closer the cutting is to the butt of the switch the better the survival.
- Push cuttings into subsoil trench at each cross mark. Plant 15" deep.
- Disc early—before weeds hide rows of trees.
- Disc often enough to keep the weeds below seedling height.
- Check plantation for insect infestation — spray if necessary.

There are reasons for planting cottonwood other than the purely financial gain. As you may know cottonwood does not generally reproduce itself on a given area. The seed is very tiny and is viable for only a short time after leaving the tree. It must land on moist, bare, mineral soil to successfully germinate and then it must have direct sunlight in order to survive. The forest floor does not provide these conditions except in loader sets or sometimes in well opened skid trails. Natural regeneration mainly occurs on the newly formed mud bars along stream courses. Because cottonwood is especially suitable to the box veneer industry our Company is interested in maintaining its own supply. Therein lies my interest in planting cottonwood. It so happened that an area of about 500 acres which is close to our mill at Greenville was very destructively burned in the fall of 1952 and it is this area which we are trying to regenerate. Natural regeneration of desirable hardwood species has not been forthcoming.

In order to plant this burned area it is necessary to clear it and prepare it for planting.

Besides the bulldozing operation, the area must be cleared of small debris, disced with a heavy disc, and then subsoiled. For the sub-soiling operation we use a Ferguson Tractor and subsoiler. It is important to use a subsoiler with a narrow cutting bar so that the soil will become closely fused soon after the cuttings are planted, so that they do not dry out. After the subsoiled trenches in the entire field are completed, the rows are marked in the opposite direction. At each point where the cross row mark and the subsoil trench intersects a stick or cutting is planted. Cross marking is necessary if cross discing is to be successful. When discing is done in one direction only the young seedlings soon lean out of the row into the disced area making subsequent cultivation impractical because of the excessive mortality caused by the disc cutting up the leaning shoots. Where cross discing is done a small square of weeds is left around the shoots and only a few of the trees get caught by the disc. About 4 cultivations by discing are necessary the first year, although this will vary with the season and site. One hand cultivation may or may not be necessary, depending upon the growth of competing weeds. The second year some cultivation will be helpful but may not be mandatory.

I'm sure you are wondering where the cuttings come from and how they are processed. Finding suitable natural cottonwood seedlings which are 1 to 4 years old, and easily accessible is difficult and unreliable because of river
fluctuations; so that it is often easiest and cheapest to grow the planting stock in a nursery. But, of course, they must be obtained from natural stock in the beginning, and if they are easily available they may be cheaper than nursery stock.

Our nurseries are planted with the rows being 40" apart and the sticks planted 1 foot apart down the row. The nursery must be cultivated, also. Good and frequent cultivation pays off in high survival and good growth, thereby growing the most cuttings per area. About 15 or 20 thousand cuttings can be grown on an acre the first year. More cuttings can be cut off the same acre the second year and again the 3rd year.

Ordinarily we expect to be started with our planting by the middle of February and finished by the end of the 1st week of March. Therefore, early in February the year old trees must be cut down, moved to a central working area, trimmed free of branches, and cut into 20" sticks. We do all of our cutting with machetes. When cutting the trimmed switches into sticks, the sections which are larger than 1-1/4 inches in diameter are generally discarded as being too difficult to plant. However, they are some of the best planting stock. Cuttings smaller than 3/8" on the little end are also discarded because of poor survival. The cuttings should be stored in shallow water butt ends down or in cold storage at 40° temperature. We suspect that storage in water increases sprouting ability.

You may be wondering just how much of this planting we have done and what our results have been. Small scale experimental plantings were made between 1951 and 1955 using the advice and assistance of the Delta Branch, Southern Forest Experiment Station, Stoneville, Mississippi. A nursery was begun in 1954 and since that time the nursery has been expanded each year. Larger-scale planting of cuttings were begun during 1956 when 40 acres were planted. This area partially failed because: a subsoiler with a wide cutting bar was used, an early summer drought occurred, cross disking could not be done, and the 8 x 8 foot spacing did not allow cultivation after the shoots leaned into the disced area between the rows.

In 1957 an additional 50 acres were planted resulting in 72% survival. The trees in this area now average about 5 ft. in height but some are near 10 ft. tall.

This year we have planted 40 acres with cuttings. Our costs per acre have been:

- $21.50 in 1956
- $17.40 in 1957
- $43.40 in 1958

The 1958 planting involved the added cost of clearing land.

We have experimented with gibberellic acid, which is one of the so called growth stimulants, and although some stimulation resulted it was not very successful, many shoots became very spindly, and some of the treatments caused increased mortality, we believe. Applications were stopped altogether after insects completely defoliated the treated shoots while the untreated check trees were not
appreciably harmed by the insects.

We have also tried waxing the upper 4" of the cuttings with nursery wax in an attempt to slow down or stop dehydration during dry periods. On our own nursery stock the survival was the same for the waxed and unwaxed stock. On the wild stock 86% of the waxed cuttings survived while only 53% of the unwaxed stock survived.

This year we have invested in an experiment of transplanting whole trees from our 1 year old nursery. We transplanted a total of 3240 trees on 40 acres at an average cost of $27.63 per acre. These were planted in bulldozed strips and will not be cultivated.
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**DISCUSSION**

Our nurseries were subsoiled 40" apart and 15" deep. Other sites may require
a different spacing. About 12,000 cuttings are planted per acre. Bundles are
stored in shallow water, after being bundled in groups of 100. This year,
cuttings were planted 9.5 feet by 9.5 feet. We had a nursery, 0.6 acre, which
I made the mistake of fertilizing. With the tops 3 years old and the roots 4
years old, the average tree is 3 inches dbh and 30 feet tall. The largest tree
is 6 inches dbh and 40 feet tall—at age 3. In precommercial thinnings, we have
removed 9 cords per acre in thinning back to 20-by-20 foot spacing. The sub—
soiler is cheaper and faster than the dibble or planting bar. One man can plant
about 660 cuttings per day with a dibble; with a subsoiler used in rows one way,
he can plant about 700, but subsoiled with cross rows he can plant about 1400
cuttings per day. Cottonwood apparently does best on silt and silt loam. We
tried it on sand, which was a failure, and Mr. Broadfoot, of the Delta Research
Center, tells us it won't do very well on buckshot clay. We have not tried com-
cmercial tree planting machines. The disk ing in the first and second year is to
control overtopping weeds and give more moisture to the cuttings.
The subject of this symposium is of particular interest to all of us for one principle reason. We are seeking ways and means to increase quality hardwood growth. Few will be interested in simple cubic foot volume growth alone and fewer still will be worried about the supply of it. This paper is aimed at discussing the possibilities of seed tree cutting for improving the establishment and development of natural hardwood reproduction for quality hardwood growth.

Since there is little factual evidence on this subject for southern hardwood, I will assume this gives me license for speculation based on observation. Operations in relatively high quality sites of smaller bottoms in southeastern Arkansas are the basis for observations offered.

Intensive management of hardwood forests has been slow in evolving. However, after several years experience with the "selection-improvement" system with accompanying CTR (cull tree removal) follow-up, some comparative observations may be made with an even-aged system. As a result, in 1956, The Crossett Company embarked on a co-operative experiment with the Delta Branch of the Southern Forest Experiment Station to compare the two systems.

Many factors are involved in controlling the grade development in young hardwood stands. Some of these factors may be controlled or affected by the management system. If it can be determined that one system is superior for the development of quality on young growth, then it is necessary to know whether or not satisfactory stocking of desirable species can be accomplished naturally by this system.

Here it should be stressed that what may be called adequate stocking of the right species, may be quite different for an even-aged stand compared to requirements for an all-aged stand. Well established reproduction completely in the open can develop maximum vigor to best compete with weeds. In addition, there is no loss to logging damage or to the deforming effects of a partial overstory. Hence, for example, in an area where the development of cherry-bark and cow oak is the objective, a stocking of 50% on a 4 milacre basis (or 150-200 per acre) may be more than adequate on an even-aged basis and much less than adequate for an all-aged stand.

The following observations are advanced to indicate that even-aged stands may develop better young growth:

1. Our principal objection to the economical clear cutting of 25 to 35 years ago is that there was no follow-up to remove culls, weeds, and deformed trees. Many beautiful stems have developed from reproduction despite the clutter that was left behind.
2. However, around residual trees there is a high percentage of slow-grown, deformed, diseased, and insect-ridden young growth.

3. Worse still, a selective improvement cut will drop the tops of these residual trees into the openings where good young growth has developed. Visualize a well-regulated acre with 10 M board ft. volume with all sizes and reproduction represented. Then cut 3 to 5 M board ft. and follow-up with a hardwood pulpwood cut to use tops, thinning and broken material.

4. Recent logging damage studies indicate that 20 to 25% of the needed young growth may be lost to logging damage. It could be more in the case of the larger-topped hardwood. This is a measure of the number of young stems that are classified as free stocking that were torn down by logging.

5. Observation of our early CTR work done in 1951, after the selection system of logging, shows that much desirable young timber 20-30 years old has developed epicormic branching since treatment. In addition, many undesirable stems have been maintained in the stand to build up stocking toward an all-aged condition. Many times on 3-log red oak sites you will leave 1-log grade 3 trees not because it is what you hope to grow but because it was the best you had to leave.

6. A good job of CTR to start new young growth is expensive and quite different from just removing a few culls per acre. The selection system will require that a good job be done on more acres than for an even-aged system.

7. In the event that browsing is a problem in reproduction, greater freedom and vigor of growth will give seedlings a better chance to outgrow annual nipping. If it is bad enough to consider fencing then the costs will be smaller for seed tree cutting. In a given holding of hardwood with a regulated cut a much smaller area will be cut each year that will require reproduction.

In 1950, a half-acre area on a good cherrybark oak site was cleared and fenced and planted in seed spots with cherrybark acorns. Oak and gum timber was logged. Ground conditions were relatively open. Culls and small hardwood were poisoned. Planting was very successful the second year after losing the first seed spots to coons. However, after several years, it was obvious the planted oaks could never compete with desirable reproduction already present at the time of cutting. This advanced reproduction was not an obvious factor at the time of cutting being suppressed by the larger stand but it had the advantage of an established root system and was ready to go on being released by cutting.

In the winter of 1953-54, a tornado swept through an area of good stands of hardwood sawtimber uncut since 1926. Most sawtimber was torn down. In an
effort to restock the area with young timber of a more desirable species, combination cherrybark and cow oak acorns were gathered in the fall of 1954. It was planned to fill in the open places by planting acorns that winter and with oak seedlings the following winter. Intensive CTR was carried on at the same time to insure the plantings having the best opportunity. This program was carried out with difficulty because it was obvious most of the area was stocked with existing reproduction. A series of seed spots were staked for observation and the next year two check plantations were set up in open areas. Current observation indicates our planting cannot compete because of existing reproduction except in logging sets where clearings were made with a bulldozer.

Growth plots have been installed in the first areas of intensive CTR following logging in creek bottoms. Current observation on remeasurements indicate that ingrowth is going to come from stems that were existing when the area was treated.

Some species such as cypress are drastically affected by any overstory. Cypress plantings on a small scale have been made since 1951 on Crossett lands. The first obvious lesson was that even one overstory stem will reduce survival and development around it. Planting in small openings failed even though immediate competition was poisoned.

The study referred to earlier in co-operation with the Delta Station was designed to measure and compare the following factors in seed tree cutting versus the selection type of cutting:

1. The amount, composition, and density of reproduction.
2. Growth and development of the stand.
3. Quality and economic potential of the products.

The study was installed in two different areas; one, a stand of big timber in the Saline bottom averaging 110 sq. ft. basal area excluding culls; the other, in an area cutover in 1926 in Chemin-a-haut bottom. This second area averages 60 sq. ft. of basal area excluding weeds and culls, although this was a sizeable portion of the stocking.

Naturally, it is too early to report on results of the objectives of the study, however, some observations can be made. In addition, it was necessary to get an accurate measure of the existing reproduction prior to logging and treatment so as to make a comparison of the additional reproduction produced by the treatment. Stocking and numbers by species were recorded on 240 permanent milacre plots in each area. This data is presented in Table I.
TABLE I

EXISTING REPRODUCTION - 1956

Basis - 240 Milacres - Each Area

<table>
<thead>
<tr>
<th>Species Group</th>
<th>Saline Stocking</th>
<th>No./A.</th>
<th>Chemin-a-haut Stocking</th>
<th>No./A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>57.1%</td>
<td>1975</td>
<td>41.4%</td>
<td>625</td>
</tr>
<tr>
<td>Common</td>
<td>5.4%</td>
<td>500</td>
<td>12.3%</td>
<td>785</td>
</tr>
<tr>
<td>Weeds</td>
<td>7.0%</td>
<td>1580</td>
<td>25.4%</td>
<td>3490</td>
</tr>
<tr>
<td>Total</td>
<td>69.5%</td>
<td>4055</td>
<td>79.1%</td>
<td>4900</td>
</tr>
</tbody>
</table>

Good species includes cherrybark, willow, water, white and cow oak, sweet gum and ash.

Fencing on the area was not completed until October 1957 so the good 1956 crop of acorns was lost. Cutting was completed in November 1956. Mechanical scarification was completed with a bulldozer on a separate area inside the fence in 1956. It should be pointed out here that in an area covered with brush of weed species, a considerable investment will be made to use mechanical means to remove the brush. The best economics will call for even-aged forestry under these conditions.

The results of the first years reproduction can only be summarized by generalization based on observation. All of the treatment area is covered with a dense stand of new sycamore seedlings with a few ash mixed in. They number the greatest in the area of bulldozing, second in the seed tree cutting, next in open areas of the selection cutting with very few catching outside the holes in the selection cutting. However, advanced reproduction has benefited greatly by the cutting and a second glance at the figures of the stocking of desirable hardwood will show that any additional reproduction will only serve as fillers.

Upon close examination of our good hardwood sites we have adequate reproduction of good species under all conditions except dense stands of young pole-size timber or small areas of very poor drainage. This brings one to the conclusion that our best means of species control lies in the improvement-thinning type of cut one would make to maintain a stand of timber. Thus, the most prevalent species is most apt to have already established reproduction prior to a harvest cut.

With this concept in mind, then a seed tree harvest cut would be a continuation of the best effort to control species composition in the new stand. Most of this area is subject to overflow by moving water which is apt to move as many acorns into the area as out of it. In any event, any new reproduction must compete with established root systems even though the
advanced growth may be small and suppressed at the time of cutting.

In an intensive management plan for a hardwood area designed for an increasing sustained yield based on a proportioned cut of growth, the selection system will cover much of the area in a short period with light cutting. This can remove the poorest timber but often forces one to leave a lot of poor growing stock on the land. Ten years later we are back to take out more of old growth and create a lot of damage to the young growth started by the first cut.

However, despite past poor cutting practice, many stands have developed nicely and need only scattered culls removed. With the addition of a system of stand condition classification taken with cruising, it is possible to identify areas in greatest need of removal of low quality material. These areas can be cut back to seed trees to impart maximum quality growth to an existing reproduction stand. Seed trees can be removed when adequate stocking is assured.

Seed tree harvest cutting can be fitted into a plan regulated by current growth. The biggest difference will be that a forester will apply a prescription to areas with the greatest need to improve quality growth.

DISCUSSION

We left 6 - 8 larger trees per acre for seed trees, and about 8 - 12 trees per acre where the trees were smaller. We favor cherrybark, cow, willow, water, and white oaks, redgum, and ash. When cutting in sawtimber stands, whether the cut is light or heavy, a good many small holes (0.1 acre or so) are opened and reproduction moves into those holes.
NATURAL REGENERATION FOLLOWING SELECTION CUTTING IN BOTTOMLAND HARDWOODS

Louis C. Maisenhelder

In preparing this paper I have been impressed by the broad field covered by the topic "Natural Regeneration Following Selection Cutting", and by how little we know about some parts of that subject. Selection cutting is regarded as the most acceptable method in most bottomland hardwood types. Under this system individual mature trees or small groups are removed at relatively short intervals and uneven-aged stands develop. To improve the quality of the stand some low-grade trees and undesirable species are also taken out. Such cutting makes openings that must be restocked. How such areas regenerate naturally is the topic for this discussion.

Since it will be impossible to consider in detail all the many variations that exist, I will restrict myself to some of the important factors in the establishment of reproduction, including some results of recent research. This information can then be applied to any specific conditions that are encountered in the application of the selection cutting system. Under any cutting system there are certain basic factors that determine how many and what species of trees will develop. I wish I could give you definite prescriptions to assure adequate stands of the desired species in any area, but our knowledge of the site and silvical requirements of the many hardwood species is not yet sufficient.

Occurrence of Reproduction

Contrary to expectations, reproduction in bottomland hardwood forests is present in most areas where it is needed. The emphasis is on the word needed. In our worries about the lack of regeneration we often look for it beneath adequately-stocked stands or in other places where it is not yet needed. When openings are made tree seedlings almost always get started. Many areas that seem unstocked are found to contain many tree seedlings when we learn to identify newly germinated juveniles and have the fortitude to push into the jungle of vegetation to seek them in place of merely looking in from the outside. A 70-acre old field abandoned at the time of the 1927 Mississippi River flood was reported in 1937 by a timber survey crew as being a briar patch without reproduction, in need of planting to restore its productivity. No planting was done, but ten years later the same area was almost fully stocked, having approximately 1,200 two-to-ten-inch trees per acre.

Other observations covering larger acreages on which selection cutting has been practiced show 80 percent of the area stocked with at least 1,000 desirable trees per acre. Even under the best conditions, though, some areas regenerate poorly or slowly. Most of these problem areas result from repeated fires, flooding during the growing season, or removal of the seed source. Artificial regeneration may be the answer for many of these...
problem areas but an understanding of the factors controlling the establishment and growth of trees can help considerably.

**Fire is Important**

The forest manager's first concern in getting reproduction should be with its major enemies—fire, flooding, and grazing. Light fires kill any seedlings which may be present and moderate to hot fires destroy saplings, poles, and even sawtimber trees, frequently eliminating seed sources. Rootstocks may be damaged or destroyed so that reproduction by sprouts is either curtailed or non-existent.

Near Stoneville, Mississippi, a hot fall fire recently burned an area having 1,326 seedlings and saplings of desirable species per acre. All seedlings and saplings up to one inch in diameter were killed outright. Two-thirds of the trees between one and two inches in diameter were killed and most of the rest were damaged. Trees between three and five inches in diameter suffered 35 percent mortality. By good fortune, more than 3,000 sprouts or seedlings per acre developed during the next growing season. Thestand will probably rebuild itself if the new reproduction can survive the next few years, but another fire in the next 10 years would greatly reduce the chances of satisfactory restocking. As it is, the seedling and sapling component has been set back at least five years.

**Effect of Flooding**

Flooding can either hinder or help the establishment of tree reproduction. Seedlings of many species are able to get started on sites subject to periodic flooding, but only a very few (black willow and baldcypress being outstanding examples) can live through inundation for even a few days during the growing season. In the dormant season, inundation for as long as several months does not appear to injure the species normally found where flooding is common. In fact, the extra moisture left in the soil after the recession of the water encourages better growth.

Nuttall oak, willow oak, green ash, and hackberry are well suited to such sites. Overcup oak and bitter pecan are common, and often take over such sites because they break dormancy later than the other species and are thus not as likely to be caught by high water after growth has started. Oak reproduction has survived and grown well when purposely flooded for a number of years during the dormant season in ponds created to attract ducks. Good surface and internal drainage during the water-free portion of the year are required for the best results and poor aeration of the soil is a decided hindrance in the development of reproduction. Many of the best species, such as cherrybark oak, cow oak, and sweetgum, will not grow on poorly drained sites.
Is Grazing Harmful?

Grazing by domestic stock is harmful in areas where reproduction is needed. Cattle trample and browse seedlings and saplings. In a study on the Delta Experimental Forest, areas having abundant weeds, vines, and tree seedlings were stocked with cattle at the rate of one steer for each 6-2/3 acres. The steers destroyed 17 to 40 percent of the current season's growth. Trumpet creeper was the hardest hit of all plant species observed. Poison ivy was another favorite, but buckvine was practically untouched. The most heavily-grazed tree species were mulberry, hackberry, soft elm, and green ash. This grazing did not eliminate tree reproduction, but height growth was seriously curtailed and the trees are developing poor form.

That reproduction can establish itself in spite of grazing is attested by results from milacre quadrat counts on two 160-acre areas in the Saline River and Chemin-a-haut River bottoms in Arkansas. The former has been heavily grazed for many years, largely by hogs, but 63 percent of the total area is stocked with at least 1,000 seedlings per acre of useful species. Thirty percent is without tree reproduction of any kind and an additional 7 percent is stocked with weed species only, principally hawthorn, ironwood, and holly. The second area has been grazed less severely, and by cattle only, but results are essentially the same. Twenty-one percent of this area has no tree reproduction of any kind and another 25 percent has weed species only. The remaining 54 percent has adequate reproduction of useful species. As on the other area, poor tree form was the most noticeable form of grazing damage.

Since grazed areas are likely to contain a good stocking of desirable trees, perhaps if livestock is subsequently excluded, satisfactory stands of trees of good form can be developed from sprouts on the existing rootstocks. However, until tests now under way have established the facts, this is only a surmise.

After giving his timberlands the best possible protection against the enemies we have just discussed, the competent forest manager will next consider certain other important factors influencing the establishment and development of tree reproduction.

Suitability of Site

An area may be in need of reproduction, but this does not settle which species are best suited to it. Such decisions must still be rather arbitrary, but tempered by past experience. Studies are now in progress to develop criteria of soil and topography by which the suitability of sites for certain species can be evaluated. Meanwhile, a good procedure is to favor the species that are growing best on the site. Sandy loam soils on well-drained ridges with adequate moisture usually grow species such as sweetgum, cherrybark oak, and cow oak. Nuttall oak, green ash, elm, and hackberry are better suited to the heavier soils on the poorly drained flats. Baldcypress and water tupelo frequent the deep sloughs and swamps, while cottonwood and black willow are pioneer species that do best on recently formed land along the larger rivers.
Ground Cover and Reproduction

Ground cover can have either a good or bad effect, depending on the kind and density of the plants and litter. Observations on sample plots show that ground cover may inhibit germination or deform or obstruct established reproduction. Wind-borne seeds of such species as cottonwood, willow, and sycamore frequently become entangled in the mass of vegetation and never reach the ground. Heavier seeds, such as those of ash, maple, and the oaks, usually get to the ground but may find insufficient light for growth. When vines are a major component of the ground cover they destroy much reproduction by climbing on it and dragging it down.

Briars and annual weeds, when not too dense, aid reproduction by lowering air and soil temperatures beneath them, and may help conserve moisture by reducing evaporation.

Vines offer the most serious competition to tree reproduction, and vines are almost universally present. Counts on sample areas have shown concentrations to vary from 0 to 210,000 stems per acre. From 0 to 8 thousand stems per acre afford negligible competition, 9 to 40 thousand stems afford moderate competition, and more than 40 thousand constitute severe competition. Under moderate and severe competition adequate regeneration is hindered. The number of stems does not tell the whole story, for it was also found that, vine for vine, poison ivy, for example, offers less competition than redvine or buckvine.

Unless logging or some other operation breaks up the ground cover, site preparation to aid seed in reaching mineral soil appears desirable on areas where vines and weeds are numerous. Bulldozing, disk ing, and burning combined with cull tree control are all possibilities under different site conditions. Exploratory tests where good stands of reproduction have resulted suggest that a close correlation exists between site preparation, the available seed supply, kind of soil, time of treatment, and the ground cover that develops during the first growing season following treatment. Under some situations the planting of seedlings or cuttings following site preparation may be more practical than relying on natural regeneration.

Light and Species Tolerance

No consideration of reproduction would be complete without some discussion of the effect of light and species tolerance. Without light there can be no growth, but how much light is required to obtain reproduction of the various species.

Once it was thought that full sunlight and bare mineral soil were necessary for hardwood reproduction. Observations on various sites and under widely different competitive conditions reveal seedlings of many species starting under rather heavy shade and surviving for several years. Mixed stands of two-year-old sweetgum and green ash seedlings, 40 thousand to the
acre, have seeded in under moderately heavy shade on bare mineral soil with plentiful moisture. The number of stems fell off only 25 percent in three years. Except for a few intolerant trees like cottonwood and black willow, seedlings of most species will live under partial shade for a reasonable length of time. Green ash, sweetgum, and most oaks will need release within a few years if they are to survive and develop, but others such as hackberry, American elm, cedar elm, red maple, and the ironwoods can exist for years under heavy shade and take over the site when more light is provided. Buckvine and trumpet creeper respond similarly to release from shading but tree reproduction usually wins out if it gets an even start with the vines.

Light, then, may not be so important in getting reproduction to start as we once believed, but it is very important in maintaining growth. Permanent silvics plots have shown this very forcibly in the case of green ash. From casual observation in the woods it appears that adequate new stands are developing under shade. After attaining a height of 3 or 4 feet, however, shaded ash seedlings or sprouts frequently die back to the ground. New sprouts then develop from the old rootstocks and together with new seedlings they continue the illusion of satisfactory regeneration. Where full light is available, two- or three-year-old seedlings grow rapidly in height. In varying degrees this same phenomenon is probably true of other species also. Thus reproduction can get started without full light but usually release must come within a few years to assure good survival and growth.

Briefly stated, the more important steps to be taken in obtaining natural regeneration following selection cutting are:

1. Determine if reproduction is needed on the area.

2. Eliminate wildfire and grazing, two of the major enemies of tree seedlings.

3. Always favor the species best suited to the sites to be restocked.

4. Destroy heavy masses of ground cover by an appropriate method of site preparation so that seed can reach mineral soil. Remember that briars and weeds frequently make a good nurse crop but that vines produce severe competition.

5. By release, provide light for young reproduction to prevent stagnation and death.

Attention to these things will aid in getting more certain regeneration of bottomland hardwoods.
DISCUSSION

We haven't enough information for a valid comparison of cottonwood with hybrid poplars, but we find there is not much difference in height growth. We think the biggest thing we might get from the poplars would perhaps be better form or resistance to disease or insects.
POSSIBILITIES OF GENETIC IMPROVEMENT
OF THE SOUTHERN BOTTOMLAND HARDWOODS

By Jonathan W. Wright

Introduction

The field of forest genetics is well enough established that I do not need to dwell on what it has to offer the forest manager of the future. All of us are familiar with the advances made in crop plants as the result of the introduction of new varieties, and it can safely be assumed that the same advances are possible in forest trees. I would estimate that at least a 20 percent—perhaps the figure is 50 or 100 percent—increase in productivity can be achieved in most tree species by the breeding of new strains. That increase is over and above the increases that can be expected as the result of better management practices, fertilizer trials, etc.

The hardwood breeder is at a serious disadvantage to the softwood breeder in one respect. The hardwoods are not extensively planted. He has the advantage over the pine breeder in two other respects. First, the angiosperms are a tremendously diversified group as compared with the gymnosperms. We cannot dodge the fact that the evolutionary factors that caused the angiosperms to evolve into tens of thousands of species and the gymnosperms to evolve into only a few hundred species are still operative. Second, the pine breeder has had to develop all his techniques from scratch whereas the angiosperm breeder can frequently borrow from a colleague in agronomy or horticulture. For example, there is a large backlog of information about pollination techniques and self-incompatibility in the genus Prunus.

The scarcity of hardwood plantings is a serious deterrent to hardwood genetics research, and it would be wise to start research on planting and genetics simultaneously when starting work on a genetically unknown species or genus. Sooner or later any serious tree improvement program involves the planting of thousands of seedlings in test plantings. Working with hundreds of trees is mere puttering. For example, a few years ago I helped establish a 350-tree geographic origin test of white ash. That planting will show the adaptability of the major geographic ecotypes to Philadelphia conditions. It does not include enough origins to give definitive information on the question of ecotypes versus clines. It can give no information on local ecotypes or the superiority of one individual parent to another. Even with the most advanced experimental designs utilizing 1-tree plots, several thousand more trees must be outplanted to answer important questions that have already arisen.

Planting is also necessary to utilize the tree breeders' results. We hear of the genetic improvement of naturally regenerated stands, but the possibilities are not great except in special circumstances. For one thing, the plus tree of the geneticist is almost identical with the superior crop tree of the forest manager. A high grade selection cutting aimed at increased quality 10 or 20
years hence would leave the stand in the same condition as would a mild "genetic" cutting aimed at improving the quality of the stand during the next rotation. For another thing, the cut-leave ratio must be large—about 100 to 1—for the genetic selection to yield noticeable genetic improvement. In other words, if in a mixed stand a species has a density of 25 trees per acre, the cutting would leave one tree of that species every four acres. With such heavy cutting reproduction would be scanty.

So much for the disadvantage caused by the lack of hardwood planting. It is not an insuperable disadvantage. After all, shade tree men, who on the average receive less technical training than do foresters, plant broad leaved trees successfully by the thousand.

The Oaks (Quercus)

The Michaux Quercetum (Schramm and Schreiner, 1954) will be a geographic origin test of not one but many hardy oak species. Already it includes over 400 individual tree seed collections of more than 40 species. It includes taxonomic as well as genetic studies. The bulk of the work is being done in Philadelphia, Pennsylvania by the Morris Arboretum of the University of Pennsylvania, the Northeastern Forest Experiment Station, and the American Philosophical Society; outplantings are being established by several other agencies. The Quercetum is an ambitious undertaking, but not expensive—its budget is still only a few thousand dollars. I commend it as the type of project needed to get a large job done.

One Quercetum result was a lack of F₁ hybrids among the many thousand seedlings grown in the nursery the first two years. Under the uniform conditions prevailing in the nursery these hybrids could have been detected if they had been present. For example, black oak (Quercus velutina Lam.) single-tree progenies were uniform enough within themselves, but different enough from northern red oak (Q. rubra L.) progenies that intermediates would have been easily recognizable.

These results are not surprising, in view of the conclusions reached by Palmer (1948) and Muller (1952) both of whom are lifelong students of the oaks. Palmer listed several hundred natural oak hybrids, but commented that they were a very small proportion of the millions of trees he had seen. Muller studied nine different species combinations in Texas. He considered Q. × margaretta Ashe to be the stabilized product of relatively ancient hybridization between Gambel oak (Q. gambelii Nutt) and Post oak (Q. stellata Wangenh.). In other combinations the hybrids were nearly confined to the intermediate habitats in the zone of contact between the parent species.

In Muller's examples hybrid vigor was manifested in a hybrid habitat. The same is true of the well known Ness hybrids, Q. virginiana Mill x lyrata Watt. (Flory and Brison, 1942). These have grown faster than the parent species when tested in College Station, Texas, but have not been tested on sites typical of either parent species. These and many other observations support
Anderson's (1948) hybrid habitat hypothesis: hybrid vigor is manifested on a hybrid habitat. Hence, from the practical standpoint we should plan on utilizing species hybrids on habitats other than those to which the parent species are native.

The Michaux Quercetum has also yielded interesting data on geographic variation within oak species. The water oak (Q. nigra L.), Shumard red oak (Q. shumardii Buckl.), and bur oak (Q. macrocarpa Michx.) proved to be exceedingly variable species. Water oak from three different localities could have been classified as belonging to three different species on the basis of progeny leaf shape though the parental specimen were similar. Four different lots of Shumard red oak from widely scattered localities were separable from each other on the basis of winter hardiness, growth rate, frost hardiness, and autumn leaf coloration.

Northern red oak, white oak (Q. alba L.), blackjack oak (Q. marilandica Muench.), and post oak proved to be moderately variable species with significant differences among origins in growth rate, autumn coloration, and winter hardiness and other characteristics. This variation followed a geographic trend in northern red oak. However, this was not the case in white oak, in which individual tree progenies from the same locality differed as much from each other as did progenies from different localities.

The oaks are justly considered to be difficult to control pollinate. The difficulty arises from two causes. A high percentage of trees is unfruitful and fails to set acorns to controlled or open pollination. Each pollination bag contains only a few flowers; at best the per-man-day yield can be only a few hundred control-pollinated acorns. The Russian Piatnitsky (1954), who is the world's most experienced oak breeder, seems to have lived with rather than overcome these difficulties and by dint of long-continued efforts has obtained moderately large progenies of several hybrid combinations. I am inclined to feel that with our high labor costs we in America will get ahead much faster by concentrating on the testing of many large open-pollinated oak progenies rather than a few control pollinated progenies that are too small to give definitive results.

The Poplars (Populus)

Genetic interest in the genus Populus has centered around interspecific hybridization (table 1). Many interspecific combinations have been attempted and have been successful. It is probable that hybrids between any two species in the genus could be obtained if desired.

This crossability chart is the product of several workers, but is based upon relatively few trees. Most reported crosses in the non-aspen sections of the genus have involved only one—four or five at the most—unselected parents of each species. Two other deficiencies of the non-aspen poplar work should be mentioned. First, there have been few studies in which hybrids and parents were compared in the same growth plots. Second, there are as yet no
published data showing significant growth differences among clones of the same F₁ cross. Thus, the almost universal reliance upon vegetative propagation has no genetic basis, and has complicated rather than simplified the testing of hybrids.

In the aspen section of the genus the story has been different. There are now published data showing the results of crossing selected ecotypes of the same or different parental species, and there are a great many studies in progress on the selection and crossing of individual selected trees. Also, at least some of the claims of hybrid vigor of species crosses are based on field tests in which both parental species were represented. The species in this section of the genus are in general rooted with difficulty, and the emphasis has been on seed-propagated progenies.

Large-leaved, fast-growing triploid European aspen (Populus tremula L.) were found in Sweden in 1936. Since then synthetic triploids have been produced on a large scale by crossing 2n and 4n trees in the greenhouse. The triploids have acceptable wood quality and are outgrowing the diploids. Plans are underway for testing and mass-producing triploids of the American quaking aspen (P. tremuloides Michx.). Presumably the cottonwoods would also be amenable to such treatment.

The Ashes (Fraxinus)

White (Fraxinus americana L.) and red ash (F. pennsylvanica Marsh.) have been the subject of geographic variation studies (Wright, 1944, 1944a). Both species are divisible into at least three distinct geographic ecotypes. Although the species are closely related they have different variation patterns and a complete knowledge of one species does not tell the story in the other. Among the geographically variable characteristics are growth rate, winter hardiness, frost hardiness, chromosome number, type of root system, aphid resistance, and autumn coloration.

The southern ecotypes grew more rapidly than the northern trees. Preliminary evidence indicates that localities near ecotype boundaries can safely take advantage of this fact by moving southern stock north a short distance across an ecotype boundary.

The pumpkin ash (F. tomentosa Michx.) is a rare species that grows in swamps from Indiana south to Louisiana and Florida. It is a hexaploid, with 6n chromosomes, and is probably the result of hybridization between 4n white ash and 2n red ash. This polyploid is fast growing but has weak wood, unlike some of the polyploid birches, aspens, and maples.
Table 1. Summary of species crosses in the genus *Pomalus*. Compiled from Stout and Schreiner (1933), Wettstein (1933), Heimburger (1936, 1951), Rehder (1940), Little (1953), Barret (1954), and Hyun (1956).

<table>
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<th>Female parent</th>
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Vegetative propagation should be given extremely low priority in any tree improvement program, whether on hardwoods or conifers. Suppose that we import the exotic Pterocarya from China. It will be cheaper to import seeds than cuttings or grafted plants. There will be less chance of importing a serious pest. And a clone selected for a particular set of Chinese conditions would probably not be the best for a particular set of southern conditions. If we are going to practice selection we must do it here, using as a basis the variability in seed-propagated populations.

Clonal propagation has been accepted as standard in the non-aspen poplar hybrids, but for what reason? There are as yet no data showing the superiority of one F₁ clone over another. Clonal selection in the absence of such data is worse than meaningless; it artificially cuts down variability without increasing the genetic level of the population.

What are the possibilities of clonal propagation in an individual tree selection program if 10 plus trees have been found that are believed to be genetically 10 percent superior to the mean of the unselected population? A grafted seed orchard established with those clones will give progeny that average 10 percent superior. Under almost any conceivable set of genetic circumstances, the best open-pollinated seedlings of those plus trees will average 11 or 12 percent superior to the unselected parents. In addition, the seedlings would give a variable enough offspring that further advances could be expected in the F₂ and F₃ generations.

Suggestions for Hardwood Genetic Research

The field of hardwood genetic research is a large one. There is no question but what we will be able to cover only a small portion of it in the next few years. Therefore, priorities as to species and types of study are important.

Because planting is a necessary adjunct to genetic research, plantability should be given first consideration in assigning priorities as to species and genera. Next in importance would be present economic importance and suspected ease of genetic improvement.

In most cases the largest genetic differences are associated with differences in geographic origin. This means that a provenance test should receive top priority when starting work on a new species. If the results warrant, then we can proceed to trials of soil ecotypes or of individual tree progenies. Concerning ourselves too quickly with details, we may result in overlooking large generalities that could make the work meaningless. A geographic origin study also provides useful plant material for later species hybridization studies.
Almost nothing is known of the possibilities of exotics in southern forestry. The fact that few promising ones have been found is of little importance because few have been tested in this part of the country. Also, most of those that have been tested were grown because they performed well in northern Europe or northern United States. More important to consider are the facts that nearly all our agriculture is based upon introduced species and that exotics have found places in the forests of Australia, New Zealand, northern Europe, and the northeastern United States—regions where they have been given a fair trial and studied intensively. It is likely that the forested regions in Mexico, southern Europe, southern China, and possibly parts of the southern hemisphere will yield 1,000 or 2,000 tree species that will grow in the southern states, and that 50 or 100 of these will outperform indigenous species under at least some conditions.

As a final point, I would like to stress the importance of adequate experimental design and statistical analysis. Most federal and state experiment stations have staff statisticians who are more than willing to offer advice to workers who have had no statistical training. Reliance upon these men can make the job of testing dozens of geographic origins or hundreds of exotic species an easy task, and can also insure that the results which are obtained are usable.

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(16) _______________

Thinning Cottonwood and Willow

K. D. Obye

Thinning of cottonwood and willow stands as a type of silvicultural treatment has enjoyed but little use in the past in the management of these species. However, pulpwood thinning of these species has been practiced on a commercial basis since 1950, and data and observations accumulated during that time point up the fact that it is a most desirable practice.

The primary objective in thinning is to eliminate mortality, utilizing the volume which would otherwise be lost through natural thinning. Proper stocking of trees of the best possible condition results in maximum volume increment. To a pulpwood consumer, this means production of more pounds of fiber per acre per year. On the other hand, to the sawmill man the most important aspect of thinning is in value, because a large part of the increment will be on better quality trees. Thinning accelerates the rate of growth of these sawtimber trees and increases the net usable volume on an acre.

It might be well to first briefly review how cottonwood and willow stands are established by Mother Nature. The seed are viable only a few hours, so they must find their way to bare, moist soil soon after leaving their source. They may be carried by the wind directly to moist seed beds, or, as is usually the case, may alight on the surface of water and be transported in that manner until they are finally deposited on bare, moist soil. In either case, if conditions are right, they will germinate and establish an even-aged stand. Thus, cottonwood and willow stands are found principally along streams on bottom-lands subject to overflow, with the cottonwood on the slightly higher elevations and willow being found in the depressions.

COTTONWOOD

As we have seen, cottonwood is found in even-aged stands on batture lands along the Mississippi River. Individual trees become dominant, forge ahead and grow indefinitely while others become suppressed and fall out, thus effecting a natural thinning. Commercial thinning of cottonwood is directed toward the removal of trees destined to become suppressed and promoting the growth of the sawlog and potential sawlog trees.

The beneficial effect commercial thinning might have on cottonwood was evident following a release cutting in 1948 in a 55-year-old stand located along the Mississippi River north of Vicksburg, Mississippi. The stand before cutting supported a basal area of 114 square feet per acre. After selective

cutting, during which 10,830 board-feet per acre were removed, a basal area of 69 square feet remained. The good trees left got a heavy to medium release, and showed a 50 percent faster annual growth rate in the two growing seasons after release than the annual growth rate in the previous ten years.

In 1952 and 1953, a large area of cottonwood was thinned by the United States Gypsum Company on their Hardin Point property located on the Mississippi River near Tunica, Mississippi. In this treatment, the suppressed trees were first selected for removal, along with others which were afflicted with grubs, rot, breakage, fire scars, or the like. Then attention was directed to the crowds and if necessary, trees were removed to relieve crowding there and give just a little space between, leaving the best trees as crop trees. During the subsequent dry years, the only areas where dying cottonwood was observed on that property were areas where thinning had not been carried on. Observation indicated that those trees that died were ones which should have been removed in a thinning operation.

In order to obtain definite data on the effect of thinning on young cottonwood stands, a series of study plots were set up on Anderson-Tully Lumber Company lands on Tennessee Bar near Fitler, Mississippi, by the Delta Research Center of the Southern Forest Experiment Station early in 1957. This stand had a total basal area of from 84 to 108 square feet per acre, with some mortality already evident in the form of standing and down dead trees. It was marked to remove the weak trees and allow the leaders to grow, cutting the basal area back to 70 square feet per acre. Unfortunately, winds from Hurricane Audrey caused considerable damage right after marking was completed, and this project had to be abandoned. A new study is planned when a suitable area can be located.

WILLOW

Black willow is also found in even-aged stands on batture lands along the Mississippi River. It differs from cottonwood, however, in the way a stand develops. Willow trees tend to grow uniformly, maintaining a densely packed stand of uniform height until the crowding becomes excessive when, rather abruptly, many trees become suppressed and the growth of the stand stagnates. A few years later a large proportion of the trees in the stand die.

Willow stands should be thinned as soon as economically feasible, and may require several additional thinnings at five year intervals. It must be pointed out here that proper thinning of willow does not mean removing the smaller diameter trees and leaving the larger diameter trees. Thinning must be directed toward relieving the crowded condition, with most attention given to spacing and uniformity of crown cover, and of course, removal of trees in poor condition no matter what the diameter.

Timber owners are often reluctant to allow larger diameter trees in a stand to be removed during a pulpwood thinning, even though condition may
justify it. They know that an individual tree containing one poor grade log is more valuable as sawtimber than as pulpwood, but fail to recognize the future increased value it’s removal as pulpwood at the time would impart to it’s neighbors through their accelerated rate of growth and better quality. As a result, it is sometimes necessary, when thinning such a timber owner’s willow, to favor all larger diameter trees and remove only smaller diameter trees. This type treatment will utilize much of the timber which would otherwise be lost through natural mortality, but will not result in maximum volume increment nor maximum acceleration of growth rate for the stand.

What was perhaps the first willow thinning on a large scale commercial basis was begun by United States Gypsum Company on their Shipland Tract near Tallula, Mississippi, in 1950. This black willow was then 28 years old and obviously overstocked, as evidenced by the wood on the ground in various stages of decay. Thinning actually was begun about five years too late.

Six permanent one-half acre sample plots were installed to furnish volume and growth data for guidance in future thinning operations. The densest part of the stand consisted of 150 trees per acre averaging 14 inches d.b.h., having a volume of 52 cords per acre. The volume per acre for the entire stand averaged 41 cords and the basal area ran from 99 square feet to 139 square feet, with average of 122 square feet per acre overall. Thinning reduced the average basal area to 88 square feet per acre and reduced the average volume to 29-1/2 cords per acre for the entire stand. An average of slightly over 11 cords per acre were removed.

One growing season after thinning, the sample plots were remeasured, and it was determined an average increase of 2.2 cords per acre per year had been realized. Re-measurement one year later revealed that the average growth rate had increased to 2.9 cords per acre per year. Further data from this willow has not been gathered, as the subsequent drouth years caused such rapid deterioration of the stand that thinning plans had to be abandoned in favor of salvage cutting.

Although based on only six sample plots, the results obtained from the Shipland Tract were so significant that it was decided to establish a controlled study of willow thinning. In 1954 the Delta Research Center established a 65-acre study area in a 24-year-old previously uncut even-aged black willow stand on United States Gypsum Company’s Choctaw Island property on the Mississippi River near Arkansas City, Arkansas. The purpose of this study was two-fold; first, to provide a measure of the benefits derived from thinning stands of willow that have reached a minimum commercial size, and second, to discover the most desirable degree of thinning. This stand before treatment

2 McKnight, J. S. Methods of Thinning Willow Stands. (Unpublished study establishment report). Southern Forest Experiment Station, Delta Research Center, Stoneville, Mississippi. 1954.
averaged 135 trees per acre with an average basal area of 129 square feet per acre, and an average volume of approximately 44 cords per acre.

The study area was divided into 3.6 acre treatment areas, and in the center of each treatment area a one-acre measurement plot was established. The following treatments were replicated three times:

1. **Check.** No trees cut.

2. **Light** thinning to reduce basal area of the stand to approximately 95 square feet per acre.

3. **Medium** thinning to reduce basal area of the stand to approximately 75 square feet per acre.

4. **Heavy** thinning to reduce basal area of the stand to approximately 55 square feet per acre.

5. **Minimum diameter limit** cut, removing all trees larger than 15 inches d.b.h.

6. **Maximum diameter limit** cut, removing all trees smaller than 13 inches d.b.h.

It was necessary to establish practical criteria to guide the marking of the various treatments. These were to remove about half the number of trees, working from below in all situations, for the heavy thinning plots; remove one out of three for the medium thinning, working from below; and only the suppressed or otherwise particularly undesirable trees in the light thinning. Incidentally, this is a practical guide for marking which can be used with reasonable success in cutting back a willow stand to the desired basal area.

For the diameter limit plots, the limits were set as a compromise between practical utilization standards and stand structure. These plots are not considered as degrees of thinning, but were included to furnish concrete evidence against the old theory that harvest by cutting to a diameter limit is a sound practice.

The plots were re-measured in January 1957, two full growing seasons after treatment, and the following conclusions were reached 3.

1. Mortality probably was more severe during the 1954 to 1956 period than ordinarily could be expected. This can be attributed to the drouth during that period.

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3 Johnson, Robert L. Methods of Thinning Willow Stands. (Unpublished progress report). Delta Research Center, Southern Forest Experiment Station, Stoneville, Mississippi. 1957.
2. The heavy and medium thinnings (55 to 75 square feet of basal area) produced more net growth than did the light thinning and check (90 to 120 square feet of basal area).

3. Mortality loss decreases as stand density decreases, and mortality may possibly be nearly eliminated by thinning to 50 to 60 square feet of basal area.

4. Mortality may offset growth in stands supporting approximately 94 square feet of basal area, which is comparable to the light thinning in this study.

5. Cutting to a diameter limit is undesirable, as the average cubic foot and basal area growth were poor and mortality was high. This is understandable, since many trees were left which should have been removed, and many trees were removed which should have been left, a trademark of diameter limit cutting.

These plots are scheduled to be re-measured during the fall of 1958, after an additional two years growth, and it is expected the effects of the various degrees of thinning may then be more fully realized.

A similar study area has been established by the Delta Research Center in a 20-year-old black willow stand on Ashbrook Point, owned by Chicago Mill and Lumber Company and located on the Mississippi River near Lake Village, Arkansas. Thinning on this area will be done later this year when the Mississippi River is at a low stage, and it is hoped the results will not be influenced by drouth years.

The United States Gypsum Company, in addition to thinning their own cottonwood and willow, have carried on thinning operations on both private and commercial timberlands, such as the Parker property on Yucatan Point near Newellton, Louisiana; Nickey Plantation at Snow Lake, Arkansas; McKnight and Chicago Mill and Lumber Company properties near Eismine, Arkansas; and the Vaughters property on Pittman Island near Eudora, Arkansas. As you see, this method of handling these species is one which is gaining an accepted place in timber management.

GENERAL

Several additional observations have been made in conjunction with cottonwood and willow thinning over the past eight years. One of these is that properly thinned stands apparently are no more susceptible to wind damage than unthinned stands. Strong winds, including Hurricane Audrey in 1957, have caused as much damage to unthinned stands supporting 120 square feet of basal area as to stands heavily thinned to 55 square feet of basal area per acre. In observing cottonwood and willow stands damaged by the 1957 winds, it was noted in every case that at the time the damage occurred the trees were either standing in water, or the soil was completely saturated. The winds tipped the trees over, uprooting them but causing little breakage of the stems.
It has long been thought that opening up a willow stand through thinning would stimulate epicormic branching on the remaining trees. To answer questions relating to the nature and extent of epicormic branching in black willow, a study was initiated in conjunction with the previously mentioned willow thinning project on Choctaw Island. Nearly one thousand trees were chosen for observation, and after two full growing seasons there appeared to be very little correlation between degree of thinning and tree size with the occurrence of new epicormic branches. This study is still open, and results should be more conclusive after a planned re-measurement next winter.

For those of you who may find yourselves actually engaging in thinning cottonwood and willow stands, this general guide for marking may be helpful; first, mark the suppressed trees for removal. Next, those obviously in poor condition due to wounds, rot, poor form, and similar reasons should be marked. Then, attention should be directed to the crown and if crowding of the crown exists, mark those trees which will relieve that condition, creating between crowns a space no greater than half their diameter, and leaving the best trees as crop trees.

Assuming cottonwood and willow stands have been thinned in the manner recommended here, the site they occupy must be given close consideration at the time of final harvest to determine the crop it is best suited to support in the future. If little sedimentation in willow has occurred, the site may be suited to the establishment of another stand of the same species. This possibly could be accomplished by natural regeneration, but would most likely have to be done by planting. In most cases, however, by the time the final willow harvest is made the site has increased in elevation because of silt deposit, and more tolerant species with less strict moisture requirements such as cottonwood or sycamore are better suited to the site and could be established by planting.

Cottonwood stands will not reproduce themselves, so it is well to anticipate the ultimate replacement of the type by more tolerant species, such as sweetgum or sycamore. Intermediate cuts should maintain optimum growth of the residual cottonwood and at the same time encourage establishment of the succeeding stand. By the time the final cut of cottonwood is made, an adequate understory of acceptable species should be ready to take over the site.

In conclusion, this discussion has touched on only a few of the many facets of thinning cottonwood and willow stands. Although it is a relatively

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new tool for management of these species, we who have been closely associated with it feel it has a very definite dollars and cents value to the timber owner. It recovers value otherwise lost through natural mortality and at the same time accelerates growth of the most valuable trees.
METHODS OF THINNING OF SWEET GUM STANDS

L. C. White

Not too many years ago, sweetgum (Liquidambar styraciflua) was considered a weed species, because of its bad drying characteristics, cross-grain, and before synthetic glues were made to glue a permanent bond for plywood; however, at the present time, due to technological progress, it is one of the most valuable hardwood species that grows today. Its uses range from plywood, lumber for furniture, veneer, and many other specialty uses, to the latest development—pulp. This has created a market which greatly increased the yield per acre of the sweetgum stands.

Sweetgum is a very prolific tree. The seeds germinate well in the forest, and sprouting is abundant from the roots of cut trees. From observation in the forest, the sprouts from roots will make just as good a tree as will the seed, and much faster. Sprouts have been observed to grow as much as five feet in one year. This area of thought should be developed further through research information. The seedlings develop slowly in the forest. In the first year of a seedlings' life, under natural conditions, it will attain a height of only 2 to 3 inches, but after the first year, they advance rapidly. The sweetgum tree usually occurs in mixed stands in the Delta, primarily with the water oaks. It reaches a height of twenty-five to thirty feet in a span of fifteen to twenty years, and the diameter of the dominant trees are six to eight inches. This is the age and size at which thinning should be initiated.

If a thinning is not made at this stage in the life cycle, heavy mortality occurs. The stands are usually very dense, and the weaker stems begin to die. If left in this condition for ten to fifteen more years, stagnation occurs. In the stagnant stand, growth is brought to almost a standstill, and in observing such stands, it has been noted that "dry-topping" or "die-back" occurs. This is not confined to the weaker trees, but in many cases the dominant trees will succumb. It has been noted that two to three or more acres of the entire stand will die in local areas. This creates a problem of keeping the natural stand advancing as rapidly as possible, once it is established.

In the winter of 1954 and 1955, the U. S. Forest Service Research Center at Stoneville, Mississippi, and Chicago Mill and Lumber Company, Tallulah, Louisiana Division, through a cooperative program, established a study of sweetgum thinning on 46.2 acres in Madison Parish, Louisiana¹.

Gum stands on this area were between fifty and sixty years of age and were not pure. A small percentage of the volume was in the following species: honeylocust (Gleditsia triacanthos L.), water oak (Quercus nigra L.), sweet

¹ McKnight, J. S. Establishment report; Methods of thinning sweetgum stands. August 12, 1955.
pecan (Carya illinoensis, Koch), red maple (Acer rubrum L.), nuttall oak (Q. nuttallii palmer), cottonwood (Populus deltoides Bartr.), green ash (Fraxinus pennsylvanica Marsh.), persimmon (Diospyros virginiana L.), American elm (Ulmus americana), and willow oak (Q. phellos L.).

The 46.2-acre study area was divided into rectangular treatment areas of 3.85 acres each, thus leaving 12 study plots. In the center of this area, a one acre measurement plot was established, leaving an isolation strip around each plot.

There were three degrees of treatment: light thinning, with a basal area left of 85 to 90 sq. ft.; medium thinning, with a basal area left of 70 to 75 sq. ft.; heavy thinning, with a basal area left of 50 to 60 sq. ft.; and the control or check plots were established.

The removals were guided by the following marking principles, and in order of marking:

1. All trees likely to die within five years because of suppression or other reasons.
2. Trees undesirable because of form or damage.
3. Undesirable species.
4. Other trees to provide the desirable degree of thinning.

Treatment areas were cut as units for pulpwood, and later for sawtimber trees. The pulpwood was sold to International Paper Company, in cooperation with the thinning study. The species sold for pulp were sweetgum, maple, hackberry, boxelder, green ash, and American elm. The sawlogs were used by Chicago Mill and Lumber Company, owner of the property.

The range of basal area between plots prior to treatment was not great. The least basal area found on any acre was 110.08 sq. ft., and the greatest, 129.54. Range in number of live trees 5 inches d.b.h. and larger, was 171 to 267 per acre. Cubic volume per acre varied from a low of 2,925 to 3,489 cubic feet of merchantable stemwood larger than four inches (ib) small end. Average per acre figures for the entire stand before treatment were as follows:

<table>
<thead>
<tr>
<th>No. Trees</th>
<th>Basal Area</th>
<th>Cu.Ft. Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>209</td>
<td>117.18</td>
<td>3,028</td>
</tr>
</tbody>
</table>

Tree size ranged from 5 inches to 26 inches d.b.h. and total heights varied from 60 to 115 feet. Nineteen percent of the total basal area of the plots to be thinned was of species other than sweetgum. The average annual growth of the stand for its approximate 55-year life, was 60 cu.ft. per acre, or about 3/4 of a cord, without counting mortality from natural thinning and logging of a few gum trees about 15 years ago.
<table>
<thead>
<tr>
<th></th>
<th>3 Check Plots</th>
<th>3 Light Thinning Plots</th>
<th>3 Medium Thinning Plots</th>
<th>3 Heavy Thinning Plots</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leave 205</td>
<td>124</td>
<td>91</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Cut 0</td>
<td>111</td>
<td>91.67</td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>Total 205</td>
<td>235</td>
<td>123.98</td>
<td>186</td>
</tr>
<tr>
<td></td>
<td>Avg. Diff. 12</td>
<td>Avg. Diff. 2</td>
<td>Avg. Diff. 1</td>
<td>Avg. Diff. 1</td>
</tr>
<tr>
<td></td>
<td>Leave -12</td>
<td>Cut 0</td>
<td>Total -12</td>
<td>Cut -12</td>
</tr>
<tr>
<td></td>
<td>Basal Area Average</td>
<td>Total Basal Area Average</td>
<td>Total Basal Area Average</td>
<td>Total Basal Area Average</td>
</tr>
<tr>
<td></td>
<td>Leave 118</td>
<td>87.25</td>
<td>92.87</td>
<td>74.34</td>
</tr>
<tr>
<td></td>
<td>Cut 3.62</td>
<td>36.73</td>
<td>36.73</td>
<td>47.68</td>
</tr>
<tr>
<td></td>
<td>Total 122</td>
<td>127.60</td>
<td>127.60</td>
<td>122.02</td>
</tr>
<tr>
<td></td>
<td>Total leaf cut leave</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leave 193</td>
<td>233</td>
<td>233</td>
<td>233</td>
</tr>
<tr>
<td></td>
<td>Cut 0</td>
<td>90.87</td>
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<td>74.34</td>
</tr>
<tr>
<td></td>
<td>Total 193</td>
<td>127.60</td>
<td>127.60</td>
<td>122.02</td>
</tr>
<tr>
<td></td>
<td>Trees/Acre Average</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>Leave 205</td>
<td>124</td>
<td>91</td>
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<td>Basal Area Average</td>
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<td>Total leaf cut leave</td>
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</tr>
<tr>
<td></td>
<td>Total 193</td>
<td>127.60</td>
<td>127.60</td>
<td>122.02</td>
</tr>
</tbody>
</table>

Table 2. RESULTS OF REMEASUREMENT SWEETGUM THINNING PLOTS

3 years growth
Before the stand was treated there was a sawtimber volume (Doyle) of 1,517 board feet per acre in logs larger than 12 inches scaling diameter. In addition to this sawtimber volume, there was 2,690 cu.ft. of stemwood in small trees and upper lengths of sawtimber trees.

In December 1957 and February 1958, a remeasurement was made of the plots. Table 2 shows the results of this remeasurement:

The information received from the remeasurement, due to the short period, succeeded in only establishing a trend, and it seems to be toward the desired results expected. In examining the above table, it will be noted that the mortality ranged from 12 trees per acre in three years, to one tree in the heavy thinning. By observation during remeasurement, it was noted that the mortality of the medium and heavy thinning was due to breakage in logging. The mortality of the light thinning was due to suppression.

The basal area increase ranged from .89 sq.ft. on the check plots to 5.04 on the heavy thinning. The slow increase of basal area in the check plots shows the high degree of stagnation which was occurring in the stand.

The cubic foot volume increase varied from an average of 242 on the check plots to 135 on the heavy thinning. The steady decline of cubic foot volume growth from the check plots to the heavy thinning, was due to the reduction in the number of stems per acre left for growth.

The board foot volume increase varied from 97 board feet on the check plots to 422 on the heavy thinnings.

In comparing the various remeasurements taken, from the check plots to the various degrees of thinning, it can be noted that the growth has been stimulated depending upon the intensity of thinning. With the short period of time elapsing, the trend is encouraging from the standpoint of releasing a stagnant stand, and growth increase.

Field observations indicate that epicormic branching in the medium and light thinning is of no importance at the present time, but in the heavy thinning plots, it may cause some degrade due to this condition.

From the facts revealed in the remeasurement at this time, the right direction is being followed to increase the yield of our sweetgum stands; which degree of thinning will be more satisfactory will depend upon results and observations in the future.

DISCUSSION:

Sweetgum appears to begin producing seed at about age 15 to 20.
The topic originally assigned to me was the thinning of water oak, Quercus nigra, but I will broaden the scope to include willow oak (Q. phellos), Nuttall oak (Q. nuttallii), and pin oak (Q. palustris). These 4 species, plus laurel oak (Q. laurifolia), make up the group often called the water red oaks. As their wood is very hard, and takes on a glassy surface when machined, the first 4 species are favorites at flooring mills. Laurel oak, in its principal range, is a species of low value, occasionally cut for pulpwood in the Southeast and rarely used for ties and timbers. It is the poorest of the red oaks, and will not be discussed further in this paper.

A Tendency To Limbiness

Silvically, the water red oaks have much in common. They are among the fastest growing red oaks, though they develop rapidly into commercial sawtimber only on heavy bottom-land soils. They all are relatively intolerant and forcibly assert dominance with full sunlight.

They all have a strong tendency to limbiness on the main stem. Pin oak is the worst—its excessive branching and the persistence of limbs in all but the densest stands limit its utility. On water oak, willow oak, and Nuttall oak most of the limbiness is from epicormic branching that results when normally dormant buds along the main stem are stimulated to growth by some disturbance. Among the causal disturbances are breakage of the tree crown, wounding of the stem, drought, flooding, suppression, and occurrence of the species on unsuitable sites.

Release also stimulates epicormic branching on intermediate or suppressed trees, but dominant and co-dominant trees are much less susceptible. In a study of willow oak near Stoneville, Mississippi, it was found that even heavy release (where all competitors of equal size were removed) did not influence amount of epicormic branching of vigorous dominant and co-dominant trees.

In a recently completed inventory of the Delta Experimental Forest, it was also apparent that the growing-season droughts of 1952 to 1955 had stimulated epicormic branching of both willow oak and Nuttall oak. Such branching was particularly evident on intermediate trees that had been released through selective logging or the removal of culls during the past 10 years. Even if crown vigor increases with normal rainfall and the epicormic branches die, their stubs will constitute defects in the merchantable stem. Where quality timber is the object of management, thinning should aim at releasing undamaged trees that are of pole size and larger and occupy dominant and co-dominant positions.
Pin oak often occurs in even-aged stands that are amenable to standard thinning procedures. Minckler (3) reported on a 37-year-old pin oak stand in southern Illinois that had grown at an average annual rate of 42 cubic feet per acre. He thinned this stand to basal areas of approximately 90, 75, and 65 square feet per acre. After four years, the heavily thinned plots had a net growth more than twice that of stands given medium or light thinning.

Improvement cuts in a stand of water oaks in the Mississippi Delta yielded additional information on response to thinning (1). Before cutting, the volume of timber in logs 14 inches and larger averaged 2,900 board-feet, Doyle scale, per acre. The forest was made up of irregular groups of sapling, pole, and sawtimber trees. The basal area averaged 105 square feet per acre in trees of all kinds, qualities, and sizes.

The 1947 cut removed 1,500 board-feet per acre, or 25 feet of basal area. In November 1949, increment borings were taken from 200 trees on sample strips through a quarter-section that was logged in June and July 1947. The sample trees were divided into four release classes—heavy, medium, light, and no release.

The definition of each release class depended on the crown class of the tree released. For overtopped trees, light release removed less than one-third of the effective competition, medium release up to one-half, and heavy release more than half. Among intermediate trees or co-dominant trees, light release took away one-fourth to one-half the competition, medium up to three-fourths. For dominant trees, light release removed up to two-thirds of the competition, while medium release took greater amounts. Culls and trees completely overtopped for so long that they gave no reasonable promise of recovery were not included in the sample.

Although the study was conducted for all commercial species combined, willow oak and Nuttall oak made up a major part of the sample and responded similarly. For trees that received heavy release, average rate of diameter growth was 26 percent higher in the 2 years after the cut than in the 10 years before. Trees with medium release increased only 1 percent in rate of growth, but it is likely that they needed more than 2 years to make their full response. In general, medium release just about enabled trees to maintain their previous rate of diameter growth. It should be noted, though, that a constant rate of diameter growth means an accelerating rate of basal area and volume growth.

Trees that had light or no release decreased 17 percent in average rate of growth. This suggests the growth loss likely to occur in crowded stands if thinning is postponed too long.
TWENTY-NINE YEARS AFTER THINNING

There are few growth figures on thinned stands of water oak (Q. nigra). In the course of gathering the meager published information for this paper, however, it was discovered that an acre of water oak had been thinned in 1926 near Opelousas, Louisiana, and that the plot had been protected from cutting and fire since that date. Although there was no replication or check, the growth on this plot is indicative of what may be accomplished through protection and controlled cutting.

The plot is on the 11,280-acre Lote Thistlethwaite Forest Reserve. It was established by V. H. Sonderegger, then a consulting forester. No tree records were taken in 1926, but 11 cords of wood were removed in the thinning. On July 14, 1928, John A. Putnam of the U. S. Forest Service and G. H. Lentz, special investigator for the U. S. Forest Service and the Louisiana Division of Forestry, measured the trees on the plot and subsequently published the records (2). The plot was remeasured for the first time in February 1958 by Mr. Putnam and the author.

In 1928 the stand contained 133 water oaks (Q. nigra) out of a total of 317 trees. The other species were cherrybark oak, Shumard oak, swamp chestnut oak, overcup oak, hickories, sycamore, sweetgum, green ash, honeylocust, American hornbeam, hackberry, boxelder, and redbud. The average tree was 5 inches in d.b.h. but diameters ranged from 1 inch to 16 inches. There was hardly any undergrowth, largely because cattle, horses, and sheep grazed the area heavily. The soil is a silty clay loam of both Red River and Mississippi River origin. The topography is generally flat, with a minor depression near the center of the plot.

Although there have been no fires and no woodcutting, except salvage of trees that died, heavy cattle grazing has apparently continued to the present. Natural mortality kept the stand thinned and produced one opening sufficiently large to encourage reproduction. However, heavy grazing has prevented seedlings from reaching cordwood size.

Most of the trees now on the plot are desirable as growing stock. They average better than 12 inches in diameter, with many over 22 inches d.b.h. A few have rotten butts and several have hispidus canker (Polyporus hispidus). Some of the least vigorous water oaks have epicormic branches on the main stem. The following tabulation very briefly describes the stand as it was in 1928 and as it is today:

<table>
<thead>
<tr>
<th>Date</th>
<th>Trees</th>
<th>Basal Area</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(no.)</td>
<td>(sq.ft.)</td>
<td>(cu.ft.)</td>
</tr>
<tr>
<td>July 1928</td>
<td>317</td>
<td>43</td>
<td>511</td>
</tr>
<tr>
<td>February 1958</td>
<td>166</td>
<td>130</td>
<td>3,123</td>
</tr>
</tbody>
</table>

-48-
Increment cores indicate that the average age of the stand is 52 years. The 11 cords removed in 1926 contained 880 cubic feet of wood and (as indicated by old stumps and stand-table comparisons), mortality accounted for about 320 cubic feet more. Total wood production over the life of the stand, then, has been about 4,323 cubic feet. This equals an average annual growth of a little over a cord per acre.

The sawtimber component developed in a very gratifying way. In 1928 there was 322 board-feet (International 1/4-inch rule to a 10-inch top) of sawtimber, and this was suitable only for construction timber. In 1958 there is 10,721 board-feet, and over half of this would yield standard sawlogs. Thus, the average annual growth rate has been 359 board-feet. In addition, there has been some mortality, perhaps an average of 10 board-feet per acre per year.

For best growth there should have been additional thinnings during the 29-year period. Probably one at the mid-point would have been highly beneficial. During the recent inventory, a tally was made of the trees that should now be removed to benefit stand growth. Removal merely of these damaged and weak trees would reduce the basal area to about 80 square feet. If each tree were considered on its individual merits without regard for its species, such a "thinning" or stand improvement would remove one-third of the water oak, almost all of the sweetgum, about a fifth of the cherrybark and Shumard oaks, and most of the other species. The one hole now occupied by reproduction would be expanded and a few others would be created. Thus, the even-aged nature of even this small area would be broken down.

Some might argue that this acre should be clear-cut. But the leading trees have grown as much as 7 inches in diameter in the last 10 years. The full effect of release is being realized on these trees. It would seem that future treatments and cuts should be aimed to encourage these growers while regeneration is filling in the openings created by selective cutting.

CONCLUSIONS

At this stage of knowledge conclusions must be tentative, but some guiding principles can be gleaned from three situations discussed above.

(1) Because the water oaks are inherently limby, they should be grown in dense, nearly even-aged groups, as small as a fifth acre or larger, until they reach pole size. Then they can be released.

(2) On their best sites and with adequate space, the water oaks grow rapidly. They should be favored through judicious release where they are competing with less desirable stems of their own or other species.

(3) As far as possible, trees picked for growers should be those with full, healthy crowns in the dominant or co-dominant positions.
(4) Slow-growing trees, and those with epicormic branches or severely damaged crowns or trunks, should be harvested if possible.

(5) Partial cutting merely to reduce levels of stocking should be confined to even-aged patches. Such cutting is likely to take on the nature of all-aged selection or improvement cutting as sawtimber begins to develop.

LITERATURE CITED

(1) Johnson, J. W.


(2) Lentz, G. H.


(3) Minckler, L. S.

CULL TREE REMOVAL IN BOTTOMLAND HARDWOODS

J. Scott McWilliams

In the consideration of cull tree removal in bottomland hardwoods, it is first desirable to form a picture of the present status of forestry work in those areas. Those who are working in bottomlands are accustomed to thinking of forestry as lagging some 10 to 15 years behind work in pine types. In the hardwoods, foresters are working with understocked stands roughly comparable to many pine stands of the mid-1940's. Fire protection has extended only to a portion of hardwood lands, and where present it is often on an inadequate basis. Markets exist only for a small portion of the growing stock volume, principally for reasons of species, size, and quality. For many bottomland hardwood areas, stumpage sales yield relatively small returns; there is a tremendous range in values, but the average stumpage return is low.

In the pine forests of the South, cull tree removal is a widely accepted practice which has been advocated since the mid-1930's and extensively used since 1947. It has reached the position of wide practice because it increases stocking of desirable species with a reasonably low investment and with relative ease. For instance, it is a simple matter to map prospective areas of cull tree removal in pine types based entirely on the single factor of number of pine seedlings per acre.

However to the manager of a bottomland hardwood forest, the problem appears to be much more difficult. He is faced with a complexity of site and types, and encounters many species with varying silvical demands; superimposed is the all-important factor of tree grade for lumber.

In considering all these complex factors and adding the factor of finances, the forest manager has understandable difficulty in beginning the use of cull tree removal. One of the first problems concerns the future utilization of various species. Even after a 10-year period of CTR work in pine, many forest managers have debated the future utilization of various hardwood species; this has resulted in extremes of CTR application from the wholesale killing of all hardwood species to a selective killing which leaves some of the more promising hardwood species. This single problem in CTR application is greatly magnified in bottomland hardwood stands.

Other principal reasons why CTR in bottomland hardwoods has lagged are:

1. Lack of appreciation of the seriousness of the cull component.

2. The lack of results from long term research in bottomland hardwoods in term of values obtained from CTR.

3. The appearance of the hardwood stand is not as dramatic and contrasting. In pine types, there is the removal of hardwood culls against the background of green coniferous reproduction, while in bottomland
hardwood areas, cull trees are usually of the same species and to the untrained eye the culls appear quite similar to desirable growing stock.

4. The last basic reason is that the management practices in bottomland hardwoods are still on a relatively extensive basis and CTR is considered as an intensive practice.

The Forest Management Aspects

The amount of cull component is an important part of the Union Producing Company management data. We describe the stand components of bottomland hardwoods in necessarily over-simplified terms.

Desirable Growing Stock: those trees which should be left for one or more cutting cycles, whatever their present size. If we think of inventorying the forest on a cut-and-leave basis, these are the "leave" trees.

Overburden: those merchantable trees that will not make a net contribution to the value of the stand over the next cutting cycle and which should be removed by commercial cutting. The "overburden" class would include trees of low vigor, trees damaged by fire, wind or insects, trees of less desirable species, and trees of poor form or low grade; overburden trees are the "cut" stems.

Cull: all other trees in the stand; they consist of rotten culls, sound culls, and weed species. Forest Survey Release #78 of the Southern Forest Experiment Station defines cull as "live trees of sawtimber or pole timber size that are unmerchantable for sawlogs now or prospectively because of defect, rot, or species."

The management of our bottomland hardwood areas was begun by a 2½% inventory, which will be repeated at 15-year intervals, and which delineates forest types and volume conditions. Data covering each compartment and stand is recorded on the stand record sheets, on the map and on the compartment card. The compartment record contains one line entry for each volume condition which included the total estimate of cull trees and their average diameters; this information forms a basis for budgeting CTR costs for each stand and compartment.

Marking the overburden for a commercial cut is the next operation. In this respect, the tree which is a border-line cull presents the most difficulty. One common solution often applied is to mark the borderline culls for cutting and include only a portion of volume in the sale volume and price; occasionally a distinctive paint mark is used to indicate the borderline culls.

Following the commercial cutting operation, the cull trees are marked for the killing operation. If done within the first year following the commercial cut, the marking operation should require about half an hour per acre. A distinctive mark, such as an X, using a different color of paint is preferable.
The actual CTR work using axes or Little Beavers requires from 1½ to two hours per acre.

Permanent sample plots, which are installed after cutting and CTR work, are recorded on the field tally sheet and later manually punched for high speed computers. Entries on this card include space to record the number and average DBH of cull trees recorded on each ½-acre permanent sample plot. Also recorded is the date and method of CTR work accomplished.

It was previously stated that the amount of the cull component was not always appreciated. To illustrate that point, examples of average stand conditions have been selected for the Hackberry-Elm-Ash type as taken from our 2½% inventory. Figure 1 illustrates total basal area per acre by diameter classes for two volume conditions. Figure 2 shows percent of basal area by diameter classes for one volume condition; this illustrates the relative importance of the cull component. Now with this average acre in mind, let us imagine we have marked and cut the overburden basal area, then let us construct a graph of percent of basal area for only growing stock and cull. Here in Figure 3 is shown the now relatively greater importance of the cull component for the residual stand. In Figure 4, the diameter classes were grouped and the stand classifications are illustrated by percent of basal area for the stand components before the cut, after the cut, and after CTR application. For every felling operation in the stand, the cull component becomes more detrimental. With the removal of overburden, the cull stems will be released and will increase in growth just as the growing stock will increase. The effect of the large culls on establishment and development of desirable reproduction can easily be imagined.

The Silvicultural Aspects

Cull tree removal is a portion of the whole classification of timber stand improvement measures, but the removal of cull trees by girdling or poisoning is not all that makes up timber stand improvement. Timber stand improvement (TSI) may include liberation cutting, weeding, thinning, improvement cutting and salvage cutting. Logically, the removal of cull trees might accomplish a portion of any of these improvement measures, but strictly speaking timber stand improvement includes a wider range of operation than does the removal of cull trees. The largest portion of CTR work in the bottomland hardwoods probably falls in the category of liberation work releasing advanced reproduction.
ILLUSTRATION OF STAND COMPONENTS OF TWO COMPOSITE STANDS OF THE HACKBERRY-ELK-ASH TYPE

Growing Stock

Overburden

1 to 2 1/2 M Per Acre
Total B.A. = 47

More Than 2 1/2 M Per Acre
Total B.A. = 63
Figure 2

ILLUSTRATION OF THE CULL COMPONENT IN A COMPOSITE STAND OF THE HACKBERRY-ELM-ASH TYPES

HACKBERRY-ELM-ASH TYPE

More Than 2½ M Per Acre
Total B.A. = 63

Growing Stack
Overburden
Cull

% OF BASAL AREA

DEH CLASSES

6"-10"
12"-16"
18"-22"
24"-28"
30"+
Figure 3

ILLUSTRATION OF THE CULL COMPONENT AFTER CUTTING IN A COMPOSITE STAND OF THE HACKBERRY-ELM-ASH TYPE

HACKBERRY-ELM-ASH-TYPE

More Than 2½ % M Per Acre
Total B.A. = 63

Growing Stock

Cull

DBH CLASSES

% OF BASAL AREA

56

6"-10"

12"-16"

18"-22"

24"-28"

30"
IMPROVEMENT OF A COMPOSITE STAND OF THE HACKBERRY-ELM-ASH TYPE

HACKBERRY-ELM-ASH TYPE

More Than 2½ M Per Acre
Total B.A. = 63

Growing Stock
Overburden
Cull

% of Basal Area

Before Cut
After Cut
After CTR

ALL DIAMETER CLASSES
In the beginning phases of CTR work in bottomland hardwoods, it is most desirable for the forest manager to form a clear picture of the classification of cull trees, or the reason for indicating the cull to be killed. Following are those we have adopted.

Rotten culls: trees too rotten to yield at least one grade-3 log, 8 feet long.

Sound culls: trees that because of knots, insect damage, or poor form will not produce at least one grade-3 log, 8 feet long.

Weed species: trees whose removal will improve the composition of a stand; the aim is largely elimination of seed source.

Providing growing space: primarily this class is used in borderline decisions. Table 1 shows the tabulation of reasons for marking cull trees on 723 acres which included three timber types; the results show that over four out of every five culls were considered to be an outright cull. It is believed that the use of a similar classification with occasional supervision of timber markers to determine their reasons for marking cull trees will reduce the possibility that any large number of trees of potential utility will be indiscriminately killed. It can not be stressed too greatly that marking of cull trees must be carefully done, and adequately inspected.

To yield some idea of intensity of CTR application, Table 2 shows three separate CTR operations. Area A was on Union Producing Company land in Richland Parish. Area B was on the Delta Experimental Forest at Stoneville, Mississippi, while Area C was on a narrow streambottom near Crossett, Arkansas. While the work on Area A & B was conducted independently on similar stands, it is interesting to note that the results were quite similar. Area C is notably different, but the CTR work was done on radically different stand conditions.

The complexity of species and type also makes an interesting picture. Table 3 shows the results of tabulation of culls by species on three different timber types. Notable is the fact that the less desirable species of bitter pecan, overcup oak, and hard elm total more than half of the culls on each type. The miscellaneous class includes weed species such as hawthorn.

Results of Cull Tree Removal

If it were possible to state the results of CTR work in terms of growth on desirable growing stock stems, or in terms of reproduction establishment of desirable species in stand openings, the application of CTR in bottomland hardwoods would be widely accepted. However, such results are not known and probably will not be available for at least 5 years. One investigation at Fordyce, Arkansas, measured the results in terms of reproduction stocking as is shown in Table 4. Although this reflects a relatively low stocking of reproduction, it must be remembered that not all of the area was opened for reproduction; the establishment of 352 additional stems per acre is probably close to satisfactory stocking.
REASONS FOR MARKING CULL TREES

MARKER'S CLASSIFICATION

<table>
<thead>
<tr>
<th>classification</th>
<th>no trees marked</th>
<th>percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotten Cull</td>
<td>2020</td>
<td>50%</td>
</tr>
<tr>
<td>Sound Cull</td>
<td>1390</td>
<td>34%</td>
</tr>
<tr>
<td>Weed Species</td>
<td>440</td>
<td>10%</td>
</tr>
<tr>
<td>Providing Growing Space</td>
<td>230</td>
<td>6%</td>
</tr>
</tbody>
</table>

4080 100%

Basis:

10th Tree Tally on 723 Acres of 3 Different Types

Table 2

EXAMPLES OF C T R APPLICATION INTENSITY

<table>
<thead>
<tr>
<th></th>
<th>AREA A</th>
<th>AREA B (1)</th>
<th>AREA C (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>acreage</td>
<td>1264</td>
<td>1200</td>
<td>80</td>
</tr>
<tr>
<td>no. culls killed per acre</td>
<td>13.5</td>
<td>14.0</td>
<td>222.0</td>
</tr>
<tr>
<td>average d.b.h. of culls</td>
<td>14.5&quot;</td>
<td>12.0&quot;</td>
<td>3.4&quot;</td>
</tr>
<tr>
<td>sq. ft. of basal area in culls per acre</td>
<td>15.4</td>
<td>11.0</td>
<td>27.8</td>
</tr>
<tr>
<td>Species</td>
<td>360 Acres</td>
<td>148 Acres</td>
<td>27 Acres</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------------</td>
<td>------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td></td>
<td>Sweet Gum - Water Oak Type</td>
<td>Overcup - Pecan Type</td>
<td>Hackberry - Elm - Ash Type</td>
</tr>
<tr>
<td>Bitter pecan</td>
<td>170 % 7</td>
<td>10 % 2</td>
<td>160 % 10</td>
</tr>
<tr>
<td>Overcup oak</td>
<td>300 % 12</td>
<td>130 % 30</td>
<td>620 % 39</td>
</tr>
<tr>
<td>Hard elm</td>
<td>930 % 37</td>
<td>246 % 55</td>
<td>340 % 22</td>
</tr>
<tr>
<td>Soft maple</td>
<td>450 % 18</td>
<td>-</td>
<td>60 % 4</td>
</tr>
<tr>
<td>Red oak</td>
<td>120 % 5</td>
<td>10 % 2</td>
<td>-</td>
</tr>
<tr>
<td>Soft elm</td>
<td>180 % 7</td>
<td>10 % 2</td>
<td>70 % 4</td>
</tr>
<tr>
<td>Hackberry</td>
<td>200 % 8</td>
<td>10 % 2</td>
<td>150 % 10</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>140 % 6</td>
<td>30 % 7</td>
<td>160 % 11</td>
</tr>
<tr>
<td></td>
<td>2490 % 100</td>
<td>440 % 100</td>
<td>1560 % 100</td>
</tr>
</tbody>
</table>

Basis: Tenth tree tally
In terms of growth, the results can only be inferred from results of improvement cutting. Table 5 illustrates the periodic increase in basal area per acre from heavy cutting, light cutting, and a check area. Since an improvement cutting plus CTR in many areas would yield a residual basal area similar to the heavy cutting, it can be assumed that the periodic increase in basal area will be acceptable following CTR work.

For the most part, the use of CTR in bottomland hardwoods must be taken on faith alone, and on the visible, but as yet unmeasured, result that has been observed by every forest manager who has tried it. Certainly, each manager knows he is "buying" productive hardwood acres very cheaply by killing cull trees.

Table 4

<table>
<thead>
<tr>
<th>Species</th>
<th>No Seedling Established Per Acre</th>
<th>Percent By Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cherrybark Oak</td>
<td>22</td>
<td>7%</td>
</tr>
<tr>
<td>White Oak</td>
<td>15</td>
<td>4%</td>
</tr>
<tr>
<td>Water &amp; Willow Oaks</td>
<td>174</td>
<td>49%</td>
</tr>
<tr>
<td>Overcup Oak</td>
<td>20</td>
<td>6%</td>
</tr>
<tr>
<td>Sweet &amp; Black Gum</td>
<td>79</td>
<td>22%</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>42</td>
<td>12%</td>
</tr>
<tr>
<td>Total</td>
<td>352</td>
<td>100%</td>
</tr>
</tbody>
</table>

1 CTR work done in 1951; reproduction tallied in 1953. Area covered was narrow overflow bottom in southern Arkansas. CTR work killed 118 trees per acre averaging 6" in dbh.
Table 5
RESULTS OF IMPROVEMENT CUTTING

BASAL AREA—SQ. FT. PER ACRE

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1940 Inventory</th>
<th>1955 Inventory</th>
<th>Periodic Annual Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cut</td>
<td>Left</td>
<td>Total B.A.</td>
</tr>
<tr>
<td>Heavy Cut</td>
<td>51</td>
<td>12</td>
<td>48 (36)</td>
</tr>
<tr>
<td>Light Cut</td>
<td>39</td>
<td>18</td>
<td>58 (42)</td>
</tr>
<tr>
<td>Check (Uncut)</td>
<td>---</td>
<td>63</td>
<td>83 (35)</td>
</tr>
</tbody>
</table>

LITERATURE CITED:

(1) Beaufait, W. R. and Johnson, R. L.
1956. FIFTEEN-YEAR RESULTS OF IMPROVEMENT CUTTING IN BOTTOMLAND HARDWOOD. Mississippi State College Agriculture Experiment Station. Information Sheet 547.

(2) Clark, Robert H.
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(3) Kennedy, Richard F.
Unpublished Data. Crossett Forestry Division

(4) McKnight, J. S. and McWilliams, J. S.

DISCUSSION

We have used poison only occasionally, generally sticking with just girdling. Transportation of the chemicals is difficult in the bottomlands, and we have had
practically no sprouting on our time and money. (From floor: In southern Illinois, we started out when we first started to 14 inches dbh.) The chief d. started out girdling all overcup oak, bitter pecan, and hard el they began looking better and we now leave many more of them.
For many years, the southern hardwood forests have been subjected to highgrading for both logs and firewood, uncontrolled fires, and overgrazing. As a result, large areas are left with old and defective trees, weed trees both large and small, and many fire scarred young trees. There are many cases where the overburden in terms of both volume and number of stems is much larger than the actual growing stock. It has been estimated that one-fifth of the growing space of productive hardwoods is now occupied by culls.

Had the landowners, both large and small, known years ago of the advantages of management of hardwood forestry, most of the highgrading would not have taken place. For the same reasons, fire and overgrazing would have been controlled. However, even under those conditions, there would have been a great demand for well-trained foresters to keep these forests in a highly productive state.

In the stands of today, the greatest need for these forests is improvement cuttings carried out under the supervision of foresters well trained in hardwoods. Of course, this work must be coupled with adequate fire control and controlled grazing.

Before attempting to mark a given stand of hardwood timber for an improvement cutting the forester in charge should know his species, their value, and have some knowledge of their growth under various growing conditions. He should have a good working knowledge of log grades, and he certainly should know what to expect from the various visible defects on the various species. The number and size of defects do not affect the grade except as they limit the length of clear surface between the defects.

It would also be well if the forester knew something of the past economic history of some species. For example, hackberry—which is still not classed as one of the most desirable species—could hardly be sold prior to World War II, but now hackberry lumber is a pretty good item. Another example is sweet pecan; prior to World War II you could not even give it away, but two years ago I marked some that sold for $20.00 per Mbf.

In order to further balance utilization with silviculture, the forester should be well acquainted with the demand in his locality for such items as staves, dimension bolts, ties and timbers, high-quality veneers, posts, piling, chemical wood and pulpwood, in addition to sawlogs.

In general, improvement cuttings should be done in two stages. The first being a commercial cut and the second to control the cull.
Commercial Improvement Cutting

If the forester is not familiar with the tract, a preliminary survey will often be helpful to determine operability and the extent of the cull tree control job. A good inventory is then needed to provide a record of the stand in terms of cutting needs, and for this, it is convenient to divide the trees into two classes: desirable growing stock and overburden. Desirable growing stock includes those trees which should be left for one or more cutting cycles, whatever their present size. Everything else is overburden. Overburden can again be divided into two classes: first, those merchantable trees that will not make a net contribution to the value of the next cutting cycle and that should be removed by logging in the initial cut; second, the cull component.

In making the decision between desirable growing stock and overburden, one should consider at least five points.

1. Species. There are better than thirty species of trees in bottomland hardwoods most of which, and sometimes all of them, are found on one tract. It is best to group them into at least three groups depending on commercial value and rate of growth. These groups would include: best species—bottomland red oak, water oak, willow oak, cherrybark oak, cow oak, cottonwood, white ash, green ash, redgum, cypress, willow, sweet pecan, and sycamore.

Intermediate species—overcup oak, white elm, rock elm, winged elm, hackberry, red maple, bitter pecan, hickories, honey-locust, blackgum, swamp cottonwood and tupelo.

Poorest or weed species—boxelder, water-locust, hawthorn, planer-tree, ironwood, and swamp privet.

Although there is some demand for boxelder for pulpwood, the remainder of these species have little or no economic value and all of them should be eliminated as soon as practical.

2. Size. Size is used to determine sawlogs. Sometimes a tentative upper diameter limit will be helpful.

3. Form and quality. The goal of management in hardwood forests is the production of the most high quality logs in suitable sizes for high-grade lumber and veneer. These are the logs that usually have a profitable cash market and may be referred to as "high-grade" logs. A high-grade log has been defined as one which is cut at least 10 inches in diameter at small end inside the bark, at least 12 feet long, straight enough to be handled as one piece, and with 60% of its surface entirely clear of defects. If a tree because of low form or quality does not now and never will contain at least one high-grade log, it is undesirable and therefore overburden.
4. Vigor and thrift. Poor risk and overmature trees should always be classed as overburden.

5. Position and space occupied. Trees with poor growing space, trees that interfere with better trees, and wolf trees should always be classed as overburden.

Thus, the overburden is composed of trees that are merchantable from the poorest class of species; the trees of the intermediate class that are interfering with growth of the best species; trees of the better species that are overtopped or crowded; trees with excessive damage by insects, fire, wind, lightning or ice; overmature and poor risk trees as well as wolf trees.

It is essential that the forester thoroughly inspects all four faces of each tree before classifying. All overburden trees of commercial value should be removed in the initial cut. With a few exceptions this will accomplish the commercial improvement cut. However, in some cases where the overburden is not operable it may be advisable to cut some of the growing stock of lower vigor and intermediate species. This practice should be used with extreme care; the disadvantages as well as advantages being carefully considered. In areas of mature saw timber, the objective should be to create openings for reproduction. Care should be taken not to make these openings large enough to create buckvine patches nor cause epicormic branches to occur.

Much of my work is done for individuals who are not in the manufacturing business but are interested in growing and marketing timber. They desire that the timber be marked and estimated. In general, I do not know whether they will dispose of the timber marked on a per thousand basis or in a lump sum. Therefore, I have to be careful to keep the cull component marked to a minimum. I realise that for one to mark all of the merchantable trees and none of the cull trees he must be a genius. However, if too many merchantable overburden trees are left unmarked the owner will probably lose and, if too many culls are marked, and estimated, the estimate will not hold, and if offered for lump sum bid, the timber will be hard to sell. Thus, the purchaser will lose by not getting what he bought and also by having to cut trees of no value.

I might mention a few outward signs of defect that denote serious defect within the tree. Trees that are hollow at both the top and bottom are usually hollow all the way. However, if there are signs of dirty water running out of the top hollow, it is a pretty sure bet that there is at least one good log in the tree. Large, rough bark, leaning trees of such species as sycamore, tupelo, bitter pecan and cypress, to name a few, are often shaky and thus culls.

**Time of Year to Mark**

Although visibility is about three times as good in late fall and winter and the snakes and insects are not out, I prefer to mark timber in the
spring, summer, and early fall. When the leaves are out I can do a much better job of determining thrift and vigor. This has been especially true in the case of cottonwood and willow during the past drought. One of the first signs of a decline in growth and vigor in cottonwood and willow is the dying of feeder branches. In the fall and winter, I cannot tell if these branches are dead. Trees with heavy foliage are usually the more thrifty.

Especial care should be taken in the logging operations or a large percentage of the advantages from marking will be destroyed. Crews especially trained in hardwood logging should be used. The skidders must be cautioned to stay out of so-called brush areas as these contain hardwood reproduction.

**Cull-Tree Control**

Cull-tree control should be carried out immediately after the commercial cut. If not carried out within one year, it will often be very difficult due to briars and weeds. The following cull types should be killed to release established growing stock and to eliminate prolific seed bearing trees of the weed species.

- **Rotten culls.** Trees too rotten to yield at least one 8' grade 3 factory log.

- **Sound culls.** Trees that because of defects or poor form will not yield at least one 8' grade 3 factory log.

- **Weed trees.** Trees that are prolific seed producers. Not of commercial value.

The marking of culls should be done only by an expert and never left to amateurs or labor crews. Care must be taken to mark only such culls as will definitely benefit the stand.

It should be born in mind when marking weed species that there may be times in the future, that through research or increased demand for low-grade hardwoods as raw material for fiber board, they may have a commercial value. There are also times when weed species, by scarcity of growing stock, are needed to cause early shedding of lateral branches on desirable growing stock and thus growing better quality trees.

**Results Obtained**

Due to the relatively short time that any research has been done in this field, there is not much definite information on the benefits to be expected from improvement cuttings. However, it has been definitely proven by experiments started in 1940 at the Delta Experimental Forest at Stoneville, Miss. that it will pay. In one instance where trees that received heavy release through logging had their average rate of diameter growth increased by 26%. It has also been demonstrated that you will get ample reproduction.
in the openings made by logging. Due to the faster rate of growth of the better species, they soon crowd out the weed tree reproduction.

**Conclusion**

Although there is a vast need for improvement cuttings in our southern bottomland hardwoods, the marking should be done only under the supervision of a trained forester. The logging operation to follow must be carried out by crews that know their business and under close supervision or all the benefits of a good marking job can be lost. Improvement cuttings will definitely pay off in increased growth of high quality timber and reproduction of the desirable species.

**Selected Bibliography**


*Improvement Cuttings in the Bottomland Hardwood Forests of Mississippi.*

(2) Johnson, J. W.

*Delta timber lands thrive after undesirable trees are cut.*

(3) Johnson, J. W.

*Improvement Cuttings in Bottomland Hardwoods.*

(4) McKnight, J. S. and J. S. McWilliams.

1956. *Improving southern hardwoods stands through commercial harvest and cull-tree control.* Society of American Foresters.

(5) Putnam, John A.


1956. *Fifteen year results of improvement cutting in bottomland hardwoods.*

(7) Putnam, John A. and J. S. McKnight.

Personally, I have never been too much in favor of wholesale TSI, of destroying trees that might eventually have some merchantable values. A few years ago overcup oak, bitter pecan, sweet pecan, hackberry, and a whole group of species were considered weeds; now all those sell and occasionally for a pretty good price. Boxelder is pretty much a weed below Vicksburg, because it gets defective at a very early age; however, you do have some good trees in some localities. I've seen quite a bit of sawlog boxelder above Vicksburg.
Anderson-Tully Company saws 60 million board feet of lumber annually into lumber, dimension, and companion products. At present, over half of this volume comes from Company lands located along the Mississippi River, between Natchez, Mississippi, and Cairo, Illinois. Outside log and stumpage purchases decrease each year, as we are growing more volume than we saw. The Company has been making planned initial improvement cuts, mostly on a condition basis, for over 20 years. We expect to have present holdings in condition for stabilized inventory, compartment management in another 10 years. However, arbitrary cutting cycles, tract sequence cutting, and calculated cutting budgets are not contemplated. Cutting will continue to be on an individual tree selection basis. We intend to regulate utilization by market demand, species composition from inventories, and general condition of stands through constant field inspection. The chief protection problem has been diplomatic elimination of long established grazing practices. For several years, we have underplanted black walnut (Juglans nigra) and red oaks (Quercus sp.) behind improvement cutting. Some cottonwood (Populus deltoides) is now being planted annually on marginal crop lands.

Anderson-Tully Company harvests both sawlogs and rotary veneer logs for its own use, and sorts specialty logs at its own mills for several outside markets. Premium sap veneer logs are also sold to special markets. High grade face veneer logs are sold at the mill on inspection, with rejects being sawed in regular lumber production. Another form of integrated utilization which we practice is the direct trading of logs with other companies.

Products

In bottomland hardwoods, the individual acre is often a mixture of types, species, age, and condition. We may, and often do, have a pure, even-aged group within the mixture. It is important that any prescribed silvicultural treatment be flexible enough to improve each acre according to its makeup. Since we often have such a diverse mixture, we also have a mixed utility. It is just as important, economically, to sort our produce, as it is to leave the correct growing stock.

The four classes of commercial hardwood logs can be represented in any stand:

- Face veneer logs
- Sap or rotary veneer logs (commercial and package)
- Sawlogs (Factory lumber)
- Tie and timber logs (structural)
In general, each is set apart by size, quality, and species, but each market has its own specifications, and the particular markets available to you are the places to get these specifications.

Standard factory grades have been proposed by the Forest Service Forest Products Laboratory, but unfortunately, these grades are not yet in general use. These grades have been outlined, in general, by log size and by the distribution of defects. Size and nature of defects have little to do with hardwood log grades. There is a direct relation between lumber grade outturn and size and grade of log, since both log and lumber are graded on this same general principle of distribution of defect. Log grade is a critical factor in hardwood lumber production. Poor lumber may bring only $50 or less, while the best grades may be worth $300. Efficient operation requires buying and selling of hardwood logs on grade, and cruising stumpage by grade.

Need

Today, prime sawlogs are still being split into pulpwood, and there are still some face veneer logs being sawed. With sawlogs five times the price of pulpwood, and face veneer logs many times the price of sawlogs, this is hard to understand. The standard reason given for this practice is the same as that given for sawing sub-marginal logs: "The log supply is limited. I have a mill to operate, and can't afford to sacrifice production." If the ice is so thin that such an operator must saw $250 veneer logs into $150 lumber, he must be in the wrong business.

There are still some blind operators paying $5 to cut, haul, and saw $3 worth of lumber from a low grade log. If we saw a thousand board feet of lumber from 20-inch red oak logs graded number 3 by the Forest Products Laboratory, and multiply the grade of lumber recovered by its market price, we get $68.57, Table 1, its value in dollars. If we subtract $17.00 for stumpage, $24.00 for logging and transportation, and $35.00 for manufacturing cost (rough, air dried) we will have lost over $7.00 on this thousand board feet of lumber. These stumpage and logging costs are adjusted to lumber tally by allowing 20% overrun on the Doyle rule. We must buy logs on grade to know what we are doing in sawing hardwood logs. It is a different story when we produce our own stumpage. With these costs and prices, there are, in reality, only two hardwood sawlog grades in factory lumber production, if we use the Forest Products Laboratory rules. Some of those operators who do not practice this economy of sawing sub-marginal logs leave this material to rot in the woods with a market for its use available. In one instance, a forester girdled and poisoned trees which were being sought by at least two companies nearby.

Landowners selling logs from integrated operations can often improve their timber stands, which could not be operated by selling to a single market. Often, the only other way in which some stands can be improved is by expensive girdling and poisoning work.
Table 1.

Lumber Grade Recovery And Value *
Lowland Red Oak
Log Grade No. 3
Log d.i.b. 20 inches

<table>
<thead>
<tr>
<th>Lumber Grade</th>
<th>Within Grade</th>
<th>% Within</th>
<th>% By Thickness</th>
<th>% W't'd</th>
<th>S P Lumber</th>
<th>Value Lumber Recovered</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/4</td>
<td>81.5</td>
<td>0.65</td>
<td>190</td>
<td>1.24</td>
<td></td>
<td></td>
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<tr>
<td>FAS</td>
<td>0.8</td>
<td>18.5</td>
<td>76.8</td>
<td>215</td>
<td>0.32</td>
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<td>12/4</td>
<td>-</td>
<td>-</td>
<td>95.3</td>
<td>290</td>
<td>-</td>
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<tr>
<td>SEL</td>
<td>0.7</td>
<td>23.2</td>
<td>97.0</td>
<td>200</td>
<td>0.32</td>
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<tr>
<td>12/4</td>
<td>-</td>
<td>-</td>
<td>4/4</td>
<td>270</td>
<td>-</td>
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<tr>
<td>4/4</td>
<td>97.0</td>
<td>29.97</td>
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<td>12/4</td>
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<td>-</td>
<td>4/4</td>
<td>60</td>
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<td>2C</td>
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<tr>
<td>3C</td>
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<td>13.4</td>
<td>50</td>
<td>20.20</td>
<td></td>
</tr>
</tbody>
</table>

Stumpage $17
Logging and transportation 24
Manufacturing 35
Total lumber value $68.57
Total cost $76.00
Loss 7.43

* Based on HARDWOOD LOG GRADES FOR STANDARD LUMBER, March, 1949, Forest Products Laboratory, Forest Service, U.S.D.A.

** From HARDWOOD MARKET REPORT, Memphis, Tennessee, February, 1958, with all Number 3 lumber lumped and estimated at $50, which is very conservative.
Continuation of this beneficial practice of integrated logging depends upon its continued use to maintain the many and varied markets necessary to good forest management.

Bolt and cordwood production should be a planned part of hardwood management, if markets are available. Improvement cuts often yield material not suitable for anything but fuel or pulpwood. Thinnings from below in certain pure, even-aged stands can prevent loss through natural mortality, and provide income at the same time. However, reducing basal area below the desirable minimum through the harvesting of growing stock for pulpwood is to be condemned. Harvesting of pulpwood and sawlogs simultaneously by the same operator is usually not practical.

**Markets and Marking**

Detailed specifications with prices from all available markets are necessary to do a good job. Take prospective buyers over the timber. Figure all possible separate sales and combinations against hauling and sorting costs.

There is a difference between integrated marketing and high-grade selling. If you wish to incur the wrath of an operator, ask him to bid on standing timber by volume. Then sell the number one logs to his competitor at a higher price, and send him the number two and number three logs.

The biggest problem will be in marketing the low grade material. Often, the only way to make an economical improvement cut is to move large quantities of low grade logs as ties. Cross-tie operators are often cussed and discussed by lumbermen and foresters alike, for "skinning" timber tracts. However, in a supervised operation, they can be of great service to forestry and industry. A tie log is a sound log that will not saw enough of the higher grades of lumber to pay its way. Strictly speaking, there are not many pure tie logs being sawn. Usually "side boards" of higher grade lumber will be removed from the log in tie manufacture. Today, with ties selling for over $2.00, it is usually not economical to saw them into No. 2 lumber. Species and grades not suitable for cross-ties or higher products can sometimes be utilized for timbers or fuel, especially if the owner is a farm operator.

One method of integrated logging uses a separate logger for each market. There must, of course, be enough volume in each product to economically justify separate logging. The highest quality product should be removed first, since this is usually the cutting of the smallest volume, and least likely to interfere with subsequent logging. Buyers of high grade veneer will usually pick up a few logs at roadside.

More often it is possible to make an economic cut only by having one operator remove all logs and then separate them at a mill or dump. This seldom involves cross-ties. Separation is sometimes a problem when more than one product is cut from the same species. Here, inspection by the buyer of the more valuable product is the best practice. Veneer logs are usually
bought on inspection only. This should be done where the rejects will not be lost to sawmill production, at the mill for instance. The high value of veneer logs will permit longer hauls than can be made with sawlogs.

Regardless of how the timber is harvested, there should never be any question about which trees are to be cut by any logger. A system of marking using different color paint, a combination of ax blazes and paint, or marking each operation in turn, if separately logged, can all be used to advantage. It is human nature for timber cutters to see large clean trees on which they can make money fastest, and to miss trees which are rather scrubby.

**Woods Supervision**

It is fine to plan and prepare a cut, but if it is not supervised, you can lose much of what there is to be gained by both good cutting practice and good economical marketing. The lack of woods supervision has probably bankrupted more hardwood lumber companies than we realize. The companies that have "cut out" have a similar pattern to their timberlands. Over the whole area will be a preponderance of one or two undesirable species. There will be large denuded areas interspersed with an occasional overstocked group and small piles of rotting logs. The material of the highest grade can stand and should stand the most supervision.

Long logs of 14 and 16 feet in the hardwood lumber business can often spell the difference between profit and loss. In fact, only long lengths can be moved at times when lengths prescribed by standard grading rules go begging. Timber cutters sometimes cut 12-foot butt logs in certain trees to get more scale, when 16 foot logs are possible. High stumps waste wood, and are often more convenient than necessary. It may take "too much swamping" to get that extra log in a top. Splitting and breaking trees, and pulling splinters through careless felling should be controlled. All of these things add up to dollars lost in any operation, but woods supervision is even more necessary in integrated utilization.

Two or more products from one species in the same operation requires care to get the best product from each tree. Where two or more products can be cut from the same tree, loggers are apt to ignore the possibility. In both these cases, logs for different markets are likely to have different specifications as to length, minimum and maximum diameter, minimum heartwood content, and a limit on defect. Much of this is a matter of judgment, based on experience, and if left to timber cutters on piece rate, the easiest and fastest way to make a log will usually be taken.

An extreme example of the value of woods supervision is with logging up large trees which have both face veneer, and sawlogs in them. Large face veneer logs often sell for $250 per thousand board feet at the mill. In redgum (Liquidamber styraciflua) trees averaging 3000 board feet and three or four 16-foot logs, the point where face veneer stops and sawlogs begin is most important. In this operation, 16-foot logs are not necessary, but 10 feet is the minimum length used. Without supervision, the second or third
16-foot log will sometimes contain 8 feet of face veneer and 8 feet of lumber, which rejects it from the face veneer class. When we saw the log, we lose about 400 board feet of veneer, or $100. We gain about $25 in sawtimber, or lose a total of $75 on the one log. We can, and do save the Company hundreds of dollars per day when cutting in this timber. Figured gum logs bring $100 more per thousand board feet, and therefore justify the most personal attention. In this timber, there is sometimes ring shake evident at the stump after felling. This defect downgrades veneer logs to the sawlog class. In this case, the logger will not always look for ring shake, or if he does notice it, he assumes that it prevails throughout the entire stem. We have found that this shake is often confined to the lower three or four feet of the butt. For example, after timber cutters had felled one shaky tree and removed a 16 foot log from the butt, there was no evidence of shake in the second log. When the butt end of the first log was sounded with the broad side of an ax, there was an indication that a four foot cut would remove all of the shake. We took the chance, and changed the 1200 board foot-$75 sawlog into a 900 board foot-$225 veneer log. This is a savings of $150 on one log by leaving four feet of it in the woods.

These, of course, are dramatic examples, and they do not happen every day. However, other woods practices can, over a period of time, be very expensive. At certain times, we divert a number of larger, better quality logs of some species to our veneer mill for hardwood plywood, depending on production schedules. In one instance, while cutting mixed logs, a timber cutter asked our logging superintendent about the advisability of leaving two feet of wood in a top in order to get a straight log below. He was told that the amount of crook was not critical, since the log would be bolted in the veneer mill. The superintendent knew that because of the mill schedule, and the quality of the log, and that since it was cottonwood, that the log in question would go to the veneer mill. For quite sometime thereafter, crooked cottonwood logs prevailed. Even small suppressed trees which would never get near a veneer spindle were logged with little regard for crook. If you ask woods personnel to be more careful with crook, you will probably get a run of short logs. If you mention the short logs, crooked logs are likely to prevail. Training and supervision are the only sound answers.

Logging crews cannot be expected to sort trees and logs any more than they can be expected to perform pure forestry work. A few months ago, a timber broker bought the stumpage on a large tract above a minimum diameter, by the thousand board feet. He said that they were selecting only the trees that should be cut to leave the stand in good growing condition. When he was asked who was doing the selecting, he replied that the timber cutters were. It can't be done. You and I know what is being selected.

**Inter-company Trades**

We find it advantageous to trade grades and species least desirable for hardwood lumber with companies in production where these logs are more desirable. They, in turn, have logs not suited to their production, which are most desirable for our use. We have traded over 27 million board feet in the
past nine years. One company producing box boards finds it more desirable
to use different grades and species than are used for the production of high
grade lumber. Both companies have some species and grades that are much
sought after by stave or stave substitute producers. By setting up trades
between all three, most efficient utilization of species and grades can be
brought about. The exchange rate, of course, is not always board foot for
board foot, since grade, size, and species greatly affect hardwood sawlog
price. The trades have worked very well for all concerned, as far as we
know. This form of integrated utilization should be explored by other
operators who own timber tracts, or buy stumpage. In such trades, it is
important to know exactly what is being exchanged by each party. Details
are difficult to remember over the period of time necessary to complete such
trades, and these should be in writing. Under these trades, the amount of
outside logs purchased can be greatly reduced, which means much at today's
high stumpage prices. Another advantage of such trades, is being able to
improve timber tracts containing material which we cannot use, but which we
can trade for logs we need.

Outlook For Better Utilization

The number of hardwood specialty uses cannot be expected to increase.
In fact, past history points to the introduction of more substitutes. However,
there are several possibilities for better and more integrated utilization.
The use of more short logs of 6 and 8 feet appears likely. The size and
average quality of the hardwood sawlog is expected to continue to diminish
indefinitely. With the introduction of more efficient, and faster portable
mills, lower grades of logs can be sawed in the woods, where higher value
products can absorb transportation costs. Better and more integrated utiliza­
tion can be practiced on the carriage. Similar to today's cross-tie and
sideboard production, several products can be taken from the same log.
Separation is the key. This trend will allow more separation at the mill,
as well as in the woods. Hardwood log grades will be even more necessary,
and rule of the thumb grades will probably be used by the smallest of operators.
Log trades between companies manufacturing different products are too beneficial
to be ignored for long. The small landowner, and operators without much
capital or timberlands can well be served by hardwood log brokers maintaining
concentration yards for the ultimate in log class separation.

Summary

Indiscriminate logging and marketing is expensive. Integrated utiliza­
tion is good economics and promotes good forestry practices. Improvement
cuts and cleaning operations are often impossible without it. The practice
maintains a variety of forest industries, which, in turn, are necessary
markets for good timber management. To be efficient, this type of operation
must be well-planned, well-marked, and well-supervised. The trend toward
small, short, and rough logs will make integrated utilization not only more
desirable, but mandatory for survival of some operators.
PULPING POSSIBILITIES OF CERTAIN SOUTHERN BOTTOMLAND HARDWOODS

M. N. May

Pine has long been the backbone of the pulp and paper industry in the South, but the usage of hardwoods has steadily grown in recent years. Figure 1 shows the total U. S. trends in softwood and hardwood consumption over the last ten years (1). On a percentage basis, hardwood usage has increased from 12.7% of the total in 1948 to 17.0% of the total in 1956. The economic pressure on increased hardwood utilization is well known. Perhaps somewhat less understood are some of the technical factors influencing this utilization.

Hardwood pulps have both advantages and disadvantages in papermaking, and there are substantial differences in the behavior of the pulps from the different hardwood species. We shall be concerned here with some of the broad requirements of the paper industry, and how some of the southern hardwoods may fit into this picture.

In picking a pulp for a papermaking job, we must first decide upon the paper properties of interest and then consider how well the pulp in question can be used to meet these requirements. In certain instances, the strength properties of the paper sheet are the principal concern, while in other instances the printing characteristics or optical properties may be the primary interest. Pulps with differing properties will be selected as necessary to meet these requirements. As we speak of the ability of various woods to meet certain use requirements, it should be kept in mind, however, that many processing steps can be employed between the tree and the final sheet of paper to influence the properties of the fiber and their resulting effect on the sheet properties. This provides a flexibility of operation which is the heart of papermaking. One selects certain woods for the inherent characteristics of their fibers. One then selects conditions of pulping, bleaching, and papermaking to obtain the desired final product. The flexibility of these operations is such that many different woods may be employed to make a given type of paper. For example, western hemlock, spruce, and fir sulfite pulps in the North, and pine kraft pulps in the South are widely employed to make the same grades of paper. However, certain other pulps are entirely unsatisfactory for this purpose.

It would be impossible for us here to consider all factors influencing pulp selection for all paper grades. However, at the risk of over-simplification, let us consider some of the differences between southern pine kraft pulps and certain selected hardwood kraft pulps and how these differences might influence their selection for papermaking purposes.

Since some consideration must be given to strength in almost any paper application, let us be concerned first with this area. Two paper strength properties generally given considerable attention are tearing strength and tensile strength. Figure 2 illustrates how these properties change with the beating of a typical bleached southern pine kraft pulp. These are tests on
FIGURE 2
SOUTHERN PINE KRAFT PULP PROPERTIES

TENSILE STRENGTH, LB/IN.

CANADIAN STANDARD FREENESS, CC.

BEATING TIME, MIN.

○ TEAR

X TENSILE

□ FREENESS
TAPPI standard handsheets prepared from pulps refined in a laboratory Valley beater. Also shown is the freeness change for this pulp with beating. In a beating or refining operation, certain changes take place in the structure of the fiber which are conducive to the development of fiber-to-fiber bonding. This results in an increase in the tensile strength of the sheet. At the same time that the fibers are being conditioned for better bonding, however, the fiber length is reduced, and considerable debris is created. The improvement in bonding, coupled with the reduction in fiber length, results in a decrease in amount of work required to tear a sheet over a specified distance, thus the so-called "tearing strength" decreases. The creation of debris and other changes substantially decrease the drainage behavior of the stock as beating increases, and the freeness thus decreases.

Pulps are refined to develop certain properties, but this is done at the expense of other properties. To achieve a certain balance of strength properties, we sacrifice a certain freedom of drainage of water from the stock, a point of economic importance because of its influence on paper machine operating speeds, and we consume energy which is also of economic importance.

To summarize, in pulp selection we are concerned first with a certain balance of sheet properties and how the pulp can meet this balance. Secondly, we are concerned with what sacrifice must be made in drainage behavior of the stock and how much power must be consumed in achieving this balance.

In Figure 3, the balance between tear and tensile strength with increased beating is shown for the southern pine pulp in comparison with a number of hardwood bleached kraft pulps. In viewing these data, however, it should be kept firmly in mind that the results can be modified quite substantially by changing pulping, bleaching, and stock preparation conditions. The southern pine pulp is a commercial bleached kraft pulp, while the hardwood pulps are laboratory prepared bleached kraft pulps with the results being taken from the work of MacLaurin and Peckham (2).

Six hardwoods were selected which show some of the variability within this broad class. Three are ring porous hardwoods (the oaks), and three are diffuse porous. This follows the line of demarkation employed by some pulp producers. Although not all are true bottomland hardwoods, they were selected to show extremes of properties within these two hardwood categories. The original reference also gives data on poplar, bay, water oak, post oak, and ironwood.

It can be seen from Figure 3 that the same tensile strength can be achieved from the pine and all of the hardwoods over a fairly broad range of tensile strength. However (although not shown), the maximum developable tensile strength for the hardwoods tends to be substantially lower than that for the southern pine. The tearing strength at a given level of tensile strength is very much lower for the hardwoods than for the southern pine. This is generally, although not invariably, true for hardwoods in comparison with southern pine pulps, and imposes a severe limitation on the utilization of hardwoods when strength is of paramount concern.
Let us now consider some of the other characteristics of the pulps at selected levels of tensile strength. Table 1 summarizes certain pulp characteristics at a tensile strength of 12 lb./in. Here again, the substantial difference in tearing strength between the pine and the hardwoods is evident, but it will also be noted that there is a twofold difference in tearing strength between sweetgum and maple at this level of tensile.

Opacity is a sheet property of considerable interest to the manufacturers of printing papers, and this is an area in which certain of the hardwoods excel. Since opacity is influenced by both the light absorbing and light scattering properties of a sheet, one must be cautious in comparing pulps of different brightness and different levels of beating. These pulps, however, are all bleached pulps of the same approximate level of brightness, and are arbitrarily selected for comparison at a given tensile strength. The two gum pulps are fairly similar in opacity to the southern pine, but the maple and the three oaks are substantially higher in opacity.

The density of a paper sheet is influenced, among other factors, by the extent of bonding between the fibers and by the dimensions of the fibers themselves. In this property, the hardwoods are seen to be quite variable.

The beating time required to develop this level of tensile strength is extremely variable, covering a nine-fold range. This varies considerably even within the principal pulp types, but the oaks tend to require much more power in the development of tensile.

In regard to pulp freeness, it can be seen that considerable sacrifice must be made in drainage behavior of these hardwood pulps in order to obtain the desired level of tensile.

Table 2 shows a similar comparison at a higher level of tensile strength. The same general pattern of differences in pulp properties exists.

One should be rather cautious in attaching great significance to some of the differences which have been mentioned above, since these are, after all, single examples of the various pulps which might be produced from these woods.

Table 3 illustrates differences which may be encountered within a given pulp and wood type. The properties of a second commercial pine kraft pulp and a commercial gum kraft pulp are compared with the properties of the pine and gum pulps already discussed. It can be seen that the second sample of southern pine developed a tensile of 22 lb./in. in slightly less time than the first sample, but with somewhat lower tear, density, and freeness at this level of tensile. The commercial gum sample required substantially more beating time than the two laboratory gum samples to develop a tensile of 22 lb./in., but it had a somewhat higher tear and appreciably lower density. Thus, these additional pulp samples are seen to behave approximately as the previous pulps, but there are also substantial differences which are no doubt due in part to pulping and bleaching. Differences in the original wood sample could also
Table 1

PHYSICAL PROPERTIES OF SOUTHERN KRAFT PULPS AT A TENSILE STRENGTH OF 12 lb./in. 1

<table>
<thead>
<tr>
<th>Pulp</th>
<th>Southern pine</th>
<th>Sweet-gum</th>
<th>Black-gum</th>
<th>Maple</th>
<th>White oak</th>
<th>Blackjack oak</th>
<th>Red oak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tear factor</td>
<td>3.0</td>
<td>1.6</td>
<td>1.7</td>
<td>0.8</td>
<td>1.4</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Opacity</td>
<td>69</td>
<td>72</td>
<td>69</td>
<td>82</td>
<td>77</td>
<td>79</td>
<td>76</td>
</tr>
<tr>
<td>Apparent density</td>
<td>10.9</td>
<td>12.0</td>
<td>11.2</td>
<td>11.0</td>
<td>9.8</td>
<td>11.2</td>
<td>10.0</td>
</tr>
<tr>
<td>Beating time, min.</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td>7</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td>Canadian Standard freeness, cc.</td>
<td>730</td>
<td>650</td>
<td>670</td>
<td>550</td>
<td>670</td>
<td>520</td>
<td>630</td>
</tr>
</tbody>
</table>

1 45-lb. handsheet, 25 x 40—500 basis.
### TABLE 2.

<table>
<thead>
<tr>
<th>Pulp</th>
<th>Southern pine</th>
<th>Sweet-gum</th>
<th>Black-gum</th>
<th>Maple</th>
<th>White oak</th>
<th>Blackjack oak</th>
<th>Red oak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tear factor</td>
<td>2.0</td>
<td>1.1</td>
<td>1.1</td>
<td>1.0</td>
<td>1.3</td>
<td>0.6</td>
<td>1.1</td>
</tr>
<tr>
<td>Opacity</td>
<td>64</td>
<td>63</td>
<td>65</td>
<td>77</td>
<td>75</td>
<td>75-</td>
<td>75</td>
</tr>
<tr>
<td>Apparent density</td>
<td>12.4</td>
<td>14.3</td>
<td>14.6</td>
<td>13.8</td>
<td>12.2</td>
<td>14.4</td>
<td>12.8</td>
</tr>
<tr>
<td>Beating time, min.</td>
<td>17</td>
<td>13</td>
<td>35</td>
<td>31</td>
<td>27</td>
<td>60+</td>
<td>29</td>
</tr>
<tr>
<td>Canadian Standard freeness, cc.</td>
<td>670</td>
<td>430</td>
<td>220</td>
<td>330</td>
<td>430</td>
<td>130-</td>
<td>340</td>
</tr>
<tr>
<td>G.E. brightness (unbeaten), %</td>
<td>85+</td>
<td>82</td>
<td>85</td>
<td>82</td>
<td>84</td>
<td>77</td>
<td>82</td>
</tr>
</tbody>
</table>

145-lb. handsheet, 25 x 40—500 basis.
contribute to these pulp variations. It is extremely important to recognize that processing can substantially influence the properties of pulp obtained from a given wood. Although this possibility is well known within the industry, no one knows what the full potential is with each species. This is an area of study in which we are very much interested, and work is now being planned to establish further the limitations on strength improvement for hardwood pulps.

Before leaving the subject of strength properties, a point of difficulty often encountered with the ring porous hardwoods such as the oaks is a "picking" problem associated with the large vessel segments found in these woods. These vessel segments tend to accumulate on the top surface of the sheet as it is formed, and apparently do not bond well to the other fibers. This most often causes difficulty in offset printing operations where high-tack inks are employed.

Also a point for consideration in viewing the pulping possibilities of various hardwoods is the response to pulping reactions. Table 4 summarizes the pulping conditions employed in the kraft cooks of the various hardwoods which we have just examined for strength. Also included are data from a recent cook in our laboratories on quaking aspen.

Sweetgum, maple, and blackjack oak were cooked under similar conditions, and yielded pulps of approximately the same permanganate number. Permanganate number is an index of the oxidizable material in the pulp and thus is indicative of lignin content. The lower the permanganate number, the lower is the lignin
content. Blackgum was found to respond much more rapidly to these conditions, and it was possible to reduce the time at maximum temperature from 50 minutes to 5 minutes. White oak responded even more readily to pulping; the time-to-maximum temperature was cut from 190 to 170 minutes, while time-at-maximum temperature was cut from 50 to 0 minutes. Red oak also responded more readily to pulping. Here the adjustment was made in active alkali, which was reduced from 25 to 18.5%. The aspen was cooked under an entirely different set of conditions, so it is rather difficult to make a comparison of cooking time.

Table 4

PULPING REQUIREMENTS OF VARIOUS SOUTHERN HARDWOODS

<table>
<thead>
<tr>
<th>Wood Species</th>
<th>Sweet-gum</th>
<th>Black-gum</th>
<th>Maple</th>
<th>Aspen</th>
<th>White oak</th>
<th>Blackjack oak</th>
<th>Red oak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfidity, %</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>20</td>
<td>28</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>Active alkali (as NaOH), %</td>
<td>25.0</td>
<td>25.0</td>
<td>25.0</td>
<td>25.0</td>
<td>25.0</td>
<td>25.0</td>
<td>18.5</td>
</tr>
<tr>
<td>Water ratio (ovendry wood), cc./g.</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>5.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Maximum temperature, °C</td>
<td>174</td>
<td>174</td>
<td>174</td>
<td>170</td>
<td>174</td>
<td>174</td>
<td>174</td>
</tr>
<tr>
<td>Time to max. temp., min.</td>
<td>190</td>
<td>190</td>
<td>190</td>
<td>120</td>
<td>170</td>
<td>190</td>
<td>190</td>
</tr>
<tr>
<td>Time at max. temp., min.</td>
<td>50</td>
<td>5</td>
<td>50</td>
<td>120</td>
<td>0</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Blowdown time, min.</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>5</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Total cooking time, min.</td>
<td>255</td>
<td>210</td>
<td>255</td>
<td>245</td>
<td>185</td>
<td>255</td>
<td>255</td>
</tr>
<tr>
<td>Unscreened yield (unbleached), %</td>
<td>44.9</td>
<td>49.4</td>
<td>45.3</td>
<td>52.7</td>
<td>49.5</td>
<td>41.5</td>
<td>50.2</td>
</tr>
<tr>
<td>Screened yield (unbleached), %</td>
<td>44.8</td>
<td>49.1</td>
<td>45.0</td>
<td>52.6</td>
<td>49.3</td>
<td>41.4</td>
<td>48.1</td>
</tr>
<tr>
<td>Permanganate no.</td>
<td>13.6</td>
<td>13.7</td>
<td>12.2</td>
<td>7.8</td>
<td>12.2</td>
<td>13.5</td>
<td>12.9</td>
</tr>
</tbody>
</table>

The pulp yields (on a weight basis) vary substantially, with the aspen having the highest yield in spite of the fact that it was cooked to a substantially lower permanganate number. For purposes of orientation, the unbleached yield on a southern pine kraft pulp cooked to a bleachable grange would be approximately 45%.
Since wood is generally purchased by volume, it is of interest to convert these yields to an approximate volume basis. This has been done in Table 5, using wood density data accumulated from a number of sources by Isenberg (3). It is seen that the yield from aspen is definitely on the low side. The yields from the oaks are substantially higher than those for the aspen, maple, or gum.

Another point for consideration in reviewing the pulping possibilities of hardwoods is their response to bleaching. It is a little difficult to compare bleaching characteristics of pulps varying in permanganate number, but qualitatively the data of MacLaurin and Pickham (2) indicated sweetgum and blackjack oak to be moderately difficult to bleach, while the blackgum and white oak pulps were fairly responsive to bleaching. The red oak and maple were intermediate. Unpublished data from our laboratories on other samples of sweetgum, blackgum, blackjack oak, and red maple indicate that these species can be readily bleached to the 86-89 brightness range by multi-stage bleaching with chlorine dioxide, as is now widely practiced.

In summary, when one considers the pulping possibilities of woods, one must consider first the paper properties of interest, and how the pulps from these woods may meet these properties. Beyond this first analysis, there is a whole spectrum of questions influencing the economic suitability covering response to pulping, bleaching, and the adverse effects of stock preparation. In spite of the grave dangers of generalizing in such a complex field, one can usually say that the hardwoods as a class exhibit certain strength deficiencies. The oak kraft pulps, as a general group, seem to be quite resistant to the development of fiber-to-fiber bonding through beating. This is manifested in substantial power requirements to develop tensile strength. This difficulty is not entirely confined to the oaks, however, and a number of other hardwoods show similar tendencies. The hardwoods as a class also tend to be slow draining. This probably stems in part from the presence of relatively large amounts of short fibered cells, but is further aggravated on beating by the creation of high-surface-area-debris.

These disadvantages are usually offset by good formation resulting from the relatively short fibers, and generally good printing characteristics stemming from high bulk (when beating is minimized), good ink receptivity, and high opacity (particularly for the oaks).

The hardwoods as a class respond readily to kraft pulping, but some respond much more readily than others. Yields are in general comparable with, or somewhat better than, those from southern pine. Kraft hardwood pulps respond to bleaching, although again there is some variation in response between species.

Of the many southern bottomland hardwoods available, the gums are by far of the greatest commercial importance. This stems largely from their relatively good strength properties, and from ease in processing. The oaks are difficult to bark, and their very high density, Table 5, causes some problems in chipping. These problems, coupled with strength deficiencies and picking difficulties, have severely limited their utilization.
Table 5

WOOD DENSITY

<table>
<thead>
<tr>
<th>Wood Species</th>
<th>Sweet-gum</th>
<th>Black-gum</th>
<th>Maple</th>
<th>Aspen</th>
<th>White oak</th>
<th>Red oak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood density (oven-dry weight per green volume), lb./cu.ft.</td>
<td>27</td>
<td>29</td>
<td>31</td>
<td>22</td>
<td>37</td>
<td>36</td>
</tr>
<tr>
<td>Pulp yield (screened, unbleached) (weight basis), % (Table 4)</td>
<td>45</td>
<td>49</td>
<td>45</td>
<td>53</td>
<td>49</td>
<td>48</td>
</tr>
<tr>
<td>Pulp yield (volume basis), lb./cu.ft. green volume</td>
<td>12</td>
<td>14</td>
<td>14</td>
<td>12</td>
<td>18</td>
<td>17</td>
</tr>
</tbody>
</table>

In spite of the limitations of the hardwoods, however, their use must increase. As the demand for wood rises in our rapidly growing industry, the hardwoods must inevitably be used to fill this demand. New processing methods will undoubtedly be developed to increase the potential of the hardwoods for papermaking. There may also be some relaxation of existing strength specifications built around the high strength softwood pulps. Be this as it may, however, we will unquestionably see increased hardwood utilization.

Literature Cited


DISCUSSION

In many respects the pulping characteristics of southern cottonwood are similar to those of aspen; it's very difficult to find data that are truly comparable. You find variations in cooking procedures, in bleaching procedures, in how much...
the pulp has been deliquified in pulping. All these things impose characteristics on the pulp in addition to the original potential of the fiber. I picked the particular group of pulps discussed in the paper because they were cooked under similar conditions. I have no data on the absorbent characteristics of hardwood pulps, but I would expect them to be good. In most instances fully bleached kraft hardwood pulp would not be similar to the properties of neutral sulfite pulp. The neutral sulfite process tends to leave more of the hemicellulose in the pulp, which appears to be conducive to good fiber-to-fiber bonding; so for pulps of approximately the same yield from the neutral sulfite and kraft processes, the sulfite process would make paper more dense, a little better bonded, a little higher in tensile strength, bursting strength, and a little lower in tear strength than kraft pulp from the same wood. The lot of commercial gum was a commercial pulp sample which was sent to us, and I would hesitate to say what species it might contain. It would probably be predominantly sweetgum and blackgum, but most paper mills consider all diffuse porous hardwoods in the gum category, so there could be quite a variety.
Brunswick Pulp and Paper Company is located in the coastal flatwoods of southeastern Georgia. Hardwoods make up forty percent of annual mill requirements. All local species of hardwoods are accepted save scrub oaks and live oak. To many we appear to be in an enviable position as regards forest utilization and hardwood forest management.

Conversely the year-round demand for hardwood pulpwood presents many problems. Weather and seasons have a profound effect on hardwood logging. Extra long hardwood runs in the mill coincidentally seem to occur during extremely wet periods. The ever increasing demand for fresh wood precludes storing more than five or six days supply of hardwood on the mill yard and none in rail yards.

All logging is done by independent contractors who operate in either pine or hardwood. Even though hardwood stumpage costs the producer less than half that of pine he much prefers to cut pine pulpwood. The reasons are many, some very obvious and some not so obvious.

First I would like to acquaint you briefly with the type of hardwood site with which we are concerned. Approximately 20 percent of the total forests within our operating area are classified as bottomland hardwood sites. Geologically the area is part of the Atlantic Coastal Plain and displays very little relief in topography. The following physiographic sites are recognised:

1. Riverbottom sloughs, swamps, and depressions within major alluvial bottoms, principally the Altamaha and Comalgee Rivers.

2. Runs, or drainageways sometimes called strands or streamers. These vary considerably in size from less than one chain in width to one mile wide. As the size of these runs increase or where two or more small runs converge into a single wide drainageway they grade into broad basins or deep swamps. These are usually situated between tidewater and upstream runs.

3. Bays: relatively large flat to depressed areas with slow surface drainage and highly organic soils.

4. Ponds: small, saucer-like depressions with no outlet for surface drainage.

The predominant type is the run or swamp drainageway. Stand data show species composition to be complex but the bulk of the volume is composed of comparatively few species. On company lands blackgum and tupelogum make up 43% of total hardwood volume, bay, poplar, and magnolia 21%, and the water,
willow, and laurel oaks 20%. Sweetgum is predominant in the remaining 16%.

Practically all hardwood pulpwood in our area is coming from regeneration cuts or clear-cutting operations. Mature or depleted stands are being harvested so that an existing understory of reproduction will be released or a new stand started. The better pure stands of blackgum and tupelogum are being left for future cutting. At the urging of Mr. Putnam we are going to try thinning some of those well-stocked stands.

All bottomland stands on company lands have been mapped and given a cutting priority rating. Annual cutting schedules are prepared but to date we have been unsuccessful in completely harvesting in an orderly manner specifically scheduled stands. It is considered an accomplishment if all hardwood cutting can be confined to a portion of any stand with a high cutting priority. Quite often it becomes necessary for the pulpwood producer to leave his area of cutting before it is completed. Every attempt is made to return and complete the cut but considerable time may elapse before all circumstances are right. This is the greatest difficulty encountered in our hardwood management program. Intensive hardwood management will not materialize until we can further weatherproof our pulpwood logging operations.

Brunswick made its initial step 10 years ago toward weatherproofing pulpwood logging. At that time a road construction program was begun. Primary hauling roads have been constructed at approximately one mile intervals on all company lands. Any sequence in hardwood pulpwood cutting would be impossible without an adequate road system.

Another type of haul road is necessary for logging pulpwood in major, alluvial riverbottoms. Here temporary haul roads lead down into and meander within the bottoms. Such temporary roads can only be used seasonally and are periodically washed out by floods. These are rebuilt and used only so long as cutting is necessary in that area.

The primary roads are located on the higher pine land but do cross and in many instances closely parallel swamp edges. A gap still remains in servicing all hardwood areas and it is generally necessary to use old woods trails to transport wood from the log landing to a primary road. Occasionally the primary road is close enough so that hardwood logs can be skidded to a roadside landing. This gap in the wood transportation system is our most serious problem. It is not practical to construct enough primary roads to serve each portion of every hardwood stand, so the solution seems to lie in improved logging equipment and methods.

An adequate network of primary hauling roads has encouraged many producers to begin using tandem trucks or trucks and trailers capable of moving 5 to 6 units of wood per load. Some producers still retain the smaller 2 ton trucks which haul only two units per load.
Many producers are equipped with crawler tractors of the 35 horsepower class. Some 50 horsepower tractors are used by large producers who cut more consistently in swampy pine and hardwood areas. For hardwood logging a tractor mounted winch is also standard equipment.

The actual logging and preparation of hardwoods for pulpwood include all those problems encountered in producing pine pulpwood plus many more. Because of the inherent nature of the timber and the more severe working conditions more time and labor is required per cord of wood produced. Equipment repairs mount and equipment life decreases more rapidly under continuous hardwood logging. With only one or two exceptions all producers are shifted quite often between pine and hardwood. Too long of a hardwood chance will force disgruntled labor into changing jobs for one cutting pine on the hill. Unless favorable conditions prevail a producer who normally would cut 80 units per week on pine will only produce 65 to 70 units per week on hardwood.

All felling of hardwoods is done with the one-man chain saw. Directional felling is necessary to avoid hang-ups and to facilitate skidding. Much jump-buttting is required since so many trees have hollow butts, butt-swell, or butt-rot. Moderate butt-swell can be eliminated by extra trimming after the log has been skidded to the landing. Some producers simply eliminate butt-swell by cutting high stumps. This practice is not encouraged when not necessary. No butt-rot or hollow is acceptable in bolts smaller than 10 inches in diameter. In larger bolts up to 50 percent of the diameter can be hollow or dry; no burned hollows are accepted.

All topping and some trimming of larger limbs is also done by the cut-down man with the chain saw which slows down felling. If each hardwood tree is properly utilized considerable more limbing and trimming is required than for pine. A shoddy operator will leave much wood in stumps and poorly trimmed tops. Many forked-topped trees can be trimmed out and used to the minimum five inch top accepted.

Skidding hardwoods is made more difficult by virtue of the terrain as well as of the trees. Water, brush, and unsound footing can be extremely troublesome. Crooked trees, forks, and flare-buts also create difficulties. Average skidding distance for a hardwood operation must of necessity be greater than for pine since log landings cannot be as frequently located. It is not uncommon during wet periods to find some producers skidding hardwood a quarter of a mile. Landings must, except when very dry, be located on a ridge or knoll, or on the pine hill adjoining the swamp.

Pallets are used by practically all of our producers. Empty pallets are unloaded on the landing. Logs are skidded and deposited adjacent and parallel to the pallets. Logs are cut into bolts with the wheel saw.

The acceptance of hardwood bolts up to 34 inches in diameter has made some type of loader essential. All crews now have homemade loaders mounted on an old tractor or truck for single stick loading. An old car axle, a
winch, and a motor are usually mounted on the rear of an old truck chassis. Producers now enjoy cutting large trees for pulpwood as fewer pieces must be processed to make a load.

Crawler tractors and felling crews can operate in many bottomland stands during fairly wet periods. But during these periods it is physically impossible for trucks and more especially trucks and trailers to leave primary hauling roads to reach the landing and pick up the loaded pallets. The brow may be anywhere from 50 yards to 1/2 mile to the nearest roadside. This is the gap in the transportation system mentioned previously.

Several approaches are being made to bridge this gap. A fork lift built on a truck chassis which will transport one loaded pallet of wood over boggy woods trails has met with considerable success. A loader is also built in. The fork lift sets limitations on the size of pallets which can be used. With larger trucks producers have begun using larger pallets which make the fork lift impractical.

Ten-wheel G. I. trucks have been stripped and modified to pick up, carry and unload one pallet of wood. Pallets roll over pins and bushings from a tractor track-laying system. Some G. I. trucks transport two pallets to the roadside. This type of transport also has limitations and is also a considerable investment.

A track laying cart such as the Bombardier cart made by Bombardier Snowmobile Limited, Valcourt, Quebec seems to be a practical solution. In conjunction with carts we are presently experimenting with the new tractor mounted Hiabob Loader. This loader is capable of loading stacked wood from the ground onto the cart and to reload from the cart into pallets placed on the primary road. Of course the ultimate would be a track laying cart with a pallet working with the Hiabob loader. But so far it has been impractical to mount a pallet on a cart.

Further weatherproofing of bottomland hardwood pulpwood operations is our most pressing problem. Solutions will be found, and there will be many, for it is recognized that no one method will work under all conditions encountered in pulpwood logging.

DISCUSSION

We use everything but live oak and scrub oaks like blackjack and turkey oak. The price of hardwood pulpwood at the wood yard is about $15.00 per unit of 168 cubic feet; stumpage averages around $3.00 a unit. We get most of our hardwood from other land owners. We have a planned cut on company lands. The bicycle saw is the standard saw at the landings, and there have been many fingers and hands cut off using them. It's a dangerous saw, and the producers seem to take practically no safety precautions. Workers are particularly bad about starting the saw by pulling on the belt, and they get their fingers caught in the pulley. We take bolts up to 34 inches diameter; we have a splitter at the mill. The large bolts are mostly water and willow oak for which we have no other market; we were
girdling that type of material until we got the splitter. We have about 100 acres of experimental hardwood plantations, including most of the red oaks. We have sold lots of logs, although there is a limited market. If you can get $30 per thousand for choice veneer logs, that's a good price. We have had combined operations in which the logger would take the butt log and the pulpwood operators the rest, and it worked very well; we prefer that type of operation where we have the logs. We utilize no cypress. The length of time pulpwood bolts can be held in storage depends on the season. All our wood is shipped within a day or two from the time it is cut. It could be held longer, but we like to get fresh wood.
Almost 30 years ago, I enrolled in the first forestry courses ever given here at LSU, my Alma-Mater. I think any man enjoys returning to the college from which he graduated, especially to participate in a meeting such as this one. I want to congratulate the faculty, President Middleton, and the alumni of the forestry school, on the fine job that has been done through the years in making this one of the best forestry schools in the south. Many people, such as Gordon Markworth, Ralph Hayes, and lately, Paul Bums, have had a hand in this steady progress and in the development of these symposiums which proves by your attendance that they are accomplishing much good. Also, I want to congratulate you professors who are saddled with the extra load of preparing for this meeting and the selection of subjects and speakers, on doing a very fine job each year.

I am most happy that you have selected this subject of "The Management of Bottomland Forests" as your theme for this meeting, because the subject is growing more and more important here in the South, particularly on the Mississippi River and its tributaries. This interest is primarily based on values of the species of hardwood with which we foresters are having to deal and actually which we know very little about. Up until the last 10 or 15 years, there have been a great many saw mill and veneer specialists who have known about the individual species, but very few technically trained foresters have been let in on the secret. The secret has been the value of forest products produced and the multiple uses of these hardwoods. To be perfectly frank, we still have a long way to go and much research, sweat and toil before we know as much as the men who have been using these hardwoods through the years. These pioneers of the past knew much and they were not inclined to pass it around to young, inexperienced men.

The subject that I have been assigned "The Effects of Pulpwood Marketing on Saw Log - Veneer Management", is not particularly to my liking for two reasons. One, it is a controversial subject, and two, I cannot give you the solution, I can only make observations and suggestions. The first ten years of my working experience were spent in the Appalachian hardwood country. My first bottomland hardwood experience was in Florida, and since that time, it has been in Mississippi. The last six years have been confined entirely to bottomland hardwood management and by now I know that there are some complex problems, many of which will be brought out at this meeting. I hope you will pardon the personal reference but I bring it out because I wish to base my statements on this subject, on the facts as I find them in connection with the company for which I work, Mississippi Products, Inc., Jackson, Mississippi. Many other hardwood users have a history somewhat similar to ours. This company was formerly known as the Adler Manufacturing Co. and was located at Louisville, Ky. Ten years ago, the president of our company, Mr. George Huth, decided to move the plant for several reasons. One of the major reasons being the matter of the availability of certain hardwood timber which the company used. A complete survey of the whole south was made and the plant was located at Jackson. We are proud that it is the largest, most modern, most complete woodworking plant in the United States. We manufacture quality television, high fidelity, phonograph, speaker, and tape recorder cabinets for the
electronics industry; sewing machine cabinets, kitchen cabinets, library furniture, desks, furniture items, veneer, panels, lumber, dimensioned stock and Nu-Tex. Celebrating our tenth anniversary at our new home in Jackson, Mr. Huth recently prepared a booklet entitled "Jackson's $50,000,000 a Year Industry". Some of you have seen this publication. Certainly a plant of this type is important, not only to the economy of Mississippi, but the south as a whole. It is one of Mississippi's largest industries, employing over 1700 people. And to substantiate this figure of 50 million dollars, I refer you to the figures in the booklet. Certainly 1700 employees create more people, more income and more business in general, in whatever town or state it may be located and this is true of our company. No one would like to see a concern of this importance put out of business, I am sure.

I think it is obvious that indiscriminate cutting of pulpwood can have a bearing on our own and many other wood using industries throughout the South. Certainly both sides should be thinking and planning about where their wood is coming from, or there will be real problems. It is about these obvious problems that I wish to talk.

Mississippi Products is a fully integrated operation owning its own timber lands. Our motto is "From the Woods to the Finished Product". When I went with this company, I was told that we wanted to buy at least half our raw material from the farmer and timber land owner, in our purchase area of approximately 100 miles around Jackson, and that we would purchase enough land to furnish the other half of our needs. This was done, and yet half way through our acquisition program, a new development became obvious. The pulp mills were beginning to change from the purchase of pine pulp to the purchase of hardwood timber. The records will bear this out. Most of the pulpwoods being used were soft hardwoods or the species that we had to depend on for our veneer log and sawing lumber usage. This was the first sign of the effects of pulpwood marketing on hardwood sawlog-veneer management, although the same procedure had taken place in the management of pine lands many years ago.

In 1954, the Stanford Research Institute issued its report, "America's Demand for Wood" and at about the same time, the U.S. Forest Service began to release its data on the timber resource review. We foresters here in the South have watched to see just what effect the predictions would have, as an expanding pulpwood economy was predicted for the South. Today, we see new pulp mills going up all over the South. Certainly a pulpwood economy is a definite promise to the future use of the South's forests. It is here and it is here to stay. So that we who use sawlogs and veneer logs may as well prepare ourselves to cope with the situation. It is up to each company to protect its investments and the future of the people who are depending on it for a livelihood. I do not think that it is an impossible situation but I do think that some adjustments are going to be necessary between the various users of wood, because in many ways each side is dependent on the other. I was interested in the statement by Weyerhaeuser Timber Co., and particularly as it might apply to our own company. You might like to consider these same facts in connection with your own company as recorded on page 9 of the report "America's Demand for Wood".
1. Bigger markets lie ahead, as a result of the expected growth in size and activity of the United States economy. In the case of my own company, I think the market will continue for the various cabinets, furniture and other products that we manufacture. It is obvious that we will have to compete (and this is a highly competitive business), and if we are to remain competitive it is necessary that we secure the raw materials that we use at reasonable costs. Stumpage prices are already getting too high, and like the pulp people, we must have reasonable stumpage rates if we remain competitive in our field.

2. No part of the various forest-products industries has been immune from inroads by competing materials and this competition will probably grow increasingly keen. Like the pulp mills, our type of plant is constantly faced with competing materials such as metal, plastics and even hardboard, which we are using to make print cabinets. With a fine engineering and sales organization, I feel confident that our company will be able to hold our own with competing materials and I base that on the fact that the American people have always lived with and respected fine woods in connection with their home and place of business. They will continue to use wood but we must advertise wood and train the younger generation about the beauty and dependability of fine wood.

3. The various forest industries are already alert, and will be increasingly alert, to the possibilities of improved forestry and logging practices and new technical developments for harvesting the whole forest crop, and for using all the material that comes to the mills from that crop. In the case of our own company, we are alert to the need of improved forestry and logging practices, and for complete utilization of all these products from our sources of supply. Our wood waste is going into a new product that we are making, called Nu-Tex. When we harvest timber from our own lands, or our neighbors land, we are bringing to the plant that wood that we can use and selling the products not wanted at the plant. This includes the tops and limbs which are going into pulpwood. We are also marking and selectively cutting, pulpwood from our lands. We are glad to have this market.

4. As competition and technical developments proceed, a larger volume of products, will be made from about the same quantity of wood, so that available timber supplies will stretch much farther than would have seemed possible in the past. With further research and technical development, I think that our company will probably be able to produce a larger volume of products from about the same quantity of wood. However, this effect will not be as pronounced as it will be with other woodworking industries.

Because our hardwood forests in the Mississippi Valley have been repeatedly cut-over and with very little management of the proper kind, these four items I have discussed above immediately raised the question in my mind of where is the type of log we use going to come from? We have just finished a forest survey in Mississippi and preliminary data show that there has been a decline of 29% in hardwood sawlog volumes since the last survey was made ten years ago, and in the immediate territory in which we are located, this decline runs as high as 40% in some survey areas. I think most of the hardwood group who are present and familiar with the matter, are very much concerned with the trend as they see it at this time. Quality hardwood logs are not available and they see their anticipated future cut (trees 6 inches to 20 inches in diameter) being rapidly cut for pulp production. I say rapidly cut because some mills use near a million board feet of pulpwood a
day. Most hardwood saw mills and veneer mills can run a month on that much volume. I can tell you frankly, we hardwood people are very much concerned about our future supply of logs, which are being cut before it has an opportunity to reach sawlog size. I have talked to many foresters and sawmill operators and these are the questions that are bothering them and about which they are most concerned.

1. Clear cutting of solid stands of sweetgum, tupelo, and yellowpoplar. Presumably on areas being cleared for agricultural purposes but which the forester and the land owner himself knows is not suitable for that purpose. I know that in my territory and many counties with which you are familiar, less than 1% of the gum pulpwood is marked for a selective cut. I have heard no one condemn the harvest of gum pulpwood when it is harvested on a management basis. Many foresters in the hardwood business believe that there are enough gum stands which need cutting selectively to furnish the pulpwood demand. We, and many others, are marking gum stands for pulpwood cuts on our own land, and it is a fine thing for we land managers, but clear cutting, no. That should stop.

2. Small owners and farmers owning small timber tracts run into emergencies and decide to clear cut their hardwood timber for pulpwood. It is very doubtful that lands cut in this manner will ever produce any more large size timber. Lands cut in this manner usually result in eliminating the seed source so necessary to perpetuate gum, poplar and other desirable species. The result is usually a return to undesirable species. Where these stands are cut so destructively, they are opened up to vines and weed species creating fire hazard. Fire, of course, results in complete loss of the reproduction left.

3. The range in price between pulpwood and sawlog-veneer is said to be the incentive which will encourage land owners to grow larger size logs. There is no doubt in the case of many pulp mills, sawlogs will be grown on their own lands and thus help plants needing saw and veneer logs. There may be individual cases where some of their lands will be managed for the production of these higher value products which are more profitable in some cases. It is obvious that the various types or systems, of management for pulpwood company lands, will have an effect on the production of sawlogs. Many of the companies are already thinking about this problem, in connection with the management of their hardwoods, which they have overlooked in the past, or done nothing. At the present time, many large land companies have decided to manage their bottomland hardwoods and are doing a fine job. This is what we all want to happen. So far, most of them are thinking in terms of selective cutting, but later they will try out coppice and other systems similar to the trial and error methods we have made in connection with pine management in the past. Certainly this is a step in the right direction because if ever any type of timber needs intensive management, it is the bottomland hardwood types. Research on this type is far behind that of pine and research is necessary in order to put these millions of acres to work growing the kind and type of hardwood to which they are best suited. As you have already heard, or will hear at this meeting, soil and site are the determining factors in the kind and quality of timber to be grown on these bottomlands.

4. Is the farmer or small land owner going to grow saw and veneer logs? They will in some cases provided emergencies don't come up and they want to clear cut and receive all the revenue they can get. Once their land is clear-cut, they
will probably never attempt a 40 to 60 year growing period in order to produce higher valued timber. If encouraged to cut on a selective system they will grow some larger timber. In any case, they will certainly need education and encouragement if they are to grow sawlogs or veneer.

I think I have pointed out that the present cutting of hardwood pulpwood is definitely having an effect on the future management of hardwood timber lands for the production of the large size timber. I think it is obvious that destructive cutting methods in this hardwood type must stop. The companies as well as the sawmills, are going to have to provide better management, not only on their own lands but lands they are cutting for other people. We have seen this same thing happen (incorrect methods of cutting) in our pine forests and though it has taken a long time, we have seen the situation corrected to some degree and further progress is being made all the time. All of us must recognize that hardwood timberlands must be managed even more intensively and carefully than pine lands, on our own lands, and the farmers lands which we are cutting. The quicker all of us get busy and stop destructive cutting practices, the better it will be for all concerned, for most of our problems are mutual and the right way to manage timber is what we all want. There is a right way to manage and cut bottomland hardwood timber. Let us do it right the first time.
Being a young hardwood forester, spending my whole time since I got out of forestry school working in hardwoods, I'm very much concerned about what I would be doing if I should be in the sawlog-veneer management field 35 years from now, considering the present cutting trend. Not just because of the pulpwood men, but also because of what is being done by some of the sawlog and veneer men. We marked last year about a million board feet for private land owners and brought it to the plant. You know how that works? The producer, when he couldn't buy a particularly good stand of timber, would come in here and say, "Mac, So-and-So out there has a pretty good stand of timber and it needs marking. And then I'd go to the landowner and set him on a forest management program, mark his timber for him, and buy it. But I only heard about it when the producer couldn't buy it otherwise. If he had had his way, it would have been clear-cut, and all we would have seen would have been logs coming to the plant. WE—not just the pulpwood people—have got to sell forest management. You fellows that are oak men have been saying "Well, the pulpwood men are not hitting me yet." And that's right, but it won't be too long, and you'd better educate those private landowners first.

All these comments I'm making, by the way, are not about company lands. Company lands are managed by foresters and eventually all of you will be managing your hardwoods; I'm not worrying about the companies. We are actually buying marked gum veneer logs from two pulp companies right now. They are managing their own lands correctly; what I'm worried about are the lands of the small private landowners. You notice Mr. Squires' paper said 50% of our wood is supposed to come from the private landowner. Twenty years from now when this thing really gets bad, I don't know where we'll get our wood if we don't change these cutting practices now. We sawlog men had better get on the ball and educate the landowner to the fact that he can make MORE money from his timber lands by managing them correctly all the way through. We've got to do our part; it is imperative that we do our part.

The state and federal agencies are of course vitally interested. You already have the educational facilities, public relations men, power, and set-up. Give the same educational push, and do it a little faster. It has been done for pine.

The pulpwood men, of course, should be just as concerned as the rest of us. The temporary super-abundance of hardwood pulpwood won't last too long, then they will be selling hardwood management just as they are now selling pine management—and it is a lot easier and more profitable to sell timber management to a man with timber than to a man with bare land.

As I see it, this is a problem facing every man in this room, which we ought to face up to in a hurry. Really this pulpwood business is wonderful. To go into a stand of timber and take out the sawtimber that should come out, and then to turn right around and take out the smaller trees, too, which should come out.
Fellows, it's nice to go into the woods and have that opportunity for good management. We have some on our own lands, and I'm grateful for it. But I'm not grateful when I see a nice young stand of timber clearcut by someone with no thought for the future, just because the landowner doesn't realize what is being done to him.

Now I realize that Mr. Squires is a good diplomat, and he saw that it went along pretty smooth, whereas I slapped right into this thing. But I'm really vitally interested in it. When I was with the Mississippi Forestry Commission I wrote such articles as "You Wouldn't Sell a Fifty-Dollar Pig for Ten Dollars, Would You?" And they were published in the papers in the Delta District. I don't know that it did too much good, but we got to a few; we just need a lot more of it.

DISCUSSION

I think one of the biggest deterrents to management for high quality sawlogs for a small owner is the lack of market for small quantities of such logs.
The title of this paper is somewhat misleading. Not only would it be presumptuous of me, but time would not permit me to cover the entire field of logging residue utilization. What I am going to do, of course, is discuss some aspects of the problem which are under study by the Forest Products Research Division of the Michigan College of Mining and Technology.

By way of furnishing you with some background information with which you can evaluate what I have to say, I would like to take just a minute to point out that our Forest Products Research Division is unique in that it has a section devoted entirely to research in Timber Harvesting. The justification for the inclusion of such studies under the general heading of Forest Products Research is perhaps nowhere better illustrated than in our current work in the field of hardwood logging residues utilization. Because a major deterrent to the use of logging residues seemed to be the difficulties inherent in extracting them from the forest, the project was initiated by the Timber Harvesting section. It was apparent, however, that the ultimate utilization of this material would influence the character of the harvesting methods employed, so the problem has progressed from timber harvesting to studies of ways and means of producing marketable products from the material which is left behind by hardwood sawlog loggers.

This project was undertaken in 1955 with the co-operation of the Lake States Forest Experiment Station of the United States Forest Service. At that time, we felt that we were looking quite a way into the future, toward the time when the users of hardwood fiber would be eyeing logging residues as a potential source of raw material. We felt that it was a function of a publicly supported research agency to anticipate future questions and work toward being ready with answers when they were asked. As so often happens, time has telescoped on us, and now, in 1958, we find ourselves beginning to feel the pressure of what we had thought would be future questions, and reasonable answers are only beginning to be within sight.

Resource Survey

Before we go any further with this discussion, let us take a look at hardwood logging residue in relation to the total requirements for hardwood fiber. The question we asked ourselves when we first thought about undertaking this project was, "Is there enough of this material being produced to make worth-while a detailed study of ways and means for harvesting it?" The available literature did not provide satisfactory answers. About all we could find were general statements estimating that approximately one-third of the volume of a tree is left in the woods. Before we could formulate plans for the harvesting of residue material, we had to have not only more accurate, but also more detailed information. Accordingly, a survey was
conducted during the summer of 1955 to provide answers to the following questions:

1. **What volume of residue is left in the woods per thousand board feet of merchantable material removed?**

2. **What volume is left per acre in cuttings of various intensities?**

3. **What is the effect of (a) species, and (b) tree size on the volume of residue?**

4. **What is the character of hardwood residue? In other words, in what forms and sizes does it occur?**

To get the answers to these questions, we made detailed measurements of the residue developed in the harvesting of 500 hardwood sawlog trees in ten widely separated locations in the Upper Peninsula of Michigan. Practical considerations dictated that some limits of size and potential utilization be placed on how much of each tree should be included in the survey. The limits chosen were as follows:

1. **No piece smaller than 2" in diameter outside the bark would be considered.**

2. **No piece shorter than 1 foot in length would be considered.**

3. **Since we were interested in the amount of wood fiber which is potentially available to industry, all volumes would be expressed as "inside bark," and deductions for cull would be made whenever cull could be observed.**

4. **All residue would be considered as usable in essentially straight, surface-clear pieces, lengths to the nearest whole foot which could be cut out. This consideration constitutes a limit in that it contemplates relatively high-value use of the fiber. If a potential user has raw material specifications which are less stringent, he can consider the figures developed by the survey as minimums, and can expect an over-run inversely proportional to the quality of his raw material.**

5. **With the thought in mind that forest management should become more widespread as time goes on, it was felt that the data developed would be of more significance if measurements were taken only in managed stands in which trees were marked for cutting.**

As soon as the survey was underway, it became apparent that there are two distinct classes of residue material on any logging operation. One is that which is developed because of the form and character of the tree itself, and consists of limbwood, top-butts, defective portions of the bole which were cut out, and long-butts. The other is that which is a function
of the logging operation. This class includes trees pushed over or broken off by the trees being felled, trees cut in road and trail construction, but which are too small to be utilized, and merchantable logs and trees which have been cut and for one reason or another left behind when the operation is finished. Class I is, of course, predictable with greater accuracy than is Class II.

Time (space) permits me to present to you only the most significant of the several interesting tabulations of the data collected in the survey, namely the expression of the volume of residue which is developed per thousand board feet of merchantable material, by species. In this connection, it should be noted that two expressions of merchantability are possible—that amount which was actually utilized, and that which would be recorded by the timber cruiser under the heading "Gross Volume." It is the latter definition which has been used, because it permits easy adjustment of these data to any local conditions of cut or utilization standards.

TABLE 1.

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>LIMBS</th>
<th>TOP-BUTTS</th>
<th>LONG-BUTTS</th>
<th>PARTS</th>
<th>TOTAL</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HARD MAPLE</td>
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<td>11.6</td>
<td>9.2</td>
<td>.4</td>
<td>59.4</td>
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<td>YELLOW BIRCH</td>
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<td>10.9</td>
<td>2.5</td>
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<tr>
<td>SOFT MAPLE</td>
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<td>10.0</td>
<td>3.1</td>
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<td>RED OAK</td>
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<td>11.1</td>
<td>5.5</td>
<td></td>
<td>57.1</td>
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<tr>
<td>BEECH</td>
<td>84.5</td>
<td>14.3</td>
<td>1.9</td>
<td></td>
<td>100.7</td>
</tr>
</tbody>
</table>

Cubic Feet

1 Volume inside bark.

The similarity between species, with the exception of Beech, is of interest, and reflects the similarity in growth and form characteristics.

For those of you who are interested, a detailed report on this survey is available for the asking. In the absence of a detailed breakdown of the data, I can give you a rule-of-thumb to remember: For each thousand board feet (gross volume, Scribner Decimal C) of northern hardwood logs harvested, there will be created the following amounts of bark-free wood:

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Regional and National Significance

Can the results of this survey be applied here in the South? The answer, I believe, is "Yes — with modifications." It is "Yes" because with a few exceptions hardwood trees are similar in growth from wherever they are found, and "with modifications" because longer-stemmed southern hardwoods will reduce somewhat the ratio of residue volume to merchantable volume. Lacking a similar survey in the South, a general knowledge of the regional differences will permit reasonable estimates.

Now we come to the answer to the initial question — "Is there enough of this material being produced to justify a detailed study of ways and means for harvesting it?" Applying the figures I have just given you to the national estimates of hardwood sawlog production given in the Stanford Report, we find that there is currently being produced enough hardwood logging residue to satisfy 120% of the present hardwood pulp requirements! The answer is clearly "Yes." The magnitude of this potential resource not only justifies, it demands research leading to its complete utilization.

Skidding Study

We know that we are dealing with a resource of considerable potential importance. We know it consists mainly of sound wood fiber. It is a fire hazard, and the landowner ought to be glad to get rid of it for little or nothing. Why don't we start bringing it in to the mills and put the conventional pulpwood producer out of business, at the same time leaving the standing trees to grow up to become sawlogs? The two chief reasons, of course, are: (1) it is in a form which defies economical handling by conventional means, and (2) it all has bark on it, the removal of which makes the problem of debarking conventional pulpwood seem like child's play.

Let us consider the problem of handling. Our studies have shown that the distribution of logging residue in a selectively cut stand is on the order of two cords per acre, and it is scattered over as many as ten locations per acre. When you take hold of a hardwood top to move it, you find that you have something which is large in bulk, but low in volume of usable product. The first job is to concentrate enough of this material in one spot to permit economical breakdown into some saleable, transportable product.

Since the problem seemed to be one of creating large volumes where none existed before, the indications were that high speed in handling might be the
answer. Because the material we wanted to concentrate was so scattered, skidding distances would have to be longer than we normally think of, but because individual loads would be relatively light, smaller, lighter equipment could be used. This led to consideration of the wheel-type industrial tractor with its high speed and low initial cost for use as a skidding tractor.

For this phase of the project we selected a five-acre tract at our Ford Forestry Center which was typical of the stands covered in the survey we have just discussed. Here we duplicated the average logging conditions which were revealed by the survey, cutting ten trees per acre and removing the sawlogs with a FWD Blue Ox Skidding Tractor.

A Ford Series 850 Industrial Tractor was secured and modified to adapt it for logging by providing overhead protection for the operator, guards for the engine compartment, and a small A-frame on the hydraulic drawbar to permit more lift on the load.

Two men, a tractor driver and a choker-setter, were employed in skidding the logging residue to a landing one-half mile distant from the tract.

The following information was learned in the process of skidding the residue from the harvesting of fifty sawlog trees:

1. The wheel tractor was very maneuverable in the nearly level terrain and fairly dense residual stand which we had.

2. It was necessary to sever limbs from only the largest tops in order to move them through the woods. This was in contrast to our expectations.

3. Although the skidding was done in the summertime, damage to the residual stand was very slight.

4. The average speed of the wheel tractor in the woods was only 2.2 miles per hour, but once it reached a logging road, it traveled at an average speed of 10.3 miles per hour, fully loaded.

5. Not having a winch for the tractor, the bulk of the tops often prevented our hooking-up a full capacity load.

6. Total cost for skidding one-half mile was 10¢ per cubic foot, or $3.25 per ton.

From the experience gained in this skidding experiment, we have synthesized an operation which would employ four industrial wheel tractors (such as the Ford 850) each equipped with a winch, for skidding residue material to a logging road. This material would then be picked up by one high-capacity wheel-type tractor (such as FWD Blue Ox, or the J. T. GO-GETTER) and skidded to a centrally
located landing. Nine men with such a combination of equipment should be able
to deliver 10-12 tons of residue material per hour to a landing one-half mile
distant at a cost of approximately $2.20 per ton of bark-free fiber. One such
landing could conceivably serve an entire section.

While the figure of $2.20 per ton compares favorably with the cost of
skidding conventional cordwood, it must be remembered that in the case of cord-
wood primary processing (bucking) has taken place, while nothing has been done
to the residue material except move it a half mile. Final evaluation of whether
$2.20 per ton is an economical figure will have to await the outcome of further
research in processing and handling at the landing.

Once again, a complete report on the skidding phase of this project is
available on request.

Bark-Free Chip Investigation

While at first it might seem that the next logical step in this logging
residue utilization project would be investigation of the economics and techniques
of primary processing, the fact of the matter is that you just about have to
select your final product before you can begin to plan a processing operation.
A review of the potential markets for hardwood residue material reveals that
most of them provide only a relatively low-value outlet. Here we come face
to face with the second of the two chief problems mentioned earlier — that of
bark removal.

Because of its form and its wide variety of sizes, it is inconceivable
that logging residue material can ever be marketed as pulpwood as we normally
think of it now. It must be chipped before it is debarked, which is a little
like putting the cart before the horse. For this reason, we decided that the
next phase of our project should be investigation of means for producing
bark-free chips.

The production of bark-free chips from hardwood logging residue involves
three steps: (1) chipping, (2) separation of the bark from the chips to which
it adheres, and (3) segregation of the bark particles from the bark-free chips.
Of these, the first (chipping) would appear to be relatively simple to achieve,
so we are concentrating our efforts on the second and third.

It is a matter of common observation that when wood "in the round" is left
in the forest, the cambium appears to disintegrate, and the sheath of bark pulls
away from the wood. This may be a combination of biological and mechanical
action, but there is some hope that this deterioration of the cambium might take
place in a pile of chips made from wood with the bark still on. If so, the
problem of separation should be simple.

In connection with work done for other purposes, there have appeared
indications that after a period of storage in piles in the open, the bark in
a mixture of bark and hardwood chips undergoes a "preferential decay." In other words, it appears that the bark may begin to disintegrate before serious decay of the wood takes place. If this can be shown to be the case, the problem of segregation might be solved merely by passing the mixture over a screen, letting the bark particles go through the screen with the fines.

The current phase of our hardwood logging residue study calls for the construction in each of the four seasons of a six-foot high and a twelve-foot high pile of hard maple chips made from logging residue chipped with the bark intact. These piles are instrumented to permit periodic measurement of temperatures at various levels within the pile, and extraction of samples of the interior atmosphere for analysis. Samples of chips from the interior of the pile will be taken periodically to test them for such features as ease of bark-chip separation, pulping characteristics, progress of decay of the bark and of the wood, moisture content, and specific gravity. It is contemplated that if the desired preferential decay of the bark does occur, we will isolate the organisms responsible for it, with the idea that inoculation of piles while they are being made could speed up the process, thus reducing inventory time.

To date we have completed the winter series of piles, plus one pile of chips made from wood which had been lying out in the forest for about 18 months. The chipper we have is a 36" disk-type horizontal feed slab chipper. This is being used because of its availability, and by no means because it is suited for the job of chipping logging residue. From the experience gained with this machine, we have some definite ideas about what a suitable residue chipper should be. It should, of course, be portable -- at least to the extent of being able to be moved on skids with an ordinary logging tractor. It should require no more than 150-200 horsepower -- again in the interest of portability. It should be capable of chipping sticks from 2" to 12" in diameter. Ideally, it should permit some adjustment of the knives so that chips of various sizes can be made. This would give the operator a somewhat broader market potential.

We have found that winter chipping of winter-cut hardwoods has produced chips which are almost entirely free of adhering bark, virtually solving the problem of bark-chip separation. Whether this same thing will happen in spring, summer, and fall chipping remains to be seen.

Since the piles were made at below-freezing temperatures, no biological activity has started. At ground level under the centers of the piles, the temperatures have held steady at 32 degrees Fahrenheit. Temperatures at one-foot intervals up through the centers of the piles fluctuate with outside temperature changes, but at a rate which is roughly inversely proportional to their distance from the outside of the pile.

Gas analysis apparatus is just now being assembled, so I have no information to give you on the composition of the atmosphere within the piles. It is
reasonable to presume, however, that until biological activity begins, there will be no changes from those conditions which existed when the piles were made.

Summary

Hardwood logging residue constitutes a major potential source of sound wood fiber for industry. Full utilization of it can have significant influence on economics, silviculture, and forest management.

High-speed, light, low-cost equipment for bunching residue material shows promise of bringing the cost of harvesting logging residue down to a point where much of it will be economically accessible.

In order to provide the widest possible margin for profit in what, for some time, promises to be a marginal operation, it will be necessary to produce material which will satisfy the requirements of a high-value market.

Since it is unreasonable to expect to be able to remove bark from residue material economically before chipping, some means of separating and then segregating bark from chips must be found. Research is underway in the field of investigating the action of biological agents to perform these functions.

The magnitude of the resource and the requirements for the conservation of high-quality hardwood growing-stock both demand research leading to the complete utilization of logging residues.

Discussion

So little is known about the basic nature of the adherence of bark to wood that you really don't know who should be studying their separation. Is it a chemical bond, mechanical bond, combination of both (probably)? Nobody really knows the nature of the forces that we have to overcome in separating bark from wood.
One of the high points of Wheeler's paper that we have not dealt with at all in research nor very little even in a general way is the competition for land use. It is very important in hardwoods. Back in the old days forestry in general had to struggle with it. We were going to use only the worst land—that couldn't be used for anything else. The situation has been fairly well resolved relative to softwoods; hardwoods will necessarily have to live with the situation because hardwoods grow on good land; good hardwoods grow nowhere else. Now if we take that old attitude that our use is a second-rate use, that we've got to give everybody else first choice before we speak up, we'll just lose out.

The competition is not only—possibly not as much—with agriculture as it is with some other uses, such as flood control, navigation control, power development, etc. Some of those projects are not only valid, but indispensable; others are mere promotion. I know from bitter experience that practically never—I know of not a single case—has the value being destroyed been adequately considered. Even on the justifiable projects, the losses can frequently be greatly reduced by due appreciation. And nobody will speak up unless it's us.

In the case of agriculture, that's another matter. Again, the forestry possibilities bear presentation, but we do not yet have the background for doing it. It's been made apparent here, the last two days, that we're accumulating a background, but it must be put in a form in which it will be convincing; we must have a demonstration. I predict that we can keep our share of the land. In Europe they go to very great pains to raise hardwood, and it pays them just as much as to raise farm crops, even in those heavily populated countries.

Another point of Wheeler's paper was the fact that even though sawtimber growth, to say nothing of the cubic volume growth, appears to equal the cut, the problem of supplying the kind of stuff that we are cutting is becoming very acute. The cut of the quality of material that keeps the wheels of industry going is far over the growth. I think Wheeler mentioned that only about 50% of our present sawtimber growing stock is in the sizes we need. And size is only one part of the picture, a minor part. Species is another part. The all-important thing is quality, accessibility, and concentration, and the latter is the one that is usually really disheartening. The number of high-value logs such as Heavrin described—$200 per Mbf and up—has been getting less and less. I hate for all the money for high-quality logs to go to Africans and Filipinos.

In opening my talk I should have been a little more general. First, I would like to see this idea of bottomland hardwoods dropped and a broader term brought into use. This bottomland, it's the predominant thing, but we're not in step with the industry which utilizes our product and markets our product, the people whose understanding and cooperation we must have, unless we include it all. They think of a field called Southern hardwoods; everything in the South, all the stuff that produces quality timber at a decent rate, including the minor streams and loessial
uplands. The southern hardwoods comprise nearly 50% of the total sawtimber production in the United States. This is an important thing.

Another point is that heretofore hardwoods in the South have been naturally overshadowed, more or less like the dairy herd on a big beef ranch in Texas. Whether foresters know it or not, the hardwood industry knows that here has been a tremendous hardwood industry in the United States from way back. The southern end of it, since 1915, has been the big end of an 8 billion board-feet-a-year industry. We should have in the profession the relative position that the wood industry as a whole has. It takes beef men to raise beef and dairy men to be dairy men; we're going to have to have some hardwood men to raise hardwood. We have some now; I think we're ready to go ahead.

The first two papers pointed out that we need to learn a great deal yet, and pointed out some possibilities. Even Bob Clark's hard luck with the cherrybark oak gave us some valuable information. The planting of cottonwood certainly pointed to the fact that maybe hardwoods are going to lead the country in really intensive management.

Seedtree cutting versus selection cutting is a subject on which I've heard much and which never seems to be resolved, probably because there is not much contention actually. All the discussion has pointed out that we must have light to bring in the good species and allow them to develop. The question is simply how large an area you're going to apply the light to. The rest of it is a matter of local conditions and economics, and the objectives and purposes of the landowner. The small landowner, if he's ever going to raise quality hardwood timber, cannot afford to start over from bare ground. Silviculturally, so long as you have a seed source or can plant, it wouldn't make any difference, but psychologically and economically, it may make a great difference.

I think there is a confusion of terms; we have no conventional term in the textbook for describing our condition. What we call a seedtree cutting looks a great deal more like a shelterwood cutting. But shelterwood is not a sensible word because it doesn't need any shelter. It will result in a patchy, even-aged stand which on the inventory records will appear to be even-aged. At the other extreme you might have little even-aged stands on a small fraction of an acre. There might be such a mosaic of them that the inventory records will look as though it were all-aged. Silviculture in southern hardwoods, except for a few species, will be even-aged silviculture, but management regulation can be either way.

I was impressed with several eye-openers in the paper on genetics. One was the relatively low priority of vegetative propagation. The idea that you can make the greatest steps ahead by cross-breeding and having made the most of that, then make our selection for vegetative reproduction was a new one to me.

The desirability of working with exotics is not entirely new to me, but the accent on it perhaps was. It is possible that exotics might be the means of filling in on some of our poor sites. Most of our southern hardwood sites are good to excellent, but some look pretty hopeless. Working with exotics might be a way to fill in that would beat breeding up our own species or trying to force a species off site.
In thinning studies I think we can just accept those principles that we are used to. In detail, of course, there are differences. In willow and cottonwood, willow especially, we have the problem of stagnation which is much less common in the southern pines. In thinning some of the other hardwoods there is the problem of developing adventitious branching. Much of the epicormic branching, we feel is due to leaving trees that were too far suppressed or trying to thin advanced stands that have already become too tight and perhaps are a little off site. Many of the pure, even-aged stands which are being thinned got there fortuitously and are a little off site. Hardwoods must be handled on the basis of discriminating tree selection all the way through to utilization.

The talks this morning were particularly interesting. I think we've lagged in the last few years in the South, and one reason is that so few foresters take a real interest in utilization. Working in hardwoods doesn't pay unless you can interest yourself in utilization. Values are being wasted. Using $35 logs for purposes that would justify the use of $100 logs is bad, but even worse is using $200 logs for purposes for which $35 logs would serve. It can't pay off.

This pulping thing is really near to my heart. I'd like to see many hardwood pulp companies. At the same time I'd like to say "amen" to John Squires' paper; it's very important that all sizes of trees be properly utilized. I think it was Heavrin, in connection with integrated utilization, who brought out the need for log jobbers. It's going to have to be demonstrated that handling timber right is a business proposition.

Mr. Anderson's paper was particularly interesting to me not only because I have been on the Brunswick operation a couple of times, but because it so aptly brings out some of the points that have been emphasized this morning. In the first place, the possibility of a very nice integration of uses for the typical produce of the hardwood forest in indicated by the range of species and sizes used and their concern for a large permanent supply regardless of quality from the viewpoint of lumber and veneer.

A few years ago we thought that the oaks, our principal hardwood resource, would be the last species pulped, if they ever were. Now, at Brunswick and a few other places, they are of primary interest. As indicated by Wheeler, the typical hardwood area carries large amounts of material below economic lumber and veneer utility in sound logs of all sizes and in large sound cull or malformed trees which demand disposal. This demonstration that all sorts of hardwoods of all sizes can and are being logged by whatever means proves best adapted and used in large volume for their own sake, rather than as supplement, is profoundly important. It speaks clearly of the great opportunity for inter-industry cooperation in rehabilitating hardwood areas as compared to competition in destructive and wasteful exploitation.

It is important to point out here that the large oak logs and bolts shown in the slides do not contradict what I have just said, nor do they support Squires' and McMillan's generally justified indictment. Some minor proportion is, no doubt, unfortunately of too high inherent value for lumber and veneer to warrant this use. However, I know that most of it is laurel oak and willow and water oak.
from poor sites, the great majority of which is marginal or submarginal due to blind pin knots, bark pockets, grub holes, bird peck and mineral stain. Such oak is all too common on the Lower Coastal Plains of the Southeast, and, insofar as they are competent to distinguish it, forest managers are fortunate to have such a market for it. Most unfortunately, though, there is much very good oak, also, in that territory, generally a little farther up from the coast, while the great majority of timber people in that territory are unqualified to distinguish the best from the poorest. Accordingly, the whole oak resource of that territory is low-rated and sold short by nearly everyone concerned and there is little reasonable market for it.

Nevertheless, in these circumstances, I saw an example of exemplary utilization illustrating application of an aspect of the principles discussed by Heavrin. The operation made no pretense of silvicultural or conservative cutting but the logging and utilization were well rationalized and conservatively adapted to circumstances. Everything large and sound enough to handle efficiently was felled by power saw and skidded, largely as whole trees, by heavy tractors after a minimum of limbing and bucking to facilitate movement. At a well arranged truck loading point, cut-up, sorting and loading facilities were under the close supervision of a competent foreman who directed separation of marginal and better veneer logs for the operators own use and sub-marginal logs and top wood for Brunswick. For every thousand feet used as logs, two units of pulpwood were salvaged at a very comfortable net margin in lieu of piling up a dead stock of low grade lumber of very questionable net value and still losing the top-wood altogether.

Still another very general hardwood situation, pertinent to some of our other discussions is well illustrated with important implications by Anderson's several slides of severely depleted, high-graded areas being cut to seed tree status or clear cut for planting. The residual timber is obviously not only sparse, but it is preponderantly unproductive and undesirable as growing stock, being largely laurel oak, off-site water oak, crooked hackberry, etc. Whether any particular stand should ever have reasonably got into such shape is certainly debatable but, being so, whether the area is some small fraction of an acre or some hundreds of acres, there is no question but that even-aged regeneration techniques are necessary. Likewise, whatever the reason may be, the existing stocking constitutes undesirable growing stock; it may even be prime original growth but dangerously over mature.

On the other hand, what could possibly be the logic in arbitrarily regenerating areas, of whatever size, of highly desirable immature growing stock, especially if our crop standards are high enough to realize half of the economic potential? A very large majority of our Southern Hardwood area is an inextricable mosaic of varying degrees of these two general conditions in areas of varying but mostly very small extent. Haven't we been wasting a great deal of thought and words here in the South through confusion of conventional terms which simply don't apply to our very unconventional silvical and economic conditions?

I should have liked to ask Mr. Anderson whether the Company is yet experimenting with adapting logging methods to the job of extracting produce of thinning and improvement cutting from the deep muck black gum and bay swamps. This is in
the aggregate one of the biggest, largely untapped concentrations of prime pulpwood in the country and if silviculturally cut, one of the finest potential sources of both veneer and pulpwood; all depending on solution of a uniquely difficult logging problem. If these stands are logged pre-maturely in the usual way, cutting from overhead for small veneer timber, their economic potential will be reduced by at least 50 percent. However, too often this is done and there seems, so far, to be no alternative but to leave the stands alone which is, no doubt, the right thing to do.