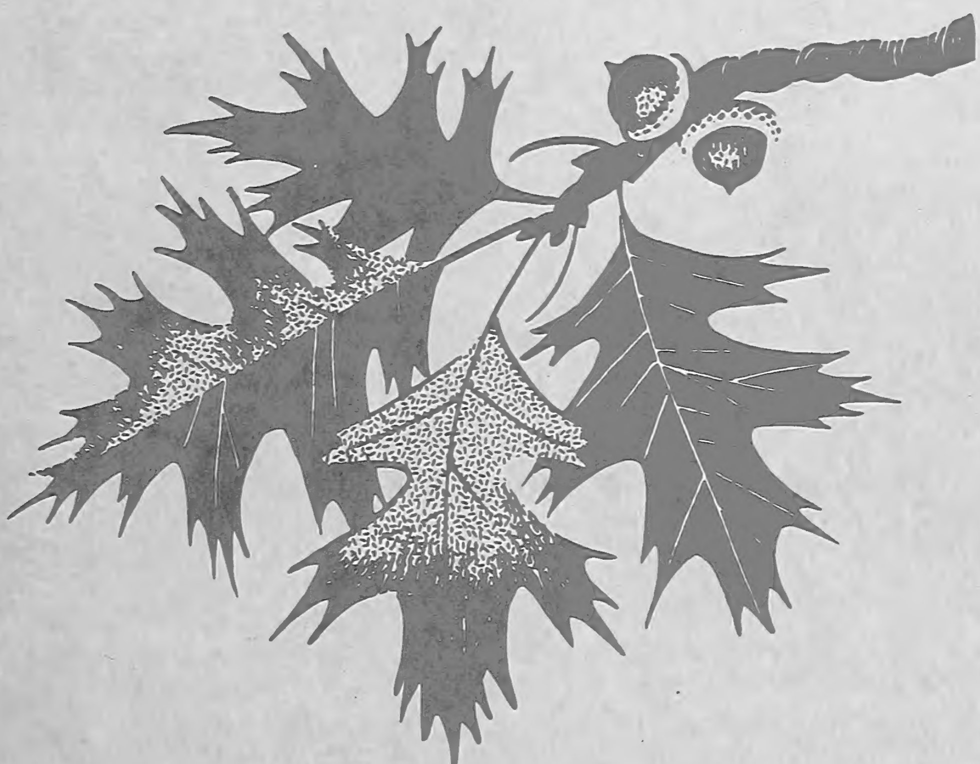
Technical Publication SA-TP 12
October 1980



# PROCEEDINGS

# MID-SOUTH UPLAND HARDWOOD SYMPOSIUM FOR THE PRACTICING FORESTER AND LAND MANAGER



## Harrison, Arkansas

## April 30 - May 2, 1980

SPONSORED BY: Arkansas Forestry Commission
Ozark-St. Francis National Forests
Southern Forest Experiment Station
Southeastern Area, State and Private Forestry
Tennessee Division of Forestry
University of Arkansas-Monticello-Extension Service

# FOREWORD

The upland hardwood forests of the Mid-South are an important source of timber, wildlife, water, and recreational activity. These forests are a unique resource with special problems and opportunities for management which have probably received less attention than they deserve.

This symposium was an effort to increase the expertise of the Mid-South's practicing foresters in managing this valuable resource by presenting the most up-to-date information available.

Special acknowledgement to J. S. McKnight for his summary of the symposium; to Dr. David L. Ganey for conducting the field tour; and to the program moderators: Dr. B. G. Blackman, Head of the Department of Forestry, University of Arkansas at Monticello; James R. Crouch, Supervisor, Ozark-St. Francis National Forest; Robert J. Lentz, Staff Director, Forestation and Management, Southeastern Area of State and Private Forestry; and James Tiner, Management Chief, Arkansas Forestry Commission for setting the stage and keeping the sessions on schedule.

Program

Co-Chairmen

FRANK SHROPSHIRE DAN SIMS

PROGRAM

MID-SOUTH UPLAND SYMPOSIUM FOR THE PRACTICING FORESTER AND LAND MANAGER

Wednesday - April 30

10:00 a.m. Registration

1:00 p.m. Call to Order and Moderator
B.G. Blackmon, Head Department of Forestry, University of Arkansas at Monticello

1:00 p.m. Welcome-B.G. (Bill) Gresham
Arkansas State Forester, Little Rock Arkansas

1:10 p.m. Keynote Address
George Kelly, Executive Director, Southern Hardwood Lumber Manufacturers Association, Memphis, Tennessee

1:30 p.m. Mid-South Upland Hardwood Resource Evaluation
Willem Van Hees, Research Forester, Southern Forest Experiment Station, New Orleans, Louisiana

2:00 p.m. Mid-South Upland Hardwood as an Energy Source
A.B. Curtis, Wood Energy Specialist, SA-S&PF, Jackson Mississippi

2:30 p.m. Utilizing the Mid-South Upland Hardwood Resource
Hugh Reynolds, Research Engineer, Northeastern Forest Experiment Station, Princeton, West Virginia

3:00 p.m. Break

3:15 p.m. Mid-South Upland Hardwood Site Yield Potentials
David L. Graney, Silviculturist, Southern Forest Experiment Station, Fayetteville, Arkansas

3:45 p.m. Changing Philosophies for Mid-South Upland Hardwood Management and Utilization
Bart A. Thielges, Chairman, Department of Forestry, University of Kentucky, Lexington, Kentucky

4:15 p.m. Overview of Mid-South Upland Hardwood Regeneration Problems and Alternatives
Dan Sims, Hardwood Specialist, SA-S&PF Atlanta, Georgia

7:00 p.m. Banquet and Moderator
James Crouch, Supervisor, Ozark-St. Francis National Forest, Russellville, Arkansas

After Dinner Speaker-Hardwood Silvicultural Emphasis in Colleges and Universities of the South
Edward Buckner, Professor of Silviculture, University of Tennessee, Knoxville, Tennessee

Thursday - May 1

8:00 a.m. Call to Order and Program Moderator
Robert Lentz, Staff Director, Forestation & Management, SA-S&PF, Altanta, Georgia

8:00 a.m. Oak Planting in Mid-South Upland Hardwoods; Problems and Prospects
Paul S. Johnson, Silviculturist, North Central Station, Columbia, Missouri

8:30 a.m. Management Alternatives for Mid-South Upland Hardwoods
Ivan L. Sander, Project Leader, North Central Station, Columbia, Missouri

9:30 a.m. "The Effect of Fire on Species Dominance in Young Upland Hardwood Stands"
Charles E. McGee, Project Leader, Southern Forest Experiment Station, Sewanee, Tennessee

10:00 a.m. Break

10:15 a.m. Panel Discussion-Our Approach to Mid-South Upland Hardwood Utilization and Management
Mayford Williams, Forester, Western Kraft Corporation, Centerville, Tennessee
Dean Wallace, Arkansas Extension Forester, Batesville, Arkansas
Jim Gleckler, District Forester, Oklahoma Forestry Division, Jay, Oklahoma
W.C. Trimble, District Forester, Arkansas Forestry Commission, Stuttgart, Arkansas

11:15 a.m. Soil Factors Affecting Mid-South Upland Hardwood Management and Growth
John Francis, Soil Scientist, Southern Forest Experiment Station, Stoneville, Mississippi

12:00 Noon Lunch

1:00 p.m. Call to Order and Program Moderator
James Tiner, Management Chief, Arkansas Forestry Commission, Little Rock, Arkansas

1:00 p.m. Water Management and Soil Loss Control in Mid-South Upland Hardwood Stands
Edwin Lawson, Project Leader, Southern Forest Experiment Station, Fayetteville, Arkansas

1:45 p.m. Wildlife Management in Mid-South Upland Hardwoods
James Sweeney, Associate Professor of Forestry and Wildlife, University of Arkansas at Monticello, Monticello, Arkansas

2:30 p.m. Minimizing Insect Damage in Mid-South Upland Hardwoods
J.D. Solomon, Entomologist, Southern Forest Experiment Station, Stoneville, Mississippi

2:50 p.m. Effective Management of Disease Problems in Mid-South Upland Hardwoods
Robert Lewis, Pathologist, Southern Forest Experiment Station, Stoneville, Mississippi

3:15 p.m. Break

3:30 p.m. The Role of FIP in Mid-South Upland Hardwood Management
Hart Applegate, Assistant State Forester, Tennessee Division of Forestry, Nashville, Tennessee

4:00 p.m. Symposium-Summary and Wrap-up
J.S. McKnight, Consultant, Atlanta, Georgia

Friday - May 2

7:30 p.m. Field Tour and Tour Leader
David L. Graney, Upland Oak Stand Density-Growth and Yield Studies

CONTENTS

## MID-SOUTH UPLAND HARDWOOD SYMPOSIUM

### KEYNOTE ADDRESS

George E. Kelly[1]

The annual meeting of the Southern Hardwood Lumber Manufacturers Association was held a month ago in New Orleans. About 450 persons attended the meeting, including manufacturers, wholesalers, furniture industry and pallet business representatives, as well as exporters, customers, suppliers, and others who are in the hardwood lumber business. This meeting is probably the best barometer of conditions in our business. From this meeting, we can pick up a pretty good cross section of what is going on. There is no doubt from the reaction of this meeting that we are entering another period of a downturn in the hardwood lumber business. Our business is marked by economic peaks and valleys. We have enjoyed 2 years of being up, but now the direction has reversed. Economics have been described as a wild ride where you hang on for dear life without being able to exert any guidance towards the final destination. I feel, however, that there are answers and alternatives available to us. Particularly in the timber growing and utilization fields, we can help to soften the blows during times of economic downturn. So, I am pleased and honored to be invited, particularly at this time, to keynote the Mid-South Upland Hardwood Symposium. The subjects you will be discussing deal directly with the problems we have in increasing growth and yield, but more important, the grade in our hardwood stands.

Let me begin my remarks by reviewing with you the picture I foresee in the long run for hardwood markets. At a meeting I attended last week, Max Petersen said the hardwood future is one of the brightest in the whole resource picture. Together, we believe the overall picture for this new decade is fairly bright. Hardwood product manufacturers and salesmen depend on foresters and land managers to begin the process of resource growing. Mills are built according to the availability of these resources. In addition, employees of these plants and mills depend upon resource productivity for job continuation. The public, too, depends upon the trees you grow for furniture, flooring, wooden pallets, railroad ties, architectural woodwork, and other products. These needs cannot be met without you and your co-workers.

Though we believe this new decade will be a good one for us, we do face a tough year ahead. An economist who spoke to us in New Orleans last month said that 1980 will be a flat year; we must untangle ourselves from the fiscal morass caused by failing public confidence in our national

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[1]Executive Vice President, Southern Hardwood Lumber Manufacturers Association, Memphis, Tennessee.

fiscal policy, spiraling interest rates, and a rapidly falling housing market. The economist said, however, that because of these situations, the public outcry over housing, fuel, and inflation costs has received the attention of the administration. In his opinion, the administration is beginning to take steps to place us back on the track, although it will be a slow process. We were pleased to hear him say that a ceiling on price goods and wages is not one of the remedies.

Hardwood markets include industries such as the furniture industry which takes about 45 percent of our production. Flooring takes about 7 percent, wooden pallets take about 18 percent, boxes and crates take another 15 percent, and railroad ties take an additional 7 percent. Each market is important not only because of what it buys, but each gives us a market for all our grades from the first and seconds, down to 2A lumber.

The furniture people say 1980 will be a flat year for them and for us. But demographic studies show that the next 10 years will be one of the strongest periods for the home furnishings business. They are basing their projection on two major groups within the population mix: the 24- to 44-yearold group which is the fastest growing segment of our population, and the 45- to 64-year-old group called the "maturity market." The first group has average family earnings in excess of $25,000 per year. They are buying their first house or are moving into larger apartments and condominiums--this means furniture sales. The older 45-to-64-year-old group represents one-third of the total population and controls over 40 percent of the national spending power. At this age, they are buying bigger houses or a second recreation house. They are more willing to spend money on quality. The furniture industry is expecting an annual growth of 9 percent.

To keep a balance for our lower grades, we also watch the flooring and pallet industries closely. Interior decorators and designers have spotted a definite trend back to hardwood floors decorated with rugs and other types of flooring covers in the better homes and offices. And, we have seen in the past 2 years a strong market for the 2-million board feet of flooring our industry makes each week. But, now with the bottom falling out of the housing market, we, too, have seen a corresponding drop in the flooring market. We do not doubt that when the housing market returns we will again see the trend for a stronger flooring market continue.

The pallet market began as a place to sell the lumber nobody else wanted and it still buys a high percentage of our lower grades. It has gained significantly in importance as the price of warehouse labor has forced more industries to palletize their warehouse and loading facilities. The national wooden pallet and container association reports that, in 1979, a record 296 million wooden pallets were produced. The pallet industry consumed about 6.8 billion board feet of all kinds of lumber. They project that annual pallet production will reach 450 million units by 1985.

Another segment of our marketing picture that is gaining attention from the American lumber producer is the export market. After going through the lumber depression of 1974 and 1975, many companies began to seriously look overseas as a way to protect themselves from a sagging domestic economy. About 5 percent of our total hardwood production is now going into the export market, primarily to the United Kingdom and Western Europe. Though no dramatic increase is expected, a gradual growth picture is anticipated. More importantly, the price paid overseas for North American lumber is a great deal better than what we get at home. We are now exporting approximately 240 million board feet of hardwood lumber a year. Since 1955, the National Lumber Exporters Association has maintained an office in England, but now the major market has switched across the channel to Europe; therefore, I am making plans to open an office in Europe.

You have just heard a brief description of what we see as the market potential for our products. The significant point to you is that the nation is looking more to the South as the major source of all hardwood projections. Nearly half of all the hardwood growing stock in the nation is located in this region. The only real potential for expanding the resource lies in these 12 Southern states. The hardwood resource of the lake states is declining; the Appalachian area is barely holding its own.

The last survey shows we are growing more hardwood than is being harvested, in addition to being lost to natural causes. Herein lies a problem which I hope will be addressed at this symposium. These survey figures lull us into a false sense of well-being. Our problem is not in the **quantity**, but the **quality** of our hardwood forests. The key to making money in the hardwood business is grade. The grade of hardwood presently growing is slowly declining--a trend that you as foresters, managers, and geneticists must reverse. We have seen in the past 30 years, or since the end of World War II, a drop in the amount of one common and better lumber cut from about 45 percent, down to around 25 percent today in total lumber production; this is where money is made. It is like comparing sirloin and filet steak cuts with roasts and hamburger.

To help offset this situation, we are working with furniture designers to use a wider variety of Southern species rather than preferred species such as oak, pecan, hickory, and ash. We are also encouraging furniture designers to use some of the lower grades in furniture parts where appearance is not as necessary. We are encouraging them to develop the preferences of the public for what we are marketing. For example, character-marked wood includes small, tight knots, giving the finished product individual character. We are working with moulding and millwork manufacturers to use some wood with small tight knots when the millwork will be covered with paint or other finish. Traditionally, these industries use clear wood, so these changes are partly a matter of changing customs.

In the end, irregardless of our success in changing marketing and design habits, you will have to be the ones to see that a higher percentage of quality trees are grown.

You can further assist our industry, and also the forestry profession in educational areas. We have been concerned over the lack of attention hardwood forestry education receives in forestry schools. True, hardwood forestry is much more difficult, and job opportunities for pine foresters are better. However, the training of men and women in hardwood management and silviculture should be given a higher priority in our schools.

Mississippi State University is developing a continuing education program on hardwood management which should be ready in the fall for its first 5-day session. Dr. Charles Lee and Dr. Douglas Richards put together a committee including their faculty and representatives from government and industry to develop the program. It will be first directed toward practicing foresters. Then, hopefully, parts of the program will be included in the undergraduate curriculum. We are quite encouraged by this approach at Mississippi and hope that other Southern schools will follow suit.

I believe the future of the Southern forest resource, hardwoods and softwoods, is extremely bright. I believe, too, that locked in the forests are answers to many questions on fuel, fiber, chemicals, medicines, and even foods that we have yet to comprehend.

Several years ago, a book entitled This Fascinating Lumber Business traced the development of the lumber industry. One section in it continues to fascinate me as we contemplate what we can do with wood. Another section in it tells about a book, Nazis in the Woodpile, written by a German refugee who was a scientist shortly before our entry into World War II. The book describes wood as one of Hitler's most important weapons.

Hermann Goering, Hitler's deputy, developed a 4-year plan for Germany's development and domination. According to the refugee, this plan was based primarily upon the development of industries, fuels, food, and other war essentials derived from wood. Wood-gas and charcoal generators provided fuel for factories and vehicles. Alcohol and motor fuel from wood augmented gasoline for airplanes, tanks, and motorized divisions. Wood alcohol was used in making smokeless powder. Textile fibers were made of wood (wood wool, wood cotton, wood silk). Even cattle were fed on fodder made from wood. Foods and food additives were developed for human consumption.

So much did the German plan for world domination depend on these wood-based industries, it was asserted that Nazi control over the forests of the world was a primary objective as Hitler chose the areas for conquest.

In light of our own strides in using wood, none of these German developments are particularly startling, but the significance is the power that Germany saw in wood. So, we must ask ourselves, "What new discoveries of wood have we yet to uncover?"

All such discoveries first lie with our ability to grow and maintain a quality timber resource. This is where you come into the picture. In fact, all such discoveries start with people like you.

Thank you for inviting me to begin this seminar. Good luck in your discussions for the next three days.

# ARKANSAS' HARDWOOD RESOURCE AVAILABILITY AND QUALITY

Willem W. S. van Hees[1/]
and
Mary S. Hedlund[2/]

Abstract.—Concern over the status of the southern hardwood resource has prompted an evaluation of current data availabilities. Many discrepancies have arisen between U.S. Forest Service Survey results and observations made by industrial foresters. To clarify this matter somewhat and provide an awareness of the types of data available, 1978 Forest Survey data from Arkansas are re-analyzed. Indicators of timber quality such as log grade suggest a decline in the resource quality. Timber availability is shown to be affected by diverse site conditions such as slope and physiographic classification, and by owner priorities.

Additional keywords: 1978 Arkansas Forestry Survey, hardwood resource trends, hardwood data availability.

Hardwood timber has always played a role in Arkansas' timber supply procurement some times more importantly than at others. Until recently main attention to the timber resource in Arkansas has been on the substantial pine resource. The quality, quantity, and growth of the pines are all high caliber, sufficient characteristics to warrant attention. However, the softwood resource has never and will not satisfy every timber requirement. Presently the status of the southern hardwood timber resource is concerning both primary and secondary users. Data needed to evaluate this status are collected by Forest Service Survey field teams. Within the Midsouth, (Alabama, Arkansas, Louisiana, Mississippi, Oklahoma, Tennessee and Texas), the Southern Forest Experiment Station is responsible for state inventories of forest resources. Resource conditions from continuous forest inventory plots systematically located on a three-mile grid are sampled.

Questions have arisen concerning the disparity between the condition of the hardwood resource as shown by Forest Survey results and what the hardwood industry perceives is actually available. To clarify this issue somewhat, timber quality trends along with hardwood availability, as limited by site and

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1/ Research Forester, Renewable Resources Evaluation Techniques, Southern Forest Experiment Station, Forest Service-USDA, New Orleans, LA.

2/ Mathematician, Renewable Resources Evaluation Techniques, Southern Forest Experiment Station, Forest Service-USDA, New Orleans, LA.

ownership characteristics, are presented. As an example of the types of information available, we re-analyze 1978 Forest Survey data from Arkansas.

Herein volumes, unless otherwise stated, refer to growing stock volume[3/] and not sawtimber volume[4/] for two reasons. First, many wood users employ cubic foot to board foot conversions other than those used by the Forest Service. Furthermore, there is a strong linear statistical relation between growing stock volume and sawtimber volume over geo-political sub-units. Second, utilization trends dictate that more than one segment of the resource be evaluated. Not only is more wood needed but the potential for utilization increases almost yearly as new machinery, processes, and techniques are developed. By examining growing stock, sawtimber is implicitly included.

## The Hardwood Resource

As of 1977, the National assessment of hardwood growing stock in the South showed an estimated 100 billion cubic feet with volume highest in the 10-inch d.b.h. class. These results placed Arkansas fifth in the South with about 10 billion cubic feet of hardwood growing stock. Here again volume is greatest in the 10-inch d.b.h. class. Even with all the emphasis on softwood supplies and management, there is more volume in southern hardwoods than in southern pines. Thus, hardwood supply problems center about availability and quality, not quantity.

In Arkansas, about 80 percent of the hardwood resource occurs in the Ozark, Ouachita, and Southwest survey regions. In our analysis the Delta region has been excluded because the resource is dispersed, extensive forest areas have been cleared for agriculture, and the outlook for increased timber supplies in this region is dim. Preliminary examination of the data showed that the remaining three survey regions contain essentially two hardwood resources, "pine site"[5/] hardwoods in the south and upland hardwoods in the north. Therefore, these three regions were regrouped into two regions, each treated separately (Fig. 1). For convenience we renamed these regions the North and the South.

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3/ Growing stock volume is the volume in cubic feet of sound wood in the bole of trees larger than five inches d.b.h. from stump to a minimum four inch top or where branching starts.

4/ Sawtimber volume is the net volume of the sawlog portion of live sawtimber trees, in board feet of the International ¼ Inch Rule.

5/ Pine site refers to a physiographic classification which indicates the suitability of a site for growing pine types, not necessarily the forest type currently growing on the site.


FIGURE I. MAJOR HARDWOOD RESOURCE REGIONS OF ARKANSAS.

The northern region is characterized by relatively rugged terrain and a predominance of upland hardwood forests. This region contains about 2.8 billion cubic feet of hardwood growing stock, which represents a 6 percent decline over the 1969 volume (Fig. 2). A loss of one million acres of commercial forest land, mainly to pastures, is responsible for the decline.

The southern region, although containing portions of the Ouachita Mountains, is generally less rugged than the northern region. Most hardwood resources in the region are found on pine sites. Presently there are 4.4 billion cubic feet of hardwood growing stock in this region. This represents a 1 percent increase over 1969 (Fig. 3). Custodial management, wherein no intensive forest management is undertaken, is the likely cause for this slight volume increase.

## Availability as Limited by Site

Certain portions of the reported hardwood volumes are not readily available because they are growing with higher valued pines. Many owners and operators do not want to damage the pine resource while extracting the hardwoods.

If the worst case is assumed, that all hardwood volume in pine or mixed pine-hardwood types is essentially unavailable, then 9 percent (246 MMCF) of the volume in the north must be deducted from the total. Hardwoods in oak-pine types account for most of this volume.

In the southern region the situation is more dramatic. Fully 35 percent (1.6 billion CF) of the hardwood resource is in association with pines. Slightly less than half of this volume is in the loblolly-shortleaf type. The remainder is in oak-pine types. The majority of these hardwoods would be difficult to reach.

The accessibility and, therefore, availability of a given stand of trees is additionally affected by the slope of the site on which it occurs. On slopes greater than a certain percent the volume cannot be extracted without excessively damaging the site or making a large capital investment in specialized equipment. In many regions 30 to 35 percent is regarded as the limiting slope for conventional harvesting systems. The following figures pertain to sites with slopes greater than or equal to 34 percent.

In the southern region much of the terrain is gentle and therefore a relatively small amount of volume is on steep slopes. On nearly 390 thousand acres of commercial forest land that is excessively steep, there are about 150 million cubic feet of hardwood growing stock (3 percent of the total hardwood volume in the southern region). Slightly more than half is oak-hickory types; the remainder is mixed in the loblolly-shortleaf type as scattered trees.

The northern region, having rougher terrain, has considerably more volume on steep slopes. Currently there are some 435 million cubic feet of hardwood timber standing on 640 thousand acres of steep slopes. This is almost 15 percent of the hardwood volume in the region. Only 5 percent of the 435 million cubic feet is in the oak-pine type, the rest is in oak-hickory types.

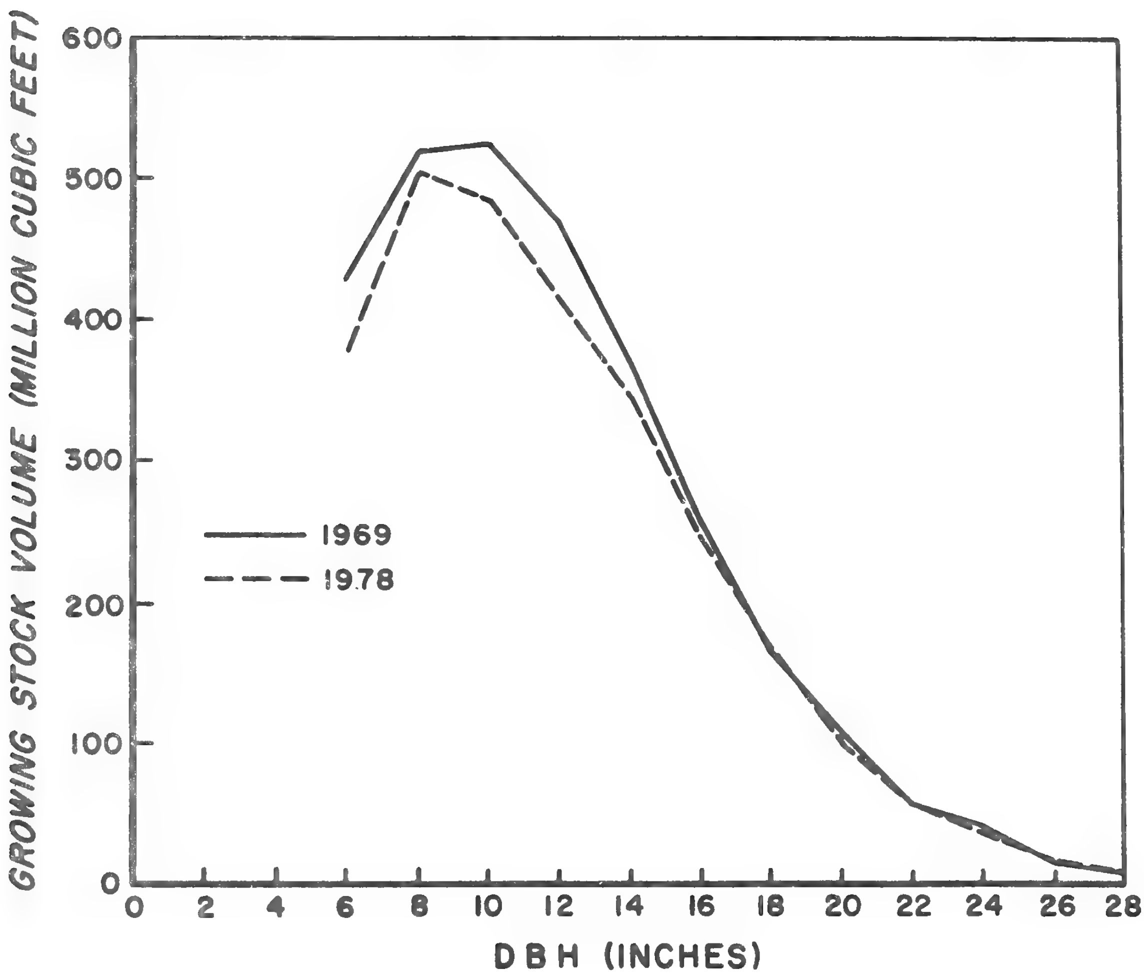


FIGURE 2. HARDWOOD GROWING STOCK VOLUME BY TREE DIAMETER, NORTH ARKANSAS, 1969 AND 1978.

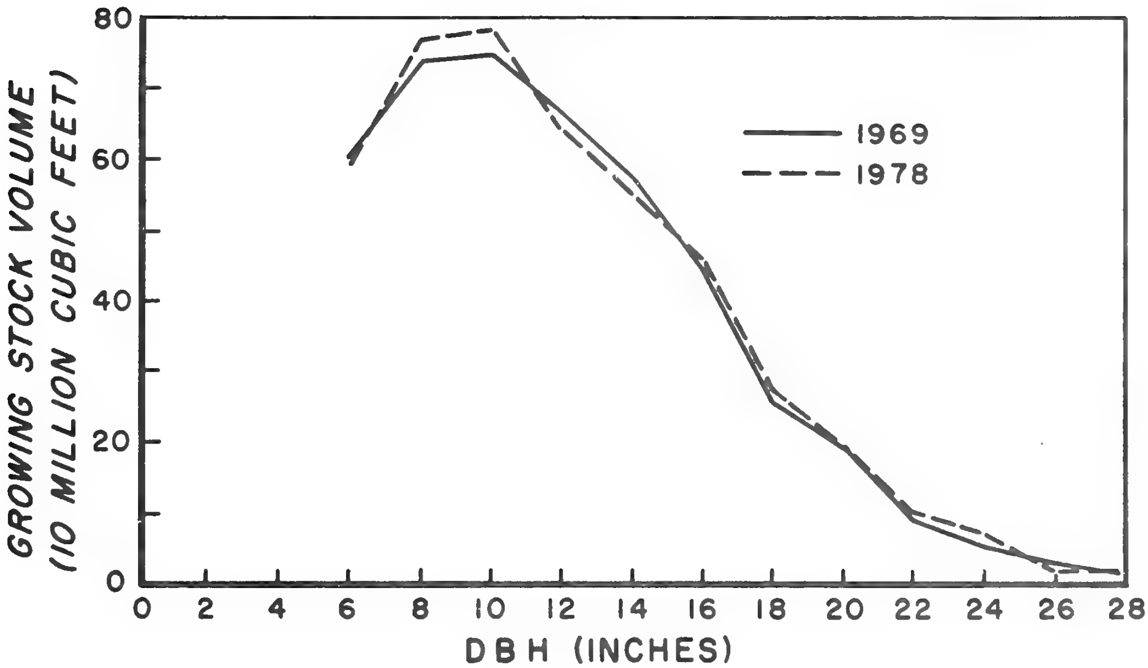


FIGURE 3. HARDWOOD GROWING STOCK VOLUME BY TREE DIAMETER, SOUTH ARKANSAS, 1969 AND 1978.

## Availability as Limited by Ownership

Ownership of commercial forest acreage plays a key role in the acquirability of a given stand. Owner objectives sometimes differ markedly from the timber production objective. Non-industrial private owners (farmers plus miscellaneous private owners), for example, will probably not provide substantial increases in quantity of timber in the near future. Additionally, many of these owners do not tend to practice intensive forestry; so, if this volume becomes available, the quality will possibly be less than optimal.

In the southern region for example, these owners control 42 percent of the oak-hickory type (Fig. 4). This type has 1.3 billion cubic feet of hardwood timber. Some of this volume will be available through leasing and purchase.

Another 28 percent of this oak-hickory type, which almost entirely occurs on pine sites, is managed by industrial foresters. Given that these acres are better suited to growing pines, industrial forest management will be oriented towards type conversion. This timber may become available when it is feasible to convert the site to pine types, but only on a one-time basis.

In the northern region fewer owners have forest management as their primary goal. The major controllers of both the oak-hickory and oak-pine types are farmers and other non-industrial private owners (Fig. 5). Although net annual growth of hardwood growing stock amounted to one-fourth of the state total, hardwood roundwood production was only 13 percent of the state total.

An additional ownership impact on availability lies in the distribution of stand-size classes. Stand-size classes refer to a classification by the Forest Service Survey in which timber stands are rated by the predominant tree-size class. These classes are sawtimber, poletimber, and seedling/sapling. In each case the stand must be at least 16.7 percent stocked with growing stock trees.[6/] In sawtimber stands, 50 percent or more of this stocking must be in sawtimber or poletimber trees with sawtimber stocking at least equal to poletimber stocking. Poletimber stands have the same requirements except that poletimber stocking must exceed sawtimber stocking. In seedling and sapling stands, at least 50 percent of the growing stock trees must be seedlings and saplings.

In the north, non-industrial private owners control the largest acreages of the three stand-size classes (Fig. 6). Unless these owners utilize and/or manage their hardwood resources more intensively, the volume currently and prospectively on these acres may become only marginally available.

In the southern region forest industry and non-industrial private owners have control of the hardwood resource (Fig. 7). Ownership of the next generation sawtimber as represented by present ownership of poletimber acreage is mainly in the hands of non-industrial private owners. Prospects for increasing sawtimber supplies are diminished in light of this ownership pattern.

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6/ Growing stock trees are all live trees except rough and rotten trees.

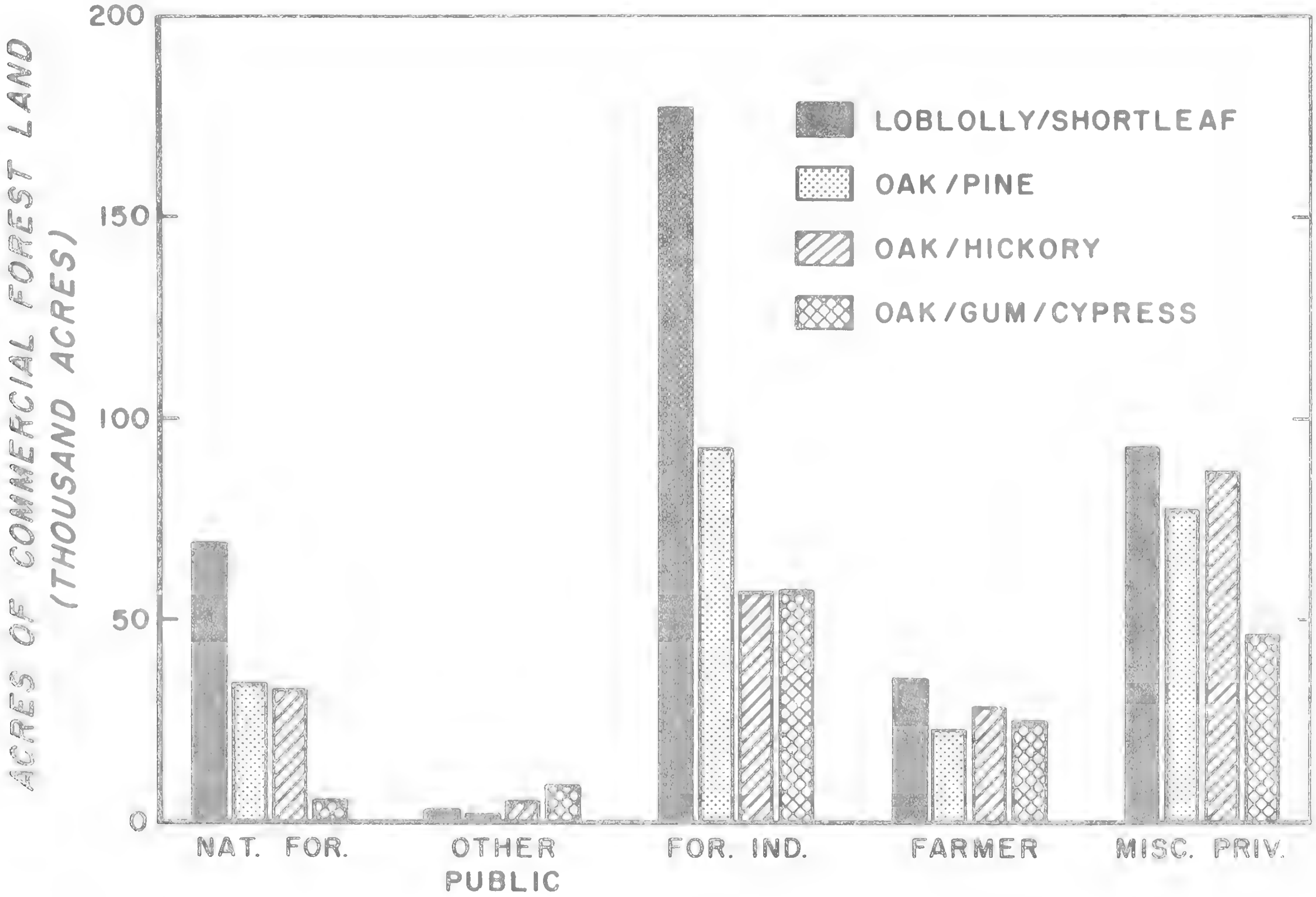


FIGURE 4. ACREAGE OF COMMERCIAL FOREST LAND BY FOREST TYPE AND BY OWNERSHIP GROUP, SOUTH ARKANSAS, 1978.

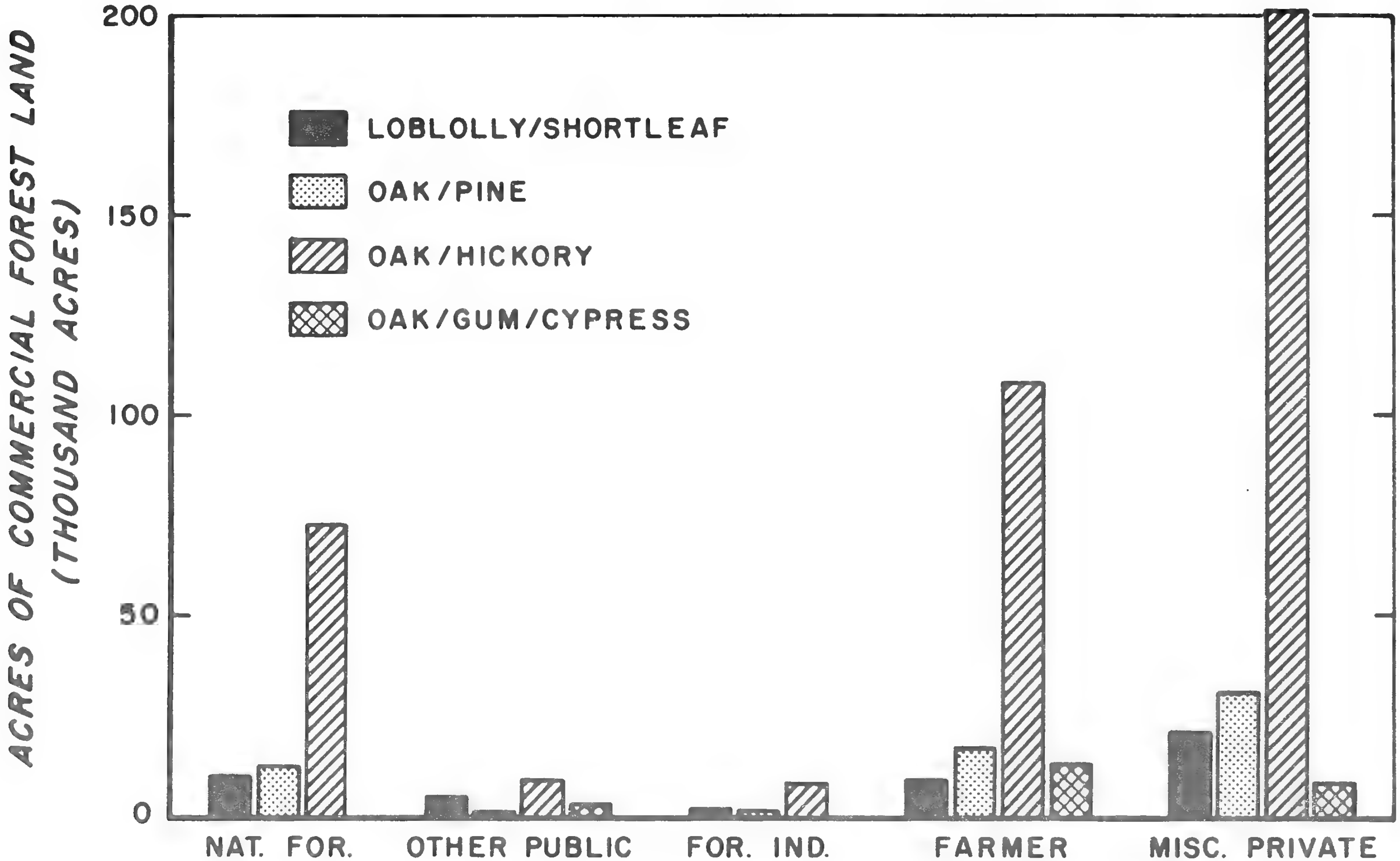


FIGURE 5. ACREAGE OF COMMERCIAL FOREST LAND BY FOREST TYPE AND AND BY OWNERSHIP GROUP, NORTH ARKANSAS, 1978.

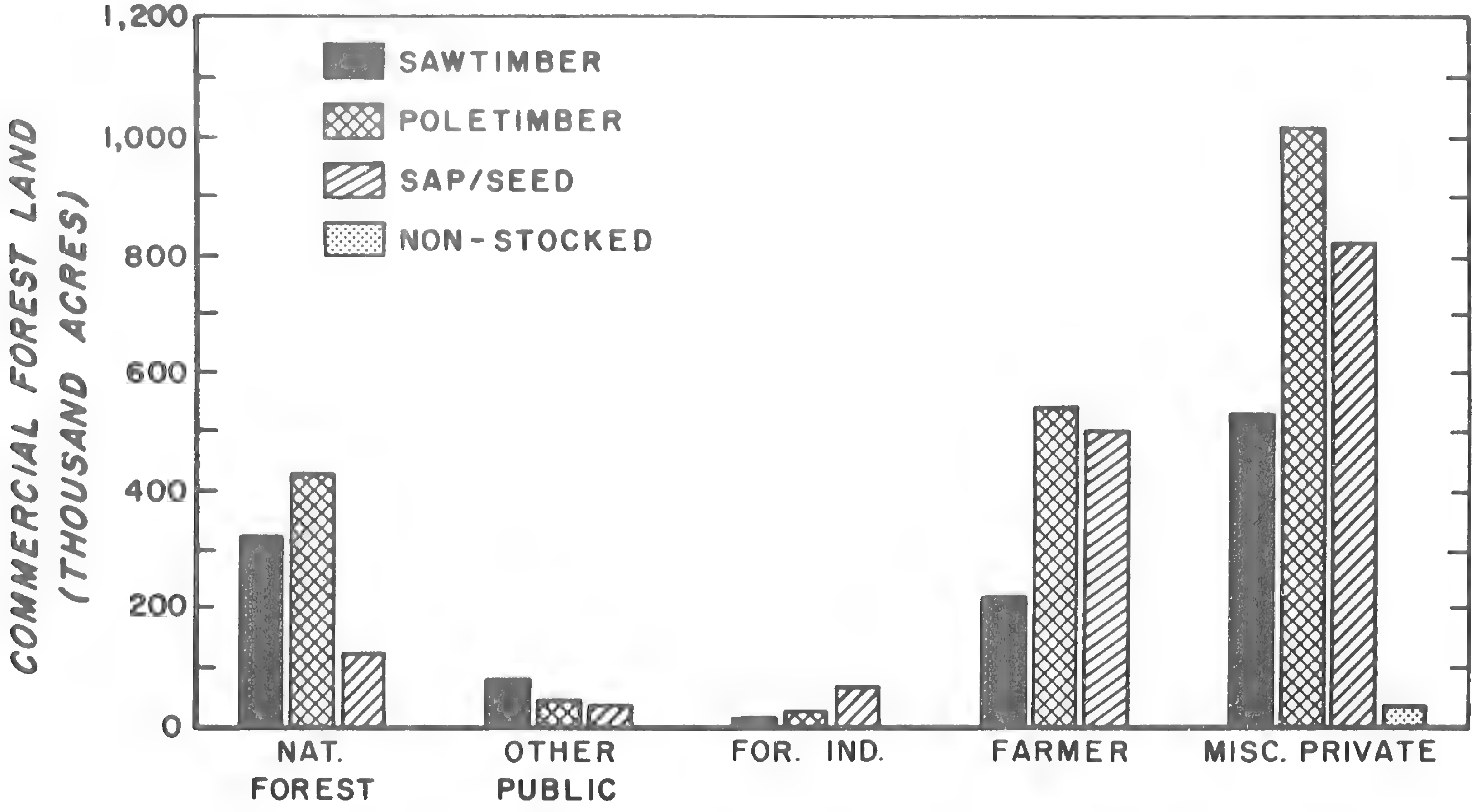


FIGURE 6. ACREAGE OF HARDWOOD FOREST TYPES BY OWNERSHIP GROUP AND BY STAND-SIZE CLASSES, NORTH ARKANSAS, 1978.

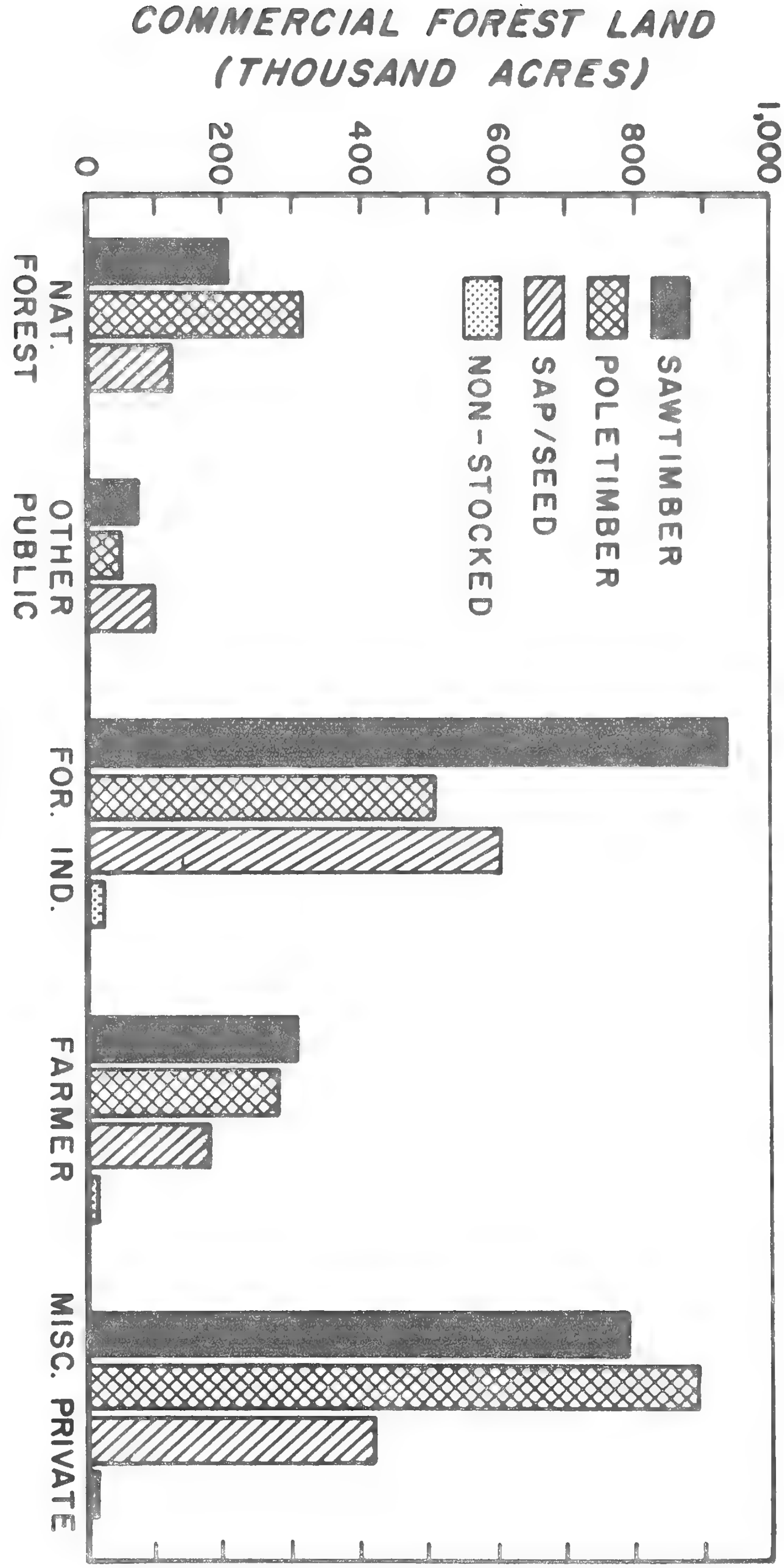


FIGURE 7. ACREAGE OF HARDWOOD FOREST TYPES BY OWNERSHIP GROUP AND BY STAND-SIZE CLASSES, SOUTH ARKANSAS, 1978.

## Quality Trends

Although ownership patterns and site characteristics are important when evaluating forest resource availability, the desirability of the timber will affect how useable the resource is. In the Southern Forest Experiment Station Forest Survey, timber quality is estimated by log grade. Log grades are based on the standards presented in "Hardwood Log Grades for Standard Lumber", issued by the Forest Products Laboratory in Madison, Wisconsin. Our cruisers grade the butt log only. Grades and volumes by grade for the remaining logs are established via an algorithm in our data reduction routine. Hardwood log grades include, in addition to grades 1, 2, and 3 for standard lumber, a grade 4 tie and timber log. Specifications for tie and timber logs are based chiefly on knot size and log soundness; clear cuttings are not required.

In 1969, nine percent (400 MMCF) of the total hardwood volume in the southern region was in grade 1 logs. In 1978, the percentage dropped to eight (362 MMCF). The percent of total volume in grades 2 and 3 also declined, 4 and 5 percent respectively. Log grade 4 however, increased by 10 percent. The northern region experienced almost identical changes; in grades 1, 2 and 3 the percents dropped 2, 3, and 5 percent while the percent in grade 4 increased 10 percent.

These figures point to a decided quality decline over the last decade.

## Summary

Our overall impression is of a hardwood resource that is neither as available nor as high in quality as a decade ago. Substantial segments of the gross growing stock volume are not readily available because of site limitations. Included here are those hardwoods growing in association with pines and those growing on inaccessible slopes. Ownership patterns also have an impact on the net hardwood availability. Non-industrial private owners, who tend not to manage their forest resources for timber production, own sizeable percentages of the available hardwood acreage. Finally, the overall quality of the resource has declined over the past decade. A higher percentage of sawlog timber is grade 4 quality.

## References

1. 1978. U.S. Department of Agriculture. Forest Statistics of the U.S., 1977. 133 pp.

# SOUTHERN HARDWOODS AS AN ENERGY SOURCE

A. B. Curtis, Jr.[1]

Abstract--Wood sells today on the open market for about one third or less than its potential value for energy when compared to fossil fuels. A phenomenal number of conversions from fossil fuel systems to wood energy systems will bring about greater demands for wood energy raw materials. Such increased demands will cause energy wood values to rise in relation to fossil fuels. When the recommended management practices are considered for the major timber types in the South, an estimated 175 million green tons of energy wood will be available annually above that needed for conventional forest products. The production of energy wood may eventually be more beneficial to landowners and forest farmers than to the users of wood energy.

Additional Keywords: Wood energy values, fossil fuel values, demand, prices stumpage values, management practices, impacts, bottomland hardwoods, upland hardwoods, hardwoods on pine sites, estimated energy wood volumes.

## INTRODUCTION

The use of southern hardwoods as an energy source will depend upon (1) the technologies involved in the harvest, delivery and use of wood for energy (2) the demand/price situation created by users of wood energy and (3) the availability of the resource.

Potential benefits from the use of hardwoods will accrue to both users and growers of wood energy raw materials. Current trends indicate that the use of wood energy may eventually be more beneficial to tree farmers than the users of wood energy.

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[1] Wood Energy Specialist, USDA Forest Service, Southeastern Area, State and Private Forestry, Jackson, MS.

## WOOD ENERGY TECHNOLOGY

The techniques of combusting wood to produce heat and subsequently steam have been with us for years. These techniques have been refined many times and are now tried and true. Such refinements include various types of grates for conventional boilers, and the development of suspension and fluidized bed burners. Thousands of direct combustion systems are now operating throughout developed countries of the world.

The addition of steam turbines and generators to boiler systems is also old technology and equipment for electric generating systems can be purchased from "off the shelf".

While machines to produce combustible gases and liquid fuels have been developed in the laboratory and pilot tested, such techniques are not, as yet, widely used. Technical problems are occurring in gasifiers and the economic feasibility of liquid fuel systems is highly questionable.

The technology involved in the harvest and delivery of energy wood is only slightly different from the harvest and delivery of raw materials for conventional forest products. While not specifically engineered for the wood burning system, the total tree chip works well in conventional wood fired boilers and in fluidized beds. Refinements or possibly new machines will be needed in the future to produce energy wood products for different types of burners. The harvest and delivery of energy wood has several advantages over conventional forest products. For example, energy wood can be harvested from any species, almost any quality and any size of tree. With currently available harvesting machinery and raw material values it is not yet economically feasible to harvest only the small diameter trees. Two machines are now being developed to harvest small diameter stems and may help to alleviate the problem. One of these machines is being developed by the Southern Forest Experiment Station, the Nicholson Company and cooperating pulp and paper industries. The other machine is being developed by the Georgia Pacific Corporation.

All told, we have the technology to harvest, deliver and use wood for energy and, in fact, the practice is already widespread. Some systems that were installed 3 or 4 years ago have already paid for the initial capital investment with fuel savings.

## THE DEMAND/PRICE SITUATION FOR ENERGY WOOD

The woodusing industry is, of course, the largest user of wood energy. Hundreds of sawmills, plywood plants, veneer mills and other small wood industries are making conversions. The pulp and paper industry has used its mill bark and black liquor for energy for many years and is now rapidly installing additional wood burning equipment to become more energy self sufficient. Also, nonwood-using industries such as brick, textile, carpet, distilling and others are demanding a share of the available wood for energy. Heavy demands are also being placed on the resource by home heating. Additional demand is expected from public institutions such as schools and hospitals, in the near future.

The potential value of wood fuel to the user in relation to fossil fuels, based upon its Btu value and burning efficiency, has been reported in numerous papers. A circular slide rule called the Fuel Value Calculator, provides a quick reference to potential wood fuel values at various moisture contents. If the demand for wood energy, brought about by increasing costs of fossil fuels and rapid construction of wood burning systems, caused it to reach its full potential value, benefits to timber stands and subsequent profits from forestry would be fabulous. For example, the Fuel Value Calculator shows that if the value of #6 fuel oil were 90 cents per gallon, a figure in line with today's values, wood chips would be worth $41.73 per green ton if burned for fuel. To equal this value, sawtimber would have to sell for some $375 per thousand board feet (Doyle Scale) at the point of use (table 1). This is, of course, a potential value, when compared to fuel oil at 90 cents per gallon, and wood has not yet reached its potential.

Table 1 shows the potential value of wood fuel to the fuel user in relation to fuel oil. These potential values bear no resemblance to the actual market values of wood raw materials for energy. Users of wood raw materials for energy can, of course, purchase wood for much lower values and can show huge profits for wood burning systems in comparison to oil burning systems. Such high profits, however, are based upon the relationship between the inflated values of alternative fossil fuels and the relatively low values of forest raw materials. Because the earth's reserves of gas and oil are limited and considered nonrenewable, inflated values of these products will most likely prevail. The question, however, that most users and potential users of wood energy are asking is: "Will wood energy always be such a bargain?" Most procurement foresters, and other purchasers of wood energy, agree that "the handwriting is on the wall" and wood will not always be cheap.

Today, in most cases, wood raw material for energy can be purchased for 30 percent or less of its equivalent value in fossil fuels. This value spread between what wood is really worth and what it brings on the market may not be as great, in the future. Wood raw material values for energy will probably never reach full potential nor be as valuable as the convenient petroleum products. It is highly probable, however, that wood energy raw materials will continue to increase in value and could bring as much as 70 to 80 percent of fossil fuel values.

To the landowner and tree farmer this, of course, sounds like good news. If, as predicted, wood values increase in relation to fossil fuels, the savings or profits to users will decrease and stumpage values will increase. Values of energy wood may never reach or exceed values of other forest products such as logs and pulpwood, but should at least set the floor value. In other words, landowners should never sell their wood for less than its value for energy.

When the factors of rapidly advancing technology, an extremely favorable demand/price relationship, and the ease of harvesting and delivering the product are considered, the rapid use of southern hardwoods for energy seems assured. With these thoughts in mind, let us consider the potential availability of our hardwood resources for energy.

Table 1--The comparative value of energy wood, sawtimber and pulpwood, if used as fuel.

| #6 Fuel Oil Costs ($/Gallon) | Energy [1] Wood ($/Ton) | Sawtimber[2] ($/MBF Doyle) | Pulpwood[3] ($/Cord) |
|---|---|---|---|
| .60 | $27.82 | $250.38 | $69.55 |
| .70 | 32.46 | 292.14 | 81.15 |
| .80 | 37.09 | 333.81 | 92.72 |
| .90 | 41.73 | 375.57 | 104.32 |

1 From Fuel Value Calculator (values extended).

2 Calculated on the basis of 18,000 pounds per MBF (Doyle scale)

3 Calculated on the basis of 5,000 pounds per cord.

## POTENTIAL AVAILABILITY

The South has approximately 200 million acres of commercial forest land with slightly over half in hardwoods. Koch estimates that as much as 30 million acres now occupied by hardwoods would be more productive if it were converted to pine. This leaves about 70 million acres that should be most productive when managed for hardwood. Of this 70 million acres, about 22 million acres are classified as bottomland hardwoods and 48 million acres are in upland and mountain hardwoods. All three major types will probably benefit by the increased demand for wood energy.

## ENERGY WOOD FROM BOTTOMLAND HARDWOODS

Generally, bottomland hardwoods in the South are poorly managed or not managed at all. These poorly managed stands have been high graded and abused by diameter limit cutting, which is one of the poorest forms of management. While such management is inexpensive and easily administered, it encourages the slow-growing, shade-tolerant species such as hickory, elm, maple, and ironwood. In this type of management, the lower quality trees not removed for sawtimber and pulpwood are left to produce the next stand of timber. As a result of this type of past management, the landowner must start over with a clear cut,removing all stems down to 2 inches d.b.h. Such clear cuttings will encourage the more desirable intolerant species. This system of management is recommended by our hardwood management specialists and the Hardwood Task Force Report. About 60 percent of the 22 million acres of bottomland hardwoods, or 13 million acres, are presently in this abused condition. If these stands are regenerated favoring the more disireable species, some 30 tons per acre, or 390 million tons, could be available for energy wood in addition to sawlogs taken off before the regeneration cut (table 2). Such harvests of energy wood would not only provide a market for small diameter trees, but would also offset the cost of removing these stems if no market were available.

The next step in the management of regenerated bottomland hardwoods would usually be precommercial thinning in about 10 to 11 years. However, with good markets for energy wood, the landowners would receive income from such thinnings. These thinnings might yield about 4 tons per acre or a total of 52 million tons. The third and last step before sawlog harvest would be a thinning at 20 years of age to remove competing pulpwood-size material for energy wood. Such a thinning could yield about 16 tons per acre or a total of 208 million tons.

If energy wood values were high enough to allow selective thinnings, timber stand improvement work could be done on the remaining 9 million acres. Such thinnings would remove competing vegetation and improve growth on remaining crop trees. From thinnings we could expect to obtain 3 to 5 tons per acre, or some 27 million tons per thinning. These thinnings could occur twice during a 20-year period for a total of 54 million tons.

All told, the energy wood removed from regenerated bottomland hardwood could amount to as much as 50 to 60 tons per acre, or some 650 million tons from the 13 million acres during the next 20 years. This volume plus the 54 million tons from unregenerated stands would provide 704 million tons all bottomland hardwoods. A picture of our managed bottomland hardwoods at the end of a 60-year rotation would show well-spaced, desirable, high quality species about 16 to 24 inches in diameter.

Table 2--Estimated 20-year yield of energy wood from bottomland hardwoods.

| Treatment | Area (MM acres) | Yield/Acre (Green tons) | Total Yield (MM green tons) |
|---|---|---|---|
| Regenerated | 13 | 30 | 390 |
| thinning in 10 years | | 4 | 52 |
| thinning in 20 years | | 16 | 208 |
| Unregenerated | 9 | | |
| thinning in 10 years | | 3 | 27 |
| thinning in 20 years | | 3 | 27 |
| **Total** | 22 | | 704[1] |

[1] Average yield: 32 tons per acre over a 20-year period, 1.6 tons per acre per year or .64 cords per acre per year in addition to production of conventional forest products.

## ENERGY WOOD FROM UPLAND HARDWOODS

There are some 48 million acres of mountain and upland hardwoods in the Southeast. These hardwood stands are in about the same condition as our bottomland stands. As with bottomland hardwoods, upland forests have been high graded and abused over the years. Upland hardwoods have also been subjected to wildfire more than the bottomland forest, because of their naturally dry conditions. About 50 percent of theses stands need regenerating as previously described. In regenerating about 24 million acres of upland hardwoods, one could anticipate harvesting some 25 tons per acre or 600 million tons of energy wood after the removal of sawtimber and pulpwood, over a 20-year period (table 3).

As in the case of bottomland hardwoods, a precommercial thinning probably would be needed in 10 to 12 years. This thinning could produce about 3 tons per acre or about 72 million tons. This thinning in upland hardwoods is even more important than for bottomland stands because of competition on upland stands for available moisture. Another thinning would be needed on upland stands in 20 years to remove pulpwood-size material. This thinning is not expected to yield as much material as the same thinning in bottomland stands because upland hardwood forests are not as productive as bottomlands. An estimated 10 tons per acre is used, for a total of 240 million tons. An exception, of course, would be in upland coves which are as productive as bottomland. So, from 24 million acres of upland hardwoods, yields of about 25 tons per acre at regeneration, 3 tons per acre at precommercial thinning, and 10 tons per acre at the 20-year thinning, giving a total of about 912 million tons of energy wood over the 20-year period. The production of energy wood is equivalent to about .76 cords per acre per year for regenerated stands. A yield of 2 to 4 tons per acre can be expected from the 24 million acres of unregenerated stands in two thinnings, providing an additional 96 million tons. In summary, an estimated 1,008 million tons of energy wood could be harvested from regenerated and unregenerated upland hardwood stands.

Table 3--Estimated 20 year yield of energy wood from upland hardwoods.

| Treatment | Area (MM acres) | Yield/Acre (Green tons) | Total Yield (MM green tons) |
|---|---|---|---|
| Regenerated | 24 | 25 | 600 |
| thinning in 10 years | | 3 | 72 |
| thinning in 20 years | | 10 | 240 |
| Unregenerated | 24 | | |
| thinning in 10 years | | 2 | 48 |
| thinning in 20 years | | 2 | 48 |
| **Total** | 48 | | 1,008[1] |

[1] Average yield: 32 tons per acre over a 20-year period, 1.6 tons per acre per year or .64 cords per acre per year in addition to production of conventional forest products.

## ENERGY WOOD FROM HARDWOODS GROWING ON PINE SITES

According to Karchesy and Koch, 888 million oven-dry tons of hardwoods are growing on pine sites. This hardwood timber, for which there is little or no market at this time, should be removed to improve stocking and growth of the desirable pine species.

All told, from these somewhat crude estimates, it appears that our three major timber types could produce 3,488 million green tons, or about 175 million green tons per year of energy wood during the next 20 years and be left in a managed and more productive condition (table 4). This volume of energy wood does not include any timber now being used for other products. It also does not include the growth of hardwood sawtimber, or pine sawtimber nor pulpwood above that now being harvested for other products.

If, in the future, energy wood were harvested as a competing product from crop trees and, if all forest residues were included, some 422 million green tons--or about twice as much as is now removed-- could be harvested and still maintain our current production of other forest products.

Table 4--Estimated 20-year yield of energy wood from silvicultural practices in the South.

| Source | Area (MM acres) | Yield (MM tons) |
|---|---|---|
| Bottomland hardwoods | 22 | 704 |
| Upland hardwoods | 48 | 1,008 |
| Pine site hardwoods | 130 | 1,776 |
| **Total** | 200 | 3,488 |

## ENERGY WOOD FROM BIOMASS FARMS AND NONCOMMERCIAL TIMBER STANDS

According to the Mitre Corporation report, conventional forest crops yield about 1.3 to 2.7 dry tons of fiber per acre, per year. Under short rotation management, or biomass farming, tree species grown at close spacings could yield as much as 4 to 8 dry tons of fiber per acre, per year. However, note that such plantations require intensive site preparation, cultivation, fertilization and, in some cases, irrigation to obtain such yields. When these factors are considered, the costs per pound of fiber produced may be excessive. With all of the energy wood now potentially available, we face the question: " Will biomass plantations ever be needed?" The answer remains to be determined.

Other intrigueing questions concern the possibility of harvesting energy wood from noncommercial species. One example certainly worthy of mention is mesquite in southwest Texas. Work has been done by the Texas Forest Service on the use of mesquite for a number of years. Manwiller and Wiley estimated that there are 34 million acres of mesquite in Texas, containing 10 to 40 green tons per acre. This 340 million plus green tons could add another 17 million tons per year during the nex 20 years.

## SUMMARY

With rapidly advancing technology in the use of wood for energy and the phenomenal number of conversions and new installations of wood energy systems, the demand for wood raw materials for energy is expected to increase dramatically. In addition, our timber stands could supply an almost insatiable demand for energy wood. If only the generally unmerchantable material from southern bottomland hardwoods, upland hardwoods, and hardwoods on pine sites were harvested for energy wood, some 175 million green tons per year would be available. This is equivalent to about 175 million barrels of oil, which would be worth some 5 billion at $30 per barrel. The total would help improve our balance of payments abroad , as well as aid those using wood for energy. Values to landowners would accrue from two sources. First, with strong markets for energy, landowners' poorly managed stands could be converted to a well managed and productive condition. At $100 per acre, for only the regenerated stands, this would be worth some $6 to 7 billion. At a value of $5 per ton of energy wood removed, some $875 million would also accrue to landowners.

The future does look extremely bright for the development of strong markets for energy wood and for those in the business of growing and utilizing forest products.

When all the values are totaled for landowners and users of wood for energy, landowners appear to be on top, with a potential income of about $8 billion to be weighed against $5 billion for users of wood energy. And this is really what the use of wood for energy is all about: better forest management, utilization, and conservation of our timber resources.

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## UTILIZING THE MID-SOUTH UPLAND HARDWOOD RESOURCE

Hugh W. Reynolds[1]

Abstract.--Most of the mid-south upland hardwood resource is of small size and low quality. Much of this resource should be removed to permit better timber stand growth. But the pallet and pulpwood markets will not absorb all of this removal. We have developed a new utilization method (System 6) to convert this surplus timber to standard size rough dimension parts, blanks, for the furniture and kitchen cabinet industries. Incorporating System 6 bolts with the pallet bolt, pulpwood, and firewood products made from the low-grade trees will increase the value of this resource.

Additional keywords: Furniture, hardwood dimension, low-grade hardwoods.

The mid-south upland hardwood area has the same problem that is found throughout the American hardwood forests. There are too many small, low quality trees taking up valuable space--space that could be used to grow large, high-quality trees of selected species. But removing these poor trees, timber stand improvement (TSI) takes money. The stumpage values are too low to permit best forestry practices.

We have developed a new technology for converting small, low-grade hardwoods to a high-valued product for the furniture and kitchen cabinet makers. The new product is standard sized blanks. Blanks are used directly to make parts, no rough mill processing is needed, so blanks are more valuable than high-grade lumber.

The high value of the blanks, together with the automated System 6 methods, permit stumpage values for low-grade timber to be raised. We expect that the higher stumpage revenues from the System 6 bolts, together with the minimal stumpage revenues from the pallet bolt and pulpwood part of the removals, will make TSI a break-even option for the hardwood forester.

### SYSTEM 6

#### The Forester's Part

Not all low-grade trees nor all parts of low-grade trees can be used in System 6. We have limited the resource to those species used by the furniture and kitchen cabinet industries. Bolts are made 6 feet long with a maximum sweep of 1-1/2 inches and of sound quality. Diameters of bolts are limited to 8-inch (7.6 inches minimum) through 12-inch (12.5 inches maximum) class.

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The remainder of the low-grade resource will be made to pallet bolts, pulpwood, and fuelwood. The sale of roundwood to these markets will not be covered here. Marketing assistance for these pallets is available through the U.S. Forest Service's State & Private Forestry branch and from state utilization foresters.

The forester having marked a stand for TSI will have to train buckers to make System 6 bolts, pallet bolts, pulpwood, and fuelwood products. If factory grade 1 or 2 saw logs are available, by all means make them. These saw logs are more valuable than are System 6 bolts. But these saw logs are larger than 12 inches in diameter, inside bark. So all timber that is 12 inches and less should be made to (1) System 6 bolts, (2) pallet bolts, (3) pulpwood, or (4) fuelwood. This is the order of value of these roundwood products.

## The Sawmiller's Part

The flow of System 6 from bolts to blanks is shown in figure 1. The sawmiller will get the 6-foot bolts directly or if logging and hauling are done tree length, he will do the bucking to 6-foot bolts. The sawmiller will have to follow the bucking order mentioned in the previous paragraph to get the most value out of the tree length logs.

Bolt breakdown is shown in figure 2. A bolt is loaded on the sawmill carriage with the best face forward. Taper is taken out on the first cut. A 3-inch (minimum) wide face is made in the first cut. Then the bolt is rotated 180°, a second cut is made to get two flat sides. The third and last cut is made to get two cants 3-1/4 or 4 inches thick. That is all the sawing that is done.

This technique of making two-sided cants was designed to solve the sawmiller's problem with small diameter wood. It does not pay to saw this small wood to standard hardwood lumber because very little 1 Common and Better lumber is obtained. But three sawlines to make a valuable cant can be a lucrative situation for the sawmiller.

We have also done some limited research work using 8-foot bolts. If the bolts have 1-1/2 inches of sweep, or less, and if they are of sound quality, the 8-foot cants are good. We have also tried "double length" bolts 12 feet long. These, however, could have more than 1-1/2 inches of sweep. Making the three sawlines with the sweep up or down gives 12-foot cants that may be too sweepy. But bucking the cants to 6 feet reduces the sweep to acceptable limits. Fourteen-foot logs could make 8- and 6-foot cants. Sixteen-foot logs could make 8-foot cants. Sawing 12-, 14-, and 16-foot logs in this way reduces the cant footage somewhat but increases sawmill production.

## The Blank Maker's Part

Since this is a paper for foresters to read, their direct interests will not extend any further than the sawmill. But we are including the rest of the System 6 process to show why the bolts and cants are made the way they are. Bolts are made to fit the resource, but cants are made to fit the blank maker's machinery and processing.

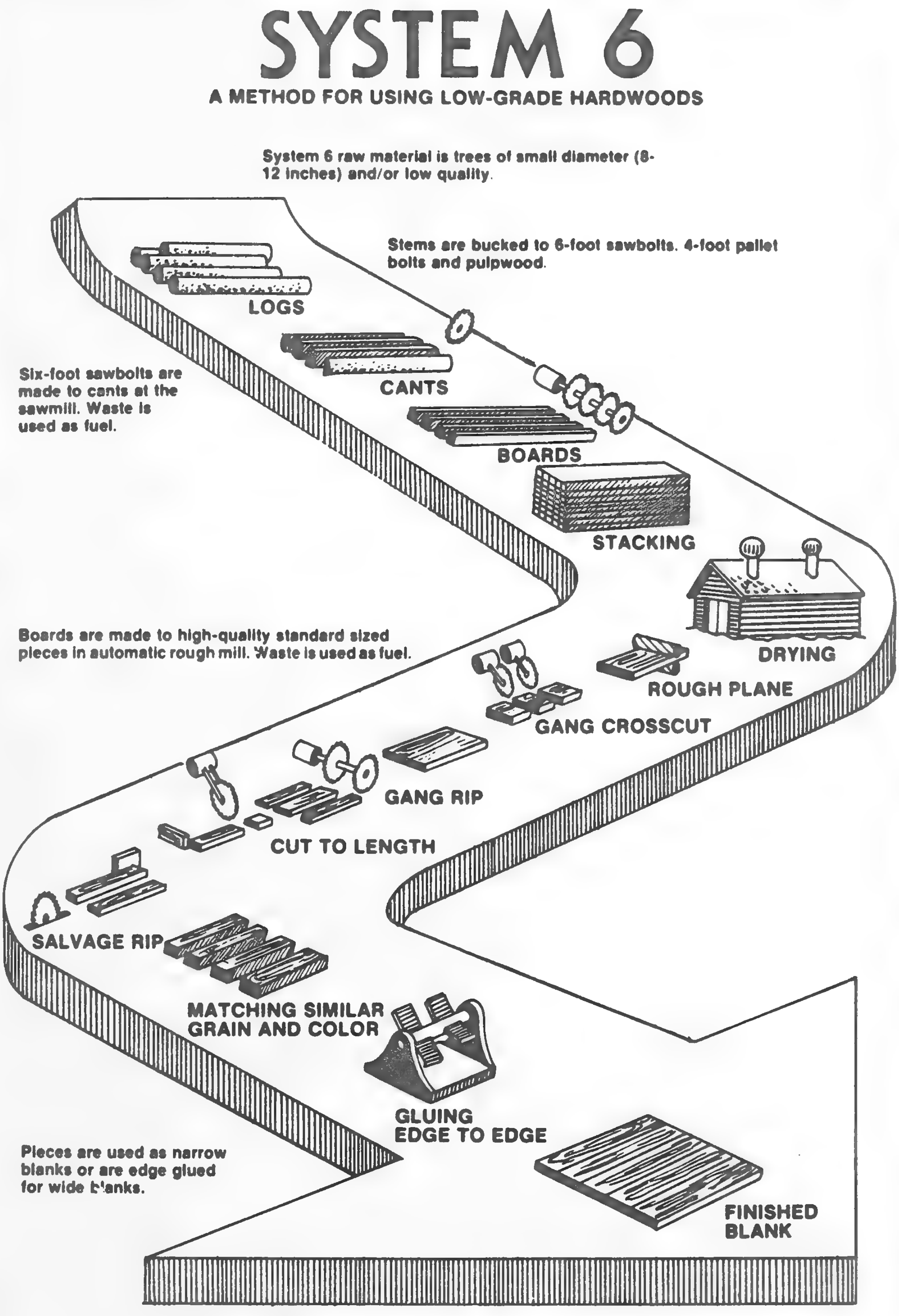
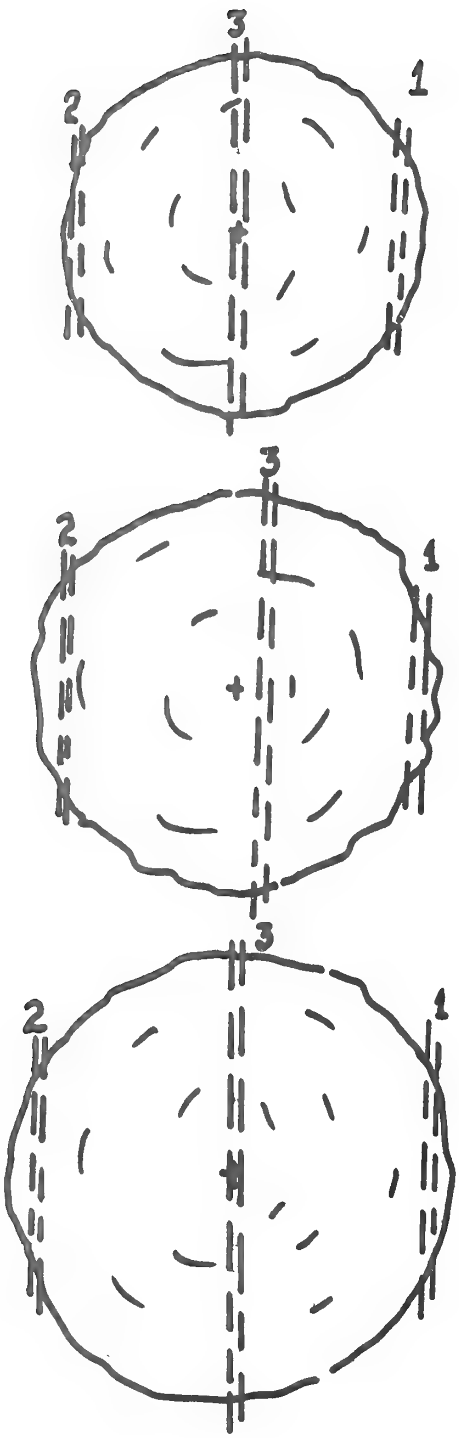



Figure 1

—A result of Forestry Sciences Laboratory research at Princeton, WV




Small Diameter Bolts

1. Saw for 3" minimum face, turn 180°
2. Saw to make 3-1/4" + 3-1/4" + kerf thick cant
3. Saw to make two 3-1/4" thick cants

Medium Diameter Bolts

1. Saw for 3" minimum face, turn 180°
2. Saw to make 3-1/4" + 4" + kerf thick cant
3. Saw to make one 3-1/4" and one 4" thick cants

Large Diameter Bolts

1. Saw for 3" minimum face, turn 180°
2. Saw to make 4" + 4" + kerf thick cant
3. Saw to make two 4" thick cants

Figure 2. Bolt sawing patterns

Let's go back to figure 1. The blank makers buy cants from the sawmiller. Using a circular gang resaw, the cants are made to boards in a single pass. The boards are immediately sticker stacked and are brought to an air drying yard.

The blank maker will expect to get no overrun in boards from the 1/4-inch International Log Rule Scale of the bolts. Both cants from a bolt measured by the NHLA grade rules for "plain sawn flitches" greater than 2 inches thick give a good approximation of the bolt footage. So the sawmiller should not expect an overrun in making cants nor will the blank maker expect an overrun from the cants.

After air drying and kiln drying the boards are ready for processing to blanks. Hit-and-miss planing is done followed by gang crosscutting. This crosscutting must be done to make shorter pieces that are straight. Then these pieces are gang ripped to remove the defects.

The gang crosscutting and gang ripping are the heart of this new technology. Every board made at the time the cant is sawed to boards is dried and is sent through the cut-up line. In this way we get maximum blank yields from the low-grade hardwood resource. And if good blank yields are obtained, the blank maker can afford to pay a good price for the cants. The sawmiller getting a good price for the cants can afford a good price for the bolts. Getting a good price for the bolts permits a stumpage price high enough for payment of TSI work. And that is what you, the forester, want.

But back to the blank maker that now has 85 percent of all waste and defects removed from the pieces leaving the gang rip. The pieces are trimmed to blank length and a salvage rip cut is made if required. Now all pieces are ready for use but many are too narrow. We edge glue the pieces to wide blanks. After planing, the blanks are ready for shipment.

Sometimes too many short blanks are made. If this is the case, we interrupt the process at the output of the piece gang ripsaw. All pieces that will only make short blanks are sent to the Serpentine end matching (Sem) line. Here the short pieces are cut with a curved butt joint. Two or three short pieces are then end glued to make one long piece. The long piece is then returned to the process to be matched for grain and color and is included with the edge gluing of regular pieces.

## The Furniture Maker's Part

Again the forester working with low-grade hardwoods is not greatly concerned with how a furniture maker operates. But you are interested in how valuable the blanks are because that eventually works back to the stumpage prices you get. Making an inexpensive product like pallet parts or a cheap product like pulp chips will not permit much, if any, stumpage. Making a product worth more than FAS lumber will permit better stumpage values.

Blanks are made to standard lengths, widths, thickness, and quality. So a furniture maker or a kitchen cabinet maker knows that he can use all of that blank. The only waste he will incur is cutting the blank to the part sizes required. This means he has no rough mill processing costs. So blanks are ready to use wood--exactly what he needs.

## SUMMARY

Foresters working with upland hardwoods, mid-south or otherwise, have a problem. Their forests have been repeatedly high graded or have been harvested by diameter limit methods. Now there are too many small, low-grade trees--trees that must be removed if the forest potential is to be realized. We have developed a new technology (System 6) to make a high-valued product out of the best of the low-grade timber. Making System 6 bolts as well as pallet bolts, pulpwood, and fuelwood from this resource should increase the stumpage value to the point where TSI work can be carried out on a break even basis.

Sawmillers should welcome System 6. It gives them a way to convert small factory grade 3 and poorer logs into a profitable product. The product is 6-foot two-sided cants. A minimum of sawing is required to make these cants from 6-foot bolts. Eight-foot bolts can also be made to 8-foot cants or 12-, 14-, or 16-foot logs can be made to long cants to be crosscut to 6- and 8-foot cants.

Furniture makers and kitchen cabinet makers have been testing the use of blanks made at our Princeton Lab. They are very enthusiastic about blanks as a substitute for the increasingly hard to get, therefore expensive, 1 Common and Better hardwood lumber. Furniture made from blanks and furniture made from lumber are exactly alike--equally beautiful.

All we lack now is the blank maker. We are building a System 6 pilot plant at the Forest Service in Princeton, West Virginia. Although it is not complete with all the automated equipment in place, we have tested low-grade hardwoods--red and white oak, black cherry, yellow-poplar, hard and soft maple, paper birch, and aspen--from West Virginia, Virginia, Maryland, Pennsylvania, and Minnesota. Results are very encouraging.

As we gain more experience with System 6 the Forest Service through the research and S&PF staffs will be coming to the mid-south. Having blank makers in your area, and your area looks like a natural for System 6, will raise stumpage values for low-grade hardwoods. Raising stumpage values so that the best forestry can be practiced is our goal as well as your goal.

# MIDSOUTH UPLAND HARDWOOD SITE-YIELD POTENTIALS

D. L. Graney[1]

Abstract.--When stand characteristics and yield of thinned and unthinned upland oak stands in the Boston Mountains were compared with published values from other areas, structure of Boston Mountain stands was more irregular than typical even-aged oak stands described elsewhere. Estimated cubic-foot volumes for unthinned Boston Mountain stands were generally higher in 40- and 50-year-old stands and lower in 60- and 70-year-old stands than has been reported elsewhere. Thinned Boston Mountain stands averaged 100 to 300 cubic feet per acre less than stands in the Central States.

Additional keywords: Quercus sp., stocking, thinning, Boston Mountains

Upland hardwoods (Oak-Hickory and Oak-Pine forest types) comprise more than 50 percent of the total commercial forest acreage in the Midsouth Region. Yet we have no published information on stocking, growth, and yield of our Midsouth hardwood stands. Schnur's (1937) yield tables developed from unthinned stands throughout the Eastern United States have been the main source of information for yield of upland oaks. Recently published growth and yield relationships for managed oak stands in the Central States (Dale 1968, 1972; Gingrich 1971a, 1971b) could be valuable to land managers in the Midsouth, but it is still unknown if growth and yield response to thinning in the Central States will apply to our hardwood stands in the Midsouth. In 1978, the Southern Forest Experiment Station Research Project at Fayetteville, Arkansas, installed an oak stocking study on Ozark National Forest lands in north central Arkansas. The objective of this study is to evaluate growth response of upland hardwoods (primarily oaks) to thinning in the Boston Mountains of Arkansas.

This paper compares stand characteristics and yield of thinned and unthinned Boston Mountain stands with those from other regions, and discusses yields expected from management of our Midsouth upland hardwood stands.

## BOSTON MOUNTAIN STOCKING STUDY

The Southern Station study is based on 105 permanent 0.4- or 0.5-acre plots distributed across the Boston Mountains in Arkansas (fig. 1). Stand age at the time of initial thinning varied from 36 to 75 years. Site index (base age 50) ranged from 46 to 83 feet. The distribution of plots by site index is typical of upland oak stands over most of the Midsouth region. All plots were chosen as representative of fully stocked even-aged upland oak stands that showed no evidence of recent fire or cutting.

Plot measurements consisted of a complete inventory of trees greater than 0.5 inch d.b.h. measured to the nearest 0.1 inch. Volumes of sample trees, which were selected at random in proportion to the number in each 1-inch diameter class, were obtained by height accumulation (Grosenbaugh 1954). Plot volumes were determined by multiplying total basal area by the average volume-basal area ratio of sample trees.

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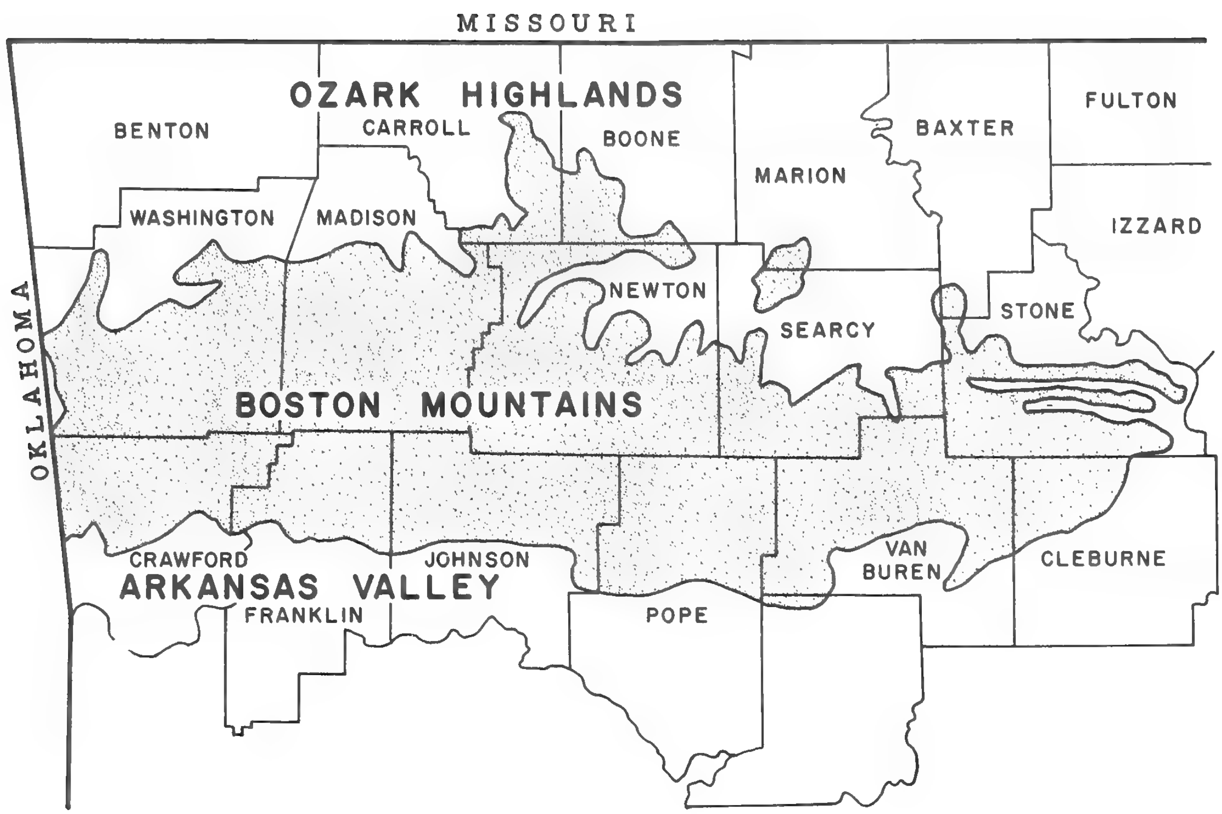


Figure 1.--The Boston Mountains of Arkansas.

Four levels of stocking were created by thinning. Residual stands were left with 40, 60, 80, or 100+ percent of full stocking as described by Gingrich (1967) and Roach and Gingrich (1968). Thinning was mostly from below. Culls and poor quality stems were removed first, then intermediate and suppressed trees of low quality and vigor. High quality desirable species were cut if necessary to attain the goals of lower stocking and more uniform spacing.

Analysis of the Boston Mountain yield data is still in the initial stages. To allow comparisons with stand and yield estimates published elsewhere, I estimated before- and after-cut stand characteristics by using regressions of the dependent variables on age and site index or on age, site index, and basal area. Board-foot volumes for Boston Mountain stands, however, are based on mean values for the various age-site index classes.

Stand Structure Before Thinning

Upland hardwood stands in the Boston Mountains are essentially even-aged, with the 60- to 70-year age classes dominant over most of the area. Most stands originated from sprouts, which developed into a dominant oak understory with the advent of effective fire control in the early 1900's. Periodic removal of the overstory in shelterwood-type cuts allowed the stands to develop into the stands now occupying the area. All stands contain several older trees that were left, for various reasons, at the time of the last overstory cut. These older trees now constitute an older age group of 5 to 10 trees per acre that are generally of larger diameter than the main stands.

Species Composition.--Although 43 tree species were represented on one or more of the Boston Mountain plots, black, northern red, and white oaks accounted for nearly 80 percent of the total basal area and more than 90 percent of the overstory basal area (table 1). White oak, the dominant species in the site 50 and 60 stands, was about equal with red and black oak on the site 70 stands. Red and black oak dominated the stands on the best Boston Mountain sites.

The non-oak overstory group 1, which includes the more desirable species (cherry, ash, walnut, basswood and sweetgum), represented only about 2 percent of the overall basal area and was most common on good sites. Hickory and blackgum, non-oak overstory group 2, accounted for about 10 percent of the total basal area but occurred mainly in the understory or midstory. In the overstory, blackgums were generally older and had larger diameters than the main stand. Hickory, on medium and poor sites, also occurred as scattered individuals representing an older age class, but on sites 70 and 80 it sometimes represented about 5 percent or more of the overstory basal area. In the understory, blackgum was more common on the poor sites (sites 50 and 60) while hickory was more numerous on good sites (sites 70 and 80).

The understory species accounted for 6 percent of the total basal area on all plots with percents ranging from about 4 percent in site 50 stands to more than 7 percent in the site 80 stands. Understory group 1 (red maple, serviceberry and redbud along with blackgum) comprised the dominant understory species on sites 50 and 60 while the group 2 species (dogwood, hophornbeam, pawpaw, etc.) were the primary understory species on the good sites.

Table 1.--Stand composition, in percent, of Boston Mountains study plots before and after thinning treatments.

| | | All Plots | | Site 50 | | Site 60 | | Site 70 | | Site 80 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Basal Area | No. Trees | Basal Area | No. Trees | Basal Area | No. Trees | Basal Area | No. Trees | Basal Area | No. Trees |
| White Oak | | | | | | | | | | | |
| | Before cut | 43.3 | 22.4 | 57.0 | 35.8 | 52.7 | 26.8 | 38.8 | 16.5 | 28.4 | 11.3 |
| | After cut | 45.1 | 24.4 | 59.1 | 35.8 | 58.4 | 26.8 | 39.2 | 19.0 | 28.3 | 13.1 |
| Black Oak, Red Oak | | | | | | | | | | | |
| | Before cut | 37.0 | 10.6 | 24.5 | 12.1 | 30.8 | 10.4 | 37.9 | 10.1 | 51.3 | 9.6 |
| | After cut | 44.0 | 14.6 | 30.9 | 16.9 | 32.0 | 11.1 | 46.7 | 14.8 | 62.2 | 14.7 |
| Post Oak, Blackjack Oak | | | | | | | | | | | |
| | Before cut | 1.2 | 0.9 | 3.6 | 3.2 | 0.4 | 0.2 | 0.8 | 0.4 | 0.3 | 0.1 |
| | After cut | 1.0 | 1.0 | 3.3 | 3.0 | 0.1 | 0.1 | 0.7 | 0.6 | 0.2 | 0.1 |
| All Oaks | | | | | | | | | | | |
| | Before cut | 81.5 | 33.9 | 85.1 | 51.1 | 83.9 | 37.4 | 77.5 | 27.0 | 80.0 | 21.0 |
| | After cut | 90.1 | 40.0 | 93.3 | 55.7 | 90.5 | 38.0 | 86.6 | 34.4 | 90.7 | 27.9 |
| Non-oak Overstory 1/ | | | | | | | | | | | |
| Group 1 | | | | | | | | | | | |
| | Before cut | 2.1 | 2.1 | 0.5 | 0.6 | 1.8 | 1.9 | 4.9 | 3.0 | 1.1 | 2.4 |
| | After cut | 1.9 | 2.4 | 0.3 | 0.8 | 1.4 | 2.1 | 4.8 | 3.4 | 1.1 | 3.4 |
| Group 2 | | | | | | | | | | | |
| | Before cut | 10.0 | 24.7 | 9.9 | 27.0 | 7.9 | 25.2 | 11.1 | 26.6 | 10.6 | 20.3 |
| | After cut | 4.9 | 21.6 | 4.5 | 24.2 | 4.8 | 23.3 | 5.5 | 22.3 | 4.6 | 15.8 |
| All Non-oak Overstory | | | | | | | | | | | |
| | Before cut | 12.1 | 26.8 | 10.4 | 27.6 | 9.7 | 27.1 | 16.0 | 29.6 | 11.7 | 22.7 |
| | After cut | 6.8 | 24.0 | 4.8 | 25.0 | 6.2 | 25.4 | 10.3 | 25.7 | 5.7 | 19.2 |
| Understory 2/ | | | | | | | | | | | |
| Group 1 | | | | | | | | | | | |
| | Before cut | 2.8 | 11.5 | 2.8 | 12.0 | 3.4 | 15.8 | 2.0 | 8.9 | 2.8 | 9.3 |
| | After cut | 1.0 | 10.2 | 1.1 | 10.1 | 1.4 | 14.3 | 0.7 | 7.5 | 1.0 | 9.0 |
| Group 2 | | | | | | | | | | | |
| | Before cut | 3.2 | 26.9 | 1.1 | 8.8 | 2.6 | 19.2 | 3.9 | 33.1 | 4.6 | 45.2 |
| | After cut | 1.8 | 25.0 | 0.5 | 8.3 | 1.5 | 21.5 | 2.2 | 30.1 | 2.0 | 42.0 |
| All Understory | | | | | | | | | | | |
| | Before cut | 6.0 | 38.4 | 3.9 | 20.8 | 6.0 | 35.0 | 5.9 | 41.0 | 7.4 | 54.5 |
| | After cut | 2.8 | 35.2 | 1.6 | 18.4 | 2.9 | 35.8 | 2.9 | 37.6 | 3.0 | 51.0 |

1/ Non-oak Overstory: Group 1: Black cherry, ash, black walnut, basswood, sweetgum
Group 2: Hickory, blackgum

2/ Understory: Group 1: Red maple, serviceberry, redbud
Group 2: Dogwood, hophornbeam, sugar maple, pawpaw, elm, witchhazel

Number of Trees.--Intermediate-aged upland oak stands in the Boston Mountains typically have many stems per acre, and, from age 36 to 75 years, have many more stems than stands in other areas (fig. 2). Also the number of stems increases in the older stands. The major contributors to many total stems in Boston Mountain stands are the 1- and 2-inch diameter classes dominated by blackgum, hickory, and species in understory groups 1 and 2. Numbers of 1- and 2-inch trees often average over 1000 per acre in the older site 70 and 80 stands. In most older stands, oak advance reproduction is sparse or absent, so regenerating these stands to oak will require some type of understory treatment. Number of trees over 2.5 inches d.b.h. in the Boston Mountain stands closely resembles Schnur's stands at ages 40 through 70 and sites 50 through 80 (fig. 3). Trees over 2.5 inches d.b.h. in the Boston Mountain stands also include many tolerant understory species and blackgum through the 5- and 6-inch diameter classes in the younger stands (fig. 4) and through the 8-inch diameter class in the older stands (fig. 5).

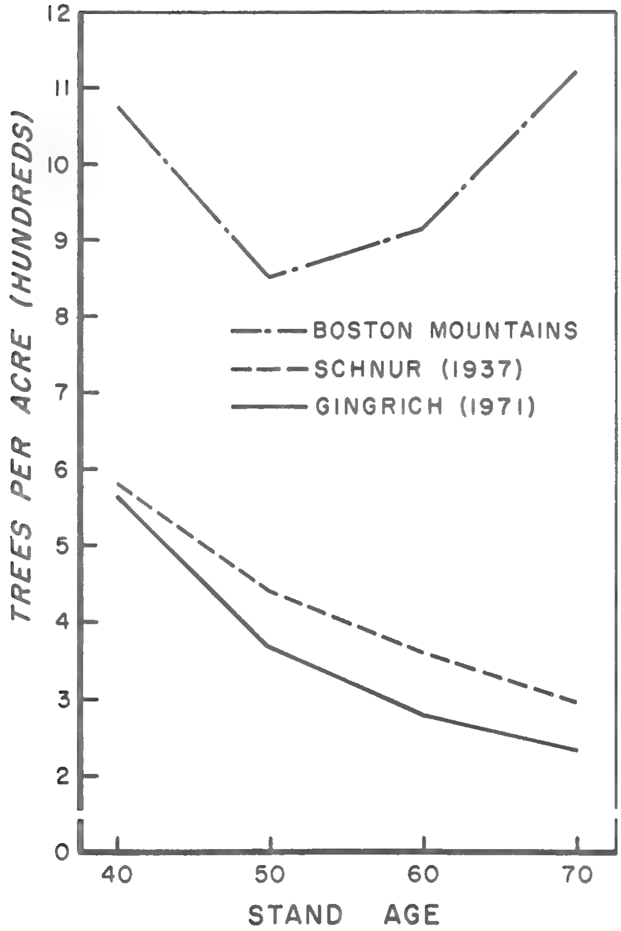


Figure 2.--Comparison of trees per acre for unthinned stands in the Boston Mountains, Central States (Gingrich 1971, and Eastern United States (Schnur 1937).

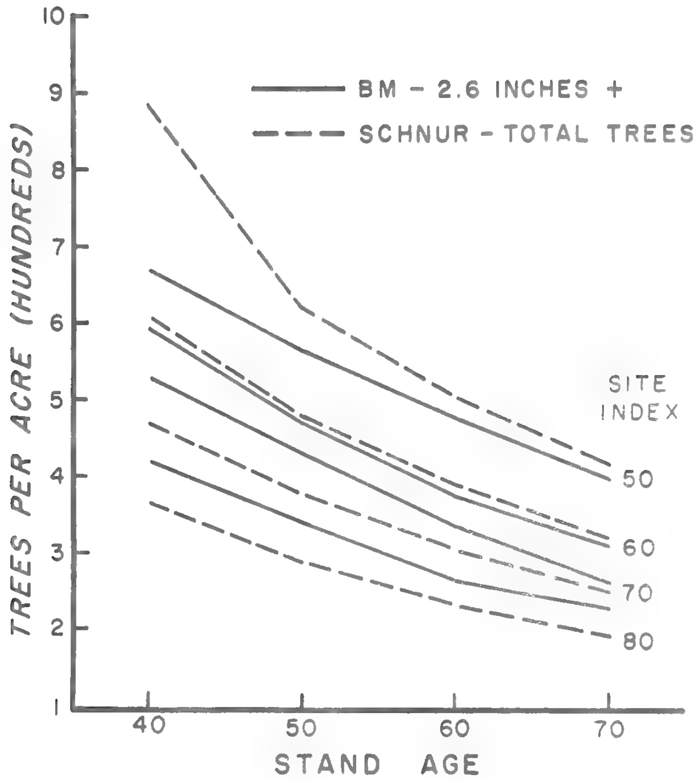


Figure 3.--Relationship between trees per acre, stand age, and site index for stands in the Boston Mountains and Eastern United States (Schnur 1937).

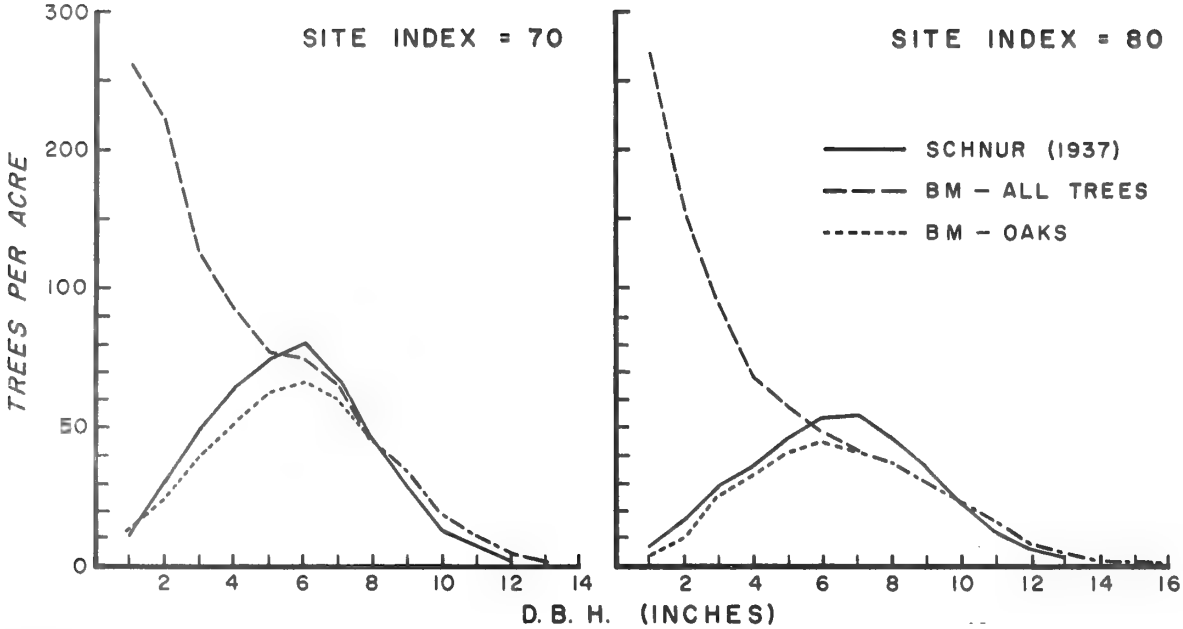


Figure 4.--Distributions of all stems and oaks for 40-year-old, unthinned Boston Mountain stands and stands in Eastern United States.

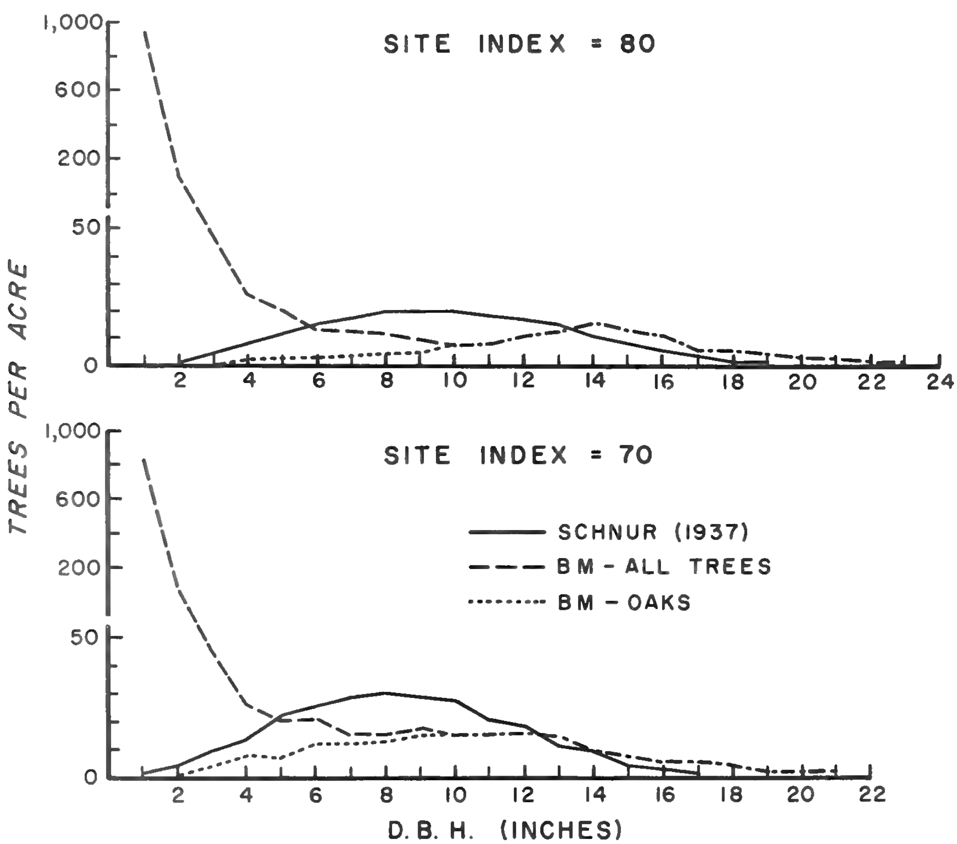


Figure 5.--Distributions of all stems and oaks for 70-year-old unthinned Boston Mountain stands and stands in Eastern United States.

Diameter distributions for all trees in Boston Mountain stands is typical of an all-aged stand on all ages and sites, but the distribution of oaks more closely resembles the even-aged situation (figs. 4 and 5). Seventy-year-old stands on all sites had fewer trees in the middle diameter classes (7 through 12 inches) than did Schnur's stands (fig. 5). The Boston Mountain stands also contained more larger-diameter trees than the stands described by Schnur. This difference could indicate that the older stands had much lower stocking at younger ages and the trees attained larger diameters than would be normally expected. Lower stocking at younger ages might also help explain the many trees persisting in the smaller diameter classes in the older stands.

Basal Area.--In comparison with Schnur's values, basal areas of Boston Mountain stands of all age classes were similar on poor sites but higher on good sites (fig. 6). (Basal area predictions for Boston Mountain stands are based only on trees over 2.5 inches d.b.h. while Schnur's values are based on all trees.) Boston Mountain site 80 stands ranged from 115 square feet at age 40 to 134 square feet at age 70, and averaged 16 (at age 40) to 11 (at age 70) square feet per acre higher than stands studied by Schnur. High basal areas in Boston Mountain stands on good sites are probably caused by the dense understory composed of many non-oak stems in the 3- to 6-inch diameter classes. Data for the 40, 50, and 60-year-old Boston Mountain stands are representative of the actual stand conditions, but data for the age 70 stands probably represent higher-than-average stocking for the area because areas with gaps in the overstory were excluded when plots were selected.

## Yield of Unthinned Stands

Yield estimates for Boston Mountain stands were strongly influenced by the stand structure discussed above. Cubic-foot volume predictions were higher than those observed by Schnur in younger stands and lower in older stands (table 2). Total cubic-foot volumes (o.b.) ranged from 1800 to 3000 (ages 40-70) on site 50 and from 3333 to 4915 on site 80. Volumes were generally much higher at all ages on poor sites and at younger ages on all sites than Gingrich (1971a) found in unthinned stands in the Central States (fig. 7). In older stands, volumes, are similar on site 65, and Central States stands have higher volumes on site 75.

Cubic foot volumes for entire stem (i.b.) and for merchantable stem to a 4-inch-top (o.b.) in Boston Mountain stands are reasonably close to those described by Schnur (1937). Inside bark volumes are slightly higher in age 40 and 50 stands and about the same in older stands (table 2).

The comparison of board-foot volumes in table 1 is only approximate; Boston Mountain volumes are based on trees 11.6 inches d.b.h. and above to 10-inch top o.b. while Schnur's values are for trees having at least one 16-foot log to an 8-inch top i.b. Schnur's volumes were consistently higher on sites 50 and 60 and for intermediate ages on sites 70 and 80, but board-foot volumes in the younger and older site 70 and 80 stands were about the same as in the Boston Mountain stands.

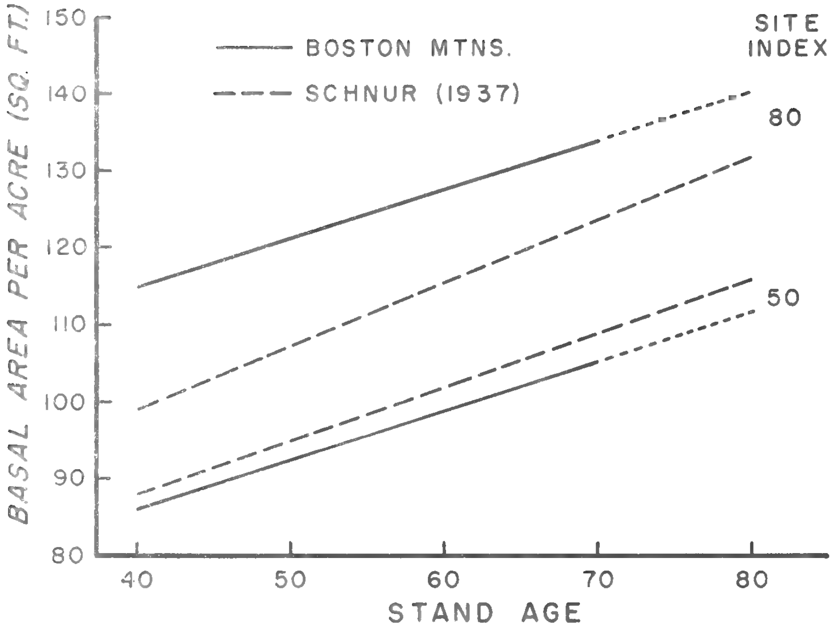


Figure 6.--Basal area per acre for unthinned stands in the Boston Mountains and Eastern United States.

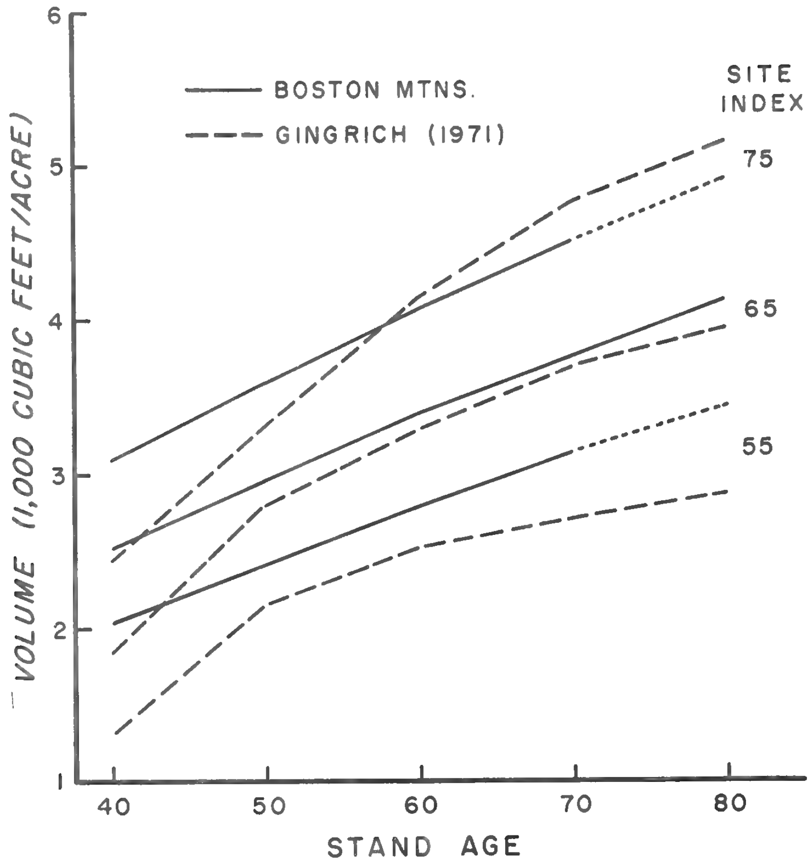


Figure 7.--Cubic-foot volumes, entire stem o.b., for unthinned stands in the Boston Mountains and Central States.

Table 2.--Comparison of per acre yields for unthinned upland oak stands in the Boston Mountains of Arkansas (BM) and eastern United States (SCH) (Schnur 1937).

| Stand Age (Yrs.) | | Basal Area ($ft^2$) | Average Diameter (inches) | Yield Per Acre Entire Stem o.b. ($ft^3$) | Entire Stem i.b. ($ft^3$) | Merch. Stem to 4-in. top o.b. ($ft^3$) | Merch. Stem to 4-in. top o.b. (cords) | Scribner Rule (bd.ft.)1/ |
|---|---|---|---|---|---|---|---|---|
| | | | | Site Index 50 | | | | |
| 40 | | | | | | | | |
| | BM | 86 | 4.8 | 1819 | 1409 | 1252 | 14.7 | 80 |
| | SCH | 88 | 4.5 | | 1360 | 1090 | 12.8 | 150 |
| 70 | | | | | | | | |
| | BM | 105 | 6.9 | 2940 | 2246 | 2778 | 32.7 | 1540 |
| | SCH | 110 | 6.9 | | 2355 | 2510 | 29.5 | 2350 |
| | | | | Site Index 60 | | | | |
| 40 | | | | | | | | |
| | BM | 96 | 5.5 | 2132 | 1766 | 1866 | 21.9 | 400 |
| | SCH | 93 | 5.3 | | 1725 | 1580 | 18.6 | 500 |
| 70 | | | | | | | | |
| | BM | 115 | 8.2 | 3573 | 2768 | 3412 | 40.1 | 3480 |
| | SCH | 115 | 8.0 | | 2970 | 3290 | 38.7 | 5650 |
| | | | | Site Index 70 | | | | |
| 40 | | | | | | | | |
| | BM | 106 | 6.1 | 2768 | 2191 | 2520 | 29.6 | 1250 |
| | SCH | 96 | 6.0 | | 2075 | 2090 | 24.6 | 1100 |
| 70 | | | | | | | | |
| | BM | 125 | 9.3 | 4104 | 3413 | 4047 | 47.6 | 9620 |
| | SCH | 120 | 9.3 | | 3575 | 4030 | 47.1 | 10550 |
| | | | | Site Index 80 | | | | |
| 40 | | | | | | | | |
| | BM | 115 | 7.1 | 3332 | 2697 | 3155 | 37.1 | 2500 |
| | SCH | 99 | 6.9 | | 2440 | 2610 | 30.7 | 2500 |
| 70 | | | | | | | | |
| | BM | 135 | 10.4 | 4915 | 4149 | 4681 | 55.1 | 15440 |
| | SCH | 124 | 10.7 | | 4225 | 4770 | 56.1 | 15900 |

1/ BM volumes for trees 11.6+ d.b.h. to a 10-inch top o.b.

## Stand Structure After Thinning

Residual stands contained a greater proportion of oaks and a lower stocking in small-diameter trees than did the original stands (table 1). Thinning in the Boston Mountain stands increased the percentage of total basal area in oaks from 80 to 90 percent and decreased the basal area of blackgum, hickory, and the understory species from 16 percent to about 8 percent. Over all plots, the oaks account for 95 to 99 percent of the overstory basal area. The proportion of total basal area in white oak increased slightly or remained much the same as before cut, but cutting generally increased the proportion of the red oaks (northern red and black) on all sites. So, stands on sites 50 and 60 are predominantly white oak; those on site 70 are mixed red oak and white oak; and site 80 stands are predominantly red oak.

Stems in the 1- and 2-inch diameter classes were reduced to about 4 percent stocking (about 200 stems per acre). Diameter distributions for all trees in the 3-inch class and above resemble more closely than the unthinned stands what one would expect in an even-aged stand (figs. 8 and 9). The many small-diameter trees in the age 70 stands (fig. 9) occur mainly in the 80-percent stocking treatments. In all age 70 stands (and most age 60 stands on sites 70 and 80), the 80-percent stocking goal was reached by removal of culls and other poor quality stems in the overstory, and smaller diameter stems were left. Residual stems in the 40 and 60 percent stocking treatments were predominantly in the overstory. The presence of the small-diameter trees in the higher stocking (and basal area) levels may have influenced the after-cut yield estimates for the Boston Mountain stands.

### Yield After Thinning

Estimates of total cubic-foot volume (entire stem o.b.) were consistently lower over all sites and ages than Dale's (1972) predicted volumes for thinned upland oak stands in the Central States (fig. 10). Boston Mountain stands averaged about 100 cubic feet lower than Central States stands on the lower stand densities, and 200 to 300 cubic feet less at the higher densities. Some of the differences in cubic-foot volumes were caused by the many small-diameter trees in the thinned Boston Mountain stands, especially in the higher stocking classes. Volume estimates based on trees 5 inches d.b.h. and above for age 40 and 50 year stands and trees 6 inches d.b.h. and above for 60 and 70 year stands more closely resembled Dale's values for the Central States (fig. 11). Another possible reason for the difference in volume could be that red or black oak were used for site index determination on all Boston Mountain plots. In this area white oak has a site index 3 to 5 feet lower than red or black oak on most sites. Because the site 50 and 60 stands were mainly white oak and site 70 stands were mixed red-white oak, volume may have been underestimated because white oak site index was overestimated.

Board-foot volumes were generally higher in thinned Boston Mountain stands than in Central States stands, probably because Boston Mountain stands had more larger-diameter trees (fig. 12). For the high stocking levels (basal area 80 to 100 sq. ft.) the Boston Mountain stands averaged 1000 to 2000 board feet more than the Central States stands. For low stocking levels (basal-area levels of 40 and 60), the board-foot volumes were nearly the same for the younger stands, but the Boston Mountain volumes were higher in older stands.

## EXPECTED RESPONSE TO THINNING (TWO CENTRAL STATES STUDIES)

The Boston Mountain stocking study has only been established for 2 years, and we have no data to indicate a response to the thinning treatments. However, information on 10-year growth response after an initial thinning (Dale 1972) and expected yields from periodic thinnings (Gingrich 1971a) are available for upland oak stands in the Central States.

### Short-term Response to an Initial Thinning (Dale 1972)

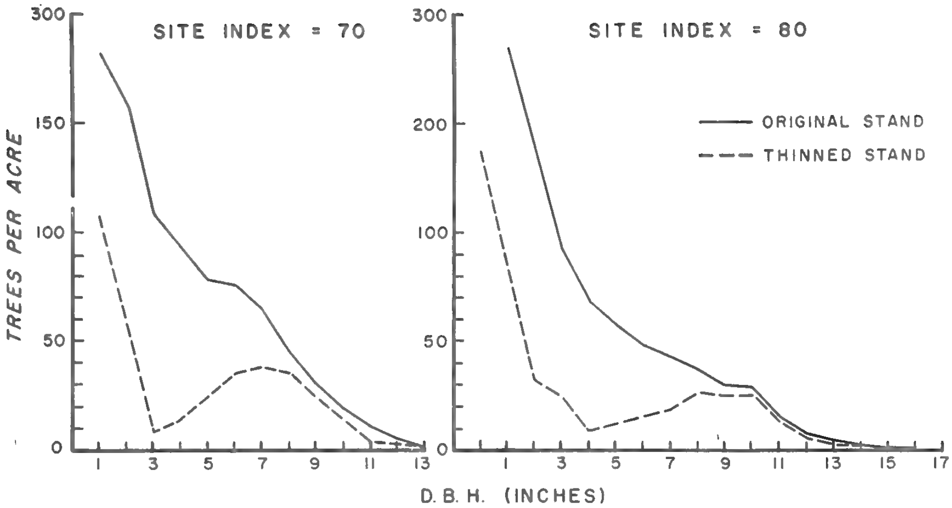


Figure 8.--Diameter distributions before and after thinning for 40-year-old Boston Mountain stands on sites 70 and 80.

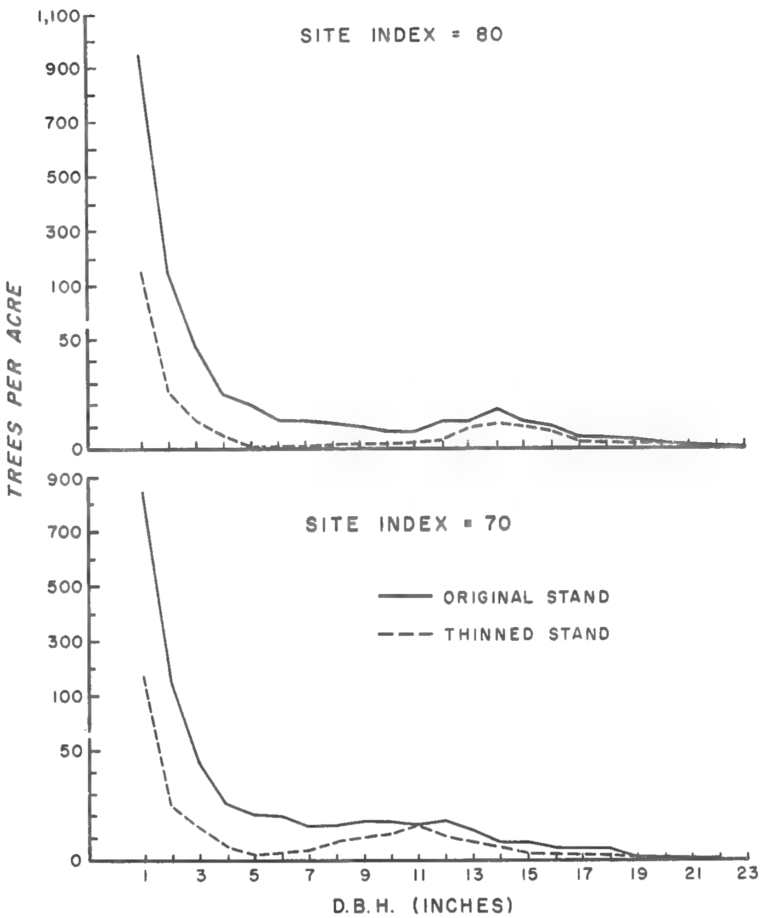


Figure 9.--Diameter distributions before and after thinning for 70-year-old Boston Mountain stands on sites 70 and 80.

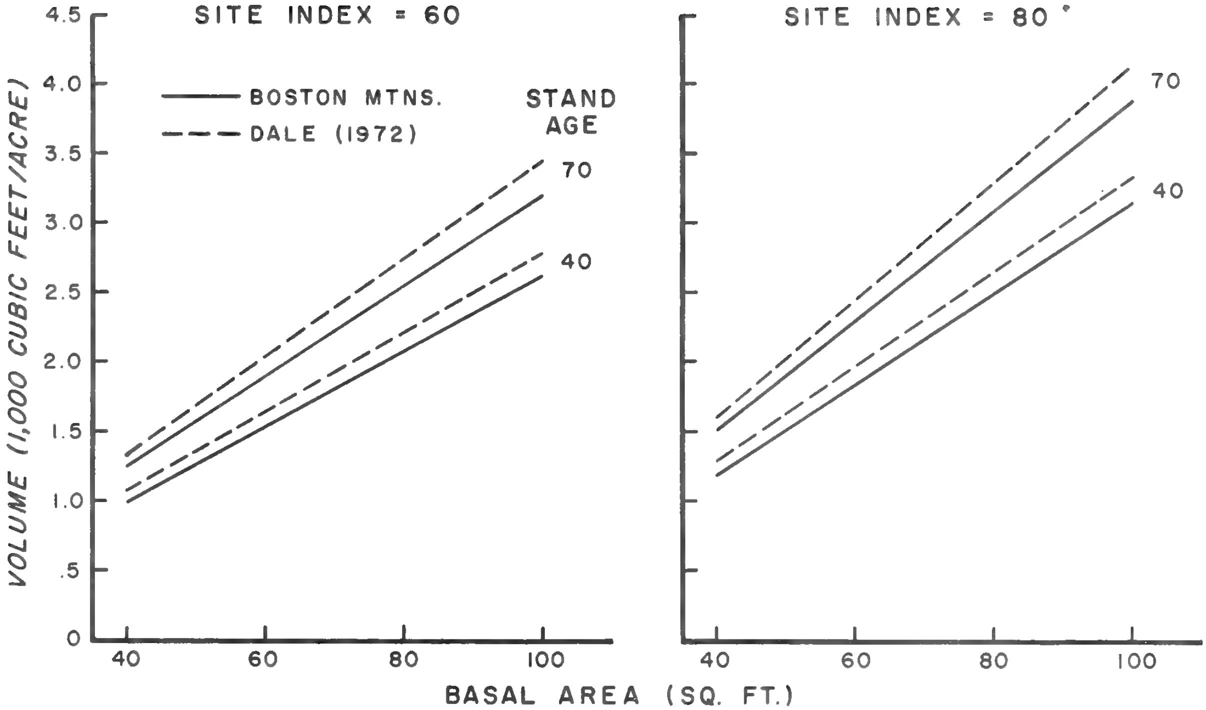


Figure 10.--Total cubic-foot volumes, entire stem o.b., for thinned stands in the Boston Mountains and Central States (Dale 1972).

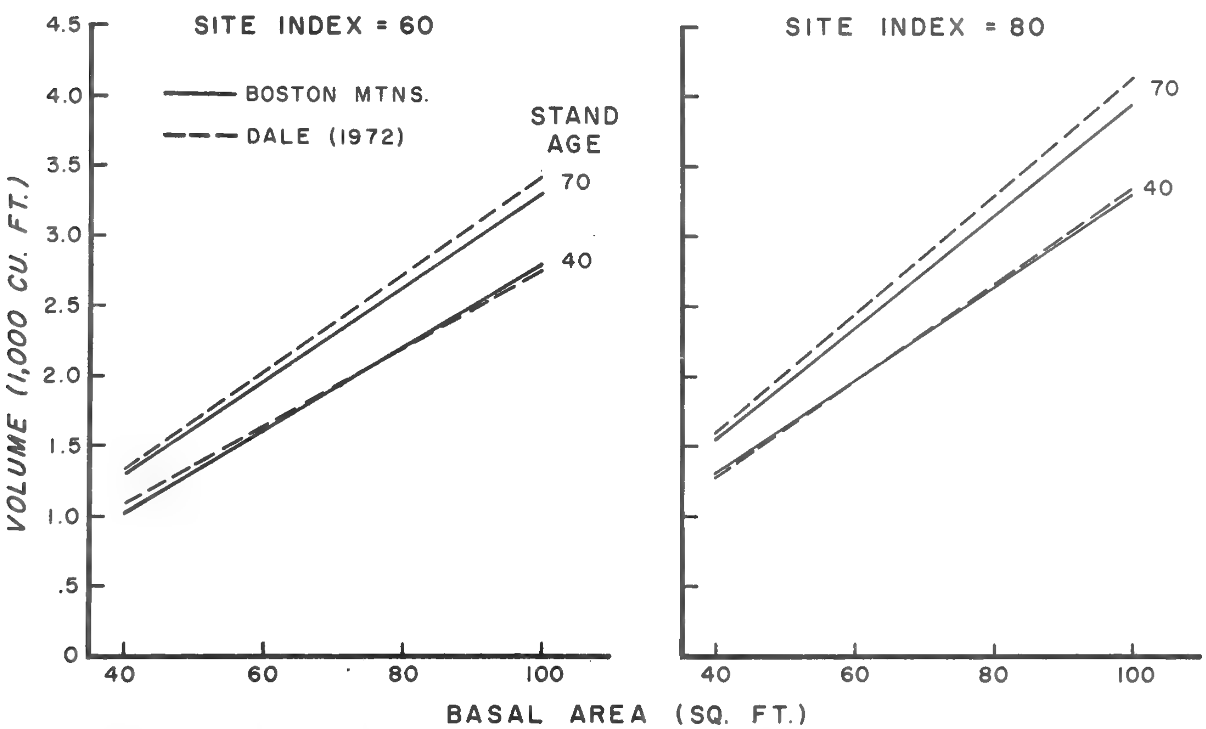


Figure 11.--Cubic-foot volumes, entire stem o.b., for thinned stands in the Boston Mountains and Central States (Dale 1972). Boston Mountain data based on trees 5 inches and above for ages 40 and 50 and 6 inches and above for ages 60 and 70.

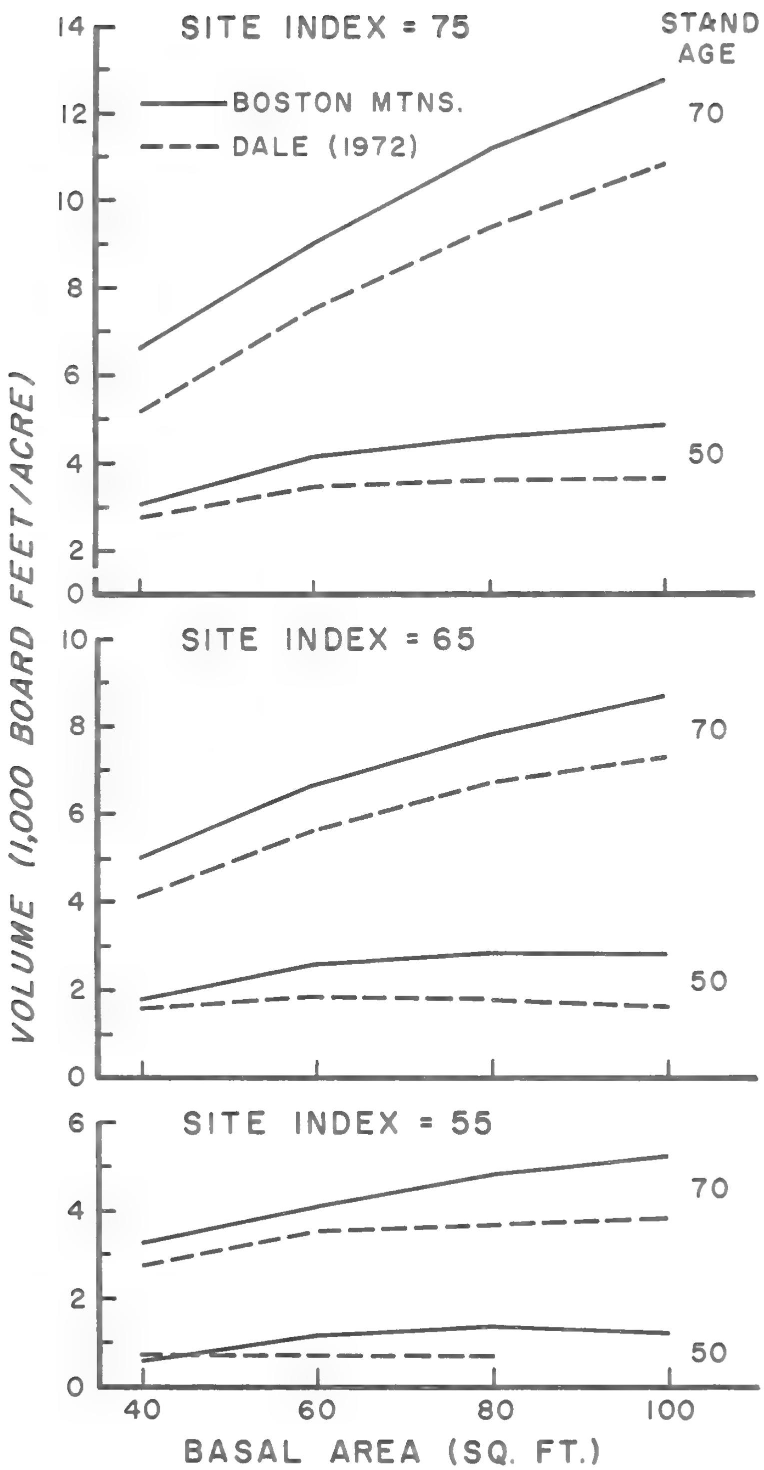


Figure 12.--Board-foot volumes per acre, International 1/4" rule, for trees over 85 inches d.b.h. in Boston Mountain and Central States (Dale 1972) stands.

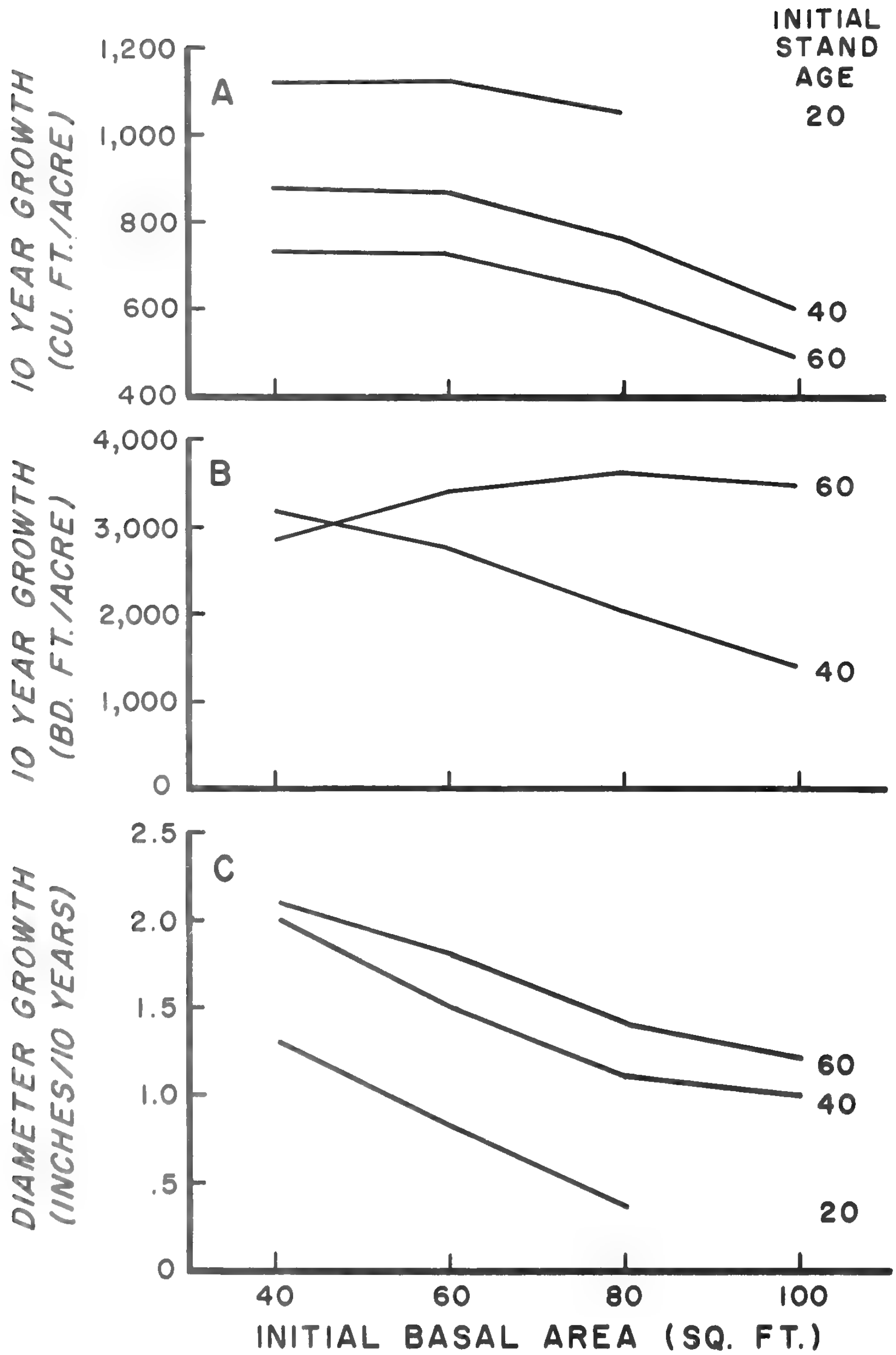


Figure 13.--Relationship of 10-year volume and diameter growth to basal area and stand age on site 75. (from Dale 1972).

Cubic-foot Growth.--Regardless of site or age, maximum cubic-foot volume growth occurred with low stocking; between 30 and 60 square feet (fig. 13-a). Greatest response to thinning occurred in the younger stands with age 20 stands producing over 1100 cubic feet in 10 years and age 60 stands producing slightly more than 700 cubic feet in the same period. Stand density levels associated with maximum volume growth in the Central States stands were generally lower than the 50 to 60 percent stocking levels recommended for upland oak stands. However Dale did not recommend an initial thinning to such low densities (30-50 sq. ft.) because the heavy thinning could increase stem taper, reduce height growth, and possibly stimulate epicormic branching on the residual trees.

Board-foot-Growth.--Growth in board-foot volume was greatest on the good sites. Maximum periodic growth rates occurred when many trees were approaching the threshold diameter, or 8.6 inches in this case (fig. 13-b). On site 75, 10-year growth for the age 60 stand averaged about 4000 board-feet for all stand basal areas between 60 and 100 square feet. So, thinning to 60 or 70 square feet would concentrate the same amount of growth on the best crop trees, which would then increase rapidly in value.

Diameter Growth.--Maximum rates of diameter growth also occurred at the very low stocking levels and declined sharply as stand basal area increased (fig. 13-c). But low stocking levels are not necessarily recommended. For example, basal area 40 would represent an understocked condition for the 40- and 60-year stands. At the recommended 60-percent stocking on site 75, average stand diameter increased 1.7 inches for the 60-year-old stand, 1.5 inches for the 40-year-old stand, and 1.2 inches for the 20-year-old stand.

Long-term Response to Periodic Thinning (Gingrich 1971a)

Based on results of a study involving periodic thinnings starting at different points in the life of even-aged upland hardwood stands in the Central States, Gingrich (1971a) has presented cumulative yields over a 50-year management period with a 10-year thinning interval. In general, the study indicated that the younger the stand when thinning is begun, the greater the yield increase for the 50-year management period. When thinning is begun at age 10 the yield increase in cubic-foot and cordwood volume can be more than 50 percent greater than when thinning is begun at age 60. On all sites, the yield from stands thinned to a residual stocking of 60 percent at 10-year intervals was at least 25 percent greater than the yield from unthinned stands (table 3).

Whether growth response and yield of Midsouth hardwoods after thinning approximate the 10-year response indicated by Dale (1972) or the cumulative yields indicated by Gingrich (1971a) may depend largely on the structure and condition of the individual stand. Young even-aged stands will possibly respond to thinning much the same as indicated for stands in the Central States. But intermediate-aged stands such as the older Boston Mountain stands, which differ in stand structure from the typical even-aged situation, might not produce the same response in growth or yield as indicated for the Central States.

Table 3 - A comparison of yields per acre for even-aged upland hardwoods.
Management period: 50 years, cutting interval: 10 years (from Gingrich 1971a).

| Stand age at first thinning (years) | Site 55 | | | Site 65 | | | Site 75 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Volume at beginning of period | Cumulative yields 50 years later | Increase in yield | Volume at beginning of period | Cumulative yields 50 years later | Increase in yield | Volume at beginning of period | Cumulative yields 50 years later | Increase in yields |
| | | | | Cubic Feet 1/ | | | | | |
| 10 | | 3900 | 3900 | | 4860 | 4860 | | 6390 | 6390 |
| 20 | 60 | 3500 | 3440 | 178 | 4830 | 4652 | 694 | 6440 | 5746 |
| 30 | 583 | 3920 | 3337 | 1200 | 5160 | 3960 | 1670 | 6640 | 4970 |
| 40 | 1320 | 4185 | 2865 | 1840 | 5265 | 3425 | 2440 | 7155 | 4715 |
| 50 | 2150 | 4100 | 1950 | 2800 | 5350 | 2550 | 3315 | 7080 | 3765 |
| 60 | 2520 | 4345 | 1825 | 3300 | 5445 | 2145 | 4140 | 7040 | 2900 |
| | | | | Cords 2/ | | | | | |
| 10 | | 37.8 | 37.8 | | 44.1 | 44.1 | | 56.7 | 56.7 |
| 20 | 0.6 | 34.0 | 33.4 | 1.6 | 42.0 | 40.4 | 6.4 | 57.4 | 51.0 |
| 30 | 5.3 | 37.6 | 32.3 | 10.6 | 45.6 | 35.0 | 16.7 | 58.8 | 42.1 |
| 40 | 12.1 | 41.4 | 29.3 | 18.2 | 48.2 | 30.0 | 23.2 | 63.4 | 40.2 |
| 50 | 19.7 | 40.5 | 20.8 | 26.9 | 51.0 | 24.1 | 30.1 | 65.0 | 34.9 |
| 60 | 22.9 | 41.8 | 18.9 | 30.8 | 52.2 | 21.4 | 37.7 | 62.7 | 25.0 |
| | | | | Board Feet 3/ | | | | | |
| 10 | | 8340 | 8340 | | 12000 | 12000 | | 18840 | 18840 |
| 20 | | 7350 | 7350 | | 12600 | 12600 | | 19880 | 19880 |
| 30 | | 9920 | 9920 | | 15520 | 15520 | | 23040 | 23040 |
| 40 | | 11880 | 11880 | 440 | 14580 | 14140 | 1380 | 24120 | 22740 |
| 50 | 400 | 11400 | 11000 | 2150 | 14900 | 12750 | 4100 | 23200 | 19100 |
| 60 | 900 | 11550 | 10650 | 5160 | 17380 | 12220 | 9238 | 22550 | 13312 |

1/ Total cubic-foot volume of entire stem, including bark, tip, stump but no branches.
2/ Standard cords to a 4-inch top inside bark, excluding bark and branches.
3/ Board-foot volume, international 1/4-inch rule, to an 8.5-inch top, outside bark.

Wherever their stands are located, managers considering thinning upland hardwood stands should keep in mind three principles stressed by Gingrich (1971a).

First, hardwood stands should be thinned from below. Small trees in the subdominant classes that have endured long periods of shade and competition are less likely to respond to release by thinning. The high vigor and best quality stems will be in the dominant and codominant crown classes.

Second, a single thinning has very little effect on the final yield of a forest stand. But a single thinning will produce the greatest return in terms of physical yield if it is done in the younger stands. First thinnings in older high-density stands may not produce the expected growth response. Such stands often contain low-vigor trees, dense clumps, and mixed species, so a first thinning could result in a net growth deficit.

Third, the earlier a stand is thinned the greater the accumulated yield over a given management period. If precommercial thinnings are not feasible, the latest effective thinning age for pulpwood production is between 30 and 40 years and between 50 and 60 years for sawtimber production. If thinning is not started by this age it may be better to leave the stand alone, or regenerate the stand if it is in poor condition.

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CHANGING PHILOSOPHIES FOR MID-SOUTH UPLAND HARDWOOD MANAGEMENT AND UTILIZATION

Bart A. Thielges [1]

Abstract.--Over the next two decades, utilization of the mid-south upland hardwood resources is expected to increase due primarily to expansion of traditional existing markets and development of new hardwood chip markets for pulp, reconstituted wood products and energy supplements. More intensive management practices on private non-industrial lands may be a spin-off of market expansion, improved stumpage prices and increased management incentives.

Additional keywords: Markets, products, land use.

## INTRODUCTION

Recent developments in national and international economics and politics have both direct and indirect implications affecting the utilization and management of the forest resources of the United States. Many of these developments, such as increased demand for wood and fiber from southern pine forests, new domestic and foreign markets for products, and stricter legislation governing land use have created a potential for more intensive utilization and management of upland mixed hardwood forests. Hardwood prospects have also brightened due to new product development and advances in harvesting and utilization technology.

It is appropriate at this time to engage in some speculation about the future of the upland hardwood resource through the next twenty years and to attempt to identify some of the significant factors which might influence utilization and management of upland hardwoods in the mid-south.

The following discussion is addressed primarily to those upland areas of the mid-south under broadleaf forest cover and occurring in western Virginia, North Carolina and South Carolina, West Virginia, Kentucky, Tennessee, southern Missouri and northern Arkansas. The forest types represented include much of the classic mixed mesophytic forest (*Acer* - *Aesculus* - *Fagus* - *Liriodendron* - *Quercus* - *Tilia*), the Appalachian oak forest (*Quercus*), and the oak-hickory forest (*Quercus* - *Carya*).

This broad belt of upland forest is characterized by an extremely diverse mixture of valuable hardwood species growing on some of the most productive forest land in North America. It represents some of the most scenic land in the eastern United States and is heavily utilized for outdoor recreation. Topographically, it ranges from moderately "rough" to impossible. These upland hardwood forests are also centrally-located to about 80% of the domestic market for their products. Managerial control of this resource resides primarily in the hands of hundreds of thousands of small, non-industrial owners, many of whom are absentee owners. These characteristics provide an environment that offers great potentials and, at the same time, imposes severe re-

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strictions on the productive utilization and management of the upland hardwood resource.

Under the hopeful assumption that increased utilization and improved markets would beget intensified and thoughtful management (a debatable philosophy in itself) the factors relating to change are presented in an inductive order with utilization possibilities preceding a discussion of management potentials.

## UTILIZATION PROSPECTS AND TRENDS

A twenty-year projection for utilization of mid-south upland hardwoods, in general, can be characterized by one word -- increase. This will result from increased demand for "traditional" hardwood products and also from expansion into new markets.

### Traditional Utilization of Upland Hardwoods

The potential for an increase in the utilization of upland hardwoods in traditional markets appears to be promising over the next 20 years. Expansion in certain markets, notably furniture, panelling and pallets seems likely. Other mainstay hardwood markets will remain at levels below peak years, but should be stable through the year 2000. Still others will continue to decline.

Overall demand for traditional products will increase, however, and the 20 year projections for various products can be summarized as:

Sawlogs -- significantly increased demand for all grades, due mainly to furniture, pallet increases;

Veneer -- increased demand for panelling, furniture applications;

Hardwood flooring -- decreased demand;

Cooperage -- stable through 2000 but below peak years;

Crossties -- below post-WW II peak but stable through period.

One of the factors that should contribute to a growth in sawlog and veneer utilization is a growing foreign export market, particularly in western Europe. The mid-south upland hardwood forests are rich in the woods that Europeans prefer for fine furniture and cabinetry, particularly oaks and ash. The United States represents a stable, regular supply as opposed to competitive supply from Africa, South America and Southeast Asia.

European import restrictions, such as those recently imposed to reduce the threat of oak wilt introduction, may present problems to very rapid expansion into this market. However, such restrictions do not appear to be insurmountable and will probably result in increased secondary processing of lumber and veneer prior to shipment. Increased domestic processing may provide impetus for expansion of U. S. firms, creation of new firms and also an increase in foreign investment through partnerships or ownerships.

Coupled with a healthy increased domestic demand for furniture and pallets, even a modest expansion into the export market should contribute to a steady and significant increase in utilization of upland hardwood sawlogs and veneers. Again, the strategic location of both forest resources and industry in the mid-south in relation to domestic and foreign markets for hardwoods is an important factor.

Non-traditional or New Products and Utilization

Expansion into new markets and new product development will probably be responsible for the major share of the projected growth in hardwood utilization over the next two decades and beyond. A significant boost to hardwood market expansion will derive from a tremendous drain on the softwood resource over the next 50 years, resulting in a shortfall of softwood materials in some markets. Mid-south upland hardwoods will be needed to take up some of this slack.

The utilization prospects may be summarized as follows:

Construction -- There will probably not be a significant increase in hardwood utilization for structural purposes, although there may be some applications in areas such as roof decking. Some of the softer woods, such as yellow poplar, may offer a possibility for framing materials. Non-structural applications offer greater possibilities. Moldings and other interior trim should be a viable market. The biggest increase in non-structural construction uses of hardwoods should occur in the area of reconstituted wood products, however. Market potentials will arise for both "soft" and "hard" hardwoods. Specific products include fiberboard, particleboard and flakeboard/waferboard. Prospects for fiberboard and flakeboard look particularly bright, and 80% of the market for these products is located east of the Mississippi River. More and more hardwood residues will be utilized in these products and, in general, hardwoods will have distinct advantages. The resource is located within the market, there are relatively few technical problems to overcome, and wood costs will be favorable compared to softwood chips which will be experiencing increased demand, and rising prices, for pulp.

Pulp and Paper -- There is a phenomenal opportunity for increased utilization of hardwoods in this industry. Favorable resource-market location is again significant, but the controlling factor is the present economic advantage of the hardwood chip. Pulpwood stumpage price for pine is currently about 3 times greater than the hardwood price. Since there is no real difference in the delivered price of these materials, a great marginal advantage accrues to hardwoods -- an advantage of about $25-35 per pulp ton, depending upon location. A spectrum of technical developments, such as delignification processes, peroxide brighteners and press drying, have paved the way for increased use of hardwood fiber. From 1963-73 hardwood pulp use increased 500% compared to about a 100% increase for softwoods. By the year 2000, hardwood pulp will increase to 35% of the total market compared to 25% at present. Continued technical advances will provide a market for more species and will increase production of short-rotation wood and utilization of juvenile wood.

Energy -- Right now, utilization of hardwoods for energy represents an unknown quantity. However, even a modest increase in utilization of wood residues and "woods waste" for energy or energy supplements should have some impact on both the chip and roundwood market. In certain areas, a lively competition for the hardwood chip may develop between pulpwood and energy markets.

A similar competition for roundwood might be contemplated in heavily-populated areas. It is difficult to speculate on the energy potentials for upland hardwoods but, again, if the demand develops, the resource is situated admist the market.

The overall forecast for increased utilization of upland hardwoods from the mid-south by the year 2000 can be summed up thusly;

-- Hardwood sawlog removals will increase steadily and significantly;

-- Hardwood veneer log removals will increase;

-- New markets will develop for smaller, low-grade hardwoods for pulp, reconstituted products, and energy.

## MANAGEMENT POTENTIALS

Management prospects and potentials are closely tied to the scope and intensity of utilization of the upland hardwood resource of the mid-south. In addition, other factors, addressing the small, non-industrial ownerships characteristic of the region, will influence these prospects and potentials. Some of these are:

Markets for Stumpage -- The landowner, as a potential manager, must be assured of a viable, readily accessible market for his product.

Prices -- The price for the product must be high enough to make even "minimal management", for example, a harvest cut, appear worthwhile. In general, the greater the profit margin, the greater the potential for more refined or intensive management although there will certainly not be a unitary (1 to 1) correlation between the two.

Tax Incentives -- In 1979, a Private Non-Industrial Woodland Owners Conference was held in Atlanta. Participants were asked to identify and prioritize their major concerns related to managing their woodlands. Of the "top 20" concerns, 16 were directed, in one way or another, at tax reforms of various types which would provide incentives for managing their lands.

Cost-sharing of Management Activities -- In the same set of priorities expressed in the Atlanta Conference, 3 of the remaining 4 "top 20" concerns addressed the need for some form of government and/or industry cost-sharing for planting, TSI, and other management activities as further incentives to forest land management. (To satisfy the curious, the remaining "top 20" concern was "increased grass roots political clout").

There is evidence that some of these constraints will be satisfied or partially relieved. A projected increase in utilization of upland hardwoods for traditional products (lumber, furniture parts, veneers, pallets, etc.) will contribute to the development of viable markets for sawlogs and veneer logs. Utilization of smaller and less valuable trees and of residues for reconstituted wood products, pulpwood and energy will create new markets in many areas.

As these markets develop and expand, significantly increased stumpage prices should follow, both for quality sawlogs and veneer logs to meet growing and, possibly, competing domestic and foreign markets. Markets for poorer quality, smaller material will develop, as well. Competition for the hardwood chip may become brisk and, with the present marginal "cushion" relative to pine, there should be a significant trend toward hardwood substitution.

These factors and, with any luck, some federal, state and/or industry generated incentives for landowners should be conducive to a tangible trend toward what we would consider more intensive management. This trend might be evidenced by increased thinnings, with the removals marketed as chips; more TSI activity to favor high value lumber and veneer stems, improve accessibility and favor reproduction; more planting, especially of fast growing, short-rotation species to access the growing chip market; increased involvement of forestry professionals with hardwood landowners in the form of consultations on sales and management practices as well as provision of technical information of the type provided by foresters in state extension, USFS State and Private Forestry, and industry LAP programs. Many wood-using industries currently operating without professional foresters on their staff, such as medium-sized sawmills, have already expressed a need to employ foresters who would work as management and technical "consultants" as well as wood-buyers, to insure a continued supply of materials in their operating areas.

Land use or, more specifically, increased pressures on the alternative uses of forest land and tougher regulations regarding its use, should also exert an influence on future management trends in the mid-south. Exploitation of coal reserves by surface mining provides a case in point, since much of this activity is concentrated on the highly-productive mixed mesophytic forest lands of the Appalachians. Under the new regulations of Public Law 95-87 (Surface Mining Control and Reclamation Act of 1977), several provisions addressing both pre-mining and post-mining operations will directly affect utilization of hardwoods and management of reclaimed forest land. Without going into specific detail, two examples can be cited.

Before PL 95-87, much forest land clearing prior to mining was accomplished by bull-dozing trees over the side of the mountain or piling and burning. Few operators bothered to take the time to arrange a timber sale. Now, the regulations address the need for efficient utilization and/or proper disposal of woody material. These developments have kept our extension faculty in Kentucky busy advising a growing number of mining operators about purchasing portable sawmills and chippers as an auxiliary enterprise or putting them in touch with contractors who will take the wood. A very popular item is a portable pole mill which can be modified to cut small diameter hardwoods to pallet stock dimensions; two are now operating in eastern Kentucky, and have found more business than they can handle. Large amounts of chips may be generated during this complete clearing process and these can be sold, or used as a mulch during post-mining reclamation operations.

Post-mining regulations under PL 95-87 are very "tough" but, at the same time, provide some real potential for hardwood afforestation and management. Sections of the law pertaining to reclamation call for restoration of the land to uses as productive or greater than pre-mining conditions, establishment of a "diverse, effective, and permanent vegetative cover", such cover to be "capable of self regeneration and plant succession at least equal in extent of cover to the natural vegetation of the area". These provisions, which must be satisfied before release of bond, will greatly improve potentials for a return to a productive forest cover on much of the surface-mined land in the mid-south.

In the rugged terrain of the West Virginia, western Virginia, eastern Kentucky and Tennessee, and northern Alabama coal fields, afforestation of sites mined by the "mountain top removal" method may provide some long-term opportunities for hardwood management where it currently is impractical. Previously inaccessible areas will have roads and, in some instances, "flat" land will be created where none existed previously. Nitrogen-fixing pioneer species such as alder and locust can be planted to improve the sites for later succession stages and species which will comprise forests of commercial value with improved accessibility. Interim biomass harvests can be made for energy and pulp chips. As hardwood forests develop, opportunities for recreational and wildlife management will arise, also.

One final aspect of long-term land use policy that may affect utilization and management potentials for mid-south upland hardwoods pertains to the status of public forests. It appears almost certain that increasing demand for recreation in the highly-populous eastern United States will virtually "tie-up" the existing public forest lands, particularly the National Forests. Increasing costs for public and personal transportation will cause people who might prefer to vacation "out west" to discover (or rediscover) the Appalachians, the Ozarks and other areas of the mid-south. The Piedmont and Coastal Plain will continue a pattern of controlled evolution to a homogeneous pinetum.

To summarize, in the very near future, upland hardwood production in the mid-south will be almost totally concentrated upon that vast, but as yet undeveloped, resource held by small, non-industrial woodland owners. I suggest that, given expanded hardwood markets, more competitive prices for hardwood stumpage and chips and, possibly, a boost in incentives, these private lands will be cast in a situation that is more conducive to productive management. This should occur steadily, albeit gradually, over the next twenty years. Technology must respond by continued development of harvesting systems adaptable to small jobs on rough terrain. Landowners will become more responsive to professional advice and guidance, and the forestry profession must respond by standing ready to provide quality management and technical services to meet their needs.

# AN OVERVIEW OF MID-SOUTH UPLAND HARDWOOD REGENERATION PROBLEMS AND ALTERNATIVES

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Abstract.--Many of the Mid-South's most productive upland hardwood sites need regenerating either because they have reached financial maturity or are inadequately stocked. Methods and requisites for regenerating these stands are discussed.

Additional keywords: Quercus spp., advanced reproduction, stump sprout potential,total canopy removal, shelterwood, selection.

Whether through neglect, exploitive cutting practices or honest mistakes, a high percentage of the South's best hardwood sites are now poorly stocked with low quality residuals. Too often, owners or buyers of timber made diameter-limit cuts and selective cuts, always selecting the biggest and best trees for removal. Their hope was that perhaps the trees they left would replace the ones they cut--and sadly enough, that is just what happened. These smaller, inferior trees, often the same age as the removed dominants, were not capable of developing into high vigor, high quality trees. The most valuable, commercial species in our southern forests are, at best, intermediate in shade tolerance. Therefore, the fastest growing, most vigorous trees will assume early dominance within the stand. These dominant trees usually have the best form and highest value. Their desirable characteristics made them the target of repeated, high-grade cutting practice of the past: piecemeal removal as they reached commercial size. This selection against dominant traits quickly makes dominants and co-dominants out of trees that can not maintain this position on their own merits. The cycle continued with each successive trip through the stand until the owner was left with virtually nothing of value.

This is certainly not a new message; we've all heard it many times before. It serves no good purpose to try to place the blame, if any, for the existing conditions. The real world of market demands and financial necessities often dictates actions that are not optimum in every way. Suffice it to say that many stands no longer fulfill the potential of the site from a timber standpoint--and are not likely to improve much with age. These are the stands, along with some well managed mature ones, that need regenerating if the owner expects to successfully manage them for their maximum site potential.

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Getting regeneration on good hardwood sites is a simple matter. Regenerating the most desirable trees and having them develop into the stand of your dreams is probably going to be a little more difficult, especially in upland areas of the mid-South. For example, regeneration cuts in the Southern Appalachians raise a concern that the oaks, especially northern red oak (Quercus rubra L.), will not be as prominent as desired in the new stand. However, there is some consolation that at least yellow-poplar (Libriodendron tuilipifera L.), and other desirable light-seeded species will prevail. When you cut good bottomland sites you may hope that cherrybark Oak (Q. falcata Michx. var. pagodaefolia Ell.), and other good oaks will be well represented. At least, you can usually count on ash (Fraxinusspp.), sycamore (Platanus occidentalis L.), sweetgum (Liquidambar straciflua L.), and other desirable light-seeded species.

When foresters in the mid-South decide to regenerate their upland hardwood stands they also desire the oaks as a major component--but, this time it is more necessity than desire. In much of the mid-South uplands, the least you can expect if you don't get oak can be pretty grim, from a timber standpoint. This is not to say that oak is the only important timber species existent in these stands. The better sites will usually contain desirable trees other than oak, such as walnut, cherry, and perhaps good quality hickory (Carya spp.). Unfortunately, these trees may only occur sporadically and cannot really be counted on like the "salvation" species in other areas. In much of the mid-South, especially outside the yellow-poplar range, if you don't get oak you can more likely expect low quality red maple (Acer rubrum L.), dogwood (Cornus florida L.), sassafras (Sassafras albidum [Nutt] Nees) and other less desirable species. For this reason, most of my emphasis will be on regenerating the upland oak species.

## SOURCES OF REGENERATION

The upland hardwood stands of the mid-South regenerate from several sources when adequate sunlight is available. These sources are discussed on the following pages.

### Seed

Trees in the new stand may develop from seed after the overhead canopy is removed. The seed of some trees such as yellow-poplar and ash remain viable in the duff layer for several years and will germinate when adequate light reaches the forest floor. Other seed comes from trees within the stand immediately before they are cut, or from seed trees. Also, birds, animals, and wind transport seeds from adjacent stands. Light-seeded species may be blown into the regeneration area from several hundred feet away (McGee et al. 1979). Many of the desirable light-seeded species such as yellow-poplar can germinate from seed after the harvest cut and successfully compete with other plants.

## Stump and Root Sprouts

A common problem associated with regenerating upland hardwood stands is that some will not regenerate to the same species. This is especially true with regard to oak stands, as stated earlier. Stump sprouts provide one source for perpetuating oak and other species that were present in the stand before the harvest cut. However, undesirable trees also sprout vigorously and can become a competitive problem. Because of their extensive root systems, the vigorous stump sprouts will often dominate other forms of regeneration. Some stands are almost entirely of stump sprout origin as evidenced by many multiple stem trees in the stand.

Where oaks are concerned, the frequency of sprouting varies with species and stump size. Northern red oak, scarlet oak (Q. coccinea Muenchh.), and chestnut oak (Q. prinus L.) usually sprout more frequently than white oak(Quercus alba L.) and black oak(Q. velutina Lam.). Small stumps, less than 12 inches, sprout more frequently than larger ones (Sander 1977). The quality and longevity of stump sprouts have been questioned, but sprouts originating from smaller stumps near or below the ground line are usually good risks (McGee et al 1979). Root sprouts are also produced by most hardwood species. Some, such as black locust (Robinia psedoacacia L.) and sassafras may regenerate entirely from root sprouts and, in some instances, are so prolific that thick clumps develop which can interfere with more desirable regeneration. These species do not usually dominate for very long, however, because of their relatively short life and sparse foliage. I have even seen intolerant species such as yellow-poplar eventually gain dominance over these species and, except in perhaps the most extreme conditions, the intermediately tolerant oak should prevail.

Black locust, a legume, may even benefit other, more slowly developing species because of its ability to fix atmospheric nitrogen in the soil. It has even been planted as a nurse crop with yellow-poplar, black cherry (Prunus serotina Ehrh.), green ash (F. pensylvanica March.), northern red oak, and white oak, (Chapman and Lane 1951). Sprouts of undersirable, tolerant species such as red maple, dogwood, and eastern hophornbean (Ostrya Virginiana (mill) K. Koch) may cause real problems and could dominate the site for many years. Desirable sprouts and seedlings may outgrow these undesirables, but in many cases control will be necessary, usually by the use of herbicides.[2]

Stump sprout expectancy can be estimated from the original stand before the harvest and, if care is taken to cut low stumps, should be an important source of valuable stems for the new stands (table 1).

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[2]See "Pesticide Precautionary Statement," last page of Proceedings.

**Table 1—Expected percentages of oak stumps that will sprout after cut[1]**

| Size class[2] | Black oak | Scarlet oak | Northern oak | White oak | Chestnut oak |
|---|---|---|---|---|---|
| 2-5 | 85 | 100 | 100 | 80 | 100 |
| 6-11 | 65 | 85 | 60 | 50 | 90 |
| 12-16 | 20 | 50 | 45 | 15 | 75 |
| 17+ | 5 | 20 | 30 | 0 | 50 |

[1]Sander (1977) from data developed by Roth and Hepting (1943), Wendel (1975, Johnson (1975), and unpublished data at Columbia, Mo.

[2]D.b.h. class of parent tree (in inches).

Advance Reproduction

On the better hardwood sites (site 75 and above), oaks may not be present in regenerated stands to the same degree that they were found in the stand that was harvested. They may be replaced by other valuable species such as yellow-poplar, ash and cherry, but in many upland mid-South areas the odds are better that they will be replaced by less desirable species. The key to assuring that the oaks will be well represented in the new stand lies in the adequacy and distribution of advance oak reproduction. A small proportion of acorns produced by the oaks in the existing stand will avoid depradation by animals and insects, fall on a favorable seed bed, become covered by a light layer of litter, and will germinate under the forest canopy. Some of these seedlings will quickly die, but if conditions are right others will endure for several years (perhaps as long as 30 or 40 years). The top growth is very slow, usually dying back and resprouting several times. However, the root system continues to develop and thus desirable advance reproduction is established. It takes several years for this reproduction to develop into the stems necessary to grow rapidly enough to compete with other plants in the new stand. Sander et al (1976) evaluated the adequacy of oak advance reproduction in the North Central States and found that stems at least 4.5 feet tall will compete most successfully in the new stand. The number of these stems needed to ensure an adequately stocked oak stand was set at 433 well-distributed stems of advance reproduction per acre. Where this advance regeneration is inadequate, it can be augmented by low origin stump sprouts, using the stump sprout expectancy chart. This guide assumes a relatively pure oak stand which will allow considerable volumes of timber from intermediate thinnings from well managed stands.

Oliver (1978), working with red oaks in the Northeast growing in association with other species, primarily red maple and black birch (*Betula lenta* L.) found that as few as 60 well-distributed stems of advance reproduction or stump sprouts, might be enough to eventually provide sufficient dominant red oaks for adequate density and spacing of oaks at rotation age (45 oaks at rotation age 60 with a 33 percent insurance factor). This assumes a mixed stand where mostly other species would be removed during intermediate cuttings. Oliver did his work in the Northeast, but his red maple and black birch competitors should be compatible to the red maple, sassafras, black locust conditions that often occur in th mid-South. Some control might still be necessary for long lived tolerant species such as dogwood and hickory.

Guidelines were also developed for the Ozark National Forest, which is near the western edge of the oak-hickory range. This forest does not have some of the faster growing mesic species of the appalachians and some North Central States to compete with the oaks. Taking this into consideration, the forest guides designate that at least 300 well distributed stems of desirable advance reproduction, at least 2 feet tall, must be present before the original stand is harvested. The 300 also includes potential stump sprouts.

While there may be some difference of opinion as to how many stems of what size are required to meet the landowner's regeneration objective, it is agreed that the degree to which oaks will be a dominant component of the new stand is in proportion to the presence of advance regeneration and stump sprout potential in the original stand. New oak seedlings without several years of root development have not been able to compete successfully.

For site index 55 to 60, oak regeneration is not much of a problem, as oaks are well suited to compete on these drought-stressed sites. However, for the best sites--75 plus--especially in the Ozark region, where desirable non-oak species are limited, oaks will still be the species to manage. As mentioned earlier, it is on these best sites that it is most critical to understand what the potential for regeneration will be if the present stand is harvested. Sandor (1977) developed an evaluation procedure for determining the adequacy of oak regeneration.

If evaluation proves that oak or other desirable, intolerant and intermediately tolerant species are adequate for meeting regeneration objectives, then total canopy removal is the most efficient method for regenerating the stand in the South. This must be a silvicultural operation, cutting or deadening all residual trees down to about 2 inches in diameter. This site preparation can be done as either a pre-harvest (Loftis 1978) or post-harvest operation. The smaller, noncommercial trees of undesirable species can be cut or treated with herbicides depending on how competitive these sprouts will be. Red maple is a prolific sprouter and may offer severe competition to more desirable species if it is not controlled. Grapevines (*Vitis* spp.), while they are desirable for some nontimber objectives (wildlife), can be a serious problem for regeneration. Trimble and Tryon (1979) recommended control by severing the vines, just above the ground, at least four years before harvest. the vines will resprout for a couple of years, but will die within 3 years if there are no large holes in the canopy.

Once the commitment is made to regenerate, whether naturally or artificially, the best practices must be followed. Anything less is ususally a waste of time, money, and effort. This is fine for those stands where adequate regeneration potential exists at harvest time. However, what are the options on those stand where advance regeneration and sprout potential is not present -- those which contain only an understory of junk species just waiting their chance to take over the site? How will the advance reproduction become established? Researchers continue to look for the best answer. Some options to consider until new research findings become available are presented in the following sections.

## REGENERATION TECHNIQUES

### Shelterwood

If there is not enough potential oak regeneration, or if it is not large enough to compete successfully, proper application of the shelterwood system should be a viable alternative. Shelterwood has been tried and mostly failed, in the past. All the information needed to assure consistent success is not yet available, but we should be able to improve on past experiences using the information we do have. Here again, only the very best silvicultural application is likely to be successful. Sandor (1979) recommends that the first cut of a three-cut shelterwood should not reduce overstory stocking below 60 percent, according to Gingrich's (1967) stocking guides. This should provide enough light for germination and survival, if enough acorns are produced and there are enough absent-minded rodents to plant them. Remove trees in the lower crown classes and try to leave a uniform residual canopy, avoiding large holes. One thing I have learned from experience, if there is junk understory present and we open the overstory up a little, we'll get a little more junk, and if we open the overstory up a lot, we'll get a lot more junk. For this reason, the understory will most likely have to be controlled. Probably the most efficient way to control this unwanted understory is by the use of a selective herbicide treatment.

If the second cut is needed it should probably be made when the stand increases back up to the 70-80 percent level. This cut should reduce stocking to about the 50 percent level when seedlings are about 3 feet tall. As long as 25 years might be required to develope adequate regeneration, but perhaps you could have what you need in about 10 to 15 years, with an intensive effort.

Selection

Single tree selection is not generally recommended for regenerating the southern upland forest. Msot of our valuable hardwoods are relatively intolerant of overhead shade and cannot develop properly without orderly and timely removal of overstory trees. Group selection, where groups of trees at least ½ acre in area are removed, can be successful, but the shade from trees on the edge will reduce the growth of trees in small openings. For this reason, openings should be at least 2 acres in size to reduce edge effect and to simplify record keeping and stand mapping.

Another option is to actually plant oak seedings which would develop into advance reproduction. This would be a possibility especially where a seed source for the desired species is not present, or for establishing genetically improved trees. The seedlings would be planted with the shelterwood system and given time to develop into strong advance regeneration before the final harvest cut. Exact methods are not yet known, but this system is being tested by the Forest Service's North Central Forest Experiment Station and others.

The use of fire is another option worth consideration. Fire obviously played a part in the establishment of almost-pure oak stands found in areas of the mid-South. C. E. McGee, Southern Forest Experiment Station, is working with fire in upland stands. His current findings appear elsewhere in this Proceedings.

Recognizing the problems that can exist with regenerating the Mid-South's upland hardwood stands emphasizes the need to know what is happening in the stand several years before the final harvest. Adequate long range planning is a prerequisite to assuring adequate natural regeneration.

Generally, one of the main problems with regenerating forest stands is that we are not committed to using the total wood resource available in these stands. Until we become less selective in what is considered useful, or is junk, and until we develop the techniques and the willingness to use that which is now considered useless, regeneration problems will not only continue with hardwoods, but with pines as well. Meanwhile, we must pursue the challenge to do the best we can to grow the trees that are in demand.

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# HARDWOOD SILVICULTURE EMPHASIS IN UNIVERSITIES IN THE SOUTH

Edward Buckner[1]

Abstract.--Responses to a questionnaire sent to SAF accredited forestry programs in the South indicate that the large number of commercially important hardwoods receive less than half the classroom attention devoted to the few commercially important yellow pines. Educators were generally aware of the inequity but felt pressures to continue a strong pine emphasis due to: 1) their location, 2) needs of their graduates, and 3) support grants. Historical, biological, and economic reasons for this imbalance are discussed in the context of a current trend toward increasing hardwood utilization.

Additional keywords: forestry education, silvics, questionnaire, hardwood management.

Implicit in the assigning of this topic for this meeting is the assumption that what foresters don't learn in college is at least partially responsible for the problems we have had in developing effective hardwood management programs. In southern universities an evaluation of the handling of hardwood silviculture must be relative to the attention given to southern yellow pines. Forest cover maps show the yellow pine type as dominant over most of the South, and these species account for most of the roundwood harvested in that region.

Despite the dominance of the yellow pine type in the South any student of forest ecology knows, as do all pine managers, that natural succession moves continuously towards hardwoods, a trend recognized by Kuchler (1964) in naming hardwoods as the "potential natural vegetation" for essentially all of this region. This relentless shift in forest cover toward hardwoods provides jobs for a large cadre of "pine foresters" whose primary effort is to disturb the land sufficiently to create favorable habitat for the pioneer species (pines) that are raw materials for the southern pine industry that dominates industrial forestry in the South. Intensive site preparation and prescribed fire are the silvicultural tools that provide the repeated disturbances that maintain the "southern pinery" and without which it would revert to hardwoods.

Since this seral sequence applies to essentially all forest sites, both bottomlands and uplands in the South, the frequently used cliche "hardwoods growing on pine sites" either represents a failure to understand basic forest ecology or an aggressive advertising program for the pine industry. While advocates of this philosophy argue that these sites are more productive in pine, the common comparison is between an expensively established, intensively managed pine stand and an unmanaged hardwood stand that has been higraded, burned, and grazed. If such is the case, more realistic comparisons are in order.

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## QUESTIONNAIRE

To evaluate the relative position of hardwood silviculture in southern universities, a questionnaire was sent to the heads of forestry programs in the South that are accredited by the Society of American Foresters with the request that they be completed by an appropriate faculty member. Completed questionnaires were returned from 10 of the 13 programs included. In the following summary, questions are in capital letters and responses are averaged (where appropriate) and underlined.

I. PLEASE ESTIMATE (A FACULTY GROUP OPINION WOULD BE APPRECIATED) THE DEGREE TO WHICH YOU FEEL THE AVERAGE B.S. FORESTRY GRADUATE IS COMPETENT TO DEVISE A GOOD MANAGEMENT PLAN FOR (RANK ON SCALE OF 1 TO 5 WITH 1 LITTLE AND 5 HIGH):

A) SOUTHERN YELLOW PINES - 4.0
B) OTHER SOFTWOODS - 2.7
C) HARDWOODS - 2.1

II. DO YOU FEEL THE STUDY OF HARDWOODS (BOTH BOTTOMLAND AND UPLAND), ESPECIALLY THEIR MANAGEMENT AND UTILIZATION, IS ADEQUATELY COVERED IN FORESTRY CURRICULA IN THE SOUTH?

Yes - 18 percent    No - 82 percent

(A) IF YOUR ANSWER WAS "NO," PLEASE SUGGEST HOW CURRICULA MIGHT BE CHANGED TO IMPROVE THE SITUATION.

(1) Only change needed is to show how basic silvicultural concepts are applicable to hardwoods.

(2) There is a current shift toward greater emphasis on hardwoods.

(3) Curricula already is too heavy with forestry courses, additional courses not answer; suggest shift in present course content, although less feasible as you go farther South.

(4) There are too many hardwood species/site situations, best to expand present courses.

(5) Add separate hardwood courses.

(6) Add field trips and short courses emphasizing hardwoods.

(7) Examples of hardwood management are hard to find.

III. LIST THE FORESTRY COURSES IN WHICH HARDWOOD SILVICULTURE AND/OR UTILIZATION IS TAUGHT AND THE PERCENTAGE OF THE EFFORT IN EACH CASE THAT IS DEVOTED TO HARDWOODS.

| Course Summary | Percent Devoted to Hardwoods |
|---|---|
| All courses submitted | 37 |
| Courses in silvics and silviculture only | 31 |
| Courses in products and utilization only | 18 |

(A) PLEASE COMMENT ON THE ABOVE TEACHING TIME DEVOTED TO HARDWOODS RELATIVE TO WHAT YOU FEEL IT SHOULD BE.

(1) Double or triple the time presently allocated to hardwoods.

(2) We need to shift emphasis to hardwoods only as the use pattern shifts to hardwoods.

(3) Present emphasis is about right as not out-of-line with hardwood use.

(4) Use hardwoods more in classroom examples is only change needed.

(5) Far too little hardwood silviculture is presently taught.

(6) Hardwood silviculture well covered considering ratio of hardwood land to pine land.

IV. DO YOU FEEL AN OBLIGATION TO EMPHASIZE THE MANAGEMENT AND UTILIZATION OF CERTAIN SPECIES OR SPECIES GROUPS (E.G., PINES, SOFTWOODS, HARDWOODS, ETC.) DUE TO: 1) YOUR LOCATION, 2) OUTSIDE SUPPORT, AND/OR 3) THE NEEDS OF YOUR GRADUATES?

Yes - 80 percent    No - 20 percent

IF YOUR ANSWER WAS YES, PLEASE ELABORATE AS TO THE SPECIES OR SPECIES GROUPS EMPHASIZED AND WHY.

(1) Most schools in deep South emphasized location and needs of graduates as primary reasons for emphasizing pine.

(2) Most of our graduates will work in the pine type.

(3) Emphasis is in the order: a) loblolly pine (Pinus taeda L.), b) slash, (P. elliottii Engelm.) and longleaf pines (P. palustris Mill.), and c) hardwoods.

(4) Emphasis is on upland and Appalachian hardwoods for Kentucky and Virginia, respectively, due to location.

V. IS OUTSIDE SUPPORT (GRANTS, INDUSTRY AWARDS, ETC.) GENERALLY EARMARKED AS TO SPECIES OR SPECIES GROUPS TO BE STUDIED?

Yes - 70 percent    No - 30 percent

(A) IF YOUR ANSWER WAS YES, PLEASE INDICATE THE APPROXIMATE PERCENTAGE EARMARKED FOR:

| | | Without Kentucky and Virginia |
|---|---|---|
| SOUTHERN YELLOW PINE | 61 | 75 |
| OTHER SOFTWOODS | 2 | 0 |
| UPLAND HARDWOODS | 15 | 3 |
| BOTTOMLAND HARDWOODS | 7 | 16 |
| GENERAL (NOT SPECIFIED) | 8 | 0 |

VI. PLEASE INDICATE THE EXTENT TO WHICH YOU AGREE OR DISAGREE WITH THE FOLLOWING STATEMENTS AS TO WHY HARDWOOD MANAGEMENT IS POORLY UNDERSTOOD BY THE AVERAGE FORESTRY GRADUATE:

HARDWOOD MANAGEMENT IS GENERALLY AVOIDED OR "SHORT-CHANGED" IN UNDERGRADUATE FORESTRY CURRICULA BECAUSE:

A) "PAT" ANSWERS AND CLEARCUT MANAGEMENT GUIDELINES FOR HARDWOODS ARE NOT KNOWN OR ARE POORLY UNDERSTOOD.

Weak agreement (Comment: Faculties were "short-changed" and passed it on to students.)

B) THERE ARE FEW LARGE FOREST OWNERSHIPS MANAGED PRIMARILY FOR HARDWOODS.

Strong agreement

C) CAPITAL INVESTMENT BY FOREST INDUSTRIES HAS BEEN FOR PLANTS THAT UTILIZE SOFTWOODS.

Strong agreement

VII. IN SUMMARY, DO YOU FEEL THERE IS A PROBLEM AS TO THE AVERAGE FORESTRY GRADUATES UNDERSTANDING OF HARDWOOD SILVICULTURE AND MANAGEMENT, AND IF SO, WHAT SHOULD BE DONE ABOUT IT? (The following selected comments reflect the range in the responses received.)

(1) Teach silvics after silviculture.
(2) Not a problem since "pine is king."
(3) Offer separate hardwood courses.
(4) Establish continuing education programs.
(5) "I'm a hardwood advocate but recognize the 'clout' softwoods carry."
(6) More is known about pine and it is simple and straightforward; time doesn't permit doing more with hardwoods.
(7) We are on right track in recognizing the problem we have created--a world full of pine silviculturalists who only know and preach one reproduction method.
(8) "No. Until hardwoods become a greater economic entity we should prepare students in those areas where they will be devoting much of their career."

(9) No problem. It is difficult to use a sweetgum stand to illustrate thinnings when small trees have little value and partial harvesting is almost non-existent. We devote appropriate time considering the area they occupy and their relative value.

(10) The problem is "time"; answer is to expand present courses but the number of species and their complexity will continue to present problem.

These results suggest that the large number of commercially important hardwoods receive less than half the classroom attention devoted to the few southern yellow pines; on a per species basis the inequity becomes tremendous. Also apparent is that forestry educators in the South recognize the short-shift given to hardwoods but most feel the pressures to maintain a strong pine emphasis are too great to enable a significant shift toward hardwoods. There were indications, however, that a shift is in progress and is supported by many who do not feel they can presently become involved.

Most thought provocative among the comments was the suggestion that silviculture be taught before silvics (or the silvical characteristics of individual species). At first glance this may seem out-of-sequence, and is certainly so according to present convention; however, it may have considerable merit for promoting hardwood management. Silviculture deals with the mechanics of a few cutting systems that are, or are not, appropriate for a species (or association) depending upon its (their) silvical characteristics. As presently taught following silvics, recalling the needed silvical characteristics for the few commercially important pines presents few problems in relating silvicultural systems to individual species, especially since most are similar and they tend to function as a single system.

Such is not the case for hardwoods. Their large number and complexity makes it difficult to recall more than a few species when silvicultural systems for managing the range of silvical categories are studied. A better approach may be to first learn the mechanics of the few cutting systems involved and the silvical requirements on which they are based, and then learn the silvical characteristics of individual species. Following this sequence appropriate cutting systems for management, having already been learned, should come to mind as the silvical characteristics of the numerous and complex hardwoods are studied. This would give added meaning to the required learning of these characteristics, the ignorance of which may be contributing to the low level of hardwood management.

## EPILOGUE

To end now would probably fulfill my charge; however, I am unwilling to simply plead "guilty as accused" when hardwood silviculturalists lay blame on the universities for inadequacies in the management of hardwoods. The content of forestry curricula over the past several decades reflected the task facing the profession and the state-of-the-art regarding hardwood management. There are good reasons why pine silviculture has, and still does, dominate forest management in the South; best we acknowledge them if we are to move ahead in hardwood management.

First and foremost is the demand situation: (1) softwoods, and pine in particular, have long fibers, a requirement in many pulp products, while hardwoods do not, (2) softwoods are preferred as structural members, which provides the largest market for lumber, and (3) multiple markets for softwoods, especially for small trees, encourages short-rotation management systems that are attractive to investors.

A further economic advantage for southern yellow pine stems from their uniformity in wood properties and silvical requirements which has enabled the evolution of a single system of management, harvesting, and utilization that applies to all species, a feat impossible with the diversities encountered among hardwoods. Closely tied to this is the insensitivity of pines to site quality enabling relatively uniform crops over wide areas thereby encouraging mechanization. In contrast, most economically important hardwoods are so site-sensitive that a single species or group complex either cannot be grown, or will not produce a uniform crop, even over a relatively narrow range of site situations.

The production and consumption pattern (difference equaling imports) for softwoods and hardwoods in the United States between 1950 and 1977 (Figure 1) reflects these advantages for softwoods, with softwood consumption

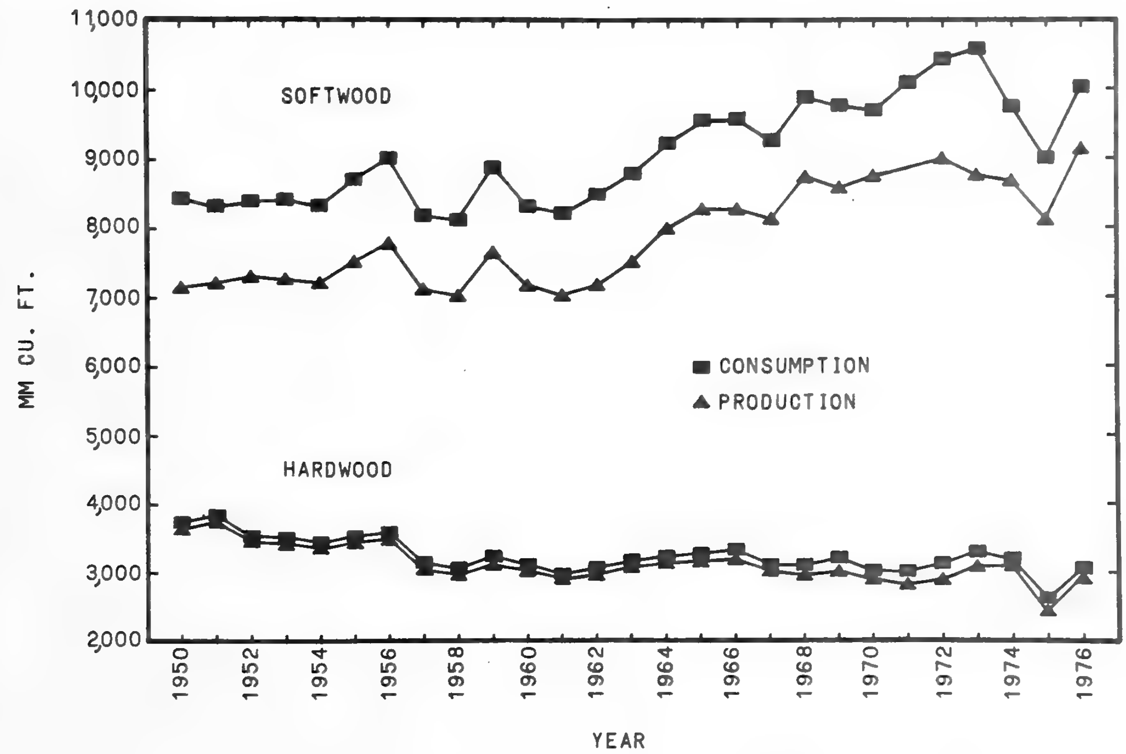


Figure 1. Softwood and Hardwood Roundwood Consumption and Production in the U.S., 1950-1977 (Phelps, 1977).

more than double that for hardwoods. Furthermore, softwood consumption and production have increased over this period while for hardwoods there has been a gradual but steady decline.

The magnitude of, and causes for, the problem become more apparent when decreases in production/consumption are viewed in the perspective of increasing supplies (Table 1). This combination clearly identifies

Table 1. Increases in hardwood growing stock and sawtimber in the South between 1952 and 1977.[2]

| GROWING STOCK (mm cu ft) | Southeast | Southcentral |
|---|---|---|
| 1952 | 37,622 | 40,626 |
| 1977 | 52,384 | 51,893 |
| Percent Increase | 39 | 28 |
| **SAWTIMBER (mm bd ft)** | | |
| 1952 | 100,017 | 112,617 |
| 1977 | 135,484 | 130,307 |
| Percent Increase | 36 | 16 |

[2] (Forest Statistics, 1978).

hardwood utilization as a research area needing attention.

Related to the strong demand for softwoods is the need to protect relatively large capital investment in pine-using plants that has fostered large land holding companies devoted to pine production and staffed with foresters who are deeply involved in long-term planning. In contrast, industries that utilize hardwoods commonly do not own forest land and seldom employ foresters. Hardwood logs and stumpage are generally purchased on the open market with little regard for management systems involved in their production, which provides an economic incentive for "hi-grading"--the reverse of long-term planning.

Public dollars have also favored softwood production by: 1) developing nursery techniques for producing softwood seedlings (pine in the South) with little emphasis on hardwoods, and 2) pushing reforestation programs on sites to which pines are best suited (critical areas such as eroded old fields, etc.).

The biological foundation for the pine emphasis of past decades is evident in Figure 2. Note that the eight site-situations tested are arranged from left to right according to increasing productivity of yellow-poplar (*Liriodendron tulipifera* L.), a species highly sensitive to site quality. While the two study locations probably represent "average" site qualities for the region, the treatments applied (irrigation and fertilization) create a range of sites representing better-than-average conditions.

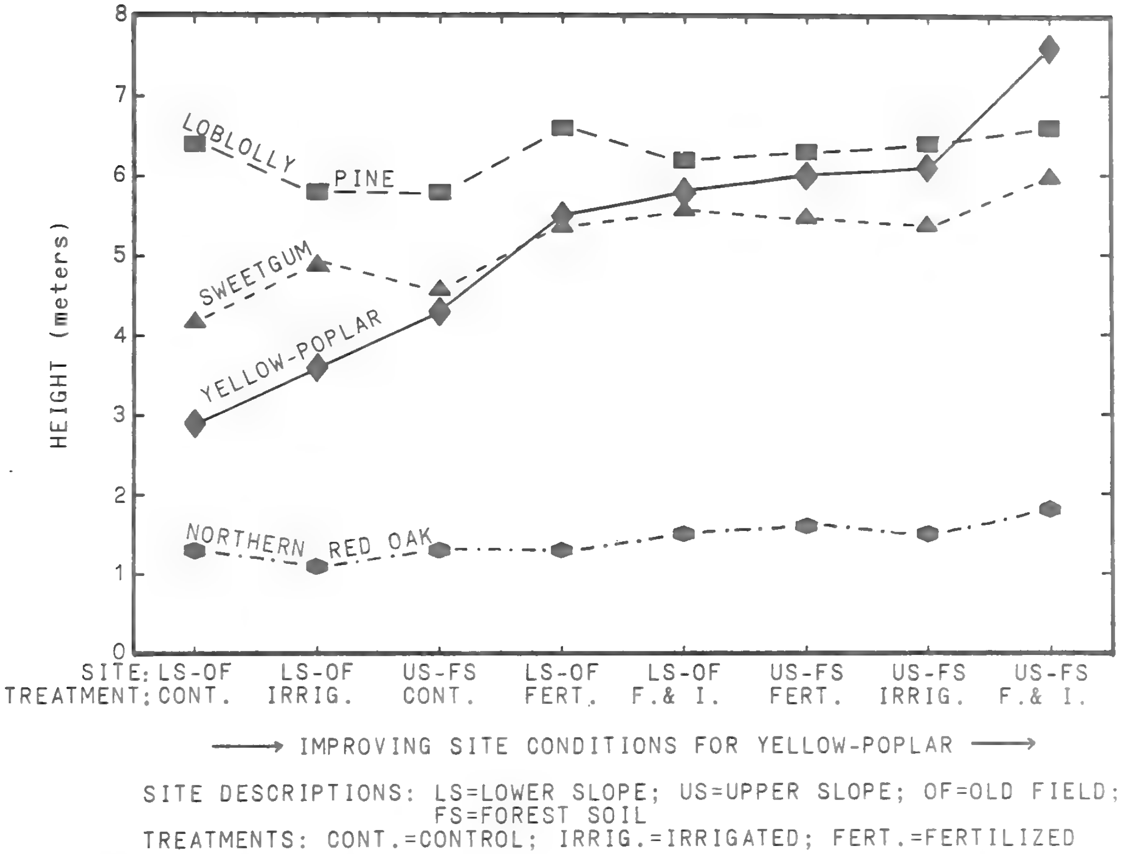


Figure 2. Seven-year Height Growth of Irrigated and Fertilized Loblolly Pine, Yellow-Poplar, Sweetgum, and Northern Red Oak planted on Two Locations Near Oak Ridge, TN. (adapted from Buckner and Maki, 1977).

After seven growing seasons the only hardwood out-performing loblolly pine was yellow-poplar on the "best" site (the study location was approximately 60 miles north of the region to which loblolly pine is native). Considering the limited areas of such high productivity available for planting plus the difficulty of identifying and handling such areas separately in large scale planting programs, the safe and probably most economical bet is pine--loblolly pine over most of the South.

The poor performance of northern red oak (Quercus rubra L.) across all site-situations tested (Figure 2) is indicative of the difficulties hardwood managers have had in dealing with the more tolerant hardwoods. The only species that performed satisfactorily on any of the study sites were relatively intolerant: loblolly pine, yellow-poplar, and sweetgum (Liquidambar styraciflua L.). Forestry faculties can do little to teach intensive silvicultural systems for the large group of intermediate-to-tolerant hardwoods when successful methodologies for their establishment have not yet been developed.

Considering the state-of-the-art with hardwoods and the job-at-hand in reforestation, the pine-emphasis that has dominated forest management in the

South, both in the classroom and field, has not been inappropriate. However, as the questionnaire results suggest, there is currently a shift in educational circles toward greater emphasis on hardwoods. Since education hopefully "anticipates" changing trends, possibly this indicates the time for hardwoods has finally come. While initial phases of this shift may be symbolized by the wood stove, which is responsible for the recent upturn in hardwoods harvested for fuel (USDA-Forest Service, 1978), wood chemistry and further innovation in utilizing hardwoods as building materials will be the catalysts that keep it going.

As this shift gains momentum it is important that we clearly identify, and restrict hardwood silviculture to, the more productive sites on which we can demonstrate their greater productivity; otherwise, the shift will be short-lived. Our profession has been embarrassed once over our inability to predict what we are capable of doing on our "best" sites. You may recall the "battle cry" a decade ago when we claimed we would maximize gains by practicing intensive forestry on our best sites and not worry about the poorer areas. The wrong people heard and responded to this slogan, in that: 1) farmers converted our best bottomland sites to soybeans, and 2) the Corps of Engineers and beavers teamed up to first drain and then impound and kill much of the remaining bottomland hardwood resource.

And what did foresters do with the good sites that were left? We were forced to admit that, with the markets and other economic constraints of the day, we could not manage them. The largest corporate forest land owner and manager in East Tennessee attempted to include the more productive northern and eastern slopes and stream bottoms in their pine management program, but finally gave up because they "couldn't fight the hardwoods." Contrary to our slogan, we have been managing most intensively the intermediate to poor sites and ignoring the good ones.

There was, however, nothing wrong with the slogan; it just came a decade or so too early. During this period significant gains in pine management have been made through: 1) genetic manipulation, 2) site preparation, and on deficient sites, 3) fertilization. Further large gains in productivity from intensive culture are, however, unlikely for species as site-insensitive as are the pines.

Some insight as to the roles these two tree-types are capable of playing in intensive forest culture can be gained from the paleobotanical record. Softwoods (gymnosperms) are geologically old, having first appeared over 250 million years ago. They probably evolved in harsh environments, represented today by cold regions and poor, dry sites--situations in which they now occur naturally. Hardwoods are more recent occupants of the earth's landscape, first appearing some 150 million years ago. They naturally replace softwoods (largely pines) in temperate zones on older, better developed soils suggesting that improving site quality provides a greater competitive advantage to hardwoods. As might be expected in the U.S. it is on the geologically old and unglaciated soils of the southeast that hardwoods culminate. They are simply "more sophisticated" in their species-site relationships than are softwoods.

In our continuing effort to increase forest productivity we are probably approaching the point of diminishing returns in our efforts with pine on intermediate to poor sites. The next "quantum" jump in productivity will likely come as we learn to manage the more demanding hardwoods on our more productive sites.

Holding back the rapid implementation of this effort has been the state-of-the-art in hardwood utilization. Present shifts promise, however, to provide the needed incentives that will enable us to "keep hardwoods on hardwood sites" because they will respond more to our management efforts and be more productive than pines.

As forest managers who like hardwoods, let's be about learning and telling how to do this.

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# OAK PLANTING IN MID-SOUTH UPLAND HARDWOODS: PROBLEMS AND PROSPECTS

Paul S. Johnson [1]

Abstract.--Solving the oak planting problem depends on identifying factors associated with the large tree-to-tree variability in shoot elongation. This variability is associated with leaf and root area, and total plant size. Thus, growth models should be developed based on the ratio of effective root absorptive area to leaf surface area and the interaction of this ratio with total seedling mass. Despite the absence of such models, encouraging recent advances have been made in oak planting and seedling culture. These advances include improvements in seedling growth via containerization, inoculation of nursery soils and growth media with specific ectomycorrhizae, stimulating root regeneration with indolebutyric acid, improving growth of bare root stock through better methods of cold-storing, and the possibility of reproducing by tissue culture. Further improvements will nevertheless be needed before oaks can be successfully planted on upland forest sites but achieving this objective appears to be feasible.

Additional keywords: *Quercus* spp., nursery methods, periodic shoot growth, root:shoot ratio, shoot elongation.

About 2 million oak (*Quercus* spp.) seedlings are produced annually in forest tree nurseries in the United States (Abbott and Fitch 1977). With this large number of oak seedlings being produced, together with the long history of growing oaks in forest nurseries, one might expect upland oak plantings to be a common sight throughout the eastern hardwood region. However, an identifiable oak planting more than a few years old is rare. What then has happened to the tens-of-millions of oak seedlings that have been planted in the last half-century? I believe the following summary by McGee [2] of 18 years of oak planting research in the Cumberland Plateau-Highland Rim area of Tennessee aptly answers that question.

> "We have planted white, black, scarlet, and northern red oaks. We have planted good sites and not so good sites. We have planted big seedlings and little seedlings. We have tried clipping, pruning, fertilizing, weeding, cleaning, and bedding. We have measured heights, diameters, ratios, and chemical contents. On some occasions we have shown highly significant effects of various treatments. But the bottom line of all this work is--we can get planted oak seedlings to live but we cannot make them grow."

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1/ Principal Silviculturist, North Central Forest Experiment Station, Forest Service, U.S. Department of Agriculture, Columbia, Missouri.

2/ Charles E. McGee. Oak planting results on the Cumberland Plateau. Presented at the Workshop on Seedling Physiology and Growth Problems in Oak Planting, November 6-7, 1979, Columbia, Missouri. North Central Forest Experiment Station and the School of Forestry, Fisheries, and Wildlife, University of Missouri, Columbia.

The experiences of others in oak planting largely reiterate McGee's. Unfortunately, observations and experiences in field trials do not, by themselves, elucidate the fundamental problems of planted oak growth. Until the mechanisms that make oaks "different" are understood, it is unlikely that much progress in oak planting research, and thus field practice, will be made. To better understand the problems of oak planting, it may be helpful to consider some of the growth characteristics common to juvenile oaks in natural environments.

## THE SHOOT GROWTH PROBLEM

Shoot growth in oak seedlings is periodic--periods of shoot elongation are interrupted by periods of shoot resting during the growing season. In a nursery where soil moisture, nutrients, light, and heat are favorable, seedlings of some upland oak species may have four or more growth flushes totaling a meter or more during their first growing season. However, in most forest environments, one or more of these environmental factors is less than the minimum required for multiple flushing in oak seedlings. Thus, conservative shoot growth of young oak reproduction persists even in environments that may permit the rapid growth of so-called "demanding" species. This conservatism favors oak survival on droughty sites by minimizing leaf areas and thus transpirational water losses, but does not favor oaks on more moist sites where it is successionally displaced by species that are less physiologically conservative.

In moist mesophytic oak forests, more than 16,000 oak seedlings per hectare may occur (Johnson 1974b; Carvell and Tryon 1961). Large seedling populations are particularly common in years following bumper acorn crops. However, even though conditions for initial establishment are favorable, these populations may quickly decline because light under mesophytic forests is usually inadequate for sustaining photosynthesis in oak seedlings (Scholz 1955; Racine 1971; Musselman and Gatherum 1969). Under these conditions, oaks are exceptionally difficult to regenerate following final harvest cutting because few seedlings attain the size necessary for adequate shoot elongation (Clark and Watt 1971; Sander et al. 1976).

In contrast, oak forests under higher water stress, such as those that we have studied in the Missouri Ozarks, usually provide enough understory light for sustaining longer survival of oak reproduction. Despite prevailing conditions of high water stress and high first-year seedling mortality, small but stable populations of oak reproduction persist--typically less than 4,000 per hectare. The shoots of surviving oaks recurrently dieback and resprout under these conditions, thereby creating "seedling-sprouts" (Liming and Johnston 1944). Thus annual increment in total plant mass in seedling-sprouts is confined mainly to the root system, which may increase its mass and extension by small annual increments over many years. Surviving reproduction consequently tends to increase its root:shoot ratio. Some species, notably white oak (*Quercus alba* L.), can endure for more than a half-century in such high stress environments and as a result their root systems may be several decades older and many times larger than their shoots (Merz and Boyce 1956). It is under such conditions of high water stress that upland oaks replace themselves and maintain their dominance.

Unfortunately, the drought tolerance mechanisms that permit survival of oaks on xeric sites are the same ones that apparently override mechanisms that could permit more rapid shoot growth under moderate stress. Although the nature and degree of this conservatism in shoot growth vary among oak species, this is the primary problem in planting all upland oaks.

Despite this dilemma, multiple flushes or long single flushes in oak shoots can be promoted by high root:shoot ratios, which apparently moderate internal plant water stress (Borchert 1975). The most obvious example of this phenomenon is in the commonly observed multiple flushes of oak seedling-sprouts and stump sprouts (Johnson 1979b). In these growth forms, a large root absorptive capacity (and perhaps food storage capacity) apparently reduces stress-induced inhibition of shoot elongation. Although the exact nature of shoot inhibition in oaks is not well understood, it is thought to be associated with plant growth regulators (Vogt 1966; Farmer 1975) as well as internal plant water relations (Borchert 1975).

Although stump sprouts and large seedling-sprouts are the most obvious examples of oak growth forms with rapid shoot growth, they are not unique in this capacity. In an upland oak planting of several hundred or more trees, a few individuals usually produce either multiple flushes or long single flushes during the first few years after planting. For example, we have observed up to 75 cm of shoot growth produced in two flushes during the second field growing season in northern red oaks (Quercus rubra L.) planted in Missouri Ozark clearcuts. These infrequent occurrences are usually obscured in the reporting of mean height or shoot growth for treatments or species. Nevertheless, this phenomenon indicates that an enormous root system is not necessary for obtaining adequate shoot growth of oak nursery stock under field conditions. Although genetic factors and microenvironment may partly explain these occurrences, the ratio of root absorptive area to leaf area of trees is also implicated (Borchert 1975; 1976).

Collectively, the foregoing observations suggest the feasibility of developing a general shoot elongation model for juvenile oaks based on the interaction of total plant mass with root:shoot ratio. Shoot elongation (SE) might be expressed as a function (f) of the ratio of absorptively effective root surface area ($A_r$) to leaf surface area ($A_1$) and total plant mass (M). For a given environment the relation could be stated as:

$$SE = f\,[(A_r/A_1)M].$$

Solving the above equation for each important species for several different light and water stress environments might thus provide guidelines for "tailoring" oak seedlings in the nursery to produce the desired response in a given field environment. I believe the development of these or similar models would be an important cornerstone in the overall solution of the oak planting problem.

Unfortunately, we do not yet have a relevant growth model, and many of the basic growth relations associated with planted oaks remain unknown. Nevertheless, recent advances in oak planting research provide a basis for optimism in solving the problem. Several of the more promising aspects of ongoing research in oak planting and propagation are discussed below.

## PROSPECTS FOR SOLVING THE PROBLEM

### Containerization

More than 25 years ago it was hypothesized that better oak nursery stock could be produced by arresting the development of the taproot, thereby stimulating the formation of lateral roots (Carpenter and Guard 1954). This is exactly what occurs in oaks grown in containers. When an oak seedling is containerized, its normal root morphology, consisting of a long taproot with few laterals, is altered to a dense fibrous root system with a taproot limited in length by the container depth. The formation of lateral roots is stimulated by "air-pruning" of roots as they emerge in the air space beneath the open-bottom container. The result is a compact root or "plug" that contains many root tips from which new roots can be regenerated. A further advantage is that the root plug remains in the protective environment of the container until it is planted.

Container sizes currently being considered for oak planting range from about 300 ml to more than 1 liter in total volume and from 20 to 30 cm in depth (Johnson 1979a; Garrett *et al*. 1979; Tinus 198_; Morehead 198_). Relatively large containers are needed for oaks to get the root mass, absorptive capacity, and leaf area necessary to sustain the desired shoot elongation after planting, but the practical upper limit for container size is probably about 750 ml in volume and 25 cm in depth.

In a greenhouse study, container-grown northern red oak stock grew faster and developed greater root and leaf areas than bare-root stock (Johnson 1979a). The correlated development of large root and leaf areas is potentially important because it provides the feedback mechanism between absorptive and assimilative plant functions needed for exponential growth of the entire planted tree.

Our field tests on containerized northern red oak, black oak (*Quercus velutina* Lam.), and English oak (*Q. robur* L.) show that maximum shoot growth usually occurs in seedlings with large tops--those with tops at least 50 cm long and basal diameters at least 8 mm. However, even among large containerized seedlings, adequate shoot elongation of trees planted in forest clearcuttings has been the exception. Only 10 percent or fewer of these trees produce 30 cm or more of net shoot growth per year during the first few years after planting.

So far, the biggest overall advantage in planting containerized oaks has been the minimization of shoot dieback, which has been a persistent problem with bare-root stock. Although this may appear to be a marginal gain, it is potentially significant because moderately high leaf areas can be maintained. In a field study of excavated black oak in the Missouri Ozarks, container stock had high leaf areas and excellent root regeneration, whereas bare-root stock had much shoot dieback and poor to nonexistent root regeneration (Dixon 1979).

Although procedures for growing seedlings in containers have been described elsewhere in detail (Tinus and McDonald 1979; Tinus 1974), I believe that modifications in these methods are necessary. For example, the broad leaves and overlapping crowns of large (50 cm and taller) oak seedlings disrupt the spray of overhead spray irrigation systems so the irrigation water is not distributed evenly among container cells. To overcome this problem we use 1.6 cm porous "trickle" irrigation tubes that rest directly on the containers under the seedling crowns. One tube is placed down each row of container cells in the greenhouse or shadehouse so the irrigation water is applied directly and uniformly to the potting medium. We use an overhead irrigation system only to apply nutrient solutions and to rinse excess nutrients from the foliage. Subirrigation systems offer another option for uniformly irrigating container cells but are somewhat more difficult to design and operate.

Producing the large oak container stock needed for forest planting requires a 7- to 8-month growing season. In the Mid-South Region, seedling production can be begun in the greenhouse in February by sowing containers with pregerminated acorns. When greenhouse temperatures become too high, either early or mid-May depending on latitude, containers can be moved to a shade house. This schedule would thus provide a 3-month greenhouse and a 4-1/2 month shade house propagation period. An alternative system would be to begin seedlings in May in the shade house and after 4-1/2 months move them to the greenhouse for 3 months. In the latter schedule, seedlings would have to be hardened in the greenhouse by gradually reducing temperature, supplemental lighting, and nutrient applications (Tinus 198_). In either system, the seedlings can be stored in the shade house during the winter if they are well mulched to prevent freeze damage. Tinus and McDonald (1979) have covered all facets of growing seedlings in containers more completely.

Mycorrhizae

Initial work with mycorrhizal associations in roots of oak seedlings indicates that infection of roots with specific ectomycorrhizae improves the survival and growth of outplanted oaks (Garrett *et al*. 1979). These advantages apparently are due to the doubling of the effective root absorptive area of mycorrhizal oaks compared to nonmycorrhizal oaks (Shemakhanova 1955; Garrett *et al*. 1979). Most of the current mycorrhizae work with North American oaks has centered on a single species, *Pisolithus tinctorius* (Pers.) Coker and Couch (Dixon 1979; Marx 198_; Wright 1979; Pope and Chaney 198_; Beckjord *et al*. 1978). However, at least 13 more species of ectomycorrhizal fungi have been identified as potentially capable of forming on oaks (Garrett *et al*. 1979).

Coupling mycorrhizal infection with containerization of oaks may greatly increase the absorptive capacity of roots. Because of the large number of lateral roots on container stock, many more potential sites are available for mycorrhizal infection than on conventional bare-root stock. First-year field results with inoculated black oak planted in the Missouri Ozarks have confirmed this--containerized seedlings had a higher infection rate than bare-root seedlings (Dixon 1979).

A comparison of container-grown seedlings showed that those that were inoculated had significantly more new lateral roots, larger total length of new unsuberized roots, and larger leaf areas than noninoculated seedlings. Also, longer shoot lengths have been reported for bare-root black oak seedlings in nursery beds inoculated with P. tinctorius (Wright 1979). The biggest increases in seedling growth and mycorrhizal infection occurred when mycorrhizal inoculation of nursery beds was coupled with the application of a nitrogen and magnesium solution to the seedling foliage.

All of these results are from the early stages of research on mycorrhizal associations in oak. Future results in this area should be even more encouraging.

Plant Growth Regulators

Plant growth regulators include both natural and synthetic substances that can control certain facets of plant growth. Naturally occurring growth regulators include the auxin indole-3-acetic acid (IAA), gibberellins, cytokinins, ethylene, abscisic acid, and B vitamins. Some synthetically produced growth regulators are napthalene acetic acid (NAA), 2,4-dichlorophenoxyl acid (2,4,-D), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), and indolebutyric acid (IBA). Most of these substances have been used in studies of various aspects of oak seedling growth.

IAA and IBA have been shown to stimulate root growth of oak seedlings (Farmer 1975; Carlson 1974; Lee et al. 1974), and gibberellic acid has been shown to stimulate radicle development in germinating acorns (Vogt 1974). Applying IBA to stimulate root regeneration appears to be particularly promising, based on results with white oak, pin oak (Quercus palustris Muenchh.), scarlet oak (Q. coccinea Muenchh.) (Moser 1978), and northern red oak (Farmer 1975). A preplanting treatment consisting of a 5 minute root soak in an aqueous solution of 3,000 ppm IBA produced a 2.6-fold increase in the number of new roots on white oak seedlings and 7.1-fold increase in the number of new roots on scarlet oak seedlings (Moser 1978). Other techniques for applying IBA to roots have also been explored. Some procedures are simple and could potentially be automated, such as inserting various IBA-impregnated materials into the root.

The greatest potential value in using auxins may be to get root growth underway before seedlings come under moisture stress after spring planting. However, because low soil temperatures limit root growth (Teskey 1978; Carlson 1974; Moser 1978; Larson 1970), auxin application may require careful timing to coordinate planting schedules with soil warming. This aspect of auxin use will require further study.

Other growth regulators, including gibberellic acid, ethylene, and kinetin, have been found to stimulate shoot elongation in oaks (Vogt 1974; Farmer 1975). Shoot growth promoters might be especially useful for triggering simultaneous flushing of seedlings in the nursery. Uneven or nonsynchronous flushing among seedlings often results in the suppression of late flushers, especially when seedling densities are high such as in container propagation systems.

Employing shoot and root growth stimulators simultaneously also offer promise, based on the performance of field planted northern red oaks treated with both IAA and kinetin (Larson 198_). To date, methods for practical application of these materials for nursery and field use have not been worked out. However, the practical use of growth regulators would be a promising means to control both the quantity and timing of root and shoot growth in the nursery and field.

## Planting Sites and Techniques

Since the development of a guide for identifying inadequate advance oak regeneration (Sander et al. 1976), interest has increased greatly in planting oaks. Future oak plantings will probably be in clearcuts following final harvest cutting or in mature stands prior to clearcutting. To perform adequately on such sites, planted oaks must possess a capacity for height growth that approximates that of competitors after final harvest. With no weed control, height growth of dominant competing vegetation in oak clearcuts in the Missouri Ozarks averages about 45 cm per year during the first decade after clearcutting. However, applying herbicides to stumps substantially reduces competition and could thus increase the number of planted oaks that attain acceptable height during the first decade.

Defining "success" criteria prior to planting will be necessary for determining the type of planting stock needed and for evaluating the performance of oaks planted among competing woody vegetation. For a given type of nursery stock and planting site, "success" probabilities for planted trees can be estimated from field trials (Johnson 1976). These probabilities can then be used to determine the number of trees per acre required to attain "adequate" stocking based on existing natural reproduction (Sander et al. 1976). Successfully implementing this or similar methods of oak interplanting will require more information and attention to silvicultural detail than most current methods of plantation establishment.

Underplanting oaks in mature stands allows the root systems to become well established before the surge of competition growth that follows clearcutting. To implement this system, both overstory and understory density control may be required to obtain the light and soil moisture necessary for adequate development of planted trees before clearcutting. Thus, oak underplanting has much in common with the shelterwood method of natural regeneration (Sander 1979). Studies in oak underplanting that involve overstory density control and time of removal are currently underway in several regions.

Site quality is also an important consideration in oak planting. For timber production, oak planting will probably not be economically feasible nor silviculturally necessary on site indexes below about 60. At the other extreme, oak planting on sites more than site index 75 may also not be practical because of the difficulty in controlling competition on such sites and the inherent upper limit of oak seedling growth that may always be exceeded by competitors. However, a better estimate of the upper site quality limit for planting oaks will depend on knowing the upper limit of shoot elongation for each species.

Spring planting of oaks is generally safer than fall planting because it avoids winter frost heaving. In addition, we have observed much shoot dieback in fall-planted oaks in the Missouri Ozarks that occurs prior to the onset of spring growth. This dieback appears to be related to shoot dehydration. Similar shoot dieback and correlated failures in root regeneration have been observed in a greenhouse study (Johnson 1979a) and in a study on internal plant water stress incurred during storage of red oak nursery stock (Webb and von Althen 198_). Although the planting season can be extended into the summer using container stock, I believe summer planting is counter-productive. Nursery stock planted in the summer soon comes under severe water stress and therefore both shoot and root elongation fail.

Soil application of fertilizers at time of planting has been shown to significantly increase height growth of planted oaks (Foster and Farmer 1970; Johnson 1974a). And the use of fertilizers in combination with other cultural improvements may be especially advantageous to shoot growth. Some of the slow release fertilizers may be particularly beneficial. Similarly, the use of plastic mulching may provide significant benefits if used in conjunction with improvements in stock quality. This has been shown by the response of containerized English oak (Quercus robur L.) to black plastic mulching--a positive response by large stock and a negative response by small stock (Johnson 198_).

## Genetic Improvement

Despite apparently large inherent variability in oak, genetic improvement work in oaks through conventional selection and breeding programs has been fraught with problems (Beineke 1979). Research on most species has not progressed beyond early selection or provenance testing phases--substantial provenance testing has been done only for northern red oak (Kriebel et al. 1976; Gall and Taft 1973; McGee 1970). The reason for this dirth of effort in oak genetics is related to a number of factors including poor seed yield in controlled pollination work and difficulties in grafting and rooting oaks from cuttings (Cech 1971). It has also been argued that the lack of interest and endeavor in oak genetics is due to the absence of established oak planting techniques. Yet, from a silvicultural perspective, the identification of seed sources or progenies with rapid juvenile shoot growth would be valuable in developing such planting methods. Despite this dilemma, several State agencies and the Eastern Region of the USDA Forest Service have recently undertaken tree improvement programs with northern red and white oaks. The objective of these programs is to develop seed orchards that will produce trees with rapid growth and good quality.

Recent developments in propagating oaks using tissue culture ("microculture") may make possible the mass production of selected genotypes (McCown 198_). This technique is now being utilized for a variety of ornamental woody species, and the same techniques are believed to be applicable to forest tree species. The successful application of microculture to reproducing oaks might thus have significant implications for future genetic improvement work as well as eliminating the problems of producing and storing acorns.

Modification of the Bare-Root Nursery System

Except for mycorrhizal inoculation of bare-root nursery beds, little attention has been given to improving the quality of bare-root oak stock. For example, even though bare-root oaks are seldom transplanted, significantly better root regeneration has been observed in 1-1 transplants than in 1-0 stock of the same shoot size and leaf surface area (Johnson 1979a). These results may be partly attributable to the more fibrous root morphology and thus larger number of sites for new root regeneration in transplants than in seedlings.

Elevated nursery beds with screen or hardware cloth bottoms that would permit air pruning of roots offer another largely unexplored opportunity for producing a bare-root seedling with a more fibrous root system. Similarly, the use of shade screening during the growing season to induce prompt flushing the following growing season is a potentially useful technique suggested by research on shaded versus unshaded northern red and scarlet oaks (McGee 1976).

Bare-root oak nursery stock is sometimes shoot-pruned to facilitate field handling of large stock and also to increase root:shoot ratio. However, shoot pruning of 1-0 white oak 2 cm above the root collar (Farmer 1979) and of large containerized and bare-root red oak 15 cm above the root collar (Johnson 1979a) was shown to significantly reduce root regeneration compared to unpruned plants. In another study, shoot-pruned pin oaks responded similarly but shoot-pruned scarlet oaks increased their root regeneration (Lee et al. 1974). Lee et al. suggested that the system of translocating growth regulators between shoots and roots of oaks may vary markedly by species. Similarly, different physiologies among oak species are also reflected in differences in root morphology, shoot growth (Carpenter and Guard 1954), and response to fertilization (Johnson 1974a).

Conventional procedures for packaging bare-root red oak stock for cold storage have been shown to result in plant water stress that can reduce both root and shoot elongation (Webb and von Althen 198_). Seedlings totally enclosed in plastic-lined kraft bags had better root regeneration--associated with the lower water stress of their shoots--than seedlings that were packaged in conventional bundles that covered only their roots. Similarly, an antitranspirant applied to dormant scarlet oak shoots increased root regeneration (Lee et al. 1974). These findings suggest that much of the poor performance of bare-root stock may have been caused by water stress incurred during storage; similar water stress may also occur over winter in stock that is fall planted or heeled-in in the nursery.

## SUMMARY AND CONCLUSIONS

Even though average shoot growth in oaks planted on forest sites has been consistently low, variability has been just as consistently high--a few individuals in most oak plantings produce multiple flushes or long single flushes. Thus, solving the oak planting problem depends on accounting for the sources of this variability in shoot elongation. Rapid shoot growth of oak natural reproduction is associated with high root:shoot ratios and large total plant mass. Therefore, I propose that shoot elongation models be developed for oak seedlings grown in different light and water stress environments based on the ratio of effective root absorptive area to leaf surface area and the interaction of this ratio with total seedling mass. Such models could serve as baselines for assessing nursery stock needs in relation to field planting environments.

Despite the lack of a general shoot growth model, recent advances in oak planting research provide a basis for optimism for solving the oak planting problem. Important aspects of this research include:

- Improvements in root regeneration and shoot growth associated with containerized oak seedlings.
- Improvements in both bare-root and containerized seedling growth associated with infection of roots with the ectomycorrhizal fungus Pisolithus tinctorius.
- Improvements in mycorrhizal infection of seedling roots related to foliar fertilization.
- The development of techniques for increasing root regeneration of oak seedlings by applying indolebutyric acid (IBA) to their roots.
- Improved methods for cold storing bare-root seedlings that reduces the seedlings' internal water losses.
- The possibility of mass producing selected oak genotypes by means of tissue culture.

These and other recent research developments represent significant advances in oak planting technology. Before they can be successfully put into practice, however, further improvements will be needed on how to optimize various plant factors within the environmental restraints dictated by the planting site.

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# SOME SILVICULTURAL AND MANAGEMENT OPTIONS FOR UPLAND HARDWOODS OF THE MID-SOUTH

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Abstract.--The silvicultural and management system used in upland hardwood stands must satisfy the owner's objectives and the biological and ecological requirements of the species. The most important hardwoods of the mid-south--oaks, yellow-poplar, and other intolerant species--grow best in even-aged stands, and clearcutting and shelterwood regeneration methods are both appropriate to use. Group selection will also favor the growth of these species but does not provide a regular yield. These forests can also be managed by the single tree selection method--an uneven-aged system--but oaks and other intolerants will eventually be eliminated. Also, sustained timber yield can be attained more easily with even-aged than with uneven-aged management.

Additional keywords: Regeneration, thinning, *Quercus*, sustained yield.

Upland hardwoods occur on a variety of sites and contain a variety of species and stand conditions. In the mid-south most of the present hardwood stands are dominated by oaks. White oak (*Quercus alba* L.), black oak (*Q. velutina* Lam.), scarlet oak (*Q. coccinea* Muenchh.), southern red oak (*Q. falcata* Michx.), and northern red oak (*Q. rubra* L.) are the most important, but hickories (*Carya* spp. Nutt.), yellow-poplar (*Lirodendron tulipifera* L.), black gum (*Nyssa sylvatica* Marsh.), sweet gum (*Liquidambar styraciflua* L.), red maple (*Acer rubrum* L.), sugar maple (*Acer saccharum* Marsh.), chestnut oak (*Q. prinus* L.), post oak (*Q. stellata* Wangenh.), and blackjack oak (*Q. marilandica* Muenchh.) may also be present or locally abundant. Most stands contain an understory of species such as dogwood (*Cornus florida* L.), sassafras (*Sassafras albidum* (Nutt.) Ness), sourwood (*Oxydendrum arboreum* (L.) DC.), downy serviceberry (*Amelanchier arborea* (Michx. f.) Fern.), and other small tree or shrub species.

The present stands reflect past treatment and many are understocked and contain few good quality trees because they were high-graded, overgrazed, or otherwise abused. Harvest cuts have been made with little or no attention to reproducing the harvested trees, or to what effect the cutting would have on the stand as a whole. If circumstances just happened to be favorable, well stocked, good quality stands developed.

Even though abused in the past, the potential for producing goods and services from our upland hardwoods is great. To realize their potential they must be managed scientifically and with an intensity we have not yet been able to accomplish.

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## SOME BASIC PRINCIPLES

In this paper I will use the term "management" to denote the application of the scientific and technical aspects of silviculture and regulating cutting. A management system contains three basic elements: (1) regeneration methods, (2) a silvicultural system, and (3) a regulatory system.

Regeneration methods are used to replace harvested trees and stands with new trees and stands of the desired species. Several regeneration methods can be included in a single silvicultural system.

A silvicultural system is the whole set of operations used to grow trees. It includes all of the cultural operations--weeding, cleaning, thinning, pruning, and fertilizing--as well as the regeneration methods. The silvicultural system must satisfy the regeneration and growing space requirements of the species being grown. It must also be compatible with the land owner's objectives. Upland hardwoods vary in their requirements. Most grow best in even-aged stands, but may, for example, require different regeneration methods. Yellow-poplar reproduces from seed stored in the duff layer and clearcutting will result in good yellow-poplar reproduction if a seed source was present and the site is suitable. Oaks, on the other hand, must be present as advance reproduction so they may require the shelterwood regeneration method.

Regulatory systems are used to achieve a sustained, regular yield of timber products and to maintain the proper rate of tree or stand replacement. We have only two regulatory systems available--even-aged or uneven-aged.

In the even-aged system cutting is regulated by area to regenerate stands as they reach rotation age. In the fully regulated forest each age class from 1 year through rotation age will be present with each occupying an area of equal size and productive capacity. The age classes may be single years or grouped at intervals such as 5 or 10 years.

In the uneven-aged system a relatively homogeneous mixture of age classes is maintained on each area set up for management. In practice, tree size is generally substituted for age and the goal is to maintain a certain diameter distribution--the familiar reverse J-shaped curve. The goal may not be exactly attained by any one cutting but it should be approximated as nearly as possible. The diameter distribution chosen must be within the regeneration and growth capabilities of the species, and cuttings must be distributed over all diameter classes. Controlling a specific diameter distribution is difficult. A more common practice is to leave certain amounts or percentages of basal area in each of three broad timber size classes--small, medium, and large.

Periodic board foot volume growth is often used to control cutting in upland hardwoods under the uneven-aged system, but control by volume alone will not regulate size class distribution. Cutting is usually heavy in the large- and medium-sized sawtimber, light in the small sawtimber, and often non-existent in the pole and sapling size classes. This manner of cutting changes the size class distribution and after 3-5 cuts no large timber is likely to be left.

## SILVICULTURAL SYSTEMS

The clearcutting and shelterwood regeneration methods are applicable to upland hardwoods in an even-aged silvicultural system. The seed tree method is either unsuited or unnecessary for regenerating upland hardwoods.

### Clearcutting

Clearcutting is the most successful method for regenerating yellow-poplar if a seed source has been present for 3-5 years. Yellow-poplar seed remains viable in the litter and duff under fully stocked stands for at least 8 years. However, highest germination occurs after 2-3 years. The light and temperature conditions created by clearcutting allows this stored seed to germinate and the seedlings to grow rapidly.

Clearcutting can also be used to regenerate oaks if the number and size of oak advance reproduction is adequate to replace the harvested stand. Other species, notably white ash, hickories, maples, and black gum, present in the stands following clearcutting also come primarily from advance reproduction.

There is no silvical reason to set an upper limit on the size of clearcut areas. Therefore, the maximum size of an area clearcut should be determined by uniformity of the stand, site, and by the aesthetic impact. In the broken topography of the mid-south, slopes are short and site quality changes frequently. Restricting clearcutting to areas with uniform site quality and stand conditions will tend to keep clearcut areas relatively small.

There is a valid silvical reason to recommend a minimum size for clearcut openings. All openings contain a 10 to 20 foot wide zone around their borders in which reproduction growth is retarded because of the influence of the surrounding stand. The percentage of an opening occupied by this zone increases rapidly for openings smaller than about 2 acres. Thus, 2 acres is about the minimum size for reproduction to grow acceptably. Other important considerations in determining opening size are (1) for a given total area clearcut, the perimeter of one opening is less than that of several openings. The residual trees around the perimeter of openings respond to the increased light by developing new branches on the lower part of the bole. Most of these branches will persist and can degrade tree quality. In several openings many more trees will be affected than in one opening of equal total area; and (2) stands originating from clearcutting will receive future silvicultural treatments and the rate of cutting is controlled by area. Thus, records must be kept by stands and they must be large enough to be readily relocated. Many small stands will make control more difficult than fewer, larger stands, especially on large forest properties. This is not critical on small forest properties where it is much easier to keep track of small stands.

## Shelterwood

The shelterwood regeneration method should be useful if the regeneration objective is to perpetuate oaks but oak advance reproduction is absent, sparse, or very small. However, the shelterwood method as applied in research studies failed to establish oak seedlings and also to provide for the continuing survival and growth of oak reproduction until large enough to compete successfully in the new stand. The only instances in which oaks were numerous and grew well in the new stands were when they were already present as large advance reproduction when the original preparatory and seed cuts were made. How, then, can the shelterwood method be used to regenerate oaks? It must be developed specifically to satisfy their silvical requirements. Unfortunately, we do not have all of the information needed for a completely developed system, but I think we have a good basis from which to begin (Sander 1979).

Two situations occur in mature or near mature stands in which oak advance reproduction is inadequate and the shelterwood regeneration method is applicable. In the first, not enough oaks are present. In the second, the number of oak stems is adequate but they are too small to grow fast enough in a new stand if the old one is removed. In either situation the stand treatment is the same but the length of time between the first cut and the final removal cut varies from 20-30 years in the first case and 15-20 in the second. If the number of oaks is inadequate, new oak seedlings will have to be established. How long this will take will depend on the occurrence and size of acorn crops. Even in good seed years only a small part of the crop becomes available for regeneration. How long it might take to get a sufficient number established is uncertain and depends to some extent on how many are needed. On the average, we might expect 5-10 years.

After this establishment period, conditions must be maintained that will allow the seedlings to survive and grow to the size necessary for them to be competitive in a new stand. The same conditions are needed when the number of advance oaks is adequate but are too small. The length of time necessary for the seedlings and small advance reproduction to grow to adequate size is uncertain. Our observations of reproduction growth under fully stocked unmanaged stands indicates 15-20 years may be needed. With intensive application of the shelterwood system we should be able to shorten this period to hopefully not more than 10 years.

The first cut of this proposed method should reduce the overstory density to not less than 60 percent stocking according to the stocking criteria for upland central hardwoods (Gingrich 1967). Although light intensity at this overstory density is not optimum for the best growth of oaks, it is sufficient for them to survive and grow. This density is also the minimum required for full site utilization and will inhibit rapid growth of other species in the understory. The first trees removed in this cut should be those in the lower crown classes. Crown coverage of the residual stand should be as uniform as possible with no large boles in the canopy.

If an understory is present, it will most likely have to be controlled or at least its density reduced, particularly if it is well developed. How dense is too dense or how much control is necessary is not known. However, I believe removal of the understory stems larger than the oaks they are competing with is the minimum.

Additional cuts should be made to maintain an overstory crown cover that will not unduly restrict oak growth. It seems reasonable to make another cut when stocking increases to about 75-80 percent. It also seems reasonable to reduce stocking to about 50 percent when the oaks are about 3 feet tall. Further control of unwanted species in the reproduction may also be needed. When at least 435 oaks per acre 4.5 feet tall or taller are present, the remaining overstory should be removed in one cut.

The method I have just outlined is not proven. I think it is a conservative approach, but I believe this is desirable until we can obtain the information needed to refine it.

Single Tree Selection

The single tree selection system is a complete silvicultural and management system. That is, each time a cutting is made, provisions are made to establish regeneration where mature trees were harvested, and the structure or size class distribution is maintained by harvesting the mature trees plus excess trees in each smaller size class. Cutting is never heavy, and a homogeneous mixture of size classes with essentially full crown coverage is maintained throughout the cutting area.

The single tree selection system is not suitable for stands composed primarily of oaks and other intolerant species if sustained yield is important and the objective is to maintain a stand of oaks or intolerant species. This is because oaks and other intolerant species are unable to reproduce and grow into successively larger size classes under the continuous crown cover maintained under this system. Furthermore, even though many current stands have a reverse J-shaped diameter distribution characteristic of an uneven-aged stand, they are, in fact, even-aged. They generally contain a mixture of oaks and other species and the reverse J-shaped distribution results from differential shade tolerance and growth rates among species and suppression of some trees by their faster-growing neighbors. Some existing stands may have 2 or 3 widely separated age classes, but this condition is usually the result of past cutting practices and not because they have always been uneven-aged.

Maintaining a reasonably well balanced diameter distribution in such stands is difficult. As the existing sapling, pole, and small sawtimber size trees pass through successively larger sizes and are harvested, the population of oaks and other intolerant species declines and an understory of shade-tolerant species develops. Eventually thres shade-tolerant species will dominate the stand (Schlesinger 1976, Trimble 1970).

Whenever sustained yield is unimportant, maintenance of a balanced diameter distribution is unnecessary. However, any cutting not designed to control the diameter distribution does not fit the definition of the single tree selection system and cannot properly be called selection cutting.

## Group Selection

Group selection is a modification of the single tree selection system in which openings are created by removing trees in groups instead of singly. The purpose of the openings is to provide the conditions needed to reproduce the more intolerant species and for this purpose the group selection system works well. Oaks, however, will only be present in the reproduction to the extent they were present as advance reproduction before the opening was created.

The size of the opening will affect reproduction growth. In small openings a significant portion of the opening is affected by the surrounding stand. Maximum growth of oaks and other intolerant species will occur only in the center of the openings and shade tolerant species may become established near the opening borders. In larger openings, reproduction growth of intolerant species is maximized over a larger portion of the opening.

This modification of the single tree selection system is clearly only a regeneration method. The sole purpose of creating the groups is to regenerate intolerant species. Therefore, to achieve regular yields, cutting must be regulated by maintaining a balanced size class distribution. This is very difficult. The individual groups cannot be considered separate distinct stands, but must be considered as integral parts of a larger area under uneven-aged management. A homogeneous mixture of size classes can be achieved if the groups occupy a small portion of the management area. However, after a number of cutting cycles the groups will occupy a significant portion of the area, the mixture of size classes will become much less homogeneous, and the distribution will become next to impossible to maintain.

Although it is incorrect to do so, many foresters (especially those on small forest properties) treat each group as a separate and distinct stand in record keeping for thinnings and other silvicultural operations. If each group is considered to be a separate even-aged stand, even-aged management is feasible and regulation will be easier than under uneven-aged management.

Regular yields may not be an important objective, especially on non-industrial, privately owned land. If this is the case, "selection" or "group selection" cutting controlled on the basis of volume alone may be appropriate, depending on the owner's other objectives. However, it should be made clear that this manner of cutting will not achieve regular yields. Growing stock and maybe some sawtimber size trees will always be present, but the yields will be irregular. Furthermore, unless a deliberate attempt to achieve and maintain a specific size class distribution is made, it should not be called selection or even group selection.

## Thinning

Thinning is an integral part of both even- and uneven-aged silvicultural systems. It is used to increase the yield of wood products (Table 1) as well as the quality of the stand. In the uneven-aged system, thinnings are integrated with regeneration cuts and their purpose is to harvest excess stems in the smaller size classes--all silvicultural operations are carried out at the same time. In the even-aged system, thinnings are separate operations made in immature stands. Their purpose is to harvest trees that would otherwise die and concentrate the growth potential of the site on fewer trees.

Table 1.--Comparison of yields[1/] per acre at age 70 of thinned and unthinned upland oak stands (from Gingrich 1971)

| Age (years) | Unthinned | | | Thinned[2/] | | |
|---|---|---|---|---|---|---|
| | Cubic feet[3/] | Cords[4/] | Board feet[5/] | Cubic feet[3/] | Cords[4/] | Board feet[5/] |
| 20 | 178 | 1.6 | --- | 178 | 1.6 | --- |
| 30 | 1,200 | 10.6 | --- | 900 | 8.6 | --- |
| 40 | 1,840 | 18.2 | 440 | 2,200 | 20.4 | 1,320 |
| 50 | 2,800 | 26.9 | 2,150 | 3,215 | 28.2 | 3,900 |
| 60 | 3,300 | 30.8 | 5,160 | 4,040 | 35.4 | 7,680 |
| 70 | 3,700 | 33.3 | 7,200 | 4,830 | 42.0 | 12,600 |

1/ Of all trees 5 inches d.b.h. and larger.
2/Residual density after each thinning--60 percent stocking.
3/Volume of entire stem including bark.
4/Standard cords to 4 inch top inside bark.
5/International 1/4 inch rule, to an 8.3 inch top outside bark.

On an average site with an oak site index of 65, thinning can increase board foot yields of upland oak stands at age 70 by about 75 percent and total cubic foot yields by about 30 percent (Table 1). Thinned stands are also of better overall quality because we have left the best trees and removed the inferior, defective, and poorest trees.

Thinnings in even-aged stands should be begun as early in the life of a stand as possible--ideally no later than age 20--and repeated at about 10-year intervals until about age 60 after which thinning may no longer benefit the entire stand. If only a few large trees can be removed, large holes may be left in the canopy and this is a situation that should be avoided.

If regenerating the stand to oak is desired, the objective of any cutting in the late stages of the rotation should be to establish and develop advance reproduction. Growth of the residual trees should still be considered, but the regeneration objective must have first priority.

## TIMBER AND OTHER USES

If timber production is the primary objective, regular sustained yield is the first priority. However, if some other resource or use is equally or more important, sustained yield may not be possible.

In a regulated even-aged forest in which stands are small, a wide diversity of vegetation is provided for wildlife at no sacrifice to sustained yield. The regeneration cuttings will result in various vegetation stages over a relatively small area and each stage will contribute to the habitat requirements of different wildlife species. When thinning these stands, a few defective or potential cavity trees can be left for cavity users. However, this may result in a slightly lower timber yield or at least a lower overall stand quality. Also, culls and unmerchantable trees can be killed instead of cut in regeneration cuttings and thinnings to provide snags, which are used by some wildlife species.

The single tree selection system limits wildlife management opportunities because it does not provide diversity of vegetation and habitat. The continuous crown cover inhibits browse production and no edge habitat exists. In oak stands, mast production is high at first but gradually declines as the oaks are harvested and replaced by other species.

If a forest is on a watershed, protecting the water supply is of primary importance but sustained timber yield should also be feasible. Established principles of good watershed management must be followed, and although timber yields are of secondary importance, regulating the forest resource should not adversely affect the water resource. It is the careless execution of silvicultural systems that damage the water resource, not the systems themselves. Practically all erosion and sedimentation resulting from silvicultural operations occur because of poorly located, constructed, and maintained roads and skid trails--no matter which silvicultural system or regeneration method is used. It should be possible to protect water quality through careful planning and execution of logging operations.

Timber production will be unimportant on areas left for stream protection, recreation, or scenic importance. Generally, trees will need to be cut periodically but the yield cannot be regulated. In these areas, any cutting should be designed and executed to enhance the purpose for which the area is being used.

Even if a forest is regulated for sustained yield, it can maintain a high visual quality if cutting operations are carefully planned and executed. Primarily, cutting areas should appear neat and orderly and trash should not be allowed to accumulate. Regeneration areas should be planned so they blend into the topographic and landscape features as much as possible. Some visual disruption most likely will occur during any cutting operation, but it should be kept to a minimum.

## CONCLUSION

The upland hardwood forests of the mid-south will be increasingly called upon to help meet the demand for goods and services. They can contribute much to the economy of the region and have a bright future if they are managed intensively. The silvicultural and management system used on these forests must be chosen to meet the owner's objectives and to satisfy the silvical requirements of the species grown. Even-aged systems best satisfy the requirements of the most valuable species--oaks, yellow-poplar, and other intolerants--and they should be compatible with most owners' objectives. Clearcutting and shelterwood are the even-aged regeneration methods suitable for use in upland hardwoods. The even-aged silvicultural system should also include thinnings applied at regular intervals to immature stands.

Single tree selection will not satisfy the silvical requirements of the most important species and is not suitable if regular sustained yield is a management objective. Group selection is a modification of the single tree selection system and works well as a regeneration method but regulating cutting is almost impossible. If timber production and sustained yield are not important, any cutting should be designed to enhance the resource or use that is important.

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THE EFFECT OF FIRE ON SPECIES DOMINANCE IN YOUNG UPLAND HARDWOOD STANDS

Charles E. McGee[1/]

Abstract.--For many years wildfire was a normal part of upland hardwood ecology. In recent years improved fire protection has drastically reduced wildfires in most upland hardwood areas, and changes in fire occurrence have probably been accompanied by changes in stand ecology. In this report even-aged hardwood stands 5 or 6 years old that have been burned are compared to an unburned stand. The species composition of the young stands at the time of the fires differed considerably from the composition of the mature stands harvested six years earlier. The mature stands were primarily oak while the young stands contained many dominant yellow-poplar, white ash, black cherry, and red maple. The primary impact of the fires has been a "knocking back" of the young stands. Other than to increase dominant red maples, single fires did not affect relative dominance. The competitive position of the oaks, yellow-poplar, black cherry, and white ash is about the same after as before the fires. Regrowth after the fires has been vigorous, and the major long term effect of the fires may be a loss of individual stem quality.

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Wildfires were once frequent in upland hardwood forests of the Southeast and may have influenced stand composition as greatly as did climate or soil (Garren 1943). But improved fire prevention has greatly reduced wildfire occurrence (Mobley and Kerr 1973). Though the benefits of fire prevention are clear, some ecological changes may not be so obvious and all change may not be beneficial. For example, researchers have speculated that wildfire elimination may be jeopardizing the dominance of oaks (Quercus spp.) on good hardwood sites (McGee 1979). Oaks seem to be giving way to other species such as yellow-poplar (Liriodendron tulipifera L.), black cherry (Prunus serotina), white ash (Fraxinus americana L.), or trees of much less value than oaks.

In this presentation high quality young stands of mixed hardwoods that have been burned are compared with unburned stands. The primary purpose of the study is to determine how fire has affected species composition, relative dominance by species, and prospects for future stand development. Special emphasis is placed on the relative position of oaks in stand structure.

The results reported here were obtained from studies on the Bankhead National Forest in North Alabama, at the southern end of the Cumberland Plateau. The plateau forests of the Bankhead are similar to many upland forests of Tennessee, Kentucky, and North Carolina. A major difference of

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the study areas from the areas of primary interest to this workshop (Arkansas, Missouri, West Tennessee, and East Oklahoma) is the presence of yellow-poplar. The site index for yellow-poplar on the burned areas ranges from about 85 to 100 feet at 50 years, probably somewhat higher than on most of the upland sites in the Missouri-Arkansas area.

The four areas studied had been commercially clearcut and most of the non-merchantable material had been injected within a year of the clearcutting. When the young hardwood stands were about 5 to 6 years old we burned three of the areas and retained one area as a check. Two burns were made in the spring and one in the fall.

Three areas (I, II, and III) are contiguous, but the fourth (Area IV) is several miles away. Each burn covered about 8-10 acres, but the central sampling area covered 5 acres. Even though three of the areas (I, II, and III) are close together they have different aspects and positions on the slope. Area I, burned spring 1976, is probably the best overall site being positioned on a lower slope with a northerly aspect. Area II, burned fall 1976, is probably the poorest site. Because it had a southerly aspect it was somewhat dry and contained less yellow-poplar and more pine (Pinus spp.) and oak when it was first measured. Area III, the check, has a favorable northerly aspect but is further upslope from Area I. Area IV, the spring burn 1978, is on a favorable aspect and ranges from a lower slope to upper middle slope.

The three fires, administered by personnel from the Black Warrior District Bankhead National Forest, provided a good range of the kinds of burns that can be anticipated in this area. Area I was burned with a strip headfire. Results were variable with 8 percent heavily burned, 72 percent moderately burned, and 20 percent very lightly burned or unburned. Area II was set just after leaf fall, and a slow fire uniformly covered the study area so that most of the litter was consumed. Area IV was burned with a moderately intense fire over the entire sampling area. Some hot spots occurred, and some fuels were left in places because the fire burned very fast.

Before the fires we sampled each area and tallied vegetation by size and species. Since the fires we have periodically remeasured the vegetation. Stocking and density estimates are based on stems over 4½ feet tall found on 40 to 60 one-hundreth acre plots in each of the four study areas. The tallest and most vigorous trees on each plot were identified by species and have been grouped to show relative dominance on each area for the best 400 trees per acre.

## RESULTS

### Numbers of stems per acre

In the normal course of stand development a young undisturbed hardwood stand loses many stems as the survivors grow and occupy the site. Area III, the check, dropped from 15,000 stems per acre to about 10,000 per acre as it aged from 6 to 9 years (Table 1).

Number of stems per acre on the burned areas, however, increased from 15,000 per acre before the fire to 30,000 per acre or more 1 or 2 years after the fire. A few of these new stems are new seedlings taking advantage of the openings caused by the fire, but most of the increase was caused by multiple sprouting from existing hardwood stems that were top-killed by the fire.

Table 1.--Stems per acre for hardwood stands before and after burning treatment (Area I, 3 years after fire; Areas II and IV, 2 years after fire; Area III, 3 years growth)

| | Area I Burned Spring 76 | Area II Burned Fall 76 | Area IV Burned Spring 78 | Mean All Burns | Area III Check No Burn |
|---|---|---|---|---|---|
| | Number per acre | | | | |
| Oaks[a/]-Initial | 2796 | 5465 | 1809 | 3357 | 3597 |
| Remeasurements | 3440 | 6778 | 2832 | 4350 | 2417 |
| Change | +644 | +1313 | +1023 | +993 | -1180 |
| Yellow-poplar-Initial | 2723 | 406 | 2818 | 1982 | 2383 |
| Remeasurements | 1330 | 156 | 1091 | 859 | 969 |
| Change | -1393 | -250 | -1727 | -1123 | -1414 |
| Black cherry-Initial | 574 | 761 | 917 | 751 | 504 |
| Remeasurements | 522 | 860 | 1262 | 881 | 165 |
| Change | -52 | +99 | +345 | +130 | -339 |
| White ash-Initial | 409 | 198 | 145 | 251 | 193 |
| Remeasurements | 621 | 477 | 265 | 454 | 227 |
| Change | +212 | +279 | +120 | +203 | +34 |
| Red maple-Initial | 380 | 2395 | 3242 | 2006 | 2098 |
| Remeasurements | 1545 | 3254 | 5143 | 3314 | 1071 |
| Change | +1165 | +859 | +1901 | +1308 | -1027 |
| All others[b/]-Initial | 5988 | 5586 | 14341 | 8638 | 6166 |
| Remeasurements | 9903 | 10808 | 26463 | 15725 | 4926 |
| Change | +3915 | +5222 | +12122 | +7087 | -1240 |
| Total initial | 12,870 | 14,811 | 23,272 | | 14,941 |
| Remeasurements | 17,361 | 22,333 | 37,056 | | 9,775 |

a/ Oaks include white, northern red, black, and chestnut oak.

b/ All others include hickory, elm, blackgum, dogwood, sourwood, pine, redcedar, sassafras, redbud, persimmon, bigleaf magnolia, buckeye, hawthorn, and eastern hophornbeam.

By the end of the second or third year after fire, considerable regrowth and mortality had occurred on the burned areas. Oaks, white ash, red maple (Acer rubrum L.), and the miscellaneous group still had more stems per acre than before the burns while yellow-poplar had lost substantial numbers in each area.

Stocking

Before the fires, over half of all plots contained at least one oak, cherry, yellow-poplar, and white ash over 4½ feet tall, and many plots contained all species. This distribution is an excellent example of how prolifically mixed hardwood stands regenerate. Oak stocking ranged from 90 percent on Area III to 62 percent on Area IV; yellow-poplar ranged from 88 percent on Area I to 46 percent on Area II; black cherry ranged from 86 percent on Area I to 45 percent on Area IV; and red maple treatment ranged from 87 percent on Area II to 15 percent on Area I.

Two or three years after the fires, burning has had little effect on oak stocking, which decreased slightly in each burned area and increased slightly in the check area. Yellow-poplar stocking changed little in the lightly burned area I, but decreased in Areas II and IV, where the fires were hotter. Black cherry stocking has not changed materially since the fires, and red maple stocking increased from 15 to 70 percent in Area I after the fire but decreased slightly in Areas II and IV.

Dominance

Number of stems per acre and their distribution are important in young hardwood stands, but a picture of stand structure is not complete until stem dominance is determined and relative heights are compared.

Although oaks averaged 464 trees per acre over 4½ feet tall on the 3 burned areas (Table 2), only 49 oaks per acre were dominant 2 or 3 years after the fires (Table 3). Yellow-poplar has fewer stems over 4½ feet tall now than at the time of the burns, but the species averages 62 stems per acre that are dominant on the three burned areas. Black cherry with 55 stems per acre and white ash with 39 stems per acre now have more stems over 4½ feet tall than at the time of the burns. Red maple and "all others" have also increased numbers of stems over 4½ feet; red maple averages 37 dominant stems per acre, and "all others" average 168. The "all others" group includes ironwood (*Carpinus caroliniana* Walt.) 26, dogwood (*Cornus florida* L.) 22, blackgum (*Nyssa sylvatica* Marsh.) 22, sweetgum (*Liquidambar styraciflua* L.) 13, redbud (*Cercis canadensis* L.) 12, sassafras (*Sassafras albidum* (Nutt.) Nees) 10, and 63 others per acre.

Dominance by species on the unburned check area does not differ greatly from that on burned areas. In area III normal mortality has reduced the numbers of stems over 4½ feet tall considerably for all species groups except white ash. There are 75 dominant oaks per acre competing with 96 dominant yellow-poplar, 52 black cherry, 56 red maple, 25 white ash, and 171 others.

Height growth of dominant stems since the fires has been exceptional for most species. Heights of dominants in Area I, the earliest burn, have almost caught up with dominants in the check (Area III), and stems in Areas II and IV are not far behind. Where the fire was hot (Areas II and IV), dominants are not quite as tall as in Area I, where the fire was more moderate and many original saplings were not top-killed.

Table 2.--Stems per acre over 4½ feet tall after burning treatments (Area I, 3 years after fire; Areas II and IV, 2 years after fire)

| | Area I Burned Spring 76 | Area II Burned Fall 76 | Area IV Burned Spring 78 | Mean All Burns | Area III Check No Burn |
|---|---|---|---|---|---|
| | - - - - - - - - - - - - Number per acre - - - - - - - - - - - - | | | | |
| Oaks | 500 | 466 | 426 | 464 | 958 |
| Change | -250 | -98 | +116 | -77 | +152 |
| Yellow-poplar | 709 | 74 | 294 | 359 | 677 |
| Change | -438 | -21 | -8 | -156 | +23 |
| Black cherry | 295 | 336 | 184 | 272 | 144 |
| Change | +9 | +67 | +79 | +52 | +15 |
| White ash | 424 | 215 | 109 | 249 | 123 |
| Change | +91 | +66 | +42 | +66 | +13 |
| Red maple | 500 | 844 | 612 | 652 | 654 |
| Change | +408 | +334 | +136 | +293 | +223 |
| All others | 2,114 | 1,889 | 4,197 | 2,733 | 2,114 |
| Change | -358 | +532 | +934 | +369 | +552 |

Table 3.--Dominant trees per acre by species groups out of 400 best trees per acre

| | Area I Burned Spring 76 | Area II Burned Fall 76 | Area IV Burned Spring 78 | Mean All Burns | Area III Check No Burn |
|---|---|---|---|---|---|
| | - - - - - - - - - - - - Number per acre - - - - - - - - - - - - | | | | |
| Oaks | 36 | 70 | 41 | 49 | 75 |
| Yellow-poplar | 118 | 18 | 50 | 62 | 96 |
| Black cherry | 61 | 61 | 44 | 55 | 52 |
| White ash | 64 | 36 | 16 | 39 | 25 |
| Red maple | 29 | 49 | 34 | 37 | 56 |
| All others | 92 | 166 | 215 | 158 | 96 |
| Total | 400 | 400 | 400 | 400 | 400 |

The average heights of dominants within each area seem quite uniform, with little variation by species (Table 4). Mean heights of dominant oaks, yellow-poplar, and red maple are similar on the three burned areas. Black cherry is 2 feet taller and white ash 2 feet shorter than the oaks, yellow-poplar, and red maple.

Table 4.--Height of dominant trees by species (based on 400 best trees per acre)

| Species | Area I Burned Spring 76 | Area II Burned Fall 76 | Area IV Burned Spring 78 | Mean All Burns | Area III Check No Burn |
|---|---|---|---|---|---|
| | feet | | | | |
| Oaks | 22 | 16 | 9 | 16 | 25 |
| Yellow-poplar | 23 | 15 | 11 | 16 | 28 |
| Black cherry | 25 | 20 | 10 | 18 | 28 |
| White ash | 18 | 16 | 9 | 14 | 24 |
| Red maple | 24 | 15 | 9 | 16 | 25 |
| Blackgum | 18 | 13 | 8 | 13 | 19 |
| Hickory | 16 | 20 | 7 | 14 | 18 |
| Sourwood | 26 | | 15 | 14 | 20 |
| Persimmon | 14 | 12 | 9 | 12 | 34 |
| Wild plum | 17 | 13 | | 10 | |
| Am. chestnut | 24 | | 10 | 11 | |
| Redgum | 26 | 20 | 11 | 19 | |
| Sumac | 14 | 11 | 10 | 12 | |
| H. club | 15 | | 8 | 8 | 13 |
| Redbud | 17 | 12 | 8 | 12 | 21 |
| Dogwood | 16 | 16 | 9 | 14 | 19 |
| Blackhaw | | 17 | | 6 | |
| Serviceberry | | 18 | | 6 | |
| Ironwood | | 10 | 9 | 6 | |
| Sugar maple | | | 8 | 3 | |
| Elm | 13 | 19 | 8 | 13 | 25 |
| Elderberry | | | 10 | 3 | |
| Loblolly pine | | 25 | | 8 | |
| Hydrangea | | | 8 | 3 | |
| Virginia pine | | 22 | 12 | 11 | |
| Mulberry | | | 8 | 3 | |
| Redcedar | | 20 | | 7 | |
| C. buckthorn | | | 9 | 3 | |
| Winged elm | | | | | 22 |
| Sassafras | 17 | | 10 | 9 | |

The oak component

A primary motivation for this study was concern over the future of the oak component in even-aged stands. Apparently, a strong oak component will be maintained in the burned and unburned areas, but each area will contain less oak than at the time of the harvests.

Area III had 75 dominant oaks per acre. These oaks are about as tall as other dominants, but they must compete with 325 dominants of other species. A comparison with incomplete pre-harvest stand data suggests that substantial increases in dominance will occur in yellow-poplar, black cherry, and red maple.

On the burned areas, 49 dominant oaks per acre must compete with 351 dominants of other species.

I expect a significant decrease in competitive vigor for black cherry, white ash, dogwood, redbud, and some other species. A decrease in height growth is also expected for red maple. Even if the oak component can take advantage of these anticipated declines in vigor, the oak component will be at best not more than 30 to 40 percent of the dominant stand. So, stands that were about 60 to 90 percent oak at time of harvest will become stands heavily populated with yellow-poplar, black cherry, white ash, and other species besides oak.

The oak component in the four study areas includes northern red (*Quercus rubra* L.), black (*Q. velutina*), white (*Q. alba*), and chestnut oak (*Q. prinus*). The four oak species are reasonably well distributed among the four study areas, though northern red oak is scarce on Area II and white oak is overly abundant on Area III (Table 5).

Table 5.--The oak component over 4½ feet tall by species after treatment

| | Area I Burned Spring 76 | Area II Burned Fall 76 | Area IV Burned Spring 78 | Area III Check No Burn |
|---|---|---|---|---|
| | - - - - - - - - - - - - - Number per acre | - - - - - - - | | |
| Northern red oak | 164 | 2 | 53 | 267 |
| Black oak | 132 | 184 | 25 | 129 |
| White oak | 77 | 118 | 16 | 354 |
| Chestnut oak | 127 | 162 | 131 | 208 |

Apparently, different oak species have responded similarly to the fire. Site differences between the areas continue to exert strong influence on species response. The lack of northern red oak on Area II is probably related to the southwesterly aspect, and the abundance of white oak on Area III is related to the slightly drier upper slope position of some of the area.

## The red maple component

Throughout much of the uplands, red maple is a vigorous competitor in young hardwood stands. In the study area red maple generally improved its competitive position in numbers, stocking, and relative dominance after the fires. For example, in Area I stocking of red maple was only 15 percent before fire. Three years after the burn, stocking of maple increased to 85 percent. In the unburned area the presence of about 2500 red maple stems, 590 of which are over 4½ feet, indicates the continued importance of the species in developing natural stands.

## DISCUSSION

In this study of fire in young hardwood stands some immediate effects and some possibly long lasting effects have been observed in stand ecology. However, the overall impact of one fire in a 5- to 6-year-old hardwood stand does not appear to have changed the basic character of the stand itself. The principle effect has been the "knocking back" or retarding of the development of the young stands. The retarded condition is shortlived, and vigorous regrowth is making up some of the growth lost to topkill. A possible long-range impact is that multiple sprouting caused by the fire may lessen individual stem quality. In this study our primary concerns have been whether species composition and species dominance have been affected by the fire.

The mature forests were primarily oak at the time of harvest. The subsequent regeneration contained significant increases in yellow-poplar, white ash, black cherry, and other species. Though the fires have had some impact on numbers of stems with a decrease in yellow-poplar and increase in red maple and some other species, species composition has changed little since the fires.

The rapidly growing oak sprouts in the dominant stand indicate that the future stand in both burned and unburned areas will contain a substantial oak component. If the growth rates of black cherry, white ash, red maple, and other species decline as anticipated the future forest will be primarily oaks and yellow-poplars. The actual mix will depend largely on when certain species lose vigor. An immediate decline in vigor would seem to favor yellow-poplar while a 5- to 10-year delay would favor the oaks. Under almost any combination of shifts in species numbers, yellow-poplar will be much more prominent than when the mature stand was harvested.

Several conclusions can be drawn from these early data. Wildfires in young hardwoods should be avoided if possible, but when they occur the damage will not be great. The greatest impacts would be the loss of growth achieved before the wildfire, some loss of individual stem quality, and a likely increase in red maple and some other less desirable stems. A second conclusion is that a single prescribed fire does not apparently offer a quick means of favoring the development of oaks. But repeated fires or fires occurring at stand ages younger than studied here may have more impact and hence more potential for controlling stand composition.

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# OUR APPROACH TO SOUTHERN UPLAND HARDWOOD UTILIZATION AND MANAGEMENT

Mayford D. Williams[1]

ABSTRACT: Low quality hardwoods are utilized in the appropriate markets. Ownership areas are analyzed for needs of individual tracts. The management program is designed to fit the needs of analysis.

## INTRODUCTION

The area of discussion consists of 80,000 acres located in four counties, (Hickman, Lewis, Perry and Wayne) approximately 75 miles S.W. of Nashville, Tennessee in the western section of the Highland Rim area. Classification of the dominant stands would be low grade hardwoods. The past history is no different than others of a low economic area. Signs of previous activities relate to the following: The past and some of the present owners burned the woodland periodically. This trend changed when the Tennessee Division of Forestry established a complete fire protection coverage of the state several years ago. The older stems still show evidence of fires. Younger stems from 10 - 20 years of age are showing clear wood and will increase in quality during future harvests. The record of past years identifies the area to a cross tie economy. Anytime most of the trees reached a size that would square a tie, the owner harvested it immediately. Approximately 30 years ago a wood charcoal plant utilized the very small hardwood stems as its raw material. Landowners harvested everything within easy cutting and hauling distance. Due to this type cutting and selling, very little hardwood management of any magnitude could be identified. The best identity of any type management would consist of a limited number of landowners planting pine during the landbank era. These stands have reached pulpwood size and some are being thinned.

1. Woodlands Manager, Western Kraft Paper Group, Centerville, TN.

## DISCUSSION

Each tract is analyzed for immediate needs relating to the management program. The woodlands are divided into three sites. Site one consists of the cove areas: These sites have a variation from narrow strips in the upper elevations to a flat base at the lower elevations. These soils are the best productive since they are generally well drained, loamy soils. The elevations generally are around 450 feet. Site two consists of the slopes; These sites vary. They will average about 25 percent. The upper limit is approximately 45 percent and lower of approximately 5 percent. Many of the slopes are associated with the shale soils, some of the south and west facing slopes have out-cropping limestone rocks. The elevation varies from approximately 500 - 900 feet. Site three represents the ridge tops: These are the level to gently sloping areas at the higher elevations, usually in the 800 - 900 foot elevation range. The soils on site three consist mostly of the cherty type. In the summer seasons these soils are very dry and less productive for hardwood management. Species associated with the various sites consist of dominant white oak - poplar, on site one or in the coves. Red oak - white oak combination is common on the slopes, or site two. Red oak - blackjack oak and hickory combination is common on the flat ridge tops, or site three.

On site three areas, the average hardwood pulpwood stem is (6 -10" d.b.h.) and 40 - 60 years of age. Site three has an average volume of 300 - 500 bd. ft. per acre and 8 - 10 tons of pulpwood. On an average acre of site one, there will be 1,000 - 1,500 bd. ft. of sawlogs and 15 tons of hardwood pulpwood. Site two's production ranges between site one and site three.

Our program, started ten years ago, was to convert site three to pine plantation, along with the upper areas of the south and west facing slopes on site two lands. The conversion program consists of a clearcut of all merchantable products, girdle the remaining stems, burn in late fall and hand set to desirable seedlings. Velpar Gridballs were used on a 30 acre experimental plot in 1979 and are being used for the first season in 1980 for extensive site preparation. The experimental 30 acres in 1979 produced promising results on first analysis of the program. Existing plantations on similar sites are producing an average of 20 cords of pine pulpwood per acre at age 20 - 22 years. Needless to say this improves the return on initial investment by producing pine pulpwood sized stems in 20 years rather than 40 - 60 years for hardwood. The site two lands primarily are for hardwood pulpwood production with some sawlogs at the lower extremities of the north and east facing slopes. As mentioned before, pine pulpwood will be grown on the south and west upper slopes. The cove areas are designated for sawlog production with emphasis on quality white oaks and poplar for heading and/or veneer products.

The markets in the area consist of small sawmills that produce cross ties as the principle product and pallet material for second product and very little grade lumber. There is a yard open one day a week for buying white oak heading logs. There are four markets for hardwood pulpwood.

After ten years of implementing the original program, an evaluation was made for guidelines to base the next ten years program. After a review with top management, taking into consideration future needs for long fiber, a decision was made to convert all site two and three lands to pine plantations.

I have encountered several occasions that memories will probably remain during these ten years of implementing the management program. Some have been pleasant and some unpleasant. I would like to relate one in particular and I will let you decide the catagory to classify it if it occured to you.

During part of the land acquisition program, the title to a tract of land was checked back to 1803. Sometime later I received a request for prior title. I felt the following explanation might serve the purpose.

I note your comment upon the fact that the record title sent you as applying to the lands under consideration dates only from the year 1803 and your request for an extension of the records prior to that date. Please be advised that the Government of the United States acquired the territory, including the tract to which your inquiry applies, by purchase from the Government of France in the year 1803. The Government of France acquired title by conquest from the Government of Spain; the Government of Spain acquired title by discovery by one Christopher Columbus, a resident of Genoa, Italy, traveler and explorer, who by agreement concerning the acquisition of title to any lands discovered, traveled and explored under the sponsorship and patronage of her Majesty, the Queen of Spain. And the Queen of Spain had verified her agreement and received sanction of her title by the consent of the Pope, a resident of Rome, and Ex-officio representative and vice-regent of Jesus Christ. Jesus Christ was the son and heir apparent of the Almighty God from whom He received His authority, and the Almighty God made the area in question.

# APPROACH TO UTILIZATION AND MANAGEMENT OF UPLAND HARDWOODS

Dean R. Wallace[1/]

**Abstract**.--The University of Arkansas Extension Forestry educational program is directed basically toward three different groups of people: (1) the tree growers (2) the tree processor-mill operator and logger and (3) the consumer of timber and other forest products. It is very important that the educational efforts be in line with the forest land owner's objectives. This primary objective in most cases is not income from upland forest acreages.

The Arkansas Extension Forester is part of an educational team representing the College of Agriculture, University of Arkansas. The primary objective of the Extension Forester is to support local county agent's forestry programs in each of the seventy five counties in Arkansas. The county agent is the local representative of the University of Arkansas.

It has been my pleasure to have worked in this position several years. One of my first experiences was here in Harrison. In 1955, forest land owners, state and U. S. Forest Service representatives together with county agents from the two local counties visited the Henry Koen Experimental Forest located a few miles south of Harrison. This was an effort to involve owners of private forest lands in this area in learning more about forest research. It was also designed to encourage these owners to consider management and marketing practices that should increase their income and their other objectives from owning these forest acreages of upland hardwoods.

In educational work, it is perhaps more or just as important to understand the attitude and objectives of the forest land owners than to over emphasize all the technical aspects of forestry. In trying to assist the forest land owner in obtaining the results that he wants, be it timber, wildlife, etc., there will be at least some very good timber grown on his acreage.

In Extension forestry work, all educational programs are directed toward three types of people or clientele: (1) the producer, timber grower or forest land owner; (2) the tree processor or mill operator and logger; (3) the consumer of timber or other forest products. Other educational work is directed toward youth, 4-H clubs, conservation and association groups. These people are often interested in the multiple use aspect of our natural resources. Involved in these educational efforts are public meetings, demonstrations, news media of all types, workshops and a limited amount of "one-to-one" contact. In Arkansas, the Extension forestry program has excellent cooperation from state and federal forestry groups and forestry and natural resource organizations and associations.

In working with the owners of hill upland hardwood lands and with mill operators in Arkansas, there are three factors or conditions one must recognize to be more effective. These three situations are (1) who owns these lands

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1/ Extention Forester, Cooperative Extension Service, University of Arkansas, Batesville, Arkansas.

(2) why do these people own these lands and (3) understand methods now being used in harvesting and utilization of timber from these upland hardwood forest lands.

The why do people own these lands could be listed in order of importance but this list would be different for different people. A few of these reasons are (1) pride of ownership or it is just a good feeling to own a little of this good earth (2) the woods are just a part of the "old home place" (3) a place for a retirement home or a place to just "get away from everything" (4) investment or resale as soon as a profit can be made (5) hedge against inflation and (6) income from timber sales. Timber sale income may not be tenth or sixth in this list of why's but it seems certain it is not number one in the minds of many, many owners of hill hardwood forest lands in Arkansas.

In regard to utilization, perhaps the methods now being used are not as outdated or old fashioned as we sometimes think. Due to land ownership pattern, terrain or logging conditions, variety of tree species, variety of products produced from these different species, transportation and fluctuation of markets for finished products, utilization and marketing of timber from upland hardwood lands has to be different and perhaps more challenging than utilization and marketing of timber from the "piney woods" forest lands. These factors make it more difficult for the mill man to predict the future demand and price than it does for producers of a pine 2 X 4 or a piece of pine plywood.

In summary, in order to encourage more and better timber and other forest products produced from the upland hardwood forest, one should attempt to understand the purpose and objective of land ownership and encourage present mill operators and loggers in the use of fuller tree utilization, the use of market survey information and apply more business principles in their day to day operations.

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# CFM FORESTRY IN NORTHEAST OKLAHOMA [1,2]

James M. Gleckler 1/

Abstract --, Discriminating among requests for technical assistance along with tailoring the services offered are the keys to a program which seeks to maximize contacts with hardwood forest owners.

Keywords: Existing hardwood timber stands; nonindustrial private forests; public assistance; woodland visit; private forestry consultant.

## INTRODUCTION

Because I am a state forester, "my approach to Mid-South upland hardwood management" would be an accounting of how CFM Forestry is practiced in my district. Two things characterize technical assistance efforts in the Jay District: First, instead of specializing in planting pine, Christmas trees, or walnut, we look to existing stands of hardwood timber as our greatest opportunity in management assistance; Second, in light of the recent professional dialogue concerning nonindustrial private forests, we have tried to formulate a responsible public assistance policy.

This policy in the Jay District involves maximizing the number of one on one forester contacts with landowners. The technical assistance program rightly falls behind woodland protection in priorities. These and other limiting factors necessitate an extensive assist to woodland owners in most cases. We rely heavily on qualified hardwood consultants to provide indepth and long-range assistance.

A further consideration is the limited markets and vendor operations common to many eastern hardwood regions. This restricts the amount of good silviculture which can be applied. Method of cutting agreements with commercial loggers and the capabilities of individual woodland owners end up being the only significant means for silvicultural application.

## WOODLAND OWNER ASSISTANCE

All requests for woodland assistance are responded to with a letter-questionaire which tells the landowner something about the assistance program and asks him some thought provoking questions about his woodlands (Appendix I). After the letter is returned to my office a visit to the property is scheduled. (Owners needing assistance in timber tresspass cases are referred directly to a private consultant.)

The letter-questionaire is used in reviewing the landowner's objectives and in discussing a history of the property with him. The owner is then asked

1/ District Forester, Oklahoma Forestry Division, Jay, Oklahoma.

to take the forester on a tour of his property. The forester purposely withholds comment and seeks additional owner ideas about management while making notes as to stand age, stocking, condition, and property lines.

At some point in the tour, when the landowner has thoroughly explained himself and begins to wonder whether this guy is ever going to tell him something about managing his timber, the forester takes over. He now guides the landowner, pointing out what he has and how to meet his objectives with it. The forester identifies trees, identifies stands in differing stages of development, measures a representative site index or two, points out fire and other damage, and basically tries to relate some of the productive potential and amenity values of hardwood forest ownership. At this point, what I call the "curious preservationist" owners are satisfied. They will probably protect their woodlands from fire and enjoy them as they are.

## DISCRIMINATING FURTHER ASSISTANCE

Owners interested in management, marketing, and other commercial operations are at this point referred to qualified consultants operating in northeast Oklahoma. Smaller and less operable owners with the desire to manage and improve their timber and the ability to perform most of the work themselves are assisted further by the state forester. They are helped in choosing one or two stands in which to do timber stand improvement work.

In the case of a growing stock stand needing thinning, the forester will help this landowner mark a part of the stand. If a regeneration area is to be created the forester, after marking the limits of the stand, will explain the extent of the tsi to be carried out. Descriptions of these "objective" stands and recommended treatments are written up on the spot (Appendix II). Simplified even-aged regeneration guidelines and thinning guidelines are also provided (Appendix III and IV).

Small woodland owners respond to this limited-objective timber stand improvement program well. They should be revisited in 9 to 12 months. Those who have made significant progress should be helped in identifying additional goals. They should also be recommended for Tree Farm certification at this visit.

Certain larger ownerships capable of commercial timber operations are offered a more intensive series of management services by district foresters (Appendix V). Examples of these owners would be State Game Refuges, Scout Camps, Church Camps, College Farms, etc.

## SUMMARY

Limitations of a public forester's time and resources require careful analysis of each request for technical assistance. Some woodland owners seek information on tree species, ecological processes and wildlife habitat. They are thoroughly satisfied with an hour's visit in the woods and some reading material. Other economically and environmentally aware owners are helped further by experienced private foresters. Owners whose circumstances make them an unlikely consultant referral receive a little more extended visit. Determining the extent of their desire and ability to perform needed woodswork, the forester trains these less operable owners to improve their hardwood stands. Detailed and long range planning is provided on some state and special category ownerships.

Coordinating our efforts with the private forestry sector, I believe that we can contribute to improved benefits from our hardwood resources.

Appendix I

STATE DEPARTMENT OF AGRICULTURE
FORESTRY DIVISION

JAMES T. RILEY
DIRECTOR

JACK D. CRAIG
COMMISSIONER

*Dear Woodland Owner:*

*Thank you for your interest in managing and conserving your forests and wildlife.*

*Forestland Management can be a very rewarding activity. Planting, marking, thinning, harvesting and other woodland cultivation practices are enjoyable, low-key out door labors which can do much to improve timber, conserve the soil, and help the land's productivity as a whole. Managed lands are usually more attractive than unmanaged forests. And, the diversity in habitat created by the above cultural practices nearly always causes an increase in wildlife.*

*In helping you manage your woodlands, I need some specific inforamtion on your goals and your expectations from your forest. Your cooperation in answering these questions and mailing the sheet back to me would be appreciated.*

*Why do you feel that you need the services of a Forester - What do you hope I can help you accomplish?*______________________________________

____________________________________________________________

*How do you presently use your woodlands?*

*Walking or Hiking* ______________ *Hunting* ____________________

*Nature Watching* _______________ *Gathering Nuts or Fruit* ________

*Cutting Fire Wood* ______________ *Harvesting Timber* ____________

*Grazing Livestock* ______________ *Sheltering Livestock* __________

*Other* ______________________

OFFICE AND MAILING ADDRESS: 122 STATE CAPITOL, OKLAHOMA CITY, OK 73105
PHONE: (405) 521-3886

Please rate the two most important uses.

1. ______________________________

2. ______________________________

Are you planning on a cash imcome from your forest in the next year or so?

Are you interested in how your forest grows, developes and reproduces itself?

Are you interested in how wild animals find food, shelter, and other necessities there?

What products for personal use (firewood, lumber) does your forest provide you with? ______________________________

______________________________

Woods fire nearly always causes serious damage to large and small trees alike. If you do not already live on the land, will you be able to supervise your property to see that fires do not destroy your timber and wildlife resources?

I appreciate your taking the time to answer these questions. My job is to try and assist you in deciding upon sound management techniques and in accomplishing your own goals and objectives. Answers to these questions will give us a firm foundation to start from.

Depending upon my scheduling, what would be a good time for us to meet on your property and discuss your plans?

Thank You

James Gleckler
District Forester
Oklahoma Forestry Division
P O Box 464
Jay, Oklahoma 74346

Appendix II

# WOODLAND MANAGEMENT

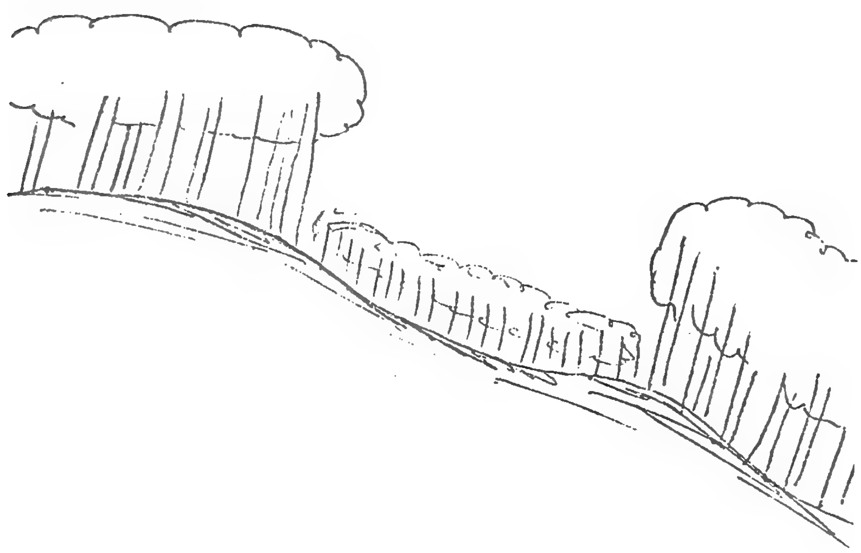
| STAND | PRODUCTIVITY (SI) | SIZE | SPECIES, AGE, CONDITION & STOCKING | PRESENT VOLUME PER ACRE | RECOMMENDED TREATMENTS |
|---|---|---|---|---|---|
| | | | | | |

## *REGENERATION GUIDLINES*

*Most woodland ownerships have one to five acre stands scattered about where the majority of the trees are eighteen (18) inches in diameter or greater, or where most of the trees are in poor condition. Such stands should be harvested and new vigorous growth allowed to establish itself.*

*These stands should be clearly marked off with the help of a forester. When enough volume is present, all logs and/or firewood should be harvested from the stands.*

*Those stems remaining after harvest are the poorest, or cull trees. All this material, large and small must be deadened or cut and allowed to resprout. (Old, large culls are often handled most easily by making two cuts around the trunk and allowing the tree to die.) Vines must also be controlled. When this is not done after harvest, the owner is left with a stand of culls which will never recover and make good trees.*



*Hardwood stands respond to such a clearing process with an abundance of sprout and sapling growth - the new forest. This growth provides aboundant wildlife browse for several years until it grows out of the "brush" and into the small tree stage. Some of these straight tall saplings will grow four (4) feet or more in height per year.*

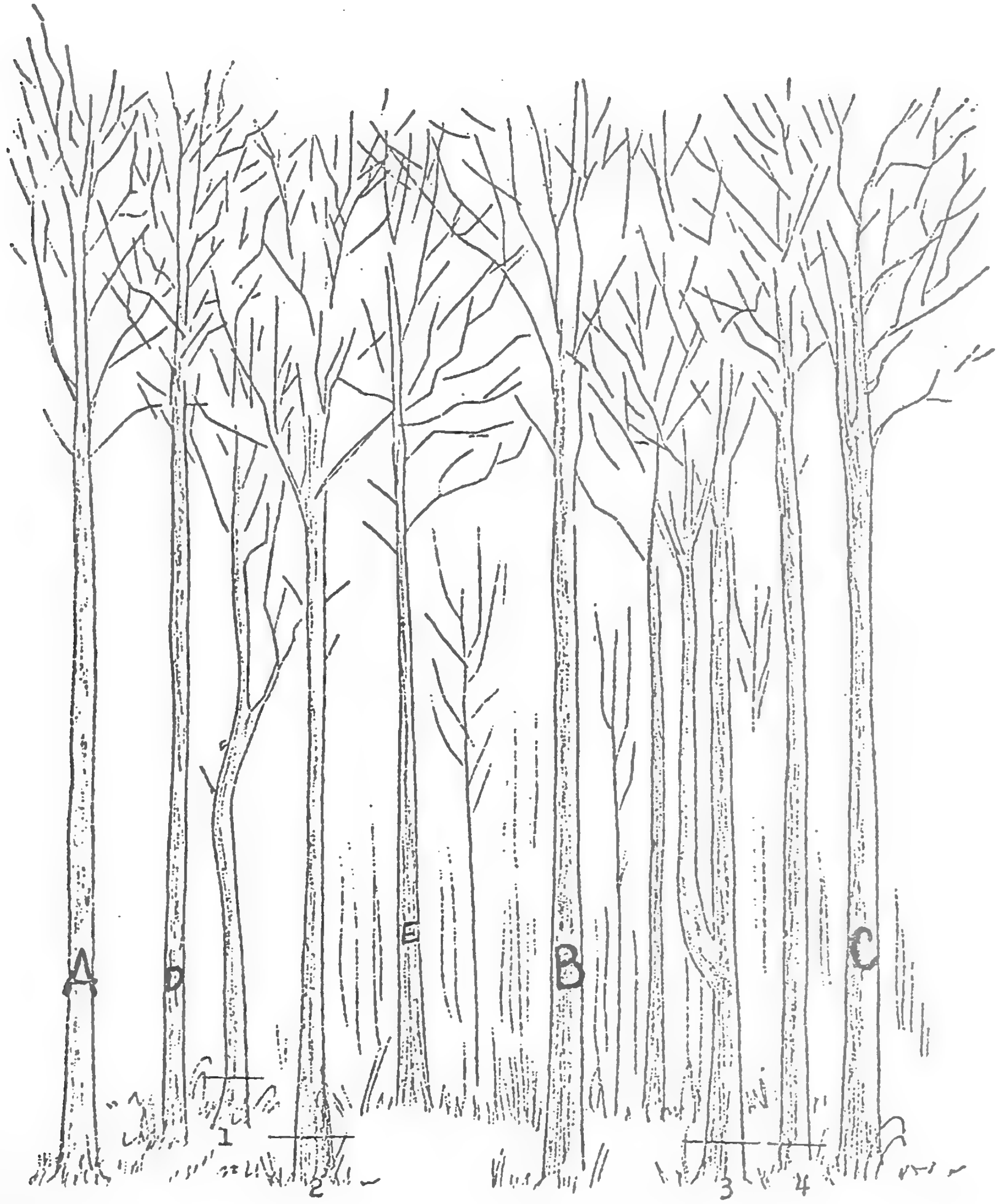
*Only those hardwood stands reproduced in this "even-aged" fashion will produce an abundance of high quality trees. The new stands must be protected from fire and should be thinned every 10 years.*

# *THINNING GUIDLINES*

*Immature hardwood stands have a majority of trees 16 inches in diameter and less. Many immature stands are overstocked and in need of thinning and timber stand improvement work.*

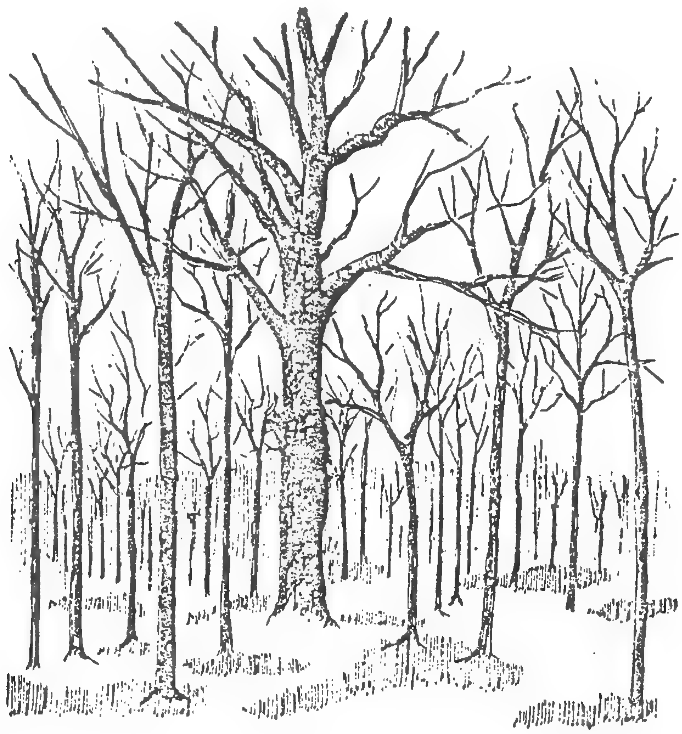
*Thinning concentrat 's the stand's growth on the best trees. Thinning allows these best trees ι remain vigorous, producing quality wood and heavy nut crops for wildlife.*

*Start by walking through the stand and selecting a best trees every 15 to 20 feet. The best tree will be straight, have a vigorous crown a little above its neighbors, and often be slightly larger in diameter. After you have selected the best trees and marked them with twine, tape or paint, neighboring trees should be cut so as to release the best tree's crown on two or three sides.*



*Trees A thru E were chosen as best trees. Threes 1 thru 4 are to be thinned: Number 1 is crooked; Tree 2 has a serious fire scar which is not healing; Number 3 has a bad fork low on the trunk; Number 4 is a good tree but is crowding tree C's crown and should be removed.*

*Vines, especially wild grape often choke and deform valuable trees. The stand should be surveyed and vines on the better trees cut. Some vines provide good wildlife food so not all should be cut.*



*Large, spreading, often defective trees obviously older than the rest of the stand take more than their share of growing space. If they are not providing an animal a good den, they should be cut or deadened.*

*Protection from fire is essential in growing quality hardwoods. Stands should be thinned every decade until mature (18 to 22 inches in diameter).*

## Detailed Management Planning on Special Ownerships

State Game Refuges, Scout and Chruch Camps, College Farm lands etc. are provided more intensive management services. To the extent judged appropriate, these services might include:

- Property mapping and boundary marking.
- Stand identification and mapping.
- Stand boundary marking and area measure.
- Stand cruising.
- Calculations and Prescriptions.
- Forest structure, growth, and regulation calculations.
- Management Plan preparation.
- Thinning and TSI marking.
- Timber Marketing.

The forester would normally begin his field data and mapping work during the initial visit with the property owner/manager.

# OUR APPROACH TO MID-SOUTH UPLAND HARDWOOD UTILIZATION AND MANAGEMENT

W.C. Trimble[1]

Abstract--How the Arkansas Forestry Commission has approached the Utilization and Management of Upland Hardwood.

Additional Keywords: Marketing Advice, Harvesting Studies, Primary Processing, Secondary Processing, Lumber Drying, Resource Data, Wood Energy, Work Shops, Technical Assistance, Technical Services.

The Utilization Department of the Arkansas Forestry Commission was instituted on the knowledge that the demand for forest products would increase rapidly in the coming years and that more efficient and effective utilization of our wood resources would be necessary. The demand for forest products is expected to double by the 2030. The challenge of meeting this increased demand requires that every effort be made to "stretch" existing timber supplies. This is a major objective of the Utilization Department.

There are approximately 160,000 small private landowners in the state who own approximately 57 percent of the forest acreage. There are approximately 700 primary processors and 600 secondary processors of forest products. Forestry is the number one manufacturing industry in the State. Forestry is still the dominant use of the land as the forests occupy 49 percent of the total land area. Anything that has to do with the protection, development, management, marketing, or manufacturing of the products of the forests directly and indirectly affects the citizens of Arkansas and the Nation.

Through our Utilization program, cooperative and direct technical assistance is provided to woodland owners and operators and processors of wood products to improve the level of utilization of Arkansas' forest products. Assistance is offered in the areas of Marketing Advice, Harvesting Studies, Primary Processing, Secondary Processing, Lumber Drying, Resource Data, Wood Energy, Work Shops.

1. Marketing Advice:

   Assistance is offered to the landowner concerned with, what to sell, when to sell and how to sell.

2. Harvesting Studies:

   Shows loggers and log yard managers are losing an average volume of 5 percent due to improper tree felling and log bucking, and under-utilization of pulpwood. The Forestry Commission, cooperating with State & Private Forestry of the U.S. Forest Service, has a computer program that analyzes these operations. Recommendation for improvement are suggested and training programs are provided if requested.

[1] District Forester, Arkansas Forestry Commission, Stuttgart, Arkansas.

3. Primary Processing:

The Sawmill Improvement Program, a computer program is offered to both pine and hardwood sawmills. Machinery, as well as sawer decisions are analyzed for efficiency.

Just a six percent improvement in the lumber recovered from the pine and hardwood Log Volume Harvested in Arkansas last year would be some 86 million board feet or about 14.3 million cubic feet. The average growth rate in Arkansas is 45 cu. ft./acre. Using this rate and the 14.3 million cubic feet, improvement in utilization would be the same as extending the forest land base by some 318,600 acres.

4. Secondary Processing:

We and the S&PF offer a computer program that analyzes the amounts and grades of lumber needed by furniture plants. The program analyzes cutting orders to reduce the amount of waste, encourage the use of lower grades of hardwood, and reduce costs.

5. Lumber Drying:

We and the S&PF offer a drying improvement study to those that air dry oak lumber. This study records grade and volume losses, and recommends ways and methods of improving present air drying practices.

6. Resource Data:

The Department works closely with the Southern Forest Experiment Station to keep abreast of the hardwood resource data. We also work with the forest industries of the State to maintain records of the number of mills and their annual production or consumption of lumber or logs. We also are attempting to maintain records of used and unused mill and logging residues.

7. Wood Energy:

We are starting a Wood Energy Program and hope to develop one that will utilize vast volumes of low-grade hardwoods. Many of the industries are already nearly self-sufficient energy wise by burning their mill residues.

8. Work Shops:

Plans are being made to present one or two Symposiums on the management and utilization of the hardwood resource. Also in the planning stage is an annual workshop on hardwood log, lumber, and tree grading.

Better utilization of timber harvest today will provide immediate benefits, not results 15-20 years from now. Better utilization will also have a beneficial impact on Arkansas' economy.

The Timber management is broken into two sections, Technical Assistance and Technical Service:

In Technical Assistance the Commission offers a variety of technical assistance programs in an effort to effectively protect, develop, and utilize the private and public forest lands of the State in such a manner as to provide optimum benefits to present and future generations. The technical assistance programs offered by the Commission consist only of technical recommendations and/or advice concerning the carrying out of forestry management practices that are provided to eligible applicants upon request. The Technical assistance is available in total or in part to all private landowners, both resident and non-resident; producers and manufacturers of wood products; private organization, federal and/or State agencies; educational institutions; and others, to the extent that the Commission purpose and efforts are accomplished.

The Commission has established certain constraints pertaining to technical assistance availability which includes applicant eligiblility and the total amount of time allowed for assistance to any one applicant by Commission Personnel. It has been determined that regardless of the number of practices requested, no more than five (5) person days per year of technical assistance, may be allowed for any one applicant.

All technical assistance programs offered by the Commission are free and available upon request, and applicants are served in turn with respect to existing workload.

1. Woodland Examinations and Prescriptions:

   Provided upon request to private non-industrial landowners. Within a reasonable period of time after receiving a request, applicant will be contacted by the Commission and informed concerning the servicing of the request. Necessary information will be obtained preparatory to an examination of the applicant's property. In all instances, applicants are requested to be present during woodland examinations. Recommendations are given verbally concerning any forest management practices needed at the time of the examination and are later summarized in the form of a written Management Plan. The amount of time spent by any Commission employee (s) in servicing this type of assistance request will not exceed three (3) person days per year for any one applicant.

2. Marketing

   Technical assistance in this area is available should recommendation be desired concerning the sale of timber and/or other forest products. The amount of time spent by any Commission employee(s) in servicing this type of assistance request will not exceed three (3) person days per year for any one applicant.

3. Reforestation

Technical assistance in this area is available should recommendation be desired concerning such matters as site preparation for natural forest regeneration, hand or machine planting, seedling care and storage, planting procedures, etc. The amount of time spent by any Commission employee(s) in servicing this type of assistance request will not exceed three (3) person days per year for any one applicant.

4. Timber Stand Improvement

Technical assistance in this area is available should recommendation be desired concerning inferior stand species control, the use of herbicides, any and all pertinent cultural practices, costs, benefits, etc. that would improve the applicants present timber stand condition. The amount of time spent by any Commission employee(s) in servicing this type of assistance request will not exceed three (3) person days per year for any one applicant.

5. Wildlife and Recreation

Technical assistance in this area is available should recommendation be desired concerning forest management practices that prioritize the aspects of wildlife and recreation. The amount of time spent by any Commission employee(s) in servicing this type of assistance request will not exceed three (3) person days per year for any one applicant.

6. Urban and Community Forestry

To private non-industrial landowners, communities, cities, organization, civic groups, etc. The purpose of this program is to effectively service the special forestry requests and needs of individuals in both rural and urban areas, as well as the collective needs of cities and communities. The amount of time spent by and Commission employee(s) in servicing this type of assistance will not exceed two (2) person days per year for any individual person applicant. No Commission personnel time constraint will be imposed on project applicants such as communities, cities, etc., due to the benefit that will be derived by the populace as a whole.

7. Technical Training

Available upon request to appropriate groups which include schools, youth groups, landowners, landowner cooperatives, private organizations, communities, civic groups, and other interested groups and organizations. No Commission personnel time constraints will be imposed on this type of technical assistance due to the impact and benefit that will be derived by the populace as a whole.

Technical Services

The Commission offers technical services in several areas in an effort to promote the accomplishment of sound forestry practices on the private and public forest lands of the state. The technical services of the Commission are primarily offered to eligible applicants in an effort to provide those services not available due to the absence of vendors, professional forestry consultants, and/or reasonable rates. However, it is also possible for an applicant to apply for both technical assistance and technical service programs. In this case, it has been determined that no more than five (5) person days per year of combination of technical assistance and technical service, in the aggregate, may be allowed for any one applicant.

1. Timber Marketing

   Provided upon request to private non-industrial landowners. When timber marking is done, it will be in accordance with sound forestry principles, which will have been previously prescribed and usually in the form of a written Management Plan.

   Upon completion of the marking job, volumes of trees to be removed are computed and copies of this report are provided to the landowner. A sample forest products sale agreement along with a listing of potential timber buyers is also provided to the landowner.

   The amount of time spent by any Commission employee(s) in servicing this type of request will not exceed three (3) person days per year for any one applicant. Also, the area of forest land to be marked shall not exceed eighty (80) acres in total.

   The rates of charge for timber marking are:

| | |
|---|---|
| Pine/Hardwood Sawtimber | $ 2.00 per MBF marked |
| Pine/Hardwood Pulpwood | .40 per cord marked |
| Post/Poles/Piling | 15.00 per m cu. ft. marked |

2. Tree Planting

   Provided upon request to private non-industrial landowners. When tree planting is done it will be performed with Commission tree planting machines and in accordance with proper and acceptable tree spacing standards. This service is not designed for large scale production efforts available from professional forestry consultants and/or commercial vendors, but is offered primarily for the landowners who are unable to secure vendor services and/or reasonable rates.

   The only constraint listed for this service is that the area of land to be planted for each applicant shall not exceed twenty (20) acres. The amount of time specified for Commission Personnel will not be listed as a constraint factor for this service due to the varying requirements of topography, soil conditions, etc., cost is $48.00 per thousand trees.

3. Nursery

   The Commission owns and operates two (2) tree seedling nurseries and an appropriate number of seed orchards in an effort to promote reforestation of bare and/or understocked forest lands for economic, recreational, wildlife, environmental, and aesthetic benefit to the private and public landowners of the State, and the general public as well.

Both pine and hardwood seedlings are produced for sale to public and private landowners, with emphasis to private non-industrial ownership. The seedlings are produced for reforestation and erosion control purposes only. The pine seedlings consist of both regular and genetically improved loblolly and shortleaf. Hardwood seedlings consist of, but are not limited to sycamore, sweetgum, cottonwood, black walnut, and various oaks.

The Commission does not assume responsibliity for planting tree seedlings or cuttings from Commisssion Nurseries, nor does the Commission guarantee survival of any trees.

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# SOIL-SITE FACTORS AFFECTING SOUTHERN UPLAND OAK MANAGEMENT AND GROWTH

John K. Francis[1]

Abstract.--Soil supplies trees with physical support, moisture, oxygen, and nutrients. Amount of moisture most limits tree growth; and soil and topographic factors such as texture and aspect, which influence available soil moisture, are most useful in predicting growth. Equations that include soil and topographic variables can be used to predict site index. Foresters can also identify good, medium, or poor sites by using simple tables that describe basic topographic and soil features.

Additional keywords: Site index, *Quercus* spp., topography.

Soil supplies trees with physical support, moisture, oxygen, and nutrients. Also, soil is an important factor influencing site quality.

## PHYSICAL SUPPORT

Healthy trees seldom windthrow unless rooting depth is restricted by soil pans, high water tables, and bedrock or hard parent material. But in upland hardwood areas, windthrow is not severe, because the shallowness of bedrock limits height growth and causes trees to root in rock fissures. Trees growing over unfractured sandstone, which impounds extra moisture, sometimes windthrow.

High water table causes shallow rooting near streams and seeps. Roots forced by lack of oxygen to grow above waterlogged horizons may not support the tree against high winds. Fragipans and clay pans may also promote windthrow by restricting root penetration.

## MOISTURE AND OXYGEN

In Midsouth uplands, lack of moisture is the main restraint on tree growth. In dry climates, trees are shorter than in moist climates, and species are more drought-hardy.

South and west slopes, which are more exposed to the sun, are drier than north and east slopes. Occasional droughts occur in areas where the soil volume is not large enough to store adequate moisture. Such is the case with shallow bedrock. Like many other foresters, I have believed that fragipans create a similar problem; however, Watt and Newhouse (1973) found no difference in growth of oaks on fragipan and nonfragipan soils in the Ozarks. Droughty spots are also found in deep soils whose sandiness or stoniness prevents them from storing enough water.

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Tree roots need oxygen for growth and survival. Upland oaks cannot endure long-term flooding and cannot grow into permanently waterlogged soil horizons. Drought sometimes affects plants growing in heavy clays that are wet in winter and dry in summer. In subsoils, aeration is so poor that roots can occupy only the area between soil peds. Then, during dry periods, available moisture may be only an inch or two from the root, but diffusion is so slow in fine clay that moisture arriving at the root is not enough for the plant's needs.

## NUTRIENTS

Nitrogen is deficient in most forest sites, so a dominant tree will usually respond to added nitrogen. In the Midsouth, Graney and Pope (1978) noted growth increases in red and white oak poles fertilized with nitrogen. Nitrogen is added by rainfall and fixed by bacteria in the soil and in plant nodules. Excess nitrogen does not accumulate, because what is not tied up in organic matter is soon changed by bacteria to nitrate ($NO_3^-$), and unused nitrate can be leached from the soil by rainwater or used by denitrifying bacteria as a source of oxygen. So, nitrogen available to plants is always scarce.

Phosphorus is often deficient in forested sites, especially on highly leached soils, wet soils, and very sandy soils. Trees respond better to fertilizer phosphorus when it is applied with nitrogen. Potassium is occasionally deficient in forest sites, especially on highly leached, sandy soils.

Lack of other nutrients is rarely limiting to natural stands. But planting a species or even a provenance of a species in new soil situations may produce nutrient deficiencies. For example, severe iron deficiency will develop in many species when they are planted on soils with high pH or free lime.

Over long periods, weathering and leaching of soils replace basic cations (such as potassium and calcium) with hydrogen and aluminum. Replacement has been greatest in old soils, particularly the Ultasols. Upland oaks tolerate a wide range of acidity; however, pH's below 5 may begin to affect negatively the growth of several species (Williston and LaFayette 1978). Free aluminum, which is known to damage many field crops and a few forest trees, may adversely affect upland oaks.

## SOIL TEXTURE AND STRUCTURE

Physical properties of the soil--texture and structure--determine how well the soil absorbs and holds water, how well air diffuses into soil, and how easily roots can push through it. Texture, mineral composition, and organic matter content determine a soil's nutrient-holding capacity. Physical properties influence root growth and vitality, which affect growth of trees aboveground.

Soil texture, the relative proportion of sand, silt, and clay in a soil, is not much affected by man or natural agents in less than a few hundred years. Soil structure, aggregations of soil particles, can be easily destroyed and is almost impossible to improve cheaply. Many of man's activities, such as running over the soil with a vehicle, damage soil structure and the root environment, especially if the soil is wet when disturbed. Insect activities, root growth, freezing and thawing, and wetting and drying will rebuild soil structure, but this renewal can take as long as 12 years (Dickerson 1976).

Erosion decreases site productivity by reducing soil depth and removing much of the site's nutrients, which are concentrated near the surface. Erosion from forest sites--even those that have been cut--is slight unless mineral soil is exposed. Most man-caused erosion in the forest is associated with roads, trails, and site preparation. To avoid erosion, minimize activities that bare mineral soil. Locate disturbance on the contour as much as possible, with barriers of covered soil below. Encourage revegetation.

## SITE INDEX

A forester's main interest in soils is in how they affect tree growth. The most widely used indicator of a soil's ability to grow trees is site index--how tall a tree species can grow on a given site in a given time, usually 50 years. Site index curves have been developed for most species. So, knowing current height and age, we can project how tall the tree would be or was at 50 years old.

Trees used to determine site index should be dominants or codominants. They should not have been damaged, diseased, or suppressed at any time during their life. Accurately characterizing the site is important because management decisions are based on these estimates. Errors in choosing good site-index trees have weakened many studies and caused many sites to be misclassified.

Where suitable site-index trees are not available, factors of the environment--soil, topography, and climate--may be used to predict site index. We usually try to reduce or eliminate the influence of climate by sampling within a limited geographic area.

Topography affects soils in several different ways, such as angle of exposure to the sun and ease of drainage. The soil profile has many horizons, each with different textures and structures. And the 13 essential plant nutrients add to the mix of variables. Some soil horizons are less important than others, and many soil and topographic features are interrelated. For example, A-horizons are usually thicker on north slopes than on south slopes; thicker A-horizons have more organic matter; and total nitrogen is usually higher with increased organic matter.

The interrelationships among soil and topographic factors are so extensive and varied that it is impossible to determine how much growth is produced by each factor. So we use multiple regression procedures in choosing a few soil and topographic features to represent all of them. Soil-site index can be represented mathematically:

$$\text{Site index} = b_1X_1 + b_2X_2 + \text{- - - - - -} \; b_nX_n$$

where $b_{1-n}$ are coefficients and

$X_{1-n}$ are representative soil and topographic features.

Influential but infrequently occurring soil factors, such as high water table, nutrient deficiency, or shallow bedrock, usually cannot be included in regression equations. Such exclusions can cause serious error for individual sites. We can compensate by estimating how excluded factors will affect trees growing on the site and by changing the site index to reflect this estimate.

Because soil composition often changes greatly every few feet, trees respond with a hodgepodge of site indexes. The task, then, is to obtain an average for the whole area. We can do this by systematically sampling the whole area or by identifying each unit of homogeneous site index or soil, obtaining its site index, and calculating an average weighted by the area of each unit.

Using soil-site prediction equations requires calculations, most with logarithms and trigonometric functions, but they can be done in the field with good handheld calculators. Site indexes from soil-site equations are based on measurements--usually percent slope; percent distance from the ridge; azimuth; depth of A1 or A1 + A2 horizons; depth to least permeable horizon; or depth to bedrock. An experienced soil scientist is often needed to identify soil horizons. Some systems require that foresters know percent sand, silt, or clay in a horizon, and even percent organic matter. These features can be estimated but are more reliably measured in the laboratory. A state agricultural testing laboratory will do this for a few dollars per sample in 2 or 3 weeks.

Foresters should test two or three soil-site systems developed for their region. The best one, tempered with experience, should give reliable predictions in most situations.

At least 15 papers give site index prediction systems for upland oaks (table 1).

Some foresters never use a "system" but, relying on backwoods "savvy," predict site index after simply looking at the trees. A more cautious approach is to combine experience with an easy-to-use plan such as Carmean's (1967), Merz's (1953), or the one below.

Certain soil and topographic factors that are easily recognized in the field occur consistently. Based on the published experience of many authors and my own observations, I have produced general descriptions of good, medium, and poor sites (table 2). Recent observation of sites in Arkansas, middle Tennessee, and north Mississippi has helped me to refine descriptions of good and poor sites and to set site index limits for each (table 3).

Table 1.--Soil-site studies on upland oaks in or near the Midsouth

| Author | Oak species | Area |
|---|---|---|
| Arend and Odell (1948) | Mixed species | Ozarks, Arkansas |
| Auchmoody and Smith (1979) | Northern red, white, scarlet, chestnut, black | W. Virginia |
| Carmean (1965) | Black | S. Ohio |
| Della-Bianca and Olson (1961) | Scarlet, black, white | Piedmont |
| Doolittle (1957) | Scarlet, black | S. Appalachians |
| Gaiser (1951) | White | S. Ohio |
| Graney (1977) | Northern red, black, white | Boston Mts., Arkansas |
| Hannah (1968) | Black, white | S. Indiana |
| Hartung and Lloyd (1969) | Mixed species | Missouri |
| Hibb (1962) | Southern red, white | W. Tennessee |
| McClurkin (1963) | White | N. Mississippi and W. Tennessee |
| Smalley (1967) | Red, white | N. Alabama |
| Trimble (1964) | Mixed species | W. Virginia and Maryland |
| Trimble and Weitzman (1956) | Northern red, white, scarlet, chestnut, black | W. Virginia and Maryland |
| Yawney (1964) | Mixed species | W. Virginia |

Good sites are generally found in bottoms, on benches, on mid- and lower slopes facing northeast, and on lower slopes facing northwest and southeast. Occasionally, other aspects and slopes are good sites, especially if they have soils recently developed from loess. Good sites almost always have deep, medium-textured, well-drained soils with less than 65 percent rock in them. Occasionally, good sites will occur in patches on broad ridges and on south or west slopes. These spots of good site are often the product of deep fertile soil or subsurface moving water. Sometimes areas that seem to be good sites support poor trees, possibly because of an imbalance in soil fertility or because of past suppression or disease.

Ridges, especially narrow ones, are usually poor sites, as are upper and midslopes facing southwest. Drought, the most common cause of poor growth, may be produced by shallow bedrock or excessive rock fragments in the soil. Shale parent material can occasionally result in poor growth.

Climate greatly influences site index. I found good sites west of the Mississippi River were 70+ for red oaks and 65+ for white oaks. Poor sites were less than 55 for red oaks and less than 50 for white oaks. East of the Mississippi, where the climate is moister, I found no difference between red and white oaks. Good sites were 80+, and poor sites were less than 65.

If properly used, these descriptions will classify a site correctly about 75 percent of the time. So the method sacrifices some precision for ease of use. Foresters should consider the advantages and disadvantages of each method for determining site index. Years of experience can outweigh

Table 2.--Description for good, medium, and poor upland oak sites in the Midsouth

| Good Sites | Should be: |
|---|---|
| Bottoms (with alluvial soil) | Deep ( > 3') |
| Benches | Medium-textured |
| Mid- and lower slopes facing NE | Well-drained |
| Lower slopes facing NW and SE and occasionally other aspects and slopes, especially those with loess parent material | Less than 65 percent rock |

| Poor Sites | |
|---|---|
| Ridges | Especially with soils that have: |
| Upper and midslopes facing SW and occasionally other aspects | Shallow bedrock ( < 24" deep) |
| | Much rock or gravel |
| But not: | |
| Broad ridges with deep friable soil | |
| Loess soils | |

| Medium Sites | |
|---|---|
| Soils and aspects that fall between descriptions for good and poor sites | |

Table 3.--Site index limits for upland red oaks and white oaks in the Midsouth

West of Mississippi River

| | Red oak | White oak |
|---|---|---|
| Good sites | - SI $\geq$ 70 | SI $\geq$ 65 |
| Medium sites | - SI 55-70 | SI 50-65 |
| Poor sites | - SI < 55 | SI < 50 |

East of Mississippi River

| | Red and white oaks |
|---|---|
| Good sites | - SI $\geq$ 80 |
| Medium sites | - SI 65-80 |
| Poor sites | - SI < 65 |

complex calculations and sophisticated laboratory analysis. But mathematics and chemistry can also compensate for lack of experience.

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# WATER MANAGEMENT AND CONTROL OF SOIL LOSS IN SOUTHERN UPLAND HARDWOOD STANDS

Edwin R. Lawson[1/]

Abstract.--Silvicultural operations in southern upland hardwood forests can be accomplished with little degradation in water quality. Logging roads are the primary source of sediment in streams, but their impact on water quality can be minimized if proper precautions are taken in planning, construction, and maintenance of roads.

Additional keywords: Water quality, forest roads, forest practices, sediment.

## HOW SILVICULTURAL ACTIVITIES AFFECT SOIL EROSION

In upland hardwood forests of the South, most water quality changes associated with silvicultural activities are from harvesting and site preparation activities and from logging roads. Studies in the eastern United States have indicated that sediment yields from harvesting and site preparation activities usually fall within or well below the estimated geologic erosion rates of 0.18 to 0.30 ton per acre per year (Patric 1976). Soil loss rates from forest lands are also far below the 1 to 5 tons per acre per year found acceptable for agricultural lands (Smith and Stamey 1965).

Logging roads, however, warrant special consideration by forest managers. Bulldozed roads on a carelessly logged watershed in West Virginia covered 3.6 percent of the logged area and lost 40 tons of soil per acre of skidroad (Hornbeck and Reinhart 1964). In another study in West Virginia, heavy use of a logging road resulted in more than 7 inches of soil loss (Weitzman and Trimble 1955). In North Carolina, 6,850 cubic yards of soil were lost from 2.3 miles of road in 4 years (Hoover 1952).

Soil losses caused by silvicultural activities are largely related to disturbance of the protective litter layer. Water coming from relatively undisturbed forest areas is usually of high quality because the canopy and litter layer provide ideal protection of the soil surface. With the litter layer intact, the upper soil horizons have very high infiltration rates, generally greater than the intensity of the most severe rain storms. Because of this porous zone, overland flow in forested areas is rarely observed (Patric 1970, Packer 1967b). Without this protective layer, however, raindrops dislodge soil particles and start the processes of sediment transport and deposition (Foster and Meyer 1977). Dislodged soil particles may decrease soil porosity by washing into soil pores and thus increase surface flow. Soil porosity can also be reduced by compaction of the soil by equipment used in forest operations.

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Changes in a forest canopy not only affect the soil surface but also may greatly change the water regime. Removal of most of the forest canopy, as with clearcutting, greatly increases runoff from the cut area because the amount of water used by the forest in the evapotranspiration process is reduced. The change in runoff or water yield is generally proportional to the amount of the forest canopy removed (Douglass 1974, Stone 1977). The reduced evapotranspiration losses increase soil water content, allowing runoff to continue longer in the spring and begin sooner in the fall. Therefore, most of the increased runoff occurs in the spring and fall through prolonged streamflow. Such increased flow is generally from only a small part of a drainage basin and does not contribute to flood peaks (Douglass and Swank 1975).

Forest management practices that disturb the vegetation are therefore likely to affect the soil and water processes. The objectives of this paper are to summarize what is known about preventing and controlling erosion and to alert managers to other water quality problems that can result from silvicultural activities.

## THE PROBLEM OF SEDIMENTATION

### Logging Roads and Sediment

Although soil movement from roads cannot be eliminated, losses from this source can be minimized. Several general concepts for minimizing erosion should be kept in mind during any forest operation or construction project: (1) Disturb as little surface soil as feasible, (2) Disperse runoff water as rapidly as possible, (3) Reduce the velocity of water flow, and (4) Minimize the time soil is directly exposed to rain.

Building roads.--Truck road and skidroad systems should be planned together, since skidroad grade, location, and direction usually depend on the location of the logging truck roads (Kochenderfer 1970). Planners should try to construct as few permanent roads as possible. Truck roads should be of adequate length and width to accommodate the anticipated needs, but no larger (Gardner 1979). Logging in dry weather will require lower road standards than in wet weather and thus reduce costs. Overbuilding of roads increases construction and maintenance costs, removes timber land from production, and increases potential for erosion. If ownerships are small, one main haul road and a well-planned skidroad system may provide adequate access (Kochenderfer 1970). If possible, truck roads should be oriented so that hauling is downhill. This reduces operating and maintenance costs.

Topographic maps and aerial photos can help planners avoid steep areas, rock outcrops, and wet areas. In the Ozark-Ouachita Highlands, truck roads can often be located near ridgetops with only a few at midslope positions. Ridgetop roads should be located just off the top on the south or west sides. This position allows better drainage and will generally allow construction of outslope roads without drainage ditches. The south and west aspects provide more rapid drying after rain or snow, especially in winter. Ridgetop roads also provide excellent scenic routes and therefore are aesthetically appealing. Truck roads may also be located at midslope positions, if skidding distances to ridgetops are prohibitive.

Logging roads, including skidroads, should be carefully laid out with an Abney level or similar instrument used to determine slope or grade. Field layout work should be done in the dormant season because visibility is good. Grade refers to the change in elevation and is commonly expressed in percent. A 10-percent slope means a 10-foot change in elevation over a 100-foot distance. Generally, roads should not be laid out with grades exceeding 10 percent. The Forest Service allows only 8-percent grades on permanent roads. After construction there will likely be some short distances with grades up to 15 percent (Baumgras 1971). Also, grades of 5-15 percent are considered the most efficient for hauling. Road surfaces exceeding 8-percent grades are difficult to keep gravel on.

All roads should be constructed far enough away from stream channels to provide a buffer zone. Kochenderfer (1970) recommends a strip at least 100 feet wide and even wider where slopes are steep, as in the Appalachians. If property boundaries or major obstructions require roads to be built closer to streams, debris such as logs, slash, rocks can be used to reduce flow velocity and trap sediment. In some areas where mass soil movement is a problem, a much wider buffer zone should be used (U.S. Environmental Protection Agency 1975). In some upland areas, soils are so shallow and rocky that once water is channelized, it continues to carry the sediment to main channels. There is also evidence that sediment moves in large macropores within the upper soil horizons to stream channels. When road drainage is adequate, however, undisturbed buffer strips between roads and streams effectively reduce the quantity of sediment transported to streams.

Where crossing streams is necessary, select areas with rocky bottoms and avoid steep banks or areas with deep, soft soil. Bridges and temporary crossings should be at right angles to streams and aligned to allow trucks to cross easily. In some areas, slabs with culverts are very effective crossings and are relatively inexpensive to construct and maintain. Where many loose rocks are present, clogging problems are avoided by using slabs without culverts.

Drainage is the key factor contributing to problems associated with roads (U.S. Environmental Protection Agency 1975). Many drainage problems can be prevented if we remember to disturb as little area as possible and disperse water quickly. Outslope road surfaces without ditches on the cut slope side provide rapid dispersal of water and reduce costs of road construction. The outslope grade should be about 3 percent (Kochenderfer 1970). Gardner et al. (1978) recommend using insloping, outsloping, grade breaks, dips, and berm designs to create effective drainage. Turnouts constructed at regular intervals can also be used to divert water onto well vegetated side slopes.

Kochenderfer (1970) suggests using broad-based dips instead of culverts on both truck roads and skidroads with grades of less than 10 percent. These dips are usually installed during road construction and are cheaper to maintain and more permanent than wooden culverts. He also recommends putting 3 inches of crushed stone on all slopes steeper than 8 percent. Broad-based dips should not be smaller than needed for a logging truck to park in it. The following formula can be used for determining spacing between dips or open-top culverts:

$$\text{Spacing} = \frac{400}{\text{Slope}} + 100 \text{ feet}$$

Several types of culverts are used to drain water across roads. Round or oval metal culverts are available up to several feet in diameter, but they are relatively expensive and cannot be used to collect surface runoff. Closed-top and open-top wooden culverts are relatively inexpensive and are effective if properly constructed and installed (Kochenderfer 1970). Open-top culverts should be installed at a 30-degree angle downgrade to avoid rough crossings. Wooden culverts do not last as long as metal ones and require more frequent cleaning, but they work well where traffic is moderate to light. Hollow logs can be used for culverts on temporary roads. Road ditches should not be used to carry water for long distances. Water collected in ditches has tremendous erosive power and will cut deep gullies, even in rather dense parent materials, if grades are steep. Care should be taken to insure that culverts are large enough to carry the expected flow from the drainage area. Culverts at least 18 inches in diameter should be used on all permanent roads to provide flow capacity and reduce clogging problems. Guidelines for spacing of culverts and selecting size of culverts needed are available (Kochenderfer 1970, Packer 1967a).

Maintaining roads.--On permanent roads, all road cuts and fill slopes should be seeded as soon after completion as possible to reduce erosion and to stabilize the surfaces (Gardner et al. 1978). Fertilizer should also be applied if it insures better cover development. All newly constructed roads should be allowed to settle a few months before use. On temporary haul roads and skidroads the surfaces should be graded to a 3 percent outslope, water bars should be installed, and all exposed mineral soil seeded after logging is completed (U.S. Environmental Protection Agency 1975).

Water bars should be installed at 30° angles to roads and used only where road grades are greater than 5 percent. Very deep cuts for water bars are unnecessary and can be a continuing source of sediment. Deep water bars commonly do not have enough mineral soil and nutrients to support vegetation, so collected water continues to erode the surface. Earthen vehicle barriers should be installed to protect the water bars and seeded areas.

Proper maintenance of roads is essential to minimize erosion and to allow efficient use by vehicles. Road surfaces should be kept relatively free of ruts that tend to concentrate water and allow it to flow downslope, thus increasing soil erosion. Unless specific problems are occurring, road surfaces and drainage ditches that have been revegetated should not be graded. The vegetation will usually be very effective in preventing erosion. Culverts should be kept free of debris, as even small obstructions can greatly reduce flow capacity. Generally, required maintenance of culverts and bridges can be done with hand tools. Trying to do such maintenance with power equipment often results in increased soil erosion and costs. Also, overhanging tree limbs should be cut to allow greater exposure to the sun, since quick-drying roads require less maintenance (Kochenderfer 1970).

## Timber Harvesting and Sedimentation

Actual cutting of timber usually does not significantly increase soil erosion or sediment in streams (Lull and Reinhart 1972, Stone 1977, Rice et al. 1972, Douglass 1974, Douglass and Swank 1975). In studies at Coweeta in North Carolina and Fernow in West Virginia clearcutting did not significantly increase turbidity (Douglass 1974, Patric 1976). Clearcutting with a carefully planned and maintained road system in West Virginia only resulted in minor increases in turbidity (Kochenderfer and Aubertin 1975). Actual logging of all merchantable wood in clearcutting usually does not disturb more than about 30 percent of the area (Megahan 1977, Ursic 1977, Rice et al. 1972). Therefore, timber harvesting alone should not have a significant effect on water quality under most harvesting situations in the eastern United States.

There are, however, several precautions that should be taken to minimize soil erosion during harvesting. First, hauling and skidding should not be done when soils are very wet. Not only is wet weather logging detrimental to the road system, but it can greatly increase equipment operation and maintenance costs. Compaction from wet weather logging may also lower site productivity (Froehlich 1979). Moerhing and Rawls (1970) found that 40-year-old loblolly pines declined in growth by as much as 40 percent where the root zones were severely compacted by logging during wet soil conditions. When soils were relatively dry, neither tree growth nor physical soil properties were significantly altered. King and Haines (1979) reported that low soil moisture content was a major factor responsible for lack of adverse effects associated with harvesting in slash pine plantations.

During harvesting operations, skidding downhill and/or across stream channels should be avoided (Kochenderfer 1970). Skidding uphill and away from stream channels disperses surface water rather than collects it. Skid trails from improper skidding procedures can be a significant source of sediment many years after logging is completed. Logs, preferably in tree-length, from buffer strips should always be cabled away from the stream channel. Logging vehicles should not be allowed in buffer strips.

After the logging operations are completed, areas of high erosion hazard should be disked or ripped and seeded. All landings and temporary logging roads on National Forest lands are seeded, water barred, and closed after logging operations are completed. The best seed mixture and fertilizer application should be tailored to local conditions. Landings almost always require special treatment because of compaction during repeated use. Also, it is especially important to prevent water from collecting in landings and flowing down roads, skidroads, and skid trails. Logs and brush can be placed on bare areas to disperse water and provide barriers to sediment movement. Where erosion is less likely, natural vegetation will usually cover bare areas within 2 or 3 years.

If the normal precautions to control erosion during and after logging are followed, the amount of sediment entering streams will be very near the preharvest levels in 3 years (Douglass 1974, Rice et al. 1972, Stone 1977, Douglass and Swank 1975, Patric 1976, Kochenderfer and Aubertin 1975).

## Site Preparation and Sedimentation

Site preparation in upland hardwood management should not be a major cause of erosion since mechanical scarification is normally not used. However, if it were necessary to use an intensive site preparation, such as shear-windrow and burn, some soil loss could be expected. Because of the unlikelihood that such site preparation methods would be used in upland hardwood management, they will not be discussed in this paper.

# OTHER WATER QUALITY CONSIDERATIONS IN HARDWOOD MANAGEMENT

In the previous discussion, the primary concern has been soil erosion and stream sedimentation associated with silvicultural activities. Other water quality parameters such as temperature of streams, nutrient levels, and pesticides may also be affected by silvicultural activities.

## Temperature

Removal of forest cover adjacent to streams can affect water temperature, and subsequently may harm aquatic organisms. The removal of overstory vegetation that protects the stream from direct solar radiation often results in increasing average water temperatures and causes greater fluctuations between minimum and maximum temperatures (Brown 1969, 1972b, Sopper 1975). At Coweeta, Swift and Messer (1971) observed a mean monthly temperature increase of 4°C after clearcutting. Kochenderfer and Aubertin (1975) in West Virginia and Pierce et al. (1970) in New Hampshire found similar increases of 5.5°C and 6°C, respectively, from clearcutting. In the Coastal Range of Oregon, Brown and Krygier (1970) reported that clearcutting resulted in an 8°C increase in mean monthly temperature. Removal of the protective vegetation adjacent to stream channels can also accelerate bank and channel erosion (Stone 1977), so adverse affects of silvicultural activities on streams can be largely eliminated by leaving a buffer strip (Swift and Baker 1973). The width of the buffer strip needed for maintaining stream temperature is not as important as stream direction, topography and shading characteristics of the vegetation (Brazier and Brown 1973, U.S. Environmental Protection Agency 1976). Techniques for estimating the effects of timber harvesting on stream water temperature have been developed (Brown 1969, 1970, 1972a).

## Nutrients

Increases in nutrient losses from forested areas may cause eutrophication of streams, and may also indicate reduced site productivity (Pierce et al. 1972, Sopper 1975). The effects of various silviculture practices on water chemistry depend on what specific nutrient changes occur. Johnson and Swank (1973) reported on annual and seasonal fluctuations of calcium, magnesium, potassium, and sodium for watersheds having the following cover types: hardwood, grass-to-forest succession, eastern white pine, and hardwood coppice. Actual cation budgets varied among the watersheds, but a long-term loss of cations by erosion or water flow has not occurred after drastic changes in ecosystems.

Douglass and Swank (1975) reported that only minor changes in mean annual concentrations of cations and anions have resulted from a variety of watershed treatments at Coweeta. Applications of lime to two watersheds resulted in appreciably higher calcium concentrations than were expected from undisturbed watersheds. Of the anions studied, only nitrate nitrogen ($NO_3$-N) increased in concentrations after treatment. Although the amounts of $NO_3$-N were 4 to 150 times greater on disturbed than on undisturbed watersheds, the maximum concentration observed was only 1.23 ppm. Their conclusion is that "water chemistry studies to date provide no evidence that forest cuttings in the mountains of North Carolina have rendered streamflow less fit for human use or degraded soil fertility." However, Pierce et al. (1972) reported much greater nutrient losses in New Hampshire, and they expressed concern over the amount of nitrogen lost. One clearcut watershed, Gale River B, had a net loss of 39 kg/ha of $NO_3$-N the second year after cutting. However, the high levels observed are believed to be unique to that region (Sopper 1975, Stone 1977). Sopper (1975) concluded that nutrient losses after clearcutting are small to negligible, and amounts lost are such a small part of the total nutrient capital that site productivity should not be reduced. While considerable data are being collected on nutrient losses associated with forest practices, little is really known about the downstream effects of increased nutrients (Stone 1977). Nutrient losses associated with soil losses should receive continued evaluation.

Herbicides and Pesticides

Water pollution from application of herbicides and pesticides can occur in silvicultural operations. Generally, such contamination results from direct application or spraying over streams or immediately next to streams (Douglass and Swank 1975). Peak concentrations of herbicides detected in streams from normal applications are usually very small, and they persist for only a short period of time (Norris 1975). Lawson (1976) detected herbicides in storm runoff in only one of three applications to small watersheds. Several studies have shown that maximum herbicide concentration in excess of 0.05 mg/liter should not occur when direct application to streams is avoided (Fredriksen et al. 1975, Norris 1975, Douglass and Swank 1975). Contamination of streams by single stem injection of approved herbicides has not been documented. So, proper application of herbicides and pesticides should not result in serious degradation of streams in forested watersheds.

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# WILDLIFE HABITAT MANAGEMENT IN MID-SOUTH UPLAND HARDWOODS

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Abstract.--Wildlife habitat management in mid-south upland hardwoods should be directed towards the production of mast and forage, and the maintenance of snags and vertical diversity. Clearcutting in small, well distributed units, shelterwood management, or uneven-aged management through group selection is probably more beneficial than either individual tree selection or large clearcuts. Thinnings at regular intervals and mid-story brush control would help maintain mast and forage production. Some dead and dying trees should be left standing during harvest and thinning operations to meet present and future needs for cavities. Stands in and adjacent to recreational areas should be managed selectively to maximize vertical diversity.

Additional keywords: Mast, forage, browse, snags, cavities, vertical diversity.

"Habitat", the vegetative community, may represent distinctly different things to the forester, the wildlife manager and the general public. Wildlife habitat management in the forest community is therefore by its very nature multiple-use management. The multiple-use concept is fairly straight forward in theory; yet initiating it as an effective forest management program is very complicated (Buckner 1977). Combining timber and wildlife goals produces a maze of options and alternatives that resists implementation.

This paper is directed to the discussion of mid-south upland hardwoods, which yield a variety of timber products. Added to this is the variety of native wildlife species that inhabit the upland hardwood community. These species have different habitat requirements, and within a species, different sexes and age classes often have different habitat requirements.

Silvicultural systems can be developed to produce wood at a high percentage of the forest's biological potential while simultaneously providing quality wildlife habitat. The level of trade-offs between wood production and wildlife habitat depends on management goals (Hall and Thomas 1979). With the many possible combinations of timber and wildlife objectives, it becomes impossible to develop any one set of management guidelines that will fit every situation. Therefore, this paper will not presume to put forth a model listing of guidelines for wildlife habitat management in upland hardwoods. Instead, it will divide wildlife habitat into four components, and examine silvicultural options that might be employed to develop each. These habitat components are mast, forage, snags (cavities), and vertical diversity.

## MAST

Mast is the fruit of various tree and shrub species. Hard mast includes the nuts of oaks, hickories, beech and walnuts; and is usually considered a

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component of the overstory. Soft mast includes the fruits of such plants as dogwoods, blueberries, huckleberries, grapes, blackberries and hawthorns that are commonly found in the understory.

There are many factors that influence mast production: genetic composition, age, size and vigor of individual trees, as well as, stand density, site quality, weather, insect populations, incidence of disease and mechanical injury. Light is also an important variable in the production of soft mast in the understory.

Understory fruit yields are significantly influenced by stand density, particularly as it relates to crown closure both in the forest canopy and midstory. The quantity of mast produced by open grown shrubs is several times more abundant than that produced under a forest canopy. The U.S. Forest Service (1971) reports in their Wildlife Habitat Management handbook that fair understory fruit yields are produced in stands with an overstory density of 60-80 $ft^2$ of basal area; but fruit yields drop significantly in stands with higher overstory densities or with midstory canopies. Fruit yields of yaupon (Ilex vomitoria) american beautyberry (Callicarpa americana) and flowering dogwood (Cornus florida) are suppressed more by overstory competition than are the forage yields from the same species (U.S. Forest Service 1971).

Of all factors influencing understory fruit production, light is the one most easily modified and controlled by silvicultural manipulation. Thinning at regular intervals and mid-story brush control would help maintain understory fruit yields. All regeneration methods, with the exception of individual tree selection, are compatible with soft mast production in the understory.

Hard mast production in the overstory generally is equated with acorn production by the various species of oaks. Acorn production varies from year to year and from species to species. Even within a species, individual trees perform differently in mast production. In general, the best acorn yields come from older trees that have attained substantial DBH and crown size (Reid and Goodrum 1957). For most species of oaks, acorn yields are negligible for trees younger than 10-19 years (Goodrum et al. 1971) or less than 12" DBH (Beck and Olson 1968). But, biggest is not always best. Trees over 100 yrs old or 26" DBH often exhibit decreased acorn production as portions of the crown die out (Goodrum et al. 1971, Shaw 1971). Beyond the influence of age and size, some trees seem inherently capable of producing larger acorn crops than others of the same species, age and size class (Sharp and Sprague 1967).

Recent fruiting history also influences year to year variability between species. The various species of oaks apparently require different numbers of years to build up the food reserves to produce a subsequent bumper crop of acorns. Goodrum et al. (1971) found that white oak (Quercus alba) and post oak (Q. stellata) tend to have relatively good mast crops every 2 yrs. Blackjack oak (Q. marilandica) on the other hand produced a good crop only every 5 years, southern red oak (Q. falcata) only every 4 years.

Rainfall and temperature control mast yields on a stand-wide basis. Lack of rainfall may reduce mast crops, especially on shallow soil sites (U.S. Forest Service 1971). Spring frost, can be even more damaging than lack of moisture, and may eliminate an entire year's production in frost areas. The effect of a killing frost is manifested in the same year's mast crop for members of the white oak group, which require only one growing season to develop mature acorns from flowers; but the effect is delayed until the following year in species of the red oak group, which require two growing seasons to develop mature acorns.

This inherent variability, as well as the variation induced by nature must all be taken into account when managing upland hardwoods for mast production. To assist the resource manager, Goodrum et al. (1971) and Shaw (1971) both provide tables showing projected acorn yields for various species of oaks in 2" diameter classes.

Several studies have indicated that 77 to 85 lbs of acorn production per acre are needed to meet the needs of moderate populations of wildlife (Evans 1968, Goodrum 1959, Goodrum et al. 1971, Reid and Goodrum 1957). Evans (1968) provided an example of a 1,000 acre oak-hickory forest in the Missouri Ozarks: to sustain a population of approximately 8 turkeys, 31 deer and 300 squirrels, there should be in the neighborhood of 40 lbs/acre of sound acorns on the ground. This converts to approximately 77 lbs/acre initial production in the crowns to account for loss to weevils, fungi and arboreal feeders. Shaw (1971) believes that all of these figures should be increased to 100 lbs/acre to provide for the use of acorns by bear and non-game species. The actual number and size of oaks needed per acre can be estimated from the tables presented by Goodrum et al. (1971) and Shaw (1971).

The necessary production of acorns for wildlife can be obtained under both uneven-aged and even-aged management systems. Following is a list of silvicultural recommendations that can be used to enhance the production of hard mast for wildlife. These recommendations have been compiled from Engle (1969) and authors cited previously in this section.

General

1) Approximately 50% of each management unit should be in acorn production; and these trees (uneven-aged management) or stands (even-aged management) should be evenly distributed over the management unit.

2) Use intermediate cuttings, such as periodic thinnings or improvement cuts, to stimulate stand growth and vigor, promote crown development and enhance mast production.

3) Delineate areas prone to frost damage and avoid positive management for mast production in these areas.

Uneven-aged

1) Maintain species diversity. Select for representatives of both the white and red oak groups (1:2 ratio) to take advantage of their complementary fluctuations in mast yield.

2) Include some representatives of other mast species such as blackgum (*Nyssa sylvatica*), and hickory (*Carya* spp.) to offset the effect of years with widespread acorn failure.

3) Identify and maintain individual trees that are consistently good mast producers.

Even-aged

1) Each pole and sapling stand should adjoin a stand of mast producing age.

2) Each newly regenerated stand should be surrounded by mature acorn producing stands.

3) Regularly shaped clearcuts should not exceed 50 acres.

4) Use the home ranges of featured species to define maximum distance between stands of mast producing age.

## FORAGE

Understory vegetation beneficial to wildlife includes numerous herbaceous species, forbs, woody vines and shrubs; the latter two being grouped into one category - browse. Logging and timber stand improvement cuts practiced in mid-south upland hardwoods have commonly been on a selective basis, with removal of only scattered trees. The resulting stands of dense, relatively undisturbed, canopied second-growth hardwoods, are characteristically poor in understory forage production for wildlife (Della-Bianca and Johnson 1965, Murphy and Ehrenreich 1965).

Many environmental factors influence the growth and nutritional value of forage in forest stands, but none have as dramatic an effect as light intensity. The production of understory forage, both in quantity and quality, is inversely related to canopy closure. Light becomes a limiting factor in understory forage production once the forest canopy is dense enough to reduce light intensity below 20% of full sunlight. The presence of a mid-story or multilayered canopy in hardwood stands further limits light transmission.

Species composition of the understory is also dependent upon canopy closure, with intolerant species being replaced by shade tolerant plants as stand density increases. The majority of plant species preferred by wildlife are medium to intolerant to shade.

Most commercial timber harvests will result in beneficial increases in forage production for wildlife (Cromer and Smith 1968). In the Missouri Ozarks, a timber sale on white oaks in one stand and the girdling of cull trees for the release of another stand, resulted in increased forage for 3-5 years (Baskett et al. 1957, Martin et al. 1955). A significant increase in stand quality and browse production occurred when a dense 11-yr old hardwood stand in the southern Appalachians was subjected to an intensive cleaning (Della-Bianca and Johnson 1965). In this study, untreated areas had only 3 lbs of woody browse per acre compared to 805 lbs/A on the lower slopes and 81 lbs/A on the upper slopes of treated stands one year after the intensive cleaning. In another study in second-growth hardwoods forests in the southern Appalachians, clearcutting and heavy selection cutting substantially increased the number of woody stems from near zero to as much as 8,000/A and 5,028 stem/A respectively (Harlow and Downing 1969). The winter supply on evergreen leaves, forbs, grasses and mushrooms was also increased four-fold on the clearcut areas.

The land manager interested in wildlife habitat management in upland hardwoods should strive to minimize annual fluctuations in food production (Crawford 1971). Since mast production varies drastically from year to year, a stable level of forage production would help lessen the impact of mast failure on wildlife populations. Management for forage production is essentailly a process of maintaining an open canopy. The need for cutting is particularly evident in the large, essentially even-aged, second-growth hardwood stands that have originated after heavy cutting in the early 1900s (Knierim et al. 1971).

When forage production is a multiple goal with regeneration, clearcutting in small, well distributed units, shelterwood cutting or heavy selective cutting (group selection) is probably more beneficial than either individual tree selection or large clearcuts. Initially, clearcutting has about a four-fold advantage over selective cutting in producing wildlife forage (Crawford and Harrison 1971). However, this advantage may be short lived. After 3 yrs, 50+ acre clearcuts in southern Appalachian stands produced such a tangle of sprouts and vines that penetration by deer was impaired, resulting in only short term value of the forage produced (Harlow and Downing 1969). Forage production on areas receiving heavy selection cuts, while not being as high initially, remains accessible to wildlife because of fewer stump sprouts and less tendency to develop thickets due to partial shading (Crawford and Harrison 1971, Harlow and Downing 1969). A decrease in ungulate accessibility was not evident, however, on 21 acre clearcuts (Harlow and Downing 1969). Another advantage of heavy selection cuts over clearcuts is that some mast-bearing trees can be left in the residual stand.

The beneficial aspects of timber harvest begin to diminish after approximately 5 years due to crown closure and stem growth out of the browsing zone (Crawford 1971, Della-Bianca and Johnson 1965, Patton and McGinnes 1964). Cleanings, thinnings and improvement cutting should be scheduled at regular intervals to extend the period of forage production. For pole stage hardwoods, heavy thinnings that remove 35-40% of the basal area, and are repeated at 7-10 yr intervals, should yield sufficient volume to allow profitable cutting, stimulate browse, and leave suitable growing stock (Knierim et al. 1971). Precommercial cleanings should be more attractive to the forest land manager when improvement in both stand vigor and wildlife habitat are recognized.

## SNAGS AND VERTICAL DIVERSITY

Multiple use management for the production of timber, mast and forage in mid-south upland hardwoods will, directly or indirectly, provide most habitat requirements for many of the wildlife species associated with the upland hardwood type. There are, however, two habitat components that might be lost or restricted under an active forest management program. These are snags and vertical diversity, particularly in the case of even-aged prescriptions.

Snags are often removed during selective harvests, and are usually felled under even-aged management prescriptions. Snags, however, are an important habitat component in forests managed for wildlife. The availability of snags on forest lands affects the abundance, diversity and species richness of cavity nesting birds. Snags are used as a foraging substrate by woodpeckers and a variety of songbirds, as perches by different species of birds of prey, and as nests for a variety of cavity nesting birds. Existing cavities in snags are also frequently used by mammals such as squirrels, mice, racoons and bats (Comer 1978).

Snags must have heart rot to make it possible for birds to excavate cavities (Comer 1978). As a result, under natural conditions cavities do not normally become abundant in stands until the last quarter of the rotation (Zeedyk and Evans 1975). Active timber management develops young, cull-free, fast growing stands which greatly reduces the number of cavities and potential cavities.

To provide this wildlife habitat component, the forest land manager should leave dead and dying trees standing whenever possible during harvest and thinning.

It would also be beneficial to kill non-commercial trees scheduled for removal during thinnings instead of felling them, and reserve a portion (10%) of each compartment for old growth (Evans 1978).

The structural characteristics of the vegetation within a stand are an important wildlife habitat consideration separate from species composition. The vertical stratification of vegetation greatly influences the total avifauna composition within a given area (Zeedyk and Evans 1975). The habitat for a variety of bird species can be provided, on a single tract of land, by developing distinct habitat layers - vertical diversity.

Under even-aged management systems, the vertical diversity within stands is minimized; but the diversity between stands (edge) is maximized (Zeedyk and Evans 1975). On a forest-wide basis the habitat requirements of most native bird species will be satisfied if the even-aged stands are managed to provide a well distributed mosaic of stand ages and cover condition. However, in any one stand the bird community will be made up of fewer species than in a comparable stand under uneven-aged management because of the difference in vertical diversity. It would be beneficial then to manage upland hardwood stands in and adjacent to recreational areas under a selective management system, to promote vertical diversity, improve unit area species richness, and enhance human enjoyment (Gill et al. 1974, Hooper et al. 1973).

Creating and maintaining a diverse vegetation community is the key to providing a large variety of native wildlife species with suitable habitat. The key to providing an optimum dispersal and range of forest conditions is plannning entire rotations. Planning, in turn, will only be successful if it is a cooperative effort. Forest land management for the production of timber and wildlife habitat requires a team effort, not the separate efforts of foresters and wildlifers.

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# MANAGEMENT OF INSECT PESTS IN MIDSOUTH UPLAND HARDWOODS[1/]

J. D. Solomon[2/]

Abstract.--The most costly insect pests of hardwood sawtimber in the Midsouth are borers. Insect defoliators have occasionally caused widespread defoliation, mostly during late season in stands of little commercial value; so dollar loss has been small. Seed insects, aphids, and other insects also hinder tree growth and reproduction. Selected cultural practices can help reduce risks and minimize insect impact. Chemical controls are occasionally needed, but their use is limited mostly to protection of high-value trees.

Not only poor management, but also insects, diseases, and fire have contributed to the low quality found in many upland hardwood stands in the Midsouth. Insects destroy seeds; kill or suppress seedlings and sprouts; contribute to poor tree form; cause growth loss, dieback, and mortality; and produce defect and degrade. Insects cause indirect losses through disruption of sustained forestry practices, regulation of forest types, and altered wildlife habitat. The major insect pests of Midsouth upland hardwoods are defoliators and borers.

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1/ Discussion of pesticides in this paper does not constitute recommendation of their use or imply that uses discussed here are registered. If pesticides are handled, applied, or disposed of improperly, they can harm humans, domestic animals, desirable plants, and pollinating insects, fish, or other wildlife, and may contaminate water supplies. Use pesticides only when needed and handle them with care. Follow the directions and heed all precautions on the container label.

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## DEFOLIATORS

### Impact of Defoliators

How much trees are injured by insect defoliation depends on extent of defoliation, tree species, season of year, frequency of defoliation, competition within stands, and tree vigor (Graham and Knight 1965).

One partial defoliation does little harm to trees. Complete defoliation, however, may cause growth loss, crown dieback, and mortality.

Deciduous hardwoods resist defoliation injury more than evergreen conifers do and can generally withstand a moderate amount of defoliation before survival is threatened. Slow growing hardwood species are usually less susceptible to injury than are fast growing species.

Early season feeders that defoliate trees during spring are most harmful because the tree's food reserves are low immediately after its leaves have developed. Late season defoliators are least harmful because the summer foliage has replenished food reserves.

Most hardwoods can withstand one complete defoliation. But heavy defoliation during successive years, especially of early season species, or two or more defoliations the same year can be disastrous.

Dominant and codominant trees generally have higher food reserves and are least affected by defoliation. And vigorous trees in well-tended stands can tolerate more defoliation than can those that have been weakened or stressed.

Sometimes defoliators can cost large amounts of money. For example, an outbreak of elm spanworm, *Ennomos subsignarius* (Hbn.), in the southern Appalachians in the late 1950's and early 1960's did severe damage (Fedde 1964). Mortality (mostly oaks) in Georgia and Tennessee caused losses of 27 million bd. ft.of sawtimber and 12,000 cords of poletimber; about the same amount was salvaged. After only two seasons of severe, early season defoliation, stands suffered 50 percent losses in radial growth. Similar losses have been caused by oak leafrollers (*Archips* sp.), forest tent caterpillar (*Malacosoma disstria* Hbn.), gypsy moth (*Lymantria dispar* (Linn.)), and other species.

Defoliation increases susceptibility of weakened trees to insect borers and disease. Surviving trees are often stunted, ill-formed, and unmerchantable. Defoliation creates openings in the forest floor, and scrub vegetation is released. Defoliation also increases fire hazard and reduces esthetic, recreational, and wildlife values.

### Defoliator Species

In recent years, variable oakleaf caterpillar (*Heterocampa manteo* (Dbldy.)) has been epidemic in several Midsouth areas. During 1970-72, over 4 million acres of oak, hickory, and other hardwoods were moderately to heavily defoliated in central and northeastern Arkansas (U. S. Department of

Agriculture, Forest Service 1970, 1972) and southern Missouri (Gass 1971). Defoliation was heaviest along ridgetops and south slopes. In 1979, defoliation occurred over 12 counties in east Texas.[3/] Light-to-moderate infestations have occurred in Mississippi and Louisiana (Anderson and Barry 1979). Although infestations in the Midsouth have been widespread and heavy at times, most trees were defoliated late in the season (August-September) and usually for no more than 1 or 2 years. So, dieback and mortality have been light, though some growth was lost.

Walkingsticks (Diapheromera femorata (Say)) have been defoliating oaks and other hardwoods in the mountains of west Arkansas and east Oklahoma for the past 3 decades (Galusha and Ketcham 1963, Anderson and Barry 1979). Defoliation has been particularly heavy in the Ouachita National Forest. More than 130,000 acres were defoliated during 1970 and 1971 (U. S. Department of Agriculture, Forest Service 1971a, 1971b). Although walkingsticks begin feeding in May and June, most defoliation occurs from August to October. But, though defoliation has often been heavy and widespread, tree mortality has been negligible because defoliation occurred in late season when tree health is least affected. Heaviest defoliation occurs along ridgetops where trees generally have little commercial value (Galusha and Ketcham 1963).

Linden looper (Erannis tiliaria (Harr.)) defoliated over 100,000 acres of upland hardwoods in northeast Alabama[4/] during 1978-79. Oak-hickory stands in the mountains were hardest hit. A recent survey indicates that defoliation will occur again in 1980.[4/] Although affected areas are mostly upland mountain stands of low quality, the outbreak should be kept under close observation because the linden looper is an early-to-midseason defoliator.

Orangestriped oakworm (Anisota senatoria (J. E. Smith)) and yellownecked caterpillar (Datana ministra (Drury)) have recently infested oaks and walnut in Arkansas, Louisiana, Mississippi, Missouri, Tennessee, and Texas. But both species are late season defoliators, and infestations are usually quite localized.

Walnut caterpillar (Datana integerrima G. & R.) defoliates walnut, butternut, pecan, and hickory in June-July and again in August-September. Recent local infestations have occurred in southwest Missouri (Gass and Phillips 1979), Arkansas, and Mississippi. Black walnut may be seriously injured or killed when defoliated 2 or more years in succession (Baker 1972).

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[3/] Oliveria, F. L. U. S. Department of Agriculture, Forest Service, Alexandria, La., personal communication.

[4/] Hyland, J. Alabama Forestry Commission, Montgomery, Ala., personal communication.

Spring cankerworm (Paleacrita vernata (Peck)) was widespread on live oak in east Texas[5] during 1979. Slug-oak sawfly (Caliroa quercuscoccineae (Dyar)) was epidemic on oaks in Kentucky, Tennessee, and Virginia in 1974-1976 (U. S. Department of Agriculture, Forest Service 1978). Asiatic oak weevil (Cyrtepistomus castaneus (Roelofs)) has been troublesome in Missouri in recent years (Gass and Phillips 1979). Elm leaf beetle (Pyrrhalta luteola (Mueller)) an introduced species, has become a major pest of ornamental elms in the Midsouth (Warren 1962). Fall webworm (Hyphantria cunea (Drury )) has often defoliated hickory, pecan, persimmon, and many other hardwoods.

Fortunately, some of the best known and most serious defoliators--forest tent caterpillar, elm spanworm, and oak leafroller--have not been epidemic in Midsouth upland hardwoods. But the dreaded gypsy moth, an introduced pest in the Northeast, is moving slowly in on southern hardwoods. It has already spread southward to Virginia, and recent trapping studies revealed the presence of moths in Tennessee and North Carolina (Anderson and Barry 1979).

## Prediction and Control

Insect defoliators are generally cyclic--populations build up for 1 or more years, then decline. During epidemics, overwintering stages need to be surveyed so the likely degree of defoliation can be forecast. Drooz and Solomon (1962) used a sampling unit for the elm spanworm of two 5-ft branches clipped from the lower half of the crown of six trees, then predicted light-to-moderate defoliation based on 1-25 egg masses per sampling unit and moderate-to-heavy defoliation based on 25 or more egg masses. Gass (1971) reported that a sample of one healthy overwintering larva of the variable oak-leaf caterpillar per square foot of soil would defoliate a stand completely the next season. Traps baited with sex pheromones have been particularly useful in monitoring spread of gypsy moth infestation (Nichols 1961).

Outbreaks of defoliators are spectacular, yet natural controls, including parasites, predators, and weather, usually suppress epidemics before serious losses occur. Silvicultural practices designed to promote stand vigor, or reduce the proportion of favored host, help limit risks (Baker 1972). Rexrode (1971) suggests reducing the number of scarlet oaks in northeastern oak stands to limit the build-up of oak leafrollers. Placing sticky bands on trunks of individual trees will snare wingless female moths, such as fall and spring cankerworms and linden loopers, before they lay their eggs. Practices such as "pick-up and destroy" and "prune out and destroy" can help reduce hibernating forms, tents, and small colonies. Insecticides are available for most defoliators and may be needed occasionally.

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[5] Oliveria, F. L. U. S. Department of Agriculture, Forest Service, Alexandria, La., personal communication.

## INSECT BORERS

### Impact of Borers

Borers are the most costly insect pests of hardwoods. Yet they are least spectacular because both larvae and galleries are largely hidden from view until the tree is cut and processed. Borer damage accumulates slowly during the life of the tree.

Morris (1964) reported on two studies of borer impact in upland oaks. He sampled northern red, black, and post oak logs cut from the Ozark National Forest near Clarksville, and Harrison, Arkansas. Borer defect and loss in value of factory-grade lumber sawn from the sampled logs averaged $12.63 per MBF at Clarksville and $18.00 per MBF at Harrison. An average of these loss figures updated to 1980 lumber prices amounts to about $42 per MBF for upland oaks in the Midsouth. At this loss rate, a mill cutting 5 million bd.ft.of oak per year would lose $210,000 to defects and degrade.

Similar studies of borer degrade have been conducted in upland oaks (northern red, black, and scarlet oaks) sawn for factory-grade lumber in central Appalachia (Donley 1974). Combined losses due to borer-caused defects averaged $26/MBF in Kentucky, $19/MBF in West Virginia, and $25/MBF in Ohio. Losses averaged for these three states and updated to 1980 lumber prices amount to about $47/MBF.[6/]

And studies (Donley et al. 1974) of white oak cooperage showed that 2 percent of the log and bolt volume and 7 percent of the stave blanks were rejected because of borer damage. So losses totaled 9 percent of the cooperage stock, which amounted to $330,000 in Ohio during 1964.

Estimates of the costs of borer impact are high, yet they would run markedly higher if they accounted for logs downgraded from veneer grades to factory grades and from factory grades to pulpwood, and for borer-caused losses in nurseries, seed orchards, and shade and ornamental trees.

### Borer Species

Oak.--Oak sawtimber is particularly hard-hit by insect borers. Red oak borer (*Enaphalodes rufulus* (Hald.)) and carpenterworm (*Prionoxystus robiniae* (Peck)) attack both red and white oaks. These borers mine the bark, then tunnel into the sapwood and heartwood and leave large worm holes, bark pockets, and associated stain and decay that constitute degrading defects when the timber is harvested. White oak borer (*Goes tigrinus* (DeG.)) severely damages white oak cooperage, particularly the smaller logs (Burns 1971, Donley et al. 1974). Oak timberworm (*Arrhenodes minutus* (Drury)), a pest of both red and white oaks, attacks at wounds where sapwood is exposed (Donley et al. 1974).

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6/ Donley, D. E. U. S. Department of Agriculture, Forest Service, Delaware, Ohio, personal communication.

Hickory.--Hickories usually escape serious injury. During droughts, however, hickory bark beetle (*Scolytus quadrispinosus* Say) may cause widespread mortality of weakened trees (Baker 1972). Hickory borer (*Goes pulcher* (Hald.)) tunnels into trunks of saplings and poles in scattered localities and causes measurable defect.

Ash.--Lilac borer (*Podosesia syringae* (Harr.)) and banded ash borer (*Podosesia aureocincta* P. & N.) attack trees of any size and cause breakage in young trees, defect in sawtimber, and scars and decline in ornamental trees.

Black locust.--Locust borer (*Megacyllene robiniae* (Forst.)) often riddles black locust and causes breakage and repeated sprout growth (Wollerman 1962). Vigorous trees on good sites suffer only minor damage. But this borer could limit use of black locust for energy farms on poor and marginal sites.

Yellow-poplar.--Borers have not been a serious problem over yellow-poplar's range. In some localities, however, root-collar borer (*Euzophera ostricolorella* Hulst) causes weakening and mortality in woodlots, seed orchards, and ornamentals (Hope and Pless 1979). Columbian timber beetle (*Corthylus columbianus* (Hopk.)) causes defect in some areas.

Black walnut.--Shoot borers (*Acrobasis* spp.) kill many terminals of young trees, causing excessive forking and poor tree form. An introduced species (*Xylosandrus germanus* (Blandf.)) associated with stem-girdling cankers (Weber 1979) could become a problem in young plantations.

Black cherry.--Bark beetles (*Phloleotribus* sp.) and cambium miners, (*Phytobia* sp.) cause gum spots and pith flecks in the wood; these defects reduce its value (Kulman 1964). Also, peachtree borers (*Synanthedon* spp.) have damaged young trees by burrowing under the bark on the lower trunk.

Maple.--Columbian timber beetle is a serious pest of maples and other species in some areas (Nord and McManus 1972). Its "flagworm" defects cause degrade in lumber, cooperage stock, and veneer.

Weakened and stressed trees.--Two-lined chestnut borer (*Agrilus bilineatus* (Weber)) causes extensive mortality of oaks and other hardwoods weakened from defoliation, drought, or fire.

Freshcut logs and green lumber.--Pinhole borers, (*Xyleborus* spp. and *Platypus* spp.) seriously threaten freshcut logs and green lumber by attacking the wood and riddling it with pinholes.

## Prediction and Control

Interpretation and evaluation of bark indicators are the best means for assessing and predicting borer damage. To classify borer damage, Morris (1964) used the number of insect-caused bark scars visible on the next-to-poorest face or quadrant of the butt log in the standing tree. He classed 2 scars or less as light damage; 3 to 10 scars, medium damage; and more than 10, heavy damage. Researchers at Stoneville, Miss., and Delaware, Ohio, are developing techniques for evaluating damage caused by carpenterworms and red oak borers.

Sticky traps with pheromone baits for assessing ash borer (Podosesia spp.) infestations are now commercially available (Conrel Co., 110 A St., Needham Hts., MA 02194). Pheromone-baited traps are being evaluated for use in assessing carpenterworm (Prionoxystus spp.) populations. When light traps, placed in stands containing 300 oaks per acre, catch four or more red oak borers a night, controls should be begun (U. S. Department of Agriculture, Forest Service 1973).

Controls for reducing borer damage must, where possible, fit into ordinary, day-to-day silvicultural operations (Sander and Phares 1976). Timber landowners should be aware of and use cultural practices that maintain or improve tree vigor. Such cultural practices would be thinning, fertilization, and matching tree species to site. Landowners should favor tree species least damaged by borers, identify and remove brood trees, harvest as soon as trees are physiologically mature, minimize injuries to residual crop trees, and survey timber stands closely during periods of severe stress. Researchers in Ohio removed brood trees from selected plots and reduced red oak borer populations by 73 percent (U. S. Department of Agriculture, Forest Service 1973, Hay 1962).

Resistant strains or clones have been found for a few borer species. Wollerman (1962) reported that the "Higbee" strain of black locust resists locust borer. Natural enemies of borers are effective controls and can be favored by practices that promote stand diversification. Wrapping trunks, mechanical "worming," and gallery fumigation can be small-scale controls.

Insect borers can generally be controlled with chemical insecticides. Because of high treatment costs, however, actual use of pesticides for borer control is limited largely to protecting nurseries, plantations, seed orchards, shade and ornamental trees, and possibly high-grade lumber and veneer trees. Certainly in high-risk areas, fresh-sawn logs and green lumber must be treated for protection from pinhole borers.

## OTHER INSECTS

Many other insects can create problems for tree growers. Seed insects cause serious losses in oaks and other hardwoods. During light seed years, the acorn crop may be largely destroyed; such destruction limits reforestation efforts and reduces supplies of mast for wildlife. Aphids, spider mites, scales, and twig and leaf gall insects are troublesome at times and require suppression. Insects are also important vectors of Dutch elm disease, oak wilt, and elm phloem necrosis.

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# DISEASE MANAGEMENT IN SOUTHERN UPLAND HARDWOODS[1]

Robert Lewis, Jr.[2]

Abstract.--Landowners should learn to recognize wilts, declines, root rots, cankers, and decays in upland hardwood stands and lessen economic impact of these diseases by using simple and inexpensive disease management practices. Killing roots of healthy trees bordering infection centers will suppress oak-wilt spots. Many trees with root rot, stem decay, and cankers can be salvaged and should be removed so sound trees have growing space. Cull trees can also be removed and sold for firewood. Natural regeneration on sites with high root-rot incidences should favor nonsusceptible species. Hardwood regeneration from sprouts should include sprout clump thinning procedures that minimize decay hazards.

## INTRODUCTION

The first economic impact of tree diseases is a reduction in the quantity and quality of merchantable wood in a stand. The primary aim of disease management is to minimize these losses.

Thousands of upland hardwood stands have been converted to pastures for beef cattle, and quality of remaining stands has declined because of poor silvicultural practices (Sternitzke and Johnson 1979). Most of these lands are controlled by small nonindustrial ownerships. Disease management procedures, then, must be designed mainly for nonindustrial landowners. These procedures, which are easy and inexpensive, should greatly reduce losses to disease.

To have successful disease management programs, landowners should know what the costly diseases are and should be able to recognize signs of these diseases in living trees. An infectious tree disease is caused by an invading biotic agent that changes a tree's normal physiology, morphology, and wood density or quality. Most tree diseases are caused by microscopic fungi that cannot be isolated and identified by people untrained in pathology or mycology. But signs of fungal invasions can be seen by most people who observe trees closely. These signs may be wilts, root rots, declines, leaf spots, stem cankers and decays.

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1/ Discussion of herbicides in this paper does not constitute recommendation of their use or imply that uses discussed here are registered. If herbicides are handled, applied, or disposed of improperly, they can harm humans, domestic animals, desirable plants, and pollinating insects, fish, or other wildlife, and may contaminate water supplies. Handle with care and follow directions.

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# WILTS, ROOT ROTS, AND DECLINES

Symptoms of wilt, root rot, and decline are visible indications of fungal infections that change a tree's normal physiology. The infections hinder translocation of nutrients and water (sapflow), and the tree usually dies. Initial symptoms appear in leaves and can be recognized by most landowners.

## Wilts

Symptoms of important hardwood wilts vary with fungus involved, tree species affected, and climatic conditions. Dutch elm disease (caused by *Ceratocystis ulmi* (Buism.) C. Mor.) and oak wilt (caused by *Ceratocystis fagacearum* (Bretz) Hunt) are familiar hardwood wilts. Wilt symptoms may develop as flagging at any place over part or all of the crown. Normally green leaves turn yellow to brown and fall prematurely. They may also wither and remain attached to the tree for a short time. Leaf margins and tips may turn brown, while petioles and leaf bases remain green. Sometimes entire leaves die, turn brown, and remain attached to the tree--symptoms like those of lightning kill. Twigs and limbs die as wilt progresses, and suckers may develop on the lower bole. Finally the entire crown dies, but roots remain alive for some time. Adventitious sprouts may develop from roots. Generally, only trees of the same or closely related species will be affected by a particular wilt in a hardwood stand.

Oak wilt is the most important known wilt in upland hardwoods. It affects all native oaks but is most virulent in red oaks. The fungus is spread through root grafts and by insect vectors. Infection may start in one tree and pass to adjacent trees to make large infection centers. These will enlarge each year and kill valuable oaks unless wilt is suppressed.

Landowners can greatly reduce root-graft transmission of oak wilt by killing or severing roots connecting infected and noninfected oaks of the same species. The procedure should isolate diseased trees from healthy ones. Injection of cacodylic acid (hydroxydimethylarsine oxide) has killed roots and reduced oak wilt spread by 50 percent (Rexrode 1977). Application of systemic silvicides to kill roots of symptomless oaks bordering an active infection center should suppress spread of oak wilt. Application of silvicides can be expected to result in mortality of treated healthy trees. Some systemic fungicides have been tried for suppressing oak wilt in Texas (Lewis 1978), but their effectiveness in a forested area is not known. To stop oak wilt spread through roots, these fungicides might eventually be used in trees bordering infection centers.

Preventing sapwood wounds during spring can reduce spread of oak wilt by insect vectors. Wounds made during spring wood formation have increased incidences of oak wilt in the northeast (Jeffery 1953). Oak wilt is favored by mild temperatures ($22^{o}$-$26^{o}C$) like those of a southern spring. Some potential insect vectors are also most active during this season. Southern areas with oak wilt should be carefully observed during spring, and cutting or other activities that wound trees should be minimized.

Trees killed by oak wilt will be colonized and decayed by other fungi such as Hypoxylon spp. Wood of recently killed trees is sound and salvageable but may harbor oak wilt fungus and insect vectors. If wood is moved from the growing site, escaping insect vectors and the fungus may be introduced and cause infections in new locations.

## Root Rots

Upland hardwoods may occasionally be affected by root rots, and leaf symptoms may be like those of wilt. Leaves gradually yellow over the entire crown before they turn brown. Most leaves remain on the tree. Roots die before the bole or crown do, and suckering seldom develops on the lower bole and rootcollar as it does on wilting trees. White or creamy fungal masses may appear in bark cracks or on rootcollars. Sporophores, mushrooms, or conks may develop on the ground near the base of affected trees or on decaying rootcollars. Trees of the same species will generally be affected by a specific root-rot fungus in a given area. An infectious disease or root rot is indicated when symptoms develop in one species while other species on the same site remain healthy.

We do not yet completely understand how most root rots of upland hardwoods develop. Some fungi may grow in tree roots for years without causing detectable disease symptoms, but in some poor environments they can damage or kill the host. These relationships are inadequately documented but can be observed in symptoms appearing during droughts.

Many laurel oaks (Quercus laurifolia Michx.) on a hill and slope near Gainesville, Florida, died during a drought in August 1978. When I observed them the next spring, Ganoderma lucidum (Leyss.) Karst. was fruiting on rootcollars. The fungus also fruited on trees that were partly dead and on trees with top dieback. Ganoderma lucidum can infect oaks without killing them (Toole 1966). Oaks in Florida apparently were infected with the fungus but did not develop symptoms and die until they were stressed by drought.

Chemical treatments for indigenous root rots are not economical, so management strategies must be used to minimize disease impact. When many merchantable trees die from root diseases, they should be cut and sold before their wood decays. Regeneration on sites with a high incidence of root rot should favor marketable species that are not susceptible to the indigenous fungus. Most nonindustrial hardwood stands are small and have a mix of species. A landowner should take advantage of this mix by making regenerative selections from nonsusceptible species on site.

## Declines

Oaks and other upland hardwoods may sometimes decline from unknown causes. Symptoms may include dwarfed leaves, gradual crown thinning, growth reduction, and twig and branch dieback. Trees may decline for several years and then die. Decline caused by an infectious agent may affect only trees of the same or similar species. Some declines may actually be unidentified wilts or root rots. A disease called live oak decline was known for 45 years in Texas before it was finally identified as oak wilt (Lewis and Oliveria 1979).

Oak decline and mortality in the northeast has been identified as a disease complex begun by gypsy moth defoliation and climaxed by lethal attacks from two-lined chestnut borers (Agrilus bilineatus Web.) and root rot caused by Armillaria mellea (Vahl. ex Fr.) (Houston 1979). Environment also influenced the decline. The often complex biological and physical factors responsible for declines may be difficult to identify, explain, and control. A landowner should seek professional assistance when making management decisions about a stand with declining trees in it.

Wilts, root rots, and declines should not be confused with leaf diseases, which are numerous. Anthracnose, leaf spots, powdery mildews, and rusts are some common leaf diseases. They are localized in leaves and may cause some defoliation but not death. They are unsightly, but control would not be economical. Leaf diseases are most important in ornamental trees.

## CANKERS AND DECAYS

### Cankers

Southern upland hardwoods are sometimes infected by canker fungi that damage a tree's morphology, physiology, and wood quality. Cankers are dead areas on boles, limbs, and twigs and are often outlined with callus. Initial stages in canker development on thick-barked species are difficult to detect because bark over cankered tissues varies little in color from bark over healthy tissues. Aged cankers are flattened or depressed areas in the wood; bark is cracked or sloughed. These depressions are made by growth of healthy wood around cankers. Various fungi cause cankers in oaks and other species, for example, Botryosphaeria spp., Endothia spp., Hypoxylon spp., and Nectria galligena Bres. These fungi, which can be identified by their reproductive structures on the host, can weaken stems to allow easy breakage, stain and decay wood, cause top dieback and destroy established apical dominance, and occasionally girdle stems and cause death.

Canker infections are started by fungal spores in bark wounds or on branch stubs. Some cankers are favored by cool spring temperatures and others by the higher summer temperatures. Those favored by high temperatures are usually most destructive during droughts, and those favored by cool temperatures usually become inactive as temperatures warm up in late spring. No chemical treatments for these cankers are economical. Natural stands do not need special attention for canker management alone. But severely cankered trees should be removed during thinnings or other silvicultural operations.

### Decays

Decays and associated defects account for more wood volume loss than all other hardwood diseases combined (Abrahamson and McCracken 1971). Decays reduce wood density and quality. Decaying trees use growing space and time, water, nutrients, and sunlight. On boles, indicators of decay are old butt scars from fires, butt bulges, rotten branch stubs, holes, blind knots, and sporophores or conks.

Many fungi decay wood. Some decay only heartwood, but others decay both sapwood and heartwood. Fungal spores are produced by sporophores on downed and standing trees. These spores are windborne and can start an infection if they land in a vulnerable place on the host.

Trunk rots are started by infections through wounds, fire scars, broken tops and branch stubs (DeGroot and McCracken 1977). But, a complex succession of nondecay microorganisms may actually condition the wood for decay before wood-decaying fungi become active. Such a succession has been observed in northern hardwoods (Shigo 1965). Trunk rots are limited to wood formed before wounding and later infection.

Canker rots are started by fungal infections through old branch stubs and are not restricted to wood formed before infection (Hepting 1971). The infection spreads through heartwood, sapwood, and cambium where it causes cankering. Canker rots are found mainly in red oaks but also occur in hickories, honey locust (*Gleditsia triacanthos* L.), some white oaks, and other hardwood species. An illustrated description of common canker rots has been prepared by McCracken (1978) and can be used to help landowners identify these decays in the field.

Decays can be minimized by effective management. Landowners should remove trees with canker and trunk rots to provide growing space for sound trees. Many decayed trees can be salvaged. Canker rots develop rapidly and should be dealt with when they are identified. Felling unmerchantable culls will reduce the amount of canker-rot infections by minimizing the distance spores are spread from sporophores on boles (McCracken and Toole 1974). Stand improvement cuts should remove trees with trunk rots and cankers that will cause culls. Primary stocking left after cuts should be trees with no rotten stubs over 3 inches (7.6 cm) in diameter, no large surface wounds, no holes, and three or fewer blind knots (healed stubs) anywhere on the bole up to 8 feet (2.4 m) above the merchantable top (Hepting et al. 1940).

Regeneration of harvested stands should include measures to reduce decay incidence. Most upland hardwood sites are relatively poor, and natural regeneration from stump sprouts may be most important.

Oaks are good stump sprouters on poor sites, and sprouts outgrow most competition (Johnson 1979). Sprout clumps may develop from one stump and require thinning. Heartwood decay is greater on poor sites than on good ones (Toole 1963), and its incidence can be increased if sprouts are not thinned properly. When thinning sprout oak clumps, landowners can reduce decay hazards by using Roth's recommendations (Roth 1956): thinning sprouts 3 inches (7.6 cm) or larger in d.b.h. will not create a decay hazard, thin larger sprouts only when the crotch is a wide "U-shape" and not when it is a "V-shape," and remove surplus sprouts with a sharp saw and make the cut smooth and slightly sloping. Never leave stubs. Successful management of regeneration will reduce decay hazards.

## CONCLUSIONS

Landowners can improve the health of their stands by removing cull trees. Firewood sales have increased greatly and provide economical opportunities for cull tree removal. Firewood from small tracts of land should be cut selectively so only diseased or cull trees are removed. But trees killed by oak wilt should not be moved to areas where the wilt is not known. Mark either cull or stock trees with paint so firewood cutters will remove only undesirable stocking. Regeneration of upland hardwoods on harvested sites will also allow economical opportunities for stand quality improvement.

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# ROLE OF FIP IN MID-SOUTH UPLAND HARDWOOD MANAGEMENT

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Abstract.--Standards for cost share eligibility and silvicultural guidelines have been developed in Tennessee to assure cost-effectiveness for the improvement of the State's hardwood timber resources under the Forestry Incentives Program. Practices for non-commercial improvement of hardwoods by crop tree release and site preparation for natural regeneration of hardwoods are described.

Additional keywords: Timber stand improvement, natural regeneration

Good morning! It is my task today to comment on some of the potential applications of FIP in managing Mid-South upland hardwoods. In doing so I plan to describe the practices that we in Tennessee have adopted and provide some of the rationale leading to their development. No doubt some of you have developed useful applications of FIP in hardwood management yourselves. If so, I hope you will write and tell me about them.

Although Tennessee is usually associated with that group of piney-woods states to the south concerning most forestry matters, we share a kinship with the North Central and Northeastern states in that our forests are dominated by hardwoods. According to the last forest survey (Hedlund and Earles, 1971), 86 percent of the State's commercial forestland acreage is classified as hardwood types (including the oak-pine type). Of this, 93 percent is in upland central hardwoods, 6 percent bottomland hardwoods, and less than 1 percent northern hardwoods. Eighty-one percent, 10.4 million acres, is controlled by farmers and other independent private owners.

Stocking was moderate or low on the average wooded acre in 1970. Net annual growth was 40 cubic feet per acre, only about 56 percent of potential (Murphy, 1972). It is easy to see there is still plenty of room for improvement of hardwood timber production in the Volunteer State.

We also have the all-too-familiar overabundance of cull and low-grade hardwood material and too few markets for it. Eight or nine pulp and paper mills utilize hardwoods grown in Tennessee, and the use of logging residues and other small roundwood for fuel is growing. Even so, markets for the large volumes of hardwood material available are still inadequate, and this fact provides little incentive for landowners to adopt active hardwood management programs.

When FIP appeared in 1974, we were suddenly involved in the development of a totally different kind of program from any we had previously administered. This one had as its objective cost-effective timber production. In some ways our State FIP was sound in this regard. In the first year, for example, 10 acres was established as the minimum size treatment area in the interest of timber production efficiency and cost-effectiveness.

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In other areas our foundations were shaky. In retrospect, too little guidance was provided to foresters and landowners alike concerning minimum qualifications for eligibility and specifications for performance. As a result, survival and growth of planted seedlings was disappointing and the effectiveness of many TSI jobs was questionable.

A formal evaluation of the 1974 FIP furnished a measure of the cost-effectiveness of the Program in the first year: tree planting practices generally yielded good or excellent returns, but annual rates of return for TSI in the oak-hickory type were poor, only 4.7 percent (Mills and Cain, 1978).

Not surprisingly, virtually all the TSI carried out in the State during that first year had been in the oak-hickory type. So to us the message was clear: we needed changes in our State Program to assure that hardwood practices were as cost-effective as we could make them. At the same time, and perhaps more important, we recognized the need to design practices that would exert as much favorable impact on our hardwoods as pine plantings do on the softwood resource in the piney-woods states.

## TSI - NON-COMMERCIAL THINNING AND CROP TREE RELEASE IN POLE-SIZE TIMBER

The term TIMBER STAND IMPROVEMENT means many things to many people. I have never met two people who have the same mental picture of the concept. It sounds good because it contains the word IMPROVEMENT, and we can probably agree that TSI objectives usually call for improvement of growth, stand quality, and species composition by reducing stocking. Most of us can also agree with Ken Lancaster, who states in his Guide to Hardwood Timber Stand Improvement (1975), that "timber stand improvement is performed to shift growth to fewer trees of better form and higher value."

It is when we begin defining stand conditions that dictate the need for TSI and how to carry out the operation that our views and opinions diverge. Everyone has his own ideas. Some say that almost all stands would benefit to some degree from TSI. A few question TSI altogether. Still others maintain that TSI can probably be justified, that is, from the standpoint of cost-effectiveness, under certain conditions of stocking, age, species composition, and site capability.

Before guidelines were developed in Tennessee, TSI was as variable as the ideas of the foresters prescribing it and the landowners and vendors carrying it out. Most often it involved various combinations of cull removal, understory release, vine and undesirable species control, and sometimes thinning. We observed a number of cases in which most of the effort went into deadening undesirable species and trees in the intermediate and suppressed crown classes. In many cases dogwoods and redbuds were injected in the name of timber production. In some, thinning was avoided, especially if it involved deadening highly favored species such as yellow poplar or white oak. There seemed to be no concensus on how TSI should be carried out.

We concluded that our goal should be to make a hardwood TSI practice available under FIP that would stand the test of cost-effectiveness, i.e., a practice that would justify the expenditure of capital in return for increases in timber quality and quantity over time. To do so would require setting down more stringent standards for foresters to determine the eligibility of candidate stands as well as silvicultural guidelines for carrying out TSI operations. This would be the first step toward insuring cost-effectiveness and would assure uniform application of standards and specifications throughout the State.

The perennial difficulty of transferring technical forestry specifications from the forester to the landowner and/or vendor was also recognized. It is not enough for the forester to know what is supposed to be done. Since he is not going to carry out the job personally, he must be able to convey the "how-to-do-it" to the landowner or vendor in a way that is clear and meaningful.

In some states foresters mark the trees to be eliminated for TSI. This is fine if you can spare the time and manpower. We were not able to do so; so we had to find another way.

We proposed to develop a handout that would describe the how-to-do-it, reasoning that if TSI really is a viable, legitimate cultural measure, it should be possible to write up guidelines in such a way as to be read, understood, and applied in an effective manner by most landowners and vendors. In any event, that was our belief and our objective.

With the help of Dan Sims, Upland Hardwood Specialist with State and Private Forestry, we developed a practice entitled, Non-Commercial Thinning and Crop Tree Release in Pole-Size Timber. Under the practice, cost sharing may be authorized for crown release of carefully selected crop trees in stands that meet eligibility requirements.

This represented a radical departure from the traditional approach we had formerly taken toward TSI. In the past we instructed landowners and vendors to look for and eliminate the so-called "bad" trees, the culls, the crooked, forked, excessively-limby, slow-growing, diseased, low-quality trees, and trees of inferior species. In short, we emphasized the negative instead of accentuating the positive. Turned loose on their own, landowners and vendors could probably find something wrong with almost every tree in the woods. To be on the receiving end of this kind of information could be a confusing and frustrating experience.

Our new approach is more positive. Now, instead of telling landowners to look for the "bad" trees, we tell them to identify a limited number of well-spaced better trees in the stand, provide them ample growing space by eliminating the immediately adjacent competitors, and not to worry that a few crop trees are slightly less than perfect. In the end you have to work with the trees found growing there.

Before considering eligibility for cost sharing, the forester evaluates the potential for a commercial TSI operation in which pulpwood and/or firewood might be marketed. As you might guess, we have found that commercial TSI operations are the exception rather than the rule. But in the years ahead, as energy wood becomes more important and as markets for fiber expand, commercial TSI operations may become commonplace. I hope they will.

If a commercial operation is clearly out of the question, the forester must determine the eligibility of the stand for cost sharing based on cost-effectiveness criteria. What, you may ask, makes TSI cost effective? According to most researchers, non-commercial TSI can probably be justified if the following conditions exist:

1. The site should be better than average for the species or species group.

2. The stand should be well stocked with trees of desirable species.

3. The stand should be young enough to insure that crop trees possess sufficient vigor to respond to release.

4. A majority of the crop trees should be in need of release treatment.

We made an additional assumption while developing the practice, and that is, that only one non-commercial operation would or should be carried out in the stand during the rotation. So we said that eligible stands must consist of pole-size timber which may range from a minimum average DBH of 6 inches to a maximum average DBH of 10 inches.

A non-commercial venture in stands that average less than 6 inches DBH would constitute an operation more akin to a cleaning, and sometime before reaching small sawlog size they might require a second non-commercial operation. Stands that average more than 10 inches DBH should not be considered because they are almost or already large enough for a commercial thinning.

Specific guidelines developed for cost share eligibility are as follows:

1. Sites must have a minimum site index of 70 for upland oaks, 75 for yellow poplar, 80 for sweetgum, 65 for bottomland oaks, or an equivalent site index capability for other species.

2. Minimum qualifying stocking will vary according to the average DBH of the stand, determined by visiting representative points in the stand and recording "in" trees on a tally sheet developed for the purpose. Minimum qualifying stocking ranges from 57 square feet of basal area for stands which average 6 inches DBH, to 67 square feet for stands that average 10 inches. These guides were extrapolated from stocking charts in Roach and Gingrich's Even-Aged Silviculture for Upland Central Hardwoods (1968) and represent the bottom or lower end of the "B" or full stocking level on the charts.

3. Qualifying stands must be at least 20 years old but no more than 45 years of age; i.e., stands must have developed to the point that the four crown classes are clearly distin-

guishable, but crop trees are still young and vigorous enough to respond to crown release.

4. At least 60 percent of the crop trees observed at sample points should need crown release. This determination is made by observing the crop tree closest to each sample point.

Average DBH, basal area per acre, and percent of crop trees needing release can be quickly calculated, making the job of eligibility determination an easy one.

We have received a few complaints that a lot of stands do not qualify and we noticed a drop in the TSI accomplishment acreage the year following implementation of guidelines. We hope this is an indication that the system is working. It also suggests what we suspect, that relatively few stands can justify a non-commercial operation.

So much for stand eligibility. How is the operation carried out once an eligible stand is identified? Briefly, we tell landowners that the principal objectives are to select and release a limited number of crop trees, a maximum of 100 per acre.

Crop trees are defined as those trees which will eventually form the main stand of high quality sawtimber when the stand reaches economic maturity. They are the best representative individuals of the stand. If possible, they should be most commercially valuable species, but when they do not occur, any species commonly marketed as sawtimber in the area is acceptable. Trees with the longest, straightest stems, freedom from forking, good natural pruning ability, freedom from defect and damage, etc., should receive priority as crop trees. Finally, crop trees must be in the dominant or codominant crown classes. Intermediates and suppressed trees are never acceptable as crop trees.

Ideally, crop trees should be spaced about 20 feet apart, but because trees in natural stands are not spaced evenly, it will be impossible to find such spacing. Even so, by using this as a guide, a maximum of 100 trees per acre may be selected. If it is impossible to locate a crop tree within a 15 to 25-foot distance from the last crop tree, the best dominant or codominant available should be selected. We furnish our foresters flagging tape for identifying crop trees on sample areas of up to an acre in size for the benefit of the landowner. We have found that the selection process is relatively simple after a little practice.

For the release operation, we specify deadening or cutting only those trees necessary to release the upper two-thirds of the crowns of crop trees. In most cases this means eliminating trees in the codominant crown class. In some instances they may be as high in quality as crop trees. Although this may be disturbing, most of these would not otherwise live to maturity. At some future time they would be eliminated by competition. Moreover, we believe that released crop trees will regain much of the growth lost by removal of competing trees.

Since they do not normally compete directly with crop trees for sunlight, most intermediate and suppressed trees of tolerant understory species are left untreated. These provide food for birds and other wildlife and lend beauty to the forest landscape, especially during spring and fall. When squirrel or other denning species are a landowner objective, one or more den trees per acre may be left untreated if found in competition with crop trees.

These instructions for TSI were written up and printed as a how-to-do-it handout for landowners. Our foresters attach a copy to FIP management plans whenever the practice is involved.

The jury is still out concerning the true cost-effectiveness of this practice, but it has been generally well received by foresters and landowners. Perhaps the next FIP evaluation will provide the answer.

## SITE PREPARATION FOR NATURAL REGENERATION OF HARDWOODS

If a crop tree release practice is only applicable in certain well-stocked young stands on good sites, what is to become of the great majority of Tennessee's hardwood-dominated forests where production is so low and where intermediate cultural treatments are useless?

Hundreds of thousands, perhaps millions, of acres of Tennessee forestland have been subjected to abuse by high-grading and other destructive cutting practices during the past 200 years. By and large, the low stocking of most hardwood stands is traceable to the cut-out-and-get-out practices of the past.

Areas that were cut most heavily in the past sometimes support the best, fully-stocked stands today. Usually, though, the worthless culls and trees of non-commercial or low value species were left and now constitute the greater proportion of stocking on cut-over lands.

Today, we are challenged with the task of making these lands productive once again. The question is, how can we transform these destitute woodlands into vigorous, well-stocked stands of commercially valuable trees?

Ideally, we need wood energy and fiber markets to be able to move the millions of tons of biomass found on these areas. In time, markets will undoubtedly materialize, but meanwhile, incentives are needed to begin returning hundreds of thousands of acres of excellent hardwood sites to high quality timber production. We saw need for a practice that would completely renovate stands by natural means rather than resorting to expensive and difficult artificial means.

With the help of Dan Sims, we combined a review of the literature with our familiarity with Tennessee hardwood types and species and concluded that a practice for natural regeneration held potential for rehabilitating hardwoods on a large scale. Moreover, we believed it could be done cost-effectively.

The task was to take advantage of the enormous capacity of our hardwoods to regenerate themselves. Quality stems can be regenerated from several reliable sources. Oak, hickory, beech, maple, blackgum, ash, and several other species establish themselves by advance regeneration, stump sprouts, and root sprouts. Seedlings from about 4½ feet high up to 1.5 inches DBH may be considered as advance reproduction, and even if broken or knocked down during logging operations, they will develop vigorous sprouts near groundline and produce well-formed stems. Stump sprouts are more numerous from smaller trees than from larger ones. Even small culls and trees in the intermediate and suppressed crown classes will usually produce good sprouts if cut close to the ground.

Root sprouts can also be expected to generate good growing stock. Sweetgum, for example, is a prolific sprouter, and various oaks and hickories produce root sprouts, although considerably fewer than sweetgum.

We know of no instances in which it is necessary to leave seed trees. If yellow poplar or ash have been present in the stand for the past few years, chances are good that adequate restocking of these species will occur from germination of seed lying dormant on the forest floor. Seed from both species has been shown to retain viability in the woods for several years. Germination occurs when light is introduced through removal of the overstory.

Scarification, as may be provided by logging, is usually not necessary. We have found that yellow poplar seeds sandwiched between moist, fallen leaves and other organic material will germinate when light is introduced even though they are not in contact with mineral soil.

The main problem in regenerating hardwoods by natural means is predicting and regulating species composition. We naturally prefer to create new stands composed of oak, walnut, yellow poplar, ash, and other species of high value potential, but often this is not possible. Red maple, blackgum, and other species of low value sometimes predominate after many years of repeated high-grading.

While improvement of species composition in new stands is highly desirable, we do not worry if the more valuable species are in the minority. Species now considered worthless or of low value are likely to become valuable in the years ahead. The most important consideration at this time is to secure restocking and complete utilization of the site. Species composition may be regulated and upgraded more effectively later, when it is time to TSI or thin the stand.

Although this is nothing new to many of you here today, we are experiencing difficulties in securing oak regeneration on good sites and even on medium sites. Recently we observed stands on some of our state forests that were subjected to improvement cuttings and thinnings in the late 1960s. On all but the poorest sites, yellow poplar has invaded and now dominates stocking in openings created by logging.

Oaks were extremely scarce in almost every case. While yellow poplar is a desirable, fast-growing component, we are concerned by the apparent inability of oak to replace itself on sites where it formerly flourished. Implications for the lack of oak in new stands are as serious for wildlife as for timber management.

Recognizing stands for natural regeneration treatment is usually no problem, but foresters must remain alert. Stands which have been recently overcut or stripped of merchantable timber are obvious candidates. Others, which have been repeatedly high-graded, subjected to severe and repeated burning, or severely overcut 10 to 50 years ago are not as obvious.

The natural beauty of an undisturbed woodland creates a false impression of its true productivity. At first glance a stand which displays no indication of recent cutting or other disturbance may create the impression of a thrifty, productive stand. Closer inspection often reveals stocking composed of undesirable or unmerchantable species, poorly-formed trees, or fire-scarred culls. An inventory of sound, well-formed growing stock may reveal a grossly understocked stand when compared to well-stocked stands of similar age on comparable sites.

Treatment is fairly simple but may be difficult to apply if the area has been logged within the last two or three years. Ideally, trees of desirable species should be cut to induce stump and root sprouting, and undesirable species should be deadened to completely eliminate them from the stand. In most cases, however, two separate treatments are impractical; so we suggest that all trees two inches and larger at the stump be cut or lopped as close to the ground as possible.

Sometimes it may be easier and cheaper to inject a few large, residual culls or stands dominated by red maple and other undesirable species. In most stands, however, cutting alone will do the job. Sprouting will occur on desirables and undesirables alike, but the faster growing intolerants are also the more desirable species and will usually dominate the stand in the end.

To satisfy requirements for cost share eligibility under FIP, sites must have a minimum site index for the species which is expected to form the bulk of the new stand. For example, a site on which yellow poplar is expected to be the predominant component must have a site index of at least 70 for yellow poplar; for upland oaks and hickory, a minimum site index of 65; for bottomland oaks, a site index of 60; for sweetgum, a site index of 75, etc.

Sites on ridgetops, upper slopes, and southern and western aspects, which fall below site productivity requirements, are excluded from eligible areas on which costs are shared. Stand size must be at least 10 acres to meet eligibility requirements, but we try to restrict stand size to a maximum of about 50 acres. On larger ownerships we recommend random dispersal of stands to serve wildlife habitat needs and to minimize adverse impacts to soil and water resources and aesthetic values.

So far we have experienced limited landowner participation in this practice. One reason may be a resistance to clearcutting, but more probably, most landowners are not as aware of it as a forestry practice as they are tree planting and TSI. Although there have been only a few participants to date, field foresters indicate a growing interest in and acceptance of the practice by landowners.

Cost share levels for these practices are not easy to establish when starting from ground zero, but from our experience to date, average statewide costs for crop tree release in pole-size timber are $32.00 per acre. For treatment of areas for natural regeneration of hardwoods, costs are $48.00 per acre. Cost share rates in Tennessee are set at 75 percent of actual cost not to exceed 75 percent of the average statewide total cost for the practice. Thus, the current maximum is $24.00 per acre for crop tree release and $36.00 per acre for site preparation for natural regeneration.

In conclusion, we believe that FIP offers considerable potential for improving upland hardwoods in the South Central states. We also think that cost-effectiveness of these practices is possible if simple rules for eligibility and silvicultural guidelines for performance are adopted.

For those of you who may be interested, a copy of Tennessee's FIP Handbook specifications for eligibility and performance of these practices and the landowner handout explaining crop tree release is attached to this paper for inclusion in the Proceedings. Should anyone have questions, I shall be happy to respond to them by mail.

## LITERATURE CITED

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SPECIFICATIONS AND SPECIAL INSTRUCTIONS FOR FIP AND ACP PRACTICES

FP2 and FR2

## Non-Commercial Thinning and Crop Tree Release in Pole-Size Timber

Treatment and Primary Objective: Cost sharing for TSI in existing stands under FIP and ACP will be made only for crown release of selected crop trees in pole-size timber where no readily available markets exist for this size material. The main purpose of this treatment is to release only those stems which will form the primary stand stocking in a free-to-grow condition while maintaining full utilization of the site throughout the rotation. Maintenance of this condition will assure maximum timber yield and quality.

Before making a TSI investment decision, the landowner, with the forester's assistance, should make an effort to market low-grade trees, culls, pulpwood-size trees, and "thinners" as pulpwood or firewood for whatever financial return they may yield. It is always best to turn a profit or, at least, break even when carrying out forest improvement measures and thus avoid needless expenses which reduce future profits. When such markets do not exist, however, TSI may be a sound investment, but care must be exercised to carry out the practice in such a manner as to derive the greatest response from the residual stand with the funds available.

Whether the operation results in the sale of products or requires the investment of funds, TSI is performed for the purpose of shifting growth to fewer trees of better form and higher value. When TSI is carried out, stand density is reduced, better spacing is achieved, stand quality and composition are upgraded, and the growth of selected crop trees is improved. This ultimately results in a shorter period of maturity and a significantly higher rate of return. In short, thinnings and release cuttings, whether commercial or non-commercial, are the very essence of forestry science, the cultivation of timber of higher quality in less time than nature alone can produce.

Determination of Cost Share Eligibility:

A. Criteria: In order to qualify:

1. Stands must be pole-size timber which may range from a minimum average DBH of 6 inches to a maximum average DBH of 10 inches. Trees to be included in the eligibility determination are those trees 4 inches DBH and larger which form the main crown canopy. Do not record:

    a. Trees smaller than 4 inches DBH, regardless of species.

    b. Trees in the intermediate or suppressed crown class, regardless of species.

    c. Tolerant understory trees such as dogwood, redbud, sourwood, buckthorn, pawpaw, and the like which do not compete with trees in the main crown canopy for light.

d. Large, older, scattered trees - minority components of the total stand - usually of low value or cull, which were not cut in previous harvest cuttings.

Tolerant understory trees should neither be considered in determining eligibility nor as trees to be eliminated under this practice.

2. Stands must be at least 20 years old but no more than 45 years of age, i.e., stands must have developed to the point that the four crown classes (dominant, codominant, intermediate, and suppressed) are clearly distinguishable, but crop trees are still young and vigorous enough to respond to crown release.

3. Sites must have a minimum site index of 70 for upland oaks, 75 for yellow poplar, 80 for sweetgum, 65 for bottomland oaks, or an equivalent site index capability for other species. Areas such as ridge tops, upper slopes, and south and west slopes, where site capability falls below the above minimums, should be delineated on the map of the property and excluded from the eligible area on which costs are shared.

4. Minimum stocking requirements will vary depending upon the average DBH of the stand, including crop and non-crop trees but excluding tolerant understory species. The table below indicates minimum stocking in basal area per acre required for cost share eligibility. 1/

| Average DBH | Sq. Ft. BA/AC. |
|---|---|
| 6 | 57 |
| 7 | 60 |
| 8 | 62 |
| 9 | 65 |
| 10 | 67 |

1/ In Roach, Benjamin A. and Samuel F. Gingrich. 1968. Even-aged silviculture for upland central hardwoods. USDA Forest Service Agriculture Handbook 355. Northeastern Forest Experiment Station, Upper Darby, Pennsylvania. 39p.

5. At least 60 percent of the crop trees observed on sample points must need crown release.

B. Procedures: Visit 15 to 30 randomly selected points within the stand. At each point dot tally the DBH of "in" trees in Column A on the reverse side of the Treatment Area Description and Management Prescription Summary form. Next, select the nearest crop tree (see definition of crop tree under Selection of Crop Trees) to the prism point, determine whether crown release is needed, and indicate by dot tallying in the appropriate space on the form. Be sure to dot tally each point visited in the space at the top of the page.

After collecting field data, multiply Column A x Column B for each DBH class and the product, Column C x each DBH class, and record it in Column D. Then determine:

1. Average DBH of the stand by dividing the sum of Column D by the sum of Column C.

2. Average basal area per acre by dividing TOTAL number of trees tallied in Column A by the number of points visited and multiplying by 10.

3. Percent of crop trees needing release by dividing the number of crop trees needing release by the total number of crop trees observed and multiplying by 100.

4. Use table of Minimum Stocking Required for Cost Share Eligibility to determine whether stand qualifies for cost sharing.

Selection of Crop Trees: Crop trees are the best representative of the stand in terms of desirable species, good form, overall high quality, rapid growth, freedom from disease or defect, and are either in the dominant or codominant crown class. Crop trees are those individuals which will be carried through to the end of the rotation. In the TSI operation crop trees will be ear-marked at a relatively early age for special attention and intensive treatment in order to optimize their growth and high quality potentials. In the selection process, emphasis will be placed on proper spacing (or even distribution), species, crown class, and form as defined below:

A. Spacing and Distribution: Under ideal stocking conditions, crop tree spacing would be about 20 x 20 feet, resulting in about 100 trees per acre. However such conditions seldom, if ever, exist in natural stands; so fewer stems are usually available as crop trees. This is OK. As long as minimum stocking requirements are met, a sufficient number of crop trees will always be present.

B. Species: When present, the more commercially valuable species such as black walnut, ash, cherry, yellow poplar, sweetgum, and the better oaks will be selected, but where they do not occur, any hardwood species commonly marketed as sawtimber in the area will qualify.

C. Crown Class: Crop trees must be dominant or codominant in the crown canopy.

D. Bole or Stem: Select trees with the longest clear bole length. Priority should be given for straightness, freedom from forking, natural pruning ability, small branch diameter, high form class, and freedom from fire and mechanical damage. Avoid trees (especially white oak) which display a tendency for epicormic branching.

Release of Crop Trees: Cut or deaden only those stems necessary to release 75 to 100 percent of the upper two-thirds of the crop tree crown. The degree of release should provide the crop tree crown with development space for about 10 years.

Plan specifications may also include deadening large scattered culls, mentioned earlier, which were not cut in previous timber harvests. Although this will provide more flexibility, caution must be exercised to insure that it remain a "crop tree release" practice and not become a "cull deadening" practice. If the stocking of large, older culls exceeds 25 percent of total stocking, chances are that stocking of pole-size timber is too low to qualify for treatment.

Trees in the intermediate and suppressed crown classes and all other trees in the stand not competing directly with crop trees will be left to grow until they can be removed in the next commercial thinning, cut for firewood, or harvested with crop trees at maturity. By leaving such trees, full utilization of the site will be assured.

Understory trees such as dogwood, redbud, buckthorn, sourwood, and pawpaw should also be left untreated since they do not normally compete directly with crop trees for sunlight. Moreover, they often provide food for various birds and animals and lend beauty to the landscape, especially during the spring and fall.

When it is suitable to provide suitable habitat for squirrels or other species that use den trees, one to three den trees per acre may be left untreated if found in competition with a crop tree. Sometimes alternate crop trees may be chosen. In any case, the increase of growth foregone will not override the value of these few den trees for wildlife. Modification of the practice to reach multiple-use objectives should be discussed in the landowner's prescription plan.

Vines growing into crop trees or in trees immediately adjacent to crop trees should be severed or deadened near the ground.

## Site Preparation For Natural Regeneration

Hundreds of thousands - perhaps millions - of acres of forestland in Tennessee have been subjected to abuse by overcutting, high-grading, and other destructive cutting practices during the past 200 years. The relatively low stocking of most hardwood stands is traceable to the cut-out-and-get-out practices of the past.

Those areas that were most heavily cut often support the best, most fully-stocked stands. Usually, though, the worthless culls and trees of non-commercial species were left and formed the principal residual stocking on cut-over lands.

Today we are challenged with the task of making these lands productive once again by promoting the establishment of new, fully-stocked stands by all means at our disposal. The component, "site preparation for natural regeneration," available under FIP (FP2) and ACP (FR2), was designed to permit cost sharing with landowners for restocking their abused forestlands by natural regeneration.

This method of regeneration is highly desirable because it is both easy and virtually foolproof. Almost without exception, hardwoods will successfully regenerate themselves provided proper conditions are created in the woods. It is also inexpensive and therefore cost effective, especially when compared to costs of artificial regeneration.

The chief difficulty in regenerating hardwoods by this method is predicting and regulating species composition. Composition of the new stand will depend in large measure upon (1) advance reproduction, (2) species composition during the recent past (1 to 10 years), and (3) present species composition.

We naturally prefer to create new stands composed of oak, walnut, yellow poplar, ash, and other species of high value potential, but many times this is not possible. Maple, gum, and other species of relatively low value often predominate after many years of repeated high-grading.

While improvement of species composition in new stands is highly desirable, do not be disturbed if the more valuable species are in the minority. Species now considered worthless or of low value are likely to become valuable in the years ahead. The most important consideration at this time is to assure restocking and complete utilization of the site. Species composition may be regulated and upgraded more effectively later when it is time to TSI or thin the stand.

When regenerating a stand by natural means, stocking may be obtained from several sources. Oak, hickory, beech, maple, blackgum, and ash establish themselves in the new stand by advance reproduction, stump sprouts, and root sprouts. Seedlings from about 4½ feet high up to 1.5 inches DBH may be considered advanced reproduction, and even if broken or torn up during timber harvesting operations, they will sprout and develop well-formed stems.

Stump sprouts and root sprouts are more numerous from smaller trees than from larger ones. In order to induce sprouting, unsalable oaks, hickory, and walnut larger than 2 inches in diameter at stump height should be cut (not injected) as close to the ground as possible (within 4 inches) to prevent decay from entering the new stem. Residuals of undesirable species should be injected with herbicide as should large vines.

Root sprouts can also be expected to generate desirable growing stock, but some species sprout more readily than others. Sweetgum, for example, is a prolific sprouter, and various oaks and hickory produce desirable root sprouts, although considerably fewer than sweetgum.

Yellow poplar and ash also regenerate from sprouts, but if they were present in the stand during the past few years, chances are good that adequate restocking of these species will occur from the germination of seed lying dormant on the forest floor. Seed from both species has been shown to retain viability in the woods for several years (up to 8 years for yellow poplar). Germination occurs when light is introduced through overstory removal.

Scarification, as may be provided by a logging operation, is not always necessary. Yellow poplar and ash seed sandwiched between moist, fallen leaves and other organic material will germinate when light is introduced and produce excellent growing stock even though not in contact with mineral soil.

Vines, especially grapevines, can cause serious problems in natural regeneration. Often when the overstory is eliminated, vines will proliferate and spread over large areas. Desirable reproduction can be shaded out before it ever has a chance to grow. Large saplings and even pole-size trees may be ridden down, deformed, and shaded out by rapidly growing vines. Landowners should be advised to inject or cut-and-poison vines to prevent their interfering with stand regeneration. (Ideally, vines should be cut 1 to 3 years prior to timber harvest and allowed to die.)

Thus, adequate natural regeneration is fairly easy to secure provided all residual trees larger than 2 inches in diameter at the stump are cut (as in the case of oaks, hickory, walnut, and other desirable species) or deadened with herbicide (as in the case of undesirable species and vines).

Before recommending a combination cut-plus-injection operation, examine the site thoroughly and make a ball-park determination of the relative proportion of desirable and undesirable species present. If the portion of stems of undesirable species is not overwhelming or dominated by red maple, you may feel secure in recommending that all standing trees be cut. Sprouting will, of course, occur on undesirables and desirables alike, but the faster growing intolerants are the more desirable species and will soon dominate the site and out-compete the undesirables.

To satisfy requirements for cost share eligibility, sites must have a minimum site index for the species which is expected to form the bulk of the new stand. For example, a site on which yellow poplar is expected to be the predominant component must have a site index of at least 70 for yellow poplar; for upland oaks and hickory, a minimum site index of 65; for bottomland oaks, a site index of 60; for sweetgum, a site index of 75.

TIMBER STAND IMPROVEMENT
BY
CROWN RELEASE OF CROP TREES IN POLE-SIZE TIMBER

Investments in forestry are sometimes made reluctantly since the return on such investments comes only after many years of timber growth. A planted pine stand seldom reaches merchantable (pulpwood) size before fifteen years of age. Therefore, it is impossible to "cash-in" on a tree planting investment in any shorter time. Even so, studies have shown that planted pines are a reasonably good investment when site preparation costs are not excessive and protection from wildfire, especially during the early years of the stand, is assured.

In the case of timber stand improvement (TSI), investment potentials are not as well documented although the "payoff" period is normally shorter than in the case of tree planting investments. It is well known, however, that TSI can be effective and economical when:

1. The stand is well stocked with desirable trees;

2. The stand is pole-size timber (timber 6 to 10 inches DBH), 20 to 45 years of age, and in thrifty condition;

3. The site is above average in timber growth potential; and

4. Effort and expense are directed toward releasing a limited number of well dispersed "crop trees" (a maximum of 100 per acre) which will eventually form the main stand of high quality sawtimber at the time the stand reaches economic maturity, usually about 80 years of age.

Before making a TSI investment decision, however, the landowner should make every effort to market low-grade trees, pulpwood-size trees, and "thinners" as pulpwood or firewood for whatever financial returns they may yield. It is always best to turn a profit or, at least, break even when carrying out stand improvement measures and avoid needless expenses which reduce future profits. When such markets do not exist, however, TSI may still be a sound investment, but care must be exercised to carry out the practice in such a manner as to derive the greatest response from the residual stand with the funds available.

Whether the operation results in the sale of products or requires the investment of funds, TSI is performed for the purpose of shifting growth to fewer trees of better form and higher value. When TSI is carried out, stand density is reduced, better spacing is achieved, stand quality and composition are upgraded, and the growth of selected crop trees is improved. This ultimately results in a shorter period of maturity and a significantly higher rate of return. In short, thinnings and release cuttings, whether commercial or non-commercial, are the very essence of forestry science, the cultivation of timber of higher quality in less time than nature alone can produce.

CROP TREE SELECTION

Crop trees are the best representative individuals of the stand. Because they will form the major portion of the stand at maturity, they will be ear-marked at a relatively early age for special attention and intensive treatment in order to take advantage of their potential for growth and quality improvement. In the selection of crop trees, emphasis should be placed on proper spacing (or even distribution), species, crown class (position in the crown canopy compared to other trees of the same age), and form as described below:

1. Spacing and Distribution: Ideally crop trees should be spaced about 20 feet apart, but because trees in natural stands are not spaced evenly, it will be impossible to find crop trees spaced this distance. Even so, by using it as a guide, a maximum of 100 trees will be selected. If it is impossible to find a crop tree within a 15 to 25-foot distance from the last crop tree, pick the best dominant or co-dominant tree (see 3a and b on next page) available OR proceed until one is found. It is suggested that plastic flagging or string be tied around 25 to 50 of the first trees selected to get a feel for distribution and spacing of crop trees. Practice will make selection easier.

2. Species: When present, the more commercially valuable species such as black walnut, cherry, ash, yellow poplar, sweetgum, and the better oaks should be selected as crop trees, but where they do not occur, any hardwood species commonly marketed as sawtimber in the area will be acceptable. The forester will advise on the selection of the most valuable species.

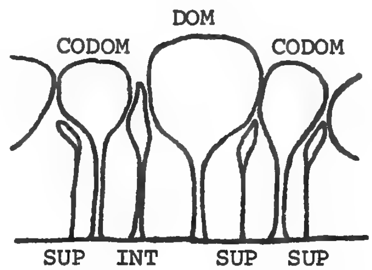
3. Crown Class: By the time the stand attains pole-size, trees in the main stand will have, through lifelong competition with their associates, assumed a certain position within the structure of the stand. Foresters recognize four relative classes of trees within a stand based upon the position and condition of the tree crowns and defined as follows:

   a. Dominants: Trees with crowns extending above the general level of the crown cover, and receiving full light from above and partly from the side; often the largest trees in the stand.

   b. Codominants: Trees with crowns forming the general level of the crown cover and receiving full sunlight from above but comparatively little from the sides.

   c. Intermediates: Trees shorter than dominants and codominants but with crowns extending into the crown cover formed by dominants and codominants, and receiving little direct sunlight above but none from the sides. Trees with small crowns crowded on the sides.

   d. Suppressed or Overtopped: Trees with crowns below the general level of the crown cover, receiving no direct sunlight either from above or from the sides. Trees with small, sparse crowns.




   Because they have competed more successfully with their neighbors in the past and are likely to continue to do so in the future, trees in the dominant and codominant crown classes should be chosen as crop trees. Never select an intermediate or suppressed tree as a crop tree.

4. Bole or Stem: Select trees with the longest clear bole length. Priority should be given for straightness, freedom from forking, natural pruning ability, small branch diameter, minimum taper, and freedom from fire and mechanical damage. Avoid trees (especially white oak) which display a tendency for epicormic branching.

## RELEASE OF CROP TREES

Cut or deaden only those stems necessary to release 75 to 100 percent of the upper two-thirds of the crop tree crown. The degree of release should provide the crop tree crown with development space on at least three sides of the crown for about 10 years.

In some stands the trees to be deadened or cut are as high in quality as the crop tree. Although this may be disturbing, remember that most of the trees that will be eliminated would not otherwise live to maturity. At some future time they will be shaded out and die. Moreover, released crop trees will regain much of the growth lost by the removal of competing trees.

Sometimes a compromise is in order. If two high-quality trees are growing side by side in close proximity, the best decision may be to accept both as crop trees and release on two or three sides.

Trees in the intermediate and suppressed crown classes and all other trees in the stand not competing directly with crop trees should be left to grow until they can be removed for pulpwood or firewood in the next commercial thinning or harvested with crop trees at maturity. By leaving such trees, full utilization of the site will be assured. Large, wide-spreading "wolf" trees and hollow culls should also be left unless they are competing directly with the crowns of selected crop trees.

Understory trees such as dogwood, redbud, buckthorn, sourwood, and pawpaw should also be left untreated since they do not normally compete directly with crop trees for sunlight. Moreover, they often provide food for various birds and animals and lend beauty to the landscape, especially during the spring and fall.

When it is desirable to provide suitable habitat for squirrels or other species that use den trees, one to three den trees per acre may be left untreated if found in competition with a crop tree. In any case, the increase of growth foregone will not override the value of these few den trees for wildlife.

Vines growing into crop trees or in trees immediately adjacent to crop trees should be severed or deadened near the ground.

TREATMENT AREA DESCRIPTION AND MANAGEMENT PRESCRIPTION SUMMARY

COUNTY: ____________ ASCS FARM NO. ________ DATE OF EXAMINATION: ________

________________________________ Prior CFM? Yes ( ) No ( )
(Landowner's Name and Address)

Landowner's Multiple-Use Objectives: ________________________________

AREA NO. ________

I. Description of Treatment Area
A. Non-Stocked Land
1. Prior Use: Pasture ( ) Cropland ( ) Forest ( )
2. Present Vegetative Cover: ________________________________

B. Forestland
1. Forest Type: Yellow Pine ( ) Oak-Pine ( ) Oak-Hickory ( )
Bottomland Hardwoods ( ) Other ( ) Specify: ________
2. Size Class: Seedling and Sapling ( ) Pole Timber ( ) Sawtimber ( )
3. Principal Species: ________________________________

4. Stocking: Average basal area per acre of merchantable tree species:
0-20 21-40 41-60 61-80 80+ (sq. ft.)

II. Site
A. Topography: Flat ( ) Rolling ( ) Flood Plain ( ) Stream Terrace ( )
Cove or Hollow ( ) Ridge or Upper Slope ( ) Side Slope ( )
B. Physiographic Class: Very Dry ( ) Moderately Dry ( ) Well Drained ( )
Moderately Wet ( ) Wet ( )
C. Slope: ________ Percent D. Aspect: N--NE--E--SE--S--SW--W--NW
E. Site Index: (For Existing Forest Type - Predominant Species)

| | No. 1 | No. 2 | No. 3 |
|---|---|---|---|
| Age of Tree | ____ | ____ | ____ |
| Height of Tree | ____ | ____ | ____ |
| Site Index | ____ | ____ | ____ |

Site Index Species: ________ Site Index (Av. to closest 5 ft.): ________

F. Site Productivity For Growing Timber: ( ) Medium (50-85 cu. ft./acre/year)
( ) High (85-120 cu. ft./acre/year)
( ) Very High (120+ cu. ft./acre/year)

III. Prescription Summary
A. Practice: FP1 ( ) FP2 ( ) FR1 ( ) FR2 ( )
B. Size of Treatment Area: ________ Acres
C. Site Preparation Method: ________________________________
D. Site Preparation Intensity: Light ( ) Moderate ( ) Heavy ( )
E. Tree Planting (Species): ________ Spacing: ________
F. Cultivation of Planted Hardwoods: Disking ( ) Chemical ( )
Frequency: ________
G. TSI: Precommercial Thinning and Crop Tree Release ( )
Site Preparation For Natural Regeneration ( ) Fencing ( )
Understory Release of White Pine Seedlings ( )
H. Water Quality Guidelines Needed? Yes ( ) No ( )

IV. Landowner does ( ) does not ( ) have additional land that will qualify for FIP cost sharing in future years. Estimated additional acreage: ________

TALLY SHEET FOR DETERMINATION OF STAND ELIGIBILITY FOR COST SHARING
FOR NON-COMMERCIAL THINNING AND CROP TREE RELEASE UNDER FP2 AND FR2

| Points Visited |
|---|
| |

| Release Nearest Crop Tree | |
|---|---|
| Yes | No |
| | |

| DBH | A<br>Tree Tally | B<br>Plots/Acre | C<br>A X B | D<br>DBH X C |
|---|---|---|---|---|
| 4 | | 114.94 | | |
| 6 | | 51.02 | | |
| 8 | | 28.65 | | |
| 10 | | 18.35 | | |
| 12 | | 12.74 | | |
| 14 | | 9.35 | | |
| 16 | | 7.16 | | |
| 18 | | 5.66 | | |
| 20 | | 4.59 | | |
| 22 | | 3.79 | | |
| 24 | | 3.18 | | |
| 26 | | 2.71 | | |
| 28 | | 2.34 | | |
| 30 | | 2.04 | | |
| 32 | | 1.79 | | |
| TOTALS | | | | |

Average DBH of Stand = $\frac{\text{Sum of Col. D}}{\text{Sum of Col. C}}$ = ________

Average Basal Area Per Acre = $\frac{\text{Sum of Col. A}}{\text{No. Points Visited}}$ X 10 = ________

Percent of Crop Trees Needing Release = $\frac{\text{No. Crop Trees Needing Release}}{\text{Total Crop Trees Observed}}$ X 100 = ________

STAND DOES ( ) DOES NOT ( ) QUALIFY FOR COST SHARING.

Minimum Stocking Required For Cost Share Eligibility

| Average Stand DBH | Sq. Ft. BA/Acre | Average Stand DBH | Sq. Ft. BA/Acre |
|---|---|---|---|
| 6 | 57 | 9 | 65 |
| 7 | 60 | 10 | 67 |
| 8 | 62 | | |



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# PESTICIDE PRECAUTIONARY STATEMENT

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key — out of the reach of children and animals — and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried in a sanitary land-fill dump, or crush and bury them in a level, isolated place.

Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S. Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure intended use is still registered.

For additional information contact your State Forestry Organization
or
USDA Forest Service, Southeastern Area
1720 Peachtree Street, N.W.
Atlanta, Georgia 30309

PROTECT

*Use Pesticides Safely*

**FOLLOW THE LABEL**

U.S. DEPARTMENT OF AGRICULTURE