Advances in Management of Southern Pine: 10th Annual Forestry Symposium, 1961

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ADVANCES IN
MANAGEMENT OF SOUTHERN PINE

LOUISIANA
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1961
10th ANNUAL
FORESTRY SYMPOSIUM
In October of 1951 the writer, in company with Professor R. W. McDermid and Extension Forester A. S. McKean, attended Louisiana’s first tree-farm certification ceremony at Urania. The principal speaker of the day was Colonel William B. Greeley, distinguished American forester and long-time friend of forestry in the South. Colonel Greeley spoke warmly of Henry Hardtner, founder of the Urania Lumber Company, as the father of southern forestry and then made this memorable statement: “There is nothing in the history of forestry so impressive as the recovery of the southern pineries and their industrial progress during the last thirty years.”

Driving home that evening we were serious and reflective. It was then that I, moved by the events and words of the day, proposed something long contemplated—that Louisiana State University sponsor an annual technical forestry meeting. The proposal was enthusiastically received by my companions and the very next morning was welcomed with equal vigor by Ralph W. Hayes, then director of the School of Forestry. Thus, an idea was born.

In the beginning several objectives were established, to which we have tried to adhere over the years. First, each meeting was to center around a definite field of interest, broad enough to admit thorough treatment but sufficiently narrow to enable us to get down to cases and come up with solutions. Hence, the term symposium was adopted and it has caused much mirth because, as everyone delights in telling us, one meaning of the word is “a drinking party.”

A second objective was always to seek qualified speakers who would present facts and ideas rather than mere opinion, although opinion backed by demonstrated results has always been welcomed. Each speaker has been carefully chosen and has appeared by invitation only, on the basis of his fitness to handle an assigned topic. It should be noted, too, that none has received any reward other than the opportunity to be heard. In no case has a speaker been encouraged to promote himself or his employer rather than the profession of forestry.
A final objective, and this one we have tried very hard to meet, has been to provide a meeting at which the field man, the one applying practices in the woods, could learn something of value to him in his work. Obviously not every paper has met this objective, but it has been our hope that something new or useful or stimulating has been carried home by each practicing forester who attended a symposium.

Thus, over the past nine years we have sought to further the progress noted by Colonel Greeley in 1951. Here at Louisiana State University we have had ten meetings at which 137 papers have been given by 126 different people on a wide variety of topics related to forestry. All of them added together represent an impressive professional effort, one of which we are very proud.

We are also proud of the heavy and enthusiastic attendance at these meetings. The very first symposium in 1952 attracted over two hundred people, when we had hoped for maybe one hundred. We had to find a larger auditorium the second year and the sixth year we moved into the university theater, the best available facility. At the tenth anniversary symposium this year there were over four hundred participants, including three men (from out-of-town, not local residents) who had attended every single one of the ten symposia. Our records show that over 4,000 people have come to these meetings. We hope each one has gone home stimulated and rewarded.

In planning the tenth symposium, of which this volume is the record, three specific objectives were set. The first was to take a short backward look at the progress in management of the southern pines over the past decade. The second was to summarize current thinking and the newer techniques utilized today to accomplish the management job. The third was to look into the future, not only to glimpse improved forestry practices but also to discern conditions and trends in the whole wood economy of the South in the years ahead.

The perceptive reader will note, as did some who attended the meeting, that many of the speakers were from outside the western Gulf region where the great majority of the participants live and work. It was deliberately done and with two objects in view. The first was to give respite to men and agencies who had served us repeatedly and well in the past. Second, and more important, a conscious attempt was made to provide speakers who would present ideas and techniques not only new but in some cases radically different from those common to this region. The hope was to stimulate thought among the listeners. Whether or not that hope was realized is left to them and to the readers of this book.
Finally, at the back of the book will be found an index to all of the papers given at the ten symposia held from 1952 to 1961. It is arranged by author only, but gives titles, dates, and inclusive pages by number of symposium. It is hoped the index will prove useful to readers, agencies, and libraries everywhere. To those of us who have planned and executed these meetings it is much more than that. It represents, we believe, solid achievement of the elusive goal of professional excellence.

A. B. Crow

Editor
# Table of Contents

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>The LSU Forestry Symposium</td>
<td>v</td>
</tr>
<tr>
<td>A. B. Crow</td>
<td></td>
</tr>
<tr>
<td>Don’t Live in Cramped Quarters</td>
<td>3</td>
</tr>
<tr>
<td>Charles A. Connaughton</td>
<td></td>
</tr>
<tr>
<td>The Revolution in Southern Pine Management</td>
<td>6</td>
</tr>
<tr>
<td>E. L. Demmon</td>
<td></td>
</tr>
<tr>
<td>The Case for Natural Regeneration</td>
<td>16</td>
</tr>
<tr>
<td>Thomas Lotti</td>
<td></td>
</tr>
<tr>
<td>Recent Advances in Site Preparation Techniques</td>
<td>26</td>
</tr>
<tr>
<td>Lawrence P. Wilhite</td>
<td></td>
</tr>
<tr>
<td>Recent Advances in Planting and Direct Seeding</td>
<td>34</td>
</tr>
<tr>
<td>H. H. Muntz</td>
<td></td>
</tr>
<tr>
<td>Recent Advances in Control of Competing Vegetation</td>
<td>41</td>
</tr>
<tr>
<td>John W. Starr</td>
<td></td>
</tr>
<tr>
<td>Thinning Practices in Short-Rotation Stands</td>
<td>50</td>
</tr>
<tr>
<td>J. W. Johnson</td>
<td></td>
</tr>
<tr>
<td>Thinning Practices in Sawlog-Rotation Stands</td>
<td>61</td>
</tr>
<tr>
<td>R. F. Kennedy</td>
<td></td>
</tr>
<tr>
<td>Recent Advances in Pine Genetics</td>
<td>68</td>
</tr>
<tr>
<td>Ray E. Goddard</td>
<td></td>
</tr>
<tr>
<td>Sawlog Forestry — Dead or Alive?</td>
<td>79</td>
</tr>
<tr>
<td>Roger I. Bruce</td>
<td></td>
</tr>
<tr>
<td>Cellulose Forestry — Key to the Future</td>
<td>90</td>
</tr>
<tr>
<td>George A. Anderson</td>
<td></td>
</tr>
<tr>
<td>Advantages and Consequences of Monoculture</td>
<td>97</td>
</tr>
<tr>
<td>L. E. Chaiken</td>
<td></td>
</tr>
<tr>
<td>Who’s Going to Use All This Wood?</td>
<td>105</td>
</tr>
<tr>
<td>Sam Guttenberg</td>
<td></td>
</tr>
<tr>
<td>Author Index to Papers Presented at First Ten Annual LSU Forestry Symposia</td>
<td>113</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Seed tree cutting, Able Chance, Francis Marion National Forest, 1950</td>
</tr>
<tr>
<td>2</td>
<td>Sound seed production from managed and unmanaged loblolly pine stands, forty to fifty years old</td>
</tr>
<tr>
<td>3</td>
<td>Fifteen-year record of loblolly pine seedfall in a young sawtimber stand between ages of thirty-five and fifty years</td>
</tr>
<tr>
<td>4</td>
<td>Average rate of loblolly pine seedfall as determined from fifteen-year record in a small sawtimber stand</td>
</tr>
<tr>
<td>5</td>
<td>Suggested schedule for seed-in-place regeneration method, South Carolina coastal plain</td>
</tr>
<tr>
<td>6</td>
<td>After four prescribed burns the understory is no longer a problem in this fifty-year-old stand of loblolly pine now ready for regeneration</td>
</tr>
<tr>
<td>7</td>
<td>Location of slash pine plantations used to check survival and average diameters as shown in University of Florida <em>Research Report No. 3</em> (1955)</td>
</tr>
<tr>
<td>8</td>
<td>Comparison of average d.b.h. by age, as predicted from University of Florida <em>Research Report No. 3</em> (1955) and as measured in check plantations</td>
</tr>
<tr>
<td>9</td>
<td>Comparison of survival as predicted from University of Florida <em>Research Report No. 3</em> (1955) and as measured in check plantations</td>
</tr>
<tr>
<td>10</td>
<td>Model of plantation productions at various ages, in terms of numbers of trees, average d.b.h. in inches, and cord volumes. From University of Florida <em>Research Report No. 3</em> (1955)</td>
</tr>
<tr>
<td>11</td>
<td>National per capita consumption of selected forest products</td>
</tr>
<tr>
<td>12</td>
<td>Acreage and volume in the Douglas-fir and southern pine region</td>
</tr>
<tr>
<td>13</td>
<td>The nation’s hardwood resources by region</td>
</tr>
</tbody>
</table>
LIST OF TABLES

1. 1959 seed production from various loblolly pine stands, Santee Experimental Forest 20

2. Loblolly pine regeneration costs, Virginia-Carolina coastal plain 24

3. Percentage kill of all trees injected in June with several forms of 2,4,5-T or 2,4-D and 2,4,5-T 44

4. Percentage kill of the four major species injected by various chemicals (both rates combined) 45

5. Per cent kill of hardwood and pine, mist blower application 46

6. Pulp yield indices for loblolly pine at various ages 62

7. Pulp growth in pounds per acre per year for various stand ages 63
1961

10th ANNUAL
FORESTRY SYMPOSIUM
"Don't live in cramped quarters." This sounds like reasonable advice but, specifically, what does it mean to a group of foresters? For this purpose, this statement applies to the mind, individually and collectively. It means that everyone's mind and talents should and must be constantly expanded to avoid restricted, cramped conditions in thinking. Unless this mental growth occurs, professional obligations cannot be fulfilled.

"Don't let the mind exist in cramped quarters" is a particularly appropriate subject of discussion at an LSU forestry symposium. It is appropriate, not because the symposium participants need the admonition more than others, but because the environment here is right to take stock of some professional needs.

Foresters completing the normal basic college curriculum have one thing in common—a certification by the school they have attended that they have a basic knowledge equipping them to begin the practice of technical forestry. The school, by announcing in its catalog that it is equipped to award a degree in forestry, has guaranteed the student that the academic work available and satisfactorily completed will prepare him to take his place in the profession. Thus, by the combined efforts and plans of student and school, a forester is prepared at graduation to make his start.

Start is emphasized because completion of academic minimums for professional work is purely a beginning. From this point on each one must participate in a training program. This training may be arranged by employers or self-arranged but, regardless of how it develops, it is a prime responsibility of the individual to obtain it.

Fortunately, there are organized opportunities which aid an individual in getting some of the training he needs from time to time. One of these is the planned symposia or clinics that are held periodically in order that professional people can learn of new developments and compare notes in group discussions. Such an approach to training needs is an indispensable supplement to technical and classical reading and study, membership in professional societies, visits to research and demonstration areas, and other such endeavors.
The LSU forestry symposium is a particularly fine illustration of the particular kind of device which keeps the professional mind from dropping into a fixed and archaic pattern. Presence of a large and enthusiastic crowd at each symposium for the past nine years is evidence of the appreciation of the profession for the opportunity which this meeting affords. It is well to remember, however, in case the effort to keep the mind growing seems too large, that each one must keep alert to needs and opportunities. It is an interesting but rather disconcerting fact that the body has a way of sending out a warning if muscles become cramped. The mind can become cramped and continue in this aggravated condition without the least bit of warning to the individual himself. Cramped muscles may not be apparent to others, but the cramped mind becomes apparent all too soon to everyone.

But why worry about living in cramped quarters? Many reasons are obvious but one in particular needs emphasizing at the moment. I refer to prevailing conditions which make it extremely important that foresters recognize now that there's a need to do the job of obtaining public confidence in their skill. The forester's mind must be opened to this need, and action should be taken on it all along the professional front.

Contrary to any belief otherwise, the public at large does not have confidence that the forester's skill is sufficient to restore and maintain wild lands at full productivity. Many people know, of course, what a forester is capable of doing, but even more feel that anyone who manages the woods commercially is destroying the resource. There are examples of land use to support both points of view but, unfortunately, the growing evidence of the forester's skill is not known and understood as widely as the results of land exploitation. Most communities near the woodlands have the proper perspective, but the bulk of our population is located in large cities far from forest realities.

Foresters, therefore, should take steps in an organized way to secure public understanding of their capabilities. "Why bother?" one might ask. The reason is simply that the success of any effort, big or small, is determined ultimately by public opinion, and foresters need the support of public opinion, just as any other profession.

To obtain public support requires public understanding. This understanding can be developed by every man in the profession, working on his own initiative. He should see that his family, his office, and his clubs, church, and lodge know what forest management means. He should see that his business associates know and aid him in telling the story. He should constantly be triggering a chain of reaction that will inform more and
more people that forest land use can be productive and rewarding to owner and public alike.

Each forester must be a disciple in this regard. If he fails, public decisions of major magnitude may turn against sound and reasonable land management. For example, demands might be made to exclude some areas from timber production to protect scenic values or to exclude timber harvesting in the interest of watershed protection, or to eliminate timber cutting near streams from the standpoint of fishing or to prohibit planting of conifers for wildlife habitat reasons. Any one of these eliminations or restrictions can be worked out compatibly with timber production if faith in the land manager’s skill prevails. If the forester is permitted to do the job for which he is trained, it is perfectly possible to combine many uses and values in the forest rather than eliminate some in the interest of others. The public needs to be informed, so that prohibitive limitations and requirements will not be levied on the forester’s land use decisions and actions.

This symposium aids in equipping the forestry profession with the tools necessary to demonstrate management skills. These demonstrations, in turn, are the evidence which is needed to shape and hold public opinion in support of foresters and forestry generally.
Introduction

Sentiment may have had something to do with my appearance on this program. I was identified with forestry in this part of the country for many years. In fact, I was a resident of Louisiana for a longer period of time—nineteen years—than in any other place. My interest in southern forestry goes back to 1925, when I joined the staff of the Southern Forest Experiment Station, and has continued ever since, even though my duties have sometimes taken me to other parts of the world and I have been more or less retired these last four years.

My remarks will concern changes that have taken place during the fifteen-year period since the end of World War II. For one to appraise changes in southern pine management is a rather large order, considering the size and complexity of the region. Traveling through parts of this region, as I have recently, and having been fairly familiar with it before the war, I am left with no doubt that forestry has made substantial strides here in recent years; the evidence can be seen almost everywhere—tree farms, plantations, natural reproduction, unburned areas. Yet with all these visual signs of progress, forest survey and other data lead us to the conclusion that the overall forestry situation here is not what it should be if this region is to produce the forest resources of which it is capable and which, according to all the prognostications, will be needed in the years ahead. Even now we are not practicing as good forestry as we know how. Here lies a great challenge for southern foresters.

Importance of Southern Pines

No one questions the importance of the southern pine forest to the well-being of the South and to the nation. We are concerned here with the South’s most important renewable resource that dominates over half of the 193 million acres of commercial forest land in eleven southern states and which now supplies the nation with approximately half of its softwood needs. Southern pines constitute about half of the total sawtimber volume.
and 37 per cent of the total cubic foot wood volume of the present forest stands in the South. How they are managed for future growth is a matter of concern to all Americans.

According to the Timber Resource Review (1953 data), the southern pines were the dominant species on about 100 million acres of commercial forest land in the South, and they contained approximately 174 billion board feet of sawtimber, or 49 billion cubic feet of sound, merchantable growing stock. This is the nation's most extensive softwood resource in area occupied and in potential growth. And, under good forest management, southern pine growth could well be doubled. Southern foresters therefore have a special responsibility in how these southern pines are managed for future growth.

**Studies of the Forestry Situation**

Toward the end of World War II, and even during the war period, much concern was expressed over the forestry situation in the United States. Timber had played a vital role in the war and had contributed materially to our military efforts. However, cutting of southern pine had in many places been heavy, and hardwoods of increasingly inferior quality had in part replaced them. One of the major problems today is to find uses for the lower quality hardwoods in pine stands.

The United States Forest Service launched a reappraisal of the nation's forest situation in 1945, the results of which were published in 1948 as "Forests and National Prosperity." Ten years later this was followed by the Timber Resource Review, published in 1958 as *Timber Resources for America's Future*.

The American Forestry Association also sponsored a study of the nation's forest situation between 1944 and 1946, which was discussed at the Third American Forestry Congress in Washington, D. C. in October, 1946, and which led to the formulation of a program for American forestry, adopted by its members in 1947. In October, 1953, a Fourth American Forestry Congress was sponsored by the American Forestry Association in Washington, D. C.; this led to the adoption of a revised program for American forestry.

Other studies of the American forestry situation have been reported during this period by the Society of American Foresters (1947) and the Stanford Research Institute (1954).

In all of these nationwide studies the South has been pointed out as a key region in the nation's forest economy. In fact, the American Forestry
Association recommendations of 1946 singled out this region by calling "special attention to the need for adequate fire protection and the improvement of cutting and other forest improvement practices in the South."

Forest surveys have been under way in the South since 1930, as part of the national survey conducted by the United States Forest Service through its regional forest experiment stations. The findings of these surveys are published periodically, by states and local economic units, providing information on kinds, amounts, and condition of the forest resources, the industries they support, and the possibilities for improving forest production. These reports describe the overall situation as to timber volumes, growth and drain, and offer recommendations to meet future timber needs. Resurveys have been made at periodic intervals, usually from seven to ten years apart.

Each of these studies of the forest situation furnishes valuable clues to what is taking place in southern forestry.

Measuring Progress in Southern Pine Cutting Practices

How can changes in southern pine timber cutting practices during the last fifteen years best be measured? It certainly cannot be done with any degree of exactness because most studies have not been made so that findings are comparable with previous observations. The difficulty is compounded by the widespread extent of timber harvesting operations continually under way in the South, the great diversity of forest land ownership and owners’ objectives, the character and efficiency of labor and extent of mechanization in woods operations, the effectiveness of forestry educational programs, changes in the economic situation, etc.

In the Forest Service reappraisal report the management status of forest lands in the South in 1945–1946 showed timber cutting practices on all ownerships as follows: fair or better—40 per cent; poor and destructive—60 per cent. Small forest ownerships, mostly farms, showed only 26 per cent of their cuttings to be fair or better. Lumber company cuttings were 66 per cent fair or better; pulp companies’—89 per cent; and national forests’—100 per cent fair or better.

The Timber Resource Review made by the United States Forest Service in the early '50's attempted to gage the status of forest management by determining the productivity of recently logged lands. For the South this study indicated that productivity following cuttings made between 1945 and 1952, for different classes of owners and on areas logged during this period, was as follows:
Ownership Class | Operating Area mil. acres | Proportion of Operating Area by Productivity Class (in per cent) |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Private (3 to 5,000 acres)</td>
<td>44</td>
<td>34</td>
</tr>
<tr>
<td>Medium Private (5,000 to 50,000 acres)</td>
<td>13</td>
<td>63</td>
</tr>
<tr>
<td>Large Private (50,000 acres and larger)</td>
<td>19</td>
<td>81</td>
</tr>
<tr>
<td>National Forest</td>
<td>9</td>
<td>89</td>
</tr>
<tr>
<td>Other Federal</td>
<td>2</td>
<td>83</td>
</tr>
<tr>
<td>State and Local</td>
<td>1</td>
<td>70</td>
</tr>
<tr>
<td>Total</td>
<td>88</td>
<td>55</td>
</tr>
</tbody>
</table>

This information, while not directly comparable to that obtained in the earlier forest reappraisal, seems to indicate that cutting practices improved somewhat between 1945 and 1953; forest productivity of the larger private holdings and those in public ownership was generally of a high order; the problem areas continued to be the lands of the more than two million small private owners, mostly farmers.

The areas resurveyed in the South for the second or third time since the 1930’s have shown increases in the area of forest land, due mainly to a decrease in the number of farms, abandonment of agricultural land, and tree planting on old fields. This trend may change, however, if more agricultural land is needed in the future, but because of soil quality, will affect the hardwood types more than the pines. Because of the common practice of cutting the larger, higher quality trees first and leaving the poorer, the volume and quality of sawlog timber has declined, even though the total cubic foot volume has increased. This is reflected in the continued decline in the size of the average tree, indicating that we are drifting towards a smaller tree economy. Whether this trend should be reversed and to what extent is to be the subject of later discussions at this symposium.

In general then, it can be said that there have been improvements in southern pine cutting practices to the extent that, on the average, lands are now in more productive condition than they were fifteen years ago, they have improved in timber stocking and growth rate, but timber quality has declined.
Fire Protection

At the end of World War II only slightly more than half of the state and private forest lands in the South were under organized fire protection. The Forest Service reappraisal report of 1946 stated that fire protection was poor or nonexistent on 56 per cent of southern forest lands. At present, approximately 88 per cent of state and private forest lands in the South are receiving fire protection.

As fire protection measures have become more effective, fire hazard has increased. This is due in part to the buildup of "rough" following periods of fire exclusion. To reduce this extreme fire hazard, as well as for silvicultural purposes, controlled or prescribed burning of the excessive amounts of fuel is now quite common practice, particularly in the longleaf and slash pine forests and to a lesser extent in the shortleaf-loblolly type. It is estimated that between three and four million acres of southern pine forest lands in all ownerships are receiving this protection measure annually. About 300,000 acres of this are on southern national forests. As a tool of forest management, such prescribed fires are beneficial in obtaining natural reproduction, in controlling brownspot needle disease, in reducing competition of worthless vegetation, and in improving forage values for livestock and game.

The increased effectiveness of fire control in the South in recent years can be measured by the decrease in the area of protected land burned annually. This is true even though the number of fires per total area protected has not shown much of a drop. During the five-year period 1946–1950 the area burned over on protected land in the South averaged about 1.66 per cent of the area protected; for the 1955–1959 period the comparable figure is less than half, or about 0.69 per cent. This improvement can be accounted for by the availability of additional funds, the use of new firefighting techniques and better equipment, expansion in prescribed use of fire, better training of fire fighters, better law enforcement, and continued education of the public to the danger of fire in the forest. Use of aircraft in fire detection and patrol, and to a limited extent in fire control, represents other recent advances.

Total expenditures for cooperative fire protection in the South increased from five million dollars in 1946 to about twenty million dollars last year. As the importance of its forests to the well-being of the South becomes more apparent we can anticipate 100 per cent fire protection for all forest lands, as well as the development of better techniques and improved equipment for fighting fires and continued educational campaigns for preventing them.
Protection from Insects and Diseases

Today more timber is destroyed by insects and diseases in southern forests than by fire.

Major causes of insect damage to southern pines continue to be the southern pine beetles, black turpentine beetles, Ips engraver beetles, tip-moths, and pine sawflies. The primary diseases affecting southern pines are fusiform rust, cone rust, *Fomes annosus* root rot, littleleaf disease, needle blights such as brownspot, and a variety of nursery diseases. Of course there are many other insects and diseases that cause damage to southern trees.

The amount of insect damage to southern pines fluctuates considerably from one year to another, depending on variations in weather, insect behavior, and other factors. Disease damage, except in forest nurseries, fluctuates much less, because once disease gets started in a stand or in an individual tree, it may expand for years, regardless of weather or other factors.

Progress has been made in recent years in the prevention, early detection, and prompt control of forest insect and disease damage through silvicultural, biological, and chemical control measures developed by research and applied by federal, state, and private cooperative efforts. Nurseries utilizing modern soil fumigation and spraying techniques have largely eliminated the important seedling diseases. Such efforts have been facilitated through the provisions of the Forest Pest Control Act of 1947. Already several southern states have established programs of cooperative pest control, directed by professional men working under the supervision of state foresters and paid out of state and federal funds.

Some of the more recent work in forest genetics aims to develop strains of trees that will be resistant to forest pests.

Pine Nurseries and Planting

No field of southern pine forestry has shown more rapid advance in recent years than has nursery and planting programs.

During World War II nursery production and planting activities were necessarily sharply curtailed. During the three years 1945, 1946, and 1947 the average area planted to southern pines each year was about 50,000 acres. In 1959 and 1960, 1 1/2 million acres were planted each year, which represented a thirty-fold increase.

During 1959, 275,000 acres planted in the South were on a cost-sharing basis under the Agricultural Conservation Program, which had been under
way since 1936. Also, much recent stimulation in planting has been on lands diverted from farming as a conservation measure under the provisions of the National Agricultural Act of 1956 (Soil Bank).

With an estimated seventeen million acres of forest land remaining in need of planting in the South, in addition to the areas clear-cut or denuded each year, and with a present nursery capacity exceeding 1½ billion pine seedlings annually, a large planting job lies ahead.

Innovations in nursery and planting techniques during recent years have led to improvements in the production and quality of planting stock, higher survivals, and lower costs. Even with all this progress a great proportion of nursery-grown seedlings still comes from seed collected with little regard to quality of parent stock.

Many improvements have been made in methods of site preparation, in mechanization of nursery and planting operations, and in the control of injurious insects and diseases.

Direct seeding of southern pines has become a practical method of reforestation in recent years as the result of research on the chemical coating of seed with bird and rodent repellents; this research was accomplished in Louisiana. As direct seeding promises satisfactory stocking at lower costs, we can anticipate that it will replace conventional planting on many areas in the future.

There is much yet to be learned in plantation management—optimum spacing, thinning, pruning, and other cultural practices to improve the quality of the final product.

**Tree Improvement Programs Through Genetics**

Important advances have been made in the improvement of forest trees in recent years through application of the principles of forest genetics or tree breeding. Although some research was undertaken in this field prior to World War II, it has only been in recent years that substantial progress has been made. Much of the stimulation for this activity can be attributed to the Committee on Southern Forest Tree Improvement, organized in 1951. This group, composed of representatives of the public agencies, forestry schools, and private industry, has concentrated its efforts on improving tree growth through seed selection, budding and grafting, establishment of seed orchards and seed producing areas, and in stimulating research in this field. These programs have aimed to produce trees of superior growth rate and wood quality. Practically all of these efforts to date have been with the southern pines. Results may be slow in coming,
but this work promises to be of great importance to owners of southern pine timberlands and to industries based on the use of southern pines.

**Naval Stores**

Revolutionary changes have taken place in recent years in methods of extracting gum resin in the production of naval stores (turpentine and rosin) from longleaf and slash pines. As a result of research in this field, the use of bark chipping at biweekly intervals and acid stimulation of the streak has now almost entirely replaced the former method of chipping weekly into the wood. Use of this new technique began on a small scale in 1946 and has increased each year until today it is almost universally used by the industry. These changes in turpentining practices have resulted in saving millions of dollars to the industry through increased gum yields and lowered labor costs, at the same time increasing the value of the worked-out trees for sawlogs, poles, pulpwood, and ties.

Research has also demonstrated that increased gum yields can be obtained through tree breeding, using known superior gum yielders as parent stock. This is necessarily a long-time proposition, but a start has been made.

Production of gum turpentine and rosin has declined in recent years due in part to the competition from the stumpwood distillation industry and from by-products of the southern kraft pulp mills, but this competition should gradually decrease as stumpwood disappears or becomes more costly, and the gum naval stores industry should again become a major factor in the production of turpentine and rosin. The recent increased demand for naval stores, resulting in higher prices, is having a stimulating effect on the industry.

**Southern Pulp and Paper Industry**

Tribute must be paid here to the role taken by the southern pulp and paper industry in promoting good forest management. No other industry has contributed more to the advancement of forestry in this region than has the pulp and paper industry. Since its initial rapid expansion just prior to World War II this industry has continued to grow until now it supplies the nation with more than half of its paper needs.

Whereas pulpwood made up only about 10 per cent of the drain on southern forests in 1946 (eight million cords), this has now increased to about 30 per cent (twenty-three million cords) in 1959; it is estimated that
by 1975 pulpwood may account for as much as 50 per cent of the total use of southern woods.

At the end of World War II pulp and paper companies owned about five million acres of southern forest land; today this has increased to about twenty million acres. Southern pulp mills are now obtaining on the average about 25 per cent of their wood needs from their own properties, and this proportion will probably not rise much above 50 per cent in the future.

The southern pulp and paper companies generally practice high order forest management on their own lands, cutting conservatively and building up the growing stock for maximum wood yields. They are also promoting good forestry practices on lands owned by others, from which they obtain most of their current wood supplies. This is done by providing timber marking services by company foresters and by offering forestry advice.

Another major change instituted by the southern pulp and paper mills has been in assisting sawmills to install debarking and chipping equipment and then purchasing the wood chips; most of this material was previously burned or wasted. This innovation of purchasing wood chips began about 1952 and has grown until today it accounts for about 12 per cent of the total wood used in southern pulp and paper production.

Prior to World War II southern pines were the source of practically all the pulpwood used in the South. Today, about 20 per cent of southern pulp production comes from hardwoods, many of which grow mixed with the pines and, through their removal, benefit pine growth. The increased use of hardwoods and chips from residues has lessened the drain on the southern pine growing stock, with beneficial results for the future.

The southern pulp and paper industry has not only been a leader in promoting southern pine management; it has opened up a huge market for wood where this did not exist before; it has contributed to the economic growth of many southern communities by providing work for people; it has opened its lands to the public for hunting and fishing; its leaders and employees have become useful citizens in their communities, and many have entered actively into civic affairs. All in all, the southern pulp and paper industry has been good for the South, and of course the South has been good for the industry—a mutually satisfactory arrangement.

Professional Foresters in the South

One measure of the growth of forestry in the South is the increase in number of professional foresters in recent years. This can be gauged by the increase of active members of the Society of American Foresters resident
in this region. Not all of these foresters are engaged in forest management activities, and of course there are a few foresters who are not members of the Society. However, the increase in number of Society members is very significant and can be taken as an indication of the overall growth of technical forestry in this region.

At the end of World War II total Society membership in the United States (junior members, members, and fellows) stood at 4,415, of which 769 resided in the eleven southern states, or about 17 per cent of the total. In 1960 total Society membership in these grades was 10,892, with 3,298 of them in the South, or 30 per cent. In other words, in the last fifteen years the number of professional foresters in the South has increased more than fourfold, while those in the rest of the United States have only slightly more than doubled. The total number in the South now approximates that for the entire United States not so many years ago.

Growth of the profession of forestry in the South is apparent to old-time Society members who note that attendance at recent southern section meetings is often larger than at national meetings prior to World War II.

Conclusions

Whereas progress has been made in the management of southern forests for timber production, there has been an increasing pressure on the forest for other uses—grazing, wildlife, recreation, and water production. All these together make up what is known as multiple-use forestry.

With the current upward trend in population, more leisure time for recreation, and increased purchasing power, demand for the products and uses of southern forests will undoubtedly increase. As much of this demand will fall on the southern pine forest, this symposium comes at an opportune time to bring foresters up to date on the latest developments in southern pine management.

President Kennedy, in his recent message to the Congress on the subject of natural resources, stated: "Our entire society is dependent upon our water, our land, our forests, and our minerals. How we use these resources influences our health, security, economy, and well-being. If we fail to use these blessings prudently, we will be in trouble within a short time."

The South has a wonderful opportunity to contribute to the nation's future needs for forest products; in fact, our future security rests in part on the abundance and productivity of southern forests. Herein is a great challenge to the forestry profession. How this challenge is met will depend in large part on the vision, ability, and aggressiveness of men such as you.
In this age of machine planting and airplane seeding, forest regeneration by self-sown seeds (natural regeneration) is seldom in the limelight. The notion is prevalent that our future forests will be largely spewed forth from the rear of an airplane or set out in precise rows by machine. Perhaps this is so. However, before we rocket off to explore the forests of another planet, let us dwell for a moment on the possibilities of natural regeneration on at least some of our southern pinelands. This may be a good idea in the face of some retrenchment and cost-cutting now current in many southern forestry operations.

Natural regeneration should be considered a forestry technique—like planting or direct seeding—to be prescribed for the prompt and heavy re-stocking of forest land with commercially desirable tree species. A major challenge to the forester is to determine which regeneration technique will do the job at the least cost on a given area. As a guide, description of some developments in the natural regeneration of loblolly pine shall be attempted. Much of the information to be presented is from the Virginia-Carolina coastal plain—an area where loblolly pine is the major commercial conifer and reaches its maximum development (heights up to 130 feet in 50 years). However, physiological differences between tree species and wide variations of soil and climate within the range of a major species require local interpretations of the described results. Basically this is a research job, but action agencies can help with pilot-plant tests.

It has been said that poor seed production is rarely a silvicultural bottleneck in itself. Given a favorable climate, a good seedbed, and absence of rodents and of sharply competing vegetation, the requisite amount of seed for the successful regeneration of the forest can usually be produced. But if any of the above factors are distinctly unfavorable, success may be impossible even with the highest possible seed yield. Even so, the primary problem is to supply the greatest amount of seed feasible under the silvical and economic conditions of the forest type and region (2). In essence, this has been the goal of researchers since about 1940 in the loblolly pine type.
of the Carolina-Virginia area (3). A principal difficulty develops in timing—that is, to provide the required amount of seed soon enough after logging or seedbed preparation. In the main this has led to the use of a seed-tree system of regeneration by many forest managers. Specifications are now available for gauging the number of seed trees needed in relation to size and fruitfulness of available trees, condition of the seedbed, and stocking of reproduction desired (8). To stimulate seed production, the release of seed trees three to five years in advance of harvest is also a recommended practice.

The successful regeneration of many coastal plain loblolly pine stands proves the usefulness of the seed-tree method. An example is the Able Chance on the Francis Marion National Forest, a mature loblolly stand cut over in 1950 to a residual of four seed trees per acre (Figure 1). Seedbed preparation involved tractor logging followed by a spring burn. By the end of the third growing season 3,100 seedlings per acre restocked 92 per cent of the area. Ten years later the area is fast developing into a pulpwood

Figure 1. Seed tree cutting, Able Chance, Francis Marion National Forest, 1950.
stand and under current management objectives will eventually become a fully stocked stand of high quality sawtimber.

Admittedly there are some shortcomings associated with the seed-tree system. One is the large investment in seed trees with possible losses from wind and lightning. Another is that a rapidly deteriorating seedbed necessitates meeting seed requirements in the first year after logging or seedbed preparation. This is often the case on the better or brushier sites. Thus, in poor seed years the number of trees needed becomes prohibitively large. Furthermore, the seed-tree system has small application in pulpwood size stands because of limited cone production from individual young trees. Finally there is always the job of seed tree removal; when delayed, it may seriously damage sapling stands.

Seed may also be provided by uncut strips. Some advantages result in marking, logging, and later removal, but there is less control of seed supply (8).

There is a fast developing interest in a seed-in-place technique which eliminates the need for leaving seed trees on many timber tracts. The idea here is to take advantage of the seed producing capacity of the total stand of trees. Since well-stocked loblolly pine stands in the Carolina-Virginia coastal plain frequently produce ample crops of seed, clearcutting after the peak of the annual seedfall but prior to germination gives promise of becoming a popular regeneration technique. In a given year, cone crop forecasts permit preliminary planning (1). Much of the confidence develops from long-term seedfall records such as those maintained on the Santee Experimental Forest in South Carolina (Figure 2). These show that annual production in 40- to 50-year-old managed stands is usually well over 100 thousand sound seeds per acre, averaging around 350 thousand. In uncut stands of the same age, production is somewhat less, averaging about 270 thousand viable seeds per year. The past seed year (1960–1961) was the poorest recorded in fifteen years. Even so, most of the managed stands produced enough for regeneration purposes, although the uncut did not. Fortunately, poor seed years are infrequent. In fifteen years, only three were classed as poor as compared to five “bumper” and seven good years (Figure 3).

The seed-in-place technique is also useful in short-rotation silviculture. For most conifers, individual trees do not produce significant amounts of seed in early life. When a tree is young, much of its energy is utilized in vegetative growth; in middle and later ages, a great part of the energy is directed to reproductive processes (7). Nevertheless, some loblolly pine trees have produced cones at seven years of age containing a fair to high propor-
Figure 2. Sound seed production from managed and unmanaged loblolly pine stands, forty to fifty years old.

Figure 3. Fifteen-year record of loblolly pine seedfall in a young sawtimber stand between ages of thirty-five and fifty years.
tion of viable seeds(6). Generally, the minimum age for production of commercial quantities of loblolly seed is around twelve to fifteen years. Optimum levels of production begin at about age thirty-five and continue beyond sixty years(7). I believe loblolly pine stands should produce quantities of seed sufficient for natural regeneration sometime between the ages of fifteen and thirty-five, probably beginning around twenty years. A recently established study in the locale of the Santee Experimental Forest aims to determine the relationships of age, site, and stocking to seed production in fifteen- to thirty-year-old loblolly pine stands. Final results will be available in about five years.

In the meantime, some general information is on hand from a preliminary investigation made in 1959 (Table 1). This shows that production from an unthinned 20- to 25-year-old stand amounted to 9,000 sound seed per acre as compared to 24,000 in an adjoining thinned stand of the same age, or about 10 per cent of the yield from comparable 50-year-old stands. Other studies in mature stands on the Santee indicate an average loss of 30 per cent of the seedfall to rodents and birds(4). They further show that seven viable seeds are required to establish one seedling in an average year on a seedbed prepared with prescribed fire. These figures indicate that an adequate catch of 2,400 established seedlings might have been expected from the aforementioned thinned stand and a marginal catch of 900 seedlings from the young unthinned stand. The 1959 seedfall, based on the fifteen years of record on the experimental forest, was 74 per cent of average. This indicates that in better seed years results should be even more encouraging.

It appears that a seed-in-place technique is best applied during a four- to five-month period, although its benefits last somewhat longer. In the proximity of the Santee Experimental Forest the average date of beginning lies between November 15 and December 1, when 50 to 75 per cent of the

### TABLE 1. 1959 seed production from various loblolly pine stands, Santee Experimental Forest.

<table>
<thead>
<tr>
<th>Stand Age (Yrs.)</th>
<th>Treatment</th>
<th>Total Seed Production (M/A.)</th>
<th>Sound Seed Production (M/A.)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-25 Unthinned</td>
<td></td>
<td>31</td>
<td>9</td>
<td>29</td>
</tr>
<tr>
<td>20-25 Thinned</td>
<td></td>
<td>57</td>
<td>24</td>
<td>42</td>
</tr>
<tr>
<td>40-50 Uncut</td>
<td></td>
<td>216</td>
<td>109</td>
<td>50</td>
</tr>
<tr>
<td>40-50 Selection cuts (3)</td>
<td></td>
<td>324</td>
<td>150</td>
<td>46</td>
</tr>
<tr>
<td>40-50 Improvement cuts (2)</td>
<td></td>
<td>341</td>
<td>225</td>
<td>66</td>
</tr>
</tbody>
</table>
From then on, clearcutting can continue until about April 1, when heavy germination of seed takes place (Figure 5). At that time, and during the early part of the growing season, there may be a heavy loss of the more or less succulent and fragile seedlings due to logging activity. Consequently it would be desirable to leave some seed trees during this period. However, with the hardening off of the seedlings later in the growing season, the chance of damage lessens. Clearcutting, over what are now actually seedlings-in-place, can be resumed after about August 1 with only a small loss of seedlings. Logging of short logs in dry weather helps keep the damage down.

A pilot plant test in a fifty-year old stand comparing regeneration from seed-in-place with the later released seedlings-in-place resulted in about equal numbers of three-year-old seedlings. However, the seed-in-place seedlings averaged 2.5 feet in height as compared to 1.4 feet for the seedlings-in-place, which spent most of the first growing season in the shade of the overwood. Chances are that the height differential will make little difference in ultimate yields. Incidentally, the loblolly pine stand averaged 14,000
board feet of sawlogs (Scribner log rule) and 3 cords of pulpwood per acre. This was a conventional tractor logging operation involving short logs only and pulpwood tops.

<table>
<thead>
<tr>
<th>CLEAR CUT SEED-IN-PLACE</th>
<th>LEAVE SEED TREES SUCCULENT PERIOD</th>
<th>CLEAR CUT SEEDLINGS-IN-PLACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOV. 15</td>
<td>APR. 1</td>
<td>AUG. 1</td>
</tr>
<tr>
<td>PEAK OF SEED FALL</td>
<td>BEGIN GERMINATION</td>
<td>SEEDLINGS HARDEN</td>
</tr>
</tbody>
</table>

**Figure 5.** Suggested schedule for seed-in-place regeneration method, South Carolina coastal plain.

A majority of the loblolly pine stands in the Virginia-Carolina coastal plain have heavy understories of hardwoods and shrubs which require control measures for successful pine regeneration. Prescribed burning for understory control and seedbed preparation is well suited to the requirements for the natural regeneration of loblolly pine. More than a decade of research on the Santee Experimental Forest conclusively showed that either dormant or growing season fires can be used effectively without damage to the pine overwood or to the prevalent sandy loam soils of the coastal plain (5). The findings apply mainly to relatively pure loblolly pine stands above sapling size. These are generally characterized by uniform fuel conditions, comprised mostly of pine needles and similar fine materials. A basic requirement is that the understory hardwoods and brush be mainly under two inches d.b.h. for effective control by fire.

The simplest procedure requires only periodic winter-prescribed fires. This may be described as learning to live with the inferior hardwoods and shrubs of the understory, because their rootstocks are not killed by dormant season burns. A chief danger is that some growing space is invariably captured by broad-leaved species at time of regeneration. The situation can be worsened by poor scheduling of the terminal winter fire if, after the main seedfall, most of the seed is destroyed. Seed trees must then be left. Before these can seed the area, additional site preparation may be needed to control interim sprout growth.

A more progressive burning program than the foregoing involves the use of growing-season or summer fires. As a minimum, a summer burn for regeneration is made some time during the last growing season prior to the
final harvest cut. The best timing is just before the beginning of the annual seedfall. However, any time after June 1 should be adequate and certainly better than any dormant season fire because of lesser sprout growth and no seed loss to fire.

A more intensive regeneration technique involves a succession of annual or biennial summer fires, especially in areas of dense underbrush or limited seed production. Two or three fires are usually enough to eradicate or weaken much of the understory and to prepare the seedbed (Figure 6).

Figure 6. After four prescribed burns the understory is no longer a problem in this fifty-year-old stand of loblolly pine now ready for regeneration.

The sequence can be stopped at the discretion of the forest manager, following the establishment of a sufficient number of seedlings. Thus, we can have the seedlings-in-place before cutting.

In good seed years or in areas of known good seed production an alternative is a harvest cut after seedfall, following the last summer burn in the series. This then involves the previously described seed-in-place technique.

A prevalence of understory competitors above two inches d.b.h. requires
some treatment other than fire as do areas with flat or sparse fuels consisting mostly of hardwood leaves. Under these conditions some form of mechanical site preparation is required. Heavy, tractor-drawn disk-harrows are generally used. Treatment is done before or after logging, depending on the regeneration system to be employed.

Cost information is always of interest to forest land managers, although generally available on a case history basis and of limited application elsewhere. For the case of natural regeneration, some mention of its cost seems desirable. Here are some recent values obtained from a large timber operation in the Virginia-Carolina coastal plain: This organization has an annual loblolly pine regeneration program of 8,000 to 9,000 acres. They direct-seed or plant only those areas which cannot be regenerated naturally. Seedbed or site preparation is accomplished by fire or disking. The prescribed burning procedure is usually a combination of one winter and two summer fires, each one year apart. Disking is done with heavy equipment after logging and is either a single or double application as a given site may require. All of the direct seeding is from airplanes and on areas above thirty acres; smaller tracts are planted. Seed-in-place is the primary technique for natural regeneration in good seed years. On areas logged before seedfall, seed tree strips are left. In poor seed years direct seeding is the alternative treatment. Accordingly, the 1960 costs per acre are given in Table 2. Depending on site preparation method used, the average regeneration costs per acre for natural regeneration ranged from $4.00 to $19.00; for direct seeding, from $8.00 to $23.00; and planting from $20.00 to $35.00. These do not include the cost of controlling large hardwoods, which on the average acre amounts to about $6.00.

In conclusion, I am of the opinion that natural regeneration will continue to be a major means of reproducing loblolly pine in the Virginia-Carolina coastal plain area. Dependable seed production from managed stands, new methods, and lowcost seedbed preparation techniques, such as

TABLE 2. Loblolly pine regeneration costs, Virginia-Carolina coastal plain.

<table>
<thead>
<tr>
<th>SITE PREPARATION</th>
<th>Cost Per A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prescribed burning (3 fires)</td>
<td>$ 4.35</td>
</tr>
<tr>
<td>Single disking (contract)</td>
<td>16.00</td>
</tr>
<tr>
<td>Double disking (contract)</td>
<td>19.00</td>
</tr>
<tr>
<td>DIRECT SEEDING</td>
<td></td>
</tr>
<tr>
<td>Seed and sowing</td>
<td>$ 3.60</td>
</tr>
<tr>
<td>PLANTING</td>
<td></td>
</tr>
<tr>
<td>Stock and planting</td>
<td>$15.60</td>
</tr>
<tr>
<td>HARDWOOD CONTROL</td>
<td></td>
</tr>
<tr>
<td>Girdling and poisoning</td>
<td>$ 6.00</td>
</tr>
</tbody>
</table>
prescribed fire, give strength to any management program for loblolly pine in that area. Research and pilot plant tests should show the extent of application beyond the limits of the Virginia-Carolina coastal plain.

LITERATURE CITED

Preparation of sites before regenerating southern pines has undergone a revolution since the Second World War. A greater proportion of sites is being prepared before regeneration, and they are being prepared more intensively. Often the techniques used have been proven in large-scale pilot tests and have been developed from studies of the silvical requirements of particular pine species and characteristics of particular sites. Several factors have contributed to this revolution in site preparation: (1) the purchase by forest industries of large areas in need of regeneration; (2) the planting or seeding of most of the available old fields, leaving cutover land and other rough areas as next in line for regeneration; (3) the increased value of stumpage and forest land, making it important to return cutover land to trees as quickly as possible; and (4) the development of machinery and chemicals capable of controlling vegetation on the more adverse sites. Also, even-aged management of southern pines has resulted in clear-cutting areas large enough to make the use of airplanes and large land-clearing equipment economically feasible in site preparation.

In the last ten or fifteen years burning as a site preparation measure has been refined, silvicides have been introduced, and mechanical preparation of forest sites has progressed from a man with a scalping tool to equipment capable of removing most of the vegetation from an area.

Advances in the Use of Fire as a Site Preparation Technique

No revolutionary changes have been made in the use of fire for preparing sites, as an aid to natural regeneration or to facilitate planting or direct seeding. But more has been learned about the effects of fire and the scheduling of prescribed burns for best results.

In direct seeding longleaf pine in Louisiana it has been learned that prescribed burning is best applied as a site preparation technique in the spring, preceding fall sowing. The light rough resulting from this burn conserves moisture by retarding the evaporation of dew, yet is not too
dense to prevent longleaf germination (Mann, 1960). Before the direct seeding of slash and loblolly pines under pine-hardwood stands in Louisiana, the understory is burned in November to prepare the seedbed for immediate sowing or sowing in February. The following summer the overstory is deadened (Mann, 1960).

In east Texas growing season fires, probably because they kill more of the competing vegetation, have been found to be better than dormant season fires in preparing seedbeds for natural regeneration of shortleaf pine (Ferguson, 1958).

Based on a ten-year study of the effects of prescribed burning on loblolly overstories, hardwood understories, and soil, burning recommendations have been made for hardwood control and seedbed preparation in loblolly stands on the Atlantic coastal plain (Lotti et al., 1960). The recommended burning schedules range from a simple program of periodic winter fires for holding the understory in check to an intensive program of a succession of summer fires followed by periodic winter fires designed to eliminate the understory almost completely.

Advances in the Use of Chemicals as Site Preparation Techniques

Chemical control of hardwoods has become important in the management of southern pines since the introduction in the 1940’s of silvicides nontoxic to man, livestock, and wildlife. Silvicides, such as 2,4,5-T, can be applied selectively to individual stems or applied to all the vegetation on an area as foliar sprays. At first, chemicals were used for releasing overtopped pines, but now chemicals are also being used to prepare sites.

In the control of individual stems silvicides are applied as basal sprays, applied to stumps or to notches or frills in the stem, or injected into the stem with tree injectors. These methods result in quicker crown kill and less sprouting than does girdling alone, although they are usually more expensive. However, the larger the control job, the lower the cost of the operation, since some of the costs for equipment and mixing of chemicals do not rise proportionately as the size of the job increases (Chaiken, 1960).

Broadcast control of hardwoods by foliar sprays, especially as a site preparation measure, has not progressed beyond the pilot-test stage in many areas, but preliminary results have been very promising. They are applied from aircraft or from the ground. Helicopters or fixed-wing aircraft can spray large areas rapidly and can be used on topography too steep for vehicular-mounted equipment.
Application of silvicides by mist blowers was introduced about 1957. Mist blowers utilize air to disperse concentrated silvicide solutions into tiny droplets and to blast the droplets onto foliage at velocities up to 180 or 190 miles per hour. Concentrations of three to five gallons of solution are used in place of forty to one hundred gallons of dilute solution for treatment of an acre. Preliminary results indicate mist blowers are very effective in the control of woody competition. Back-pack and vehicular-mounted models are available. Mist blowers have advantages over aircraft in the treatment of multistoried stands and areas too small or too close to agricultural crops for aerial spraying. Costs of control by mist blowers appear to be similar to costs of aerial application.

At present, the use of chemicals has greater application in timber stand improvement than in site preparation. Except in areas of light competition, the trees and brush killed by silvicides are a mechanical impediment to artificial regeneration other than seeding by aircraft. Chemical application, though usually sufficient to release already present pines, often does not control competing vegetation long enough for seedlings to become dominant. Mist blowers may partially overcome this last problem, since they can treat stands from ground level up to fifty-five or sixty feet in one operation.

Chemical control is generally more effective against hardwoods than against palmetto and grasses. Mechanical control of palmetto often leaves the site so boggy that it is difficult to plant, and some palmetto sites are too wet for mechanical control. Grasses and herbs often respond so strongly to deadening of an overstory that competition to pine seedlings becomes almost as severe as before. The grasses that invade after palmetto has been deadened by diskng do not suppress pine seedlings but do constitute a flash fuel that probably has a greater frequency of fire starts than the original palmetto cover. If economically feasible chemical controls for palmetto and grasses could be developed, the use of silvicides for site preparation and, no doubt, for timber stand improvement also could be greatly expanded.

Advances in Mechanical Site Preparation Techniques

Mechanical site preparation techniques utilize machinery ranging from standard farm implements to large equipment specifically designed for the clearing of difficult sites.

Heavy-duty farm disk harrows are used to prepare sites for the direct seeding of pines in Louisiana (Mann, 1960). Sites are burned in the
spring, single disked, usually in strips, in late summer, and seeded the fol­
lowing winter or spring. Disking before seeding slash pine is required to
reduce competition for moisture. Loblolly seedlings, although more drought
resistant than slash, are slower growing in the first year; hence disking
prior to seeding is required to prevent overtopping by grass. On the driest
sandy sites disking before seeding longleaf is also recommended to insure
high first-year survival, but on average longleaf sites burning usually is the
only site preparation required.

Fire-line construction and maintenance plows are commonly used. Con­
struction plows are used to prepare furrows, and the seedlings are planted
in the furrows or on the mounds between furrows, depending on the rela­
tive wetness of the site. Maintenance plows are used to prepare disked
strips for planting.

Large land-clearing equipment such as bulldozers or K–G blades uproot
or sever the stems of brush and hardwoods. Heavy chains or steel cables
drawn between two tractors are used for the same purpose. Root rakes
windrow brush that has been cut or uprooted. Tandem drum choppers are
most frequently applied in the removal of scrub oaks from sandhill sites.
Tandem disk harrows are used on flatwood sites and on hardwood sites
after the larger trees are removed.

Let me point out the particular advantages of some of this mechanical
equipment for southern areas where intensive forestry is practiced.

The sandhills of west Florida present rigorous requirements for pine
establishment and growth. For adequate slash pine establishment on these
deep sands almost complete eradication of the existing scrub oaks and wire
grass is required. For best growth the thin A1 horizon that holds much of
the water and nutrients in these soils must not be removed and must be
disturbed as little as possible. Because of the low amount of organic matter
in these soils, it is desirable to incorporate the vegetation deadened by site
preparation into the mineral soil. The Marianna Research Center of the
Southern Forest Experiment Station has developed a technique that meets
these requirements well (Woods et al., 1958). Planting sites are burned
about the first of May, at the time of full leaf emergence, allowed six to
eight weeks for the oaks to sprout, chopped with an eleven-ton Marden
Brush Cutter about June 15, allowed time for the oaks to resprout, chopped
again in August or September, and planted to pine the following winter.
The tandem choppers, being offset, kill oak roots and wire grass by a slid­
ing, shearing action, do not remove or invert the top soil, and crush and
chop the vegetation into the soil, thus meeting the requirements for pine
establishment on these adverse sites.
In contrast to the sandhills of west Florida, the sandhills of North and South Carolina and Georgia generally have a clay layer within several feet of the soil surface (Woods, 1959). Possibly because of this clay layer, disturbance of the surface soil is not so critical, nor is complete eradication of the existing vegetation so necessary, as on the west Florida sandhills. Preparation of old fields in the Carolina and Georgia sandhills consists of plowing single furrows six to eight feet apart to a depth of three to four inches, either before or at the time of planting. If furrowing is done before planting, about thirty days are allowed for soil stabilization; if thirty days cannot be allowed, longleaf seedlings are planted about one-fourth to one-half inch higher than usual to allow for silting. Preparation of scrub oak sites on these sandhills consists of complete clearing of the site by a drum chopper or by chaining, followed by plowing and disking with a fire-break or gang-disk plow to further reduce sprouting. A minimum of six months is then allowed for soil stabilization before planting. A less expensive site preparation method for the scrub oak sites is to plow furrows six to eight feet apart, eight to ten inches deep, and about eighteen inches wide and to plant in the furrows. Chemical treatment of the resprouting oaks on these sandhills may be necessary in the first one or two years after planting, particularly for longleaf and especially on areas with undisturbed strips between furrows (Shipman, 1958).

In the lower coastal plain of southeast Georgia and northeast Florida, cutover flatwoods sites are usually prepared for planting by burning and disking. The burning and disking is done one or two years after clear-cutting to allow time for some rotting of logging slash and stumps. Disking is done with heavy tandem offset disk harrows. The entire planting area is generally disked at least once. This may be sufficient treatment for areas with light brush, if the soil is dry enough to be worked well by the harrow. On rougher or wetter sites a second scarification may follow immediately or a few months after the first disking. This may be a second complete disking, a strip disking, or on wet sites, a bedding operation. Beds are constructed by a pass with a plow set to throw the soil out, followed by a harrow set to pull the soil back into a bed. Strips or beds are six to eight feet wide, with two or three feet between the edges. Seedlings are planted in the center of the strips or beds.

Tandem drum choppers are used to some extent on the lower coastal plain. Choppers disturb the soil less than harrows, hence leave a firmer planting bed, and are preferred by some forest managers for this reason. However, choppers apparently are not as effective in killing palmetto because chopped palmetto stems usually resprout. Harrows, on the other hand, slice the stems and pull many of the stem sections partially out of the ground, breaking and
exposing the roots, which apparently is necessary to kill palmetto. Although choppers effectively prepare the scrub oak ridges that occasionally occur in the lower coastal plain, most landowners have such small acreages of this type that they cannot afford the investment in heavy choppers. Consequently, these occasional ridges are often prepared by cutting or knocking down the oaks with K-G blade, bulldozer, or chain, windrowing the oaks with root-rakes, and then giving the area between the windrows the same disking treatment as the surrounding flatwoods.

Site preparation techniques for the lower coastal plain are not so definite or well proven as they are for some other areas, such as the sandhills of west Florida. In the flatwoods the best seasons for burning and disking, the best intervals between operations, and the required intensities of preparation for the various sites are not yet known. These aspects of site preparation are being studied, however, and I would like to outline a cooperative site preparation research project that has recently been initiated in southeast Georgia and northeast Florida. This project, consisting of several studies covering various aspects of site preparation, is sponsored by the Georgia Forest Research Council and is being conducted by the Lake City Research Center of the Southeastern Forest Experiment Station. Other cooperators in the project are the Georgia Forestry Commission and five pulp and paper companies: Brunswick Pulp and Paper Company, Owens-Illinois Glass Company, Rayonier, Inc., St. Regis Paper Company, Union Bag-Camp Paper Corporation.

Installation of the first study in this project will be completed this year. The primary objective of this study is to develop equations predicting the early growth and survival of slash pines planted on prepared sites. The equations will be derived from plot data collected on density of competing vegetation before and after site preparation, intensity of preparation, and site index. The study is replicated in time: a third of the plots will be planted each winter for three successive years. All of the plots will be burned, some will be left undisked, others will be broadcast disked one, two, or three times. Locations sampled will include the ranges of ground-cover densities, ground-cover composition, and site indices found on flatwoods sites. Areas immediately adjacent to ponds or on scrub oak ridges are not included in the study, for they require site preparation techniques other than, or in addition to, disking. All of the plots will be observed for ten years after planting; a representative third of the total number will be observed until the end of the pulpwood rotation.

In a supplemental game habitat study the Georgia and Florida Game Commissions are measuring vegetation on these same plots before and after treatment to determine the subsequent changes in game food and cover plants. This information will be useful in managing game and in judging
effects on wildlife brought about by site preparation. The vegetational data
gathered should also furnish information on the resulting ecological succes­sion of ground-cover species. In an associated study the United States Fish
and Wildlife Service and the Wildlife Management Department of the Univer­sity of Florida are studying wildlife populations on prepared and unpre­pared areas on cooperators’ lands.

Wet Lands Site Preparation

At the present time there are no plans in our cooperative project to study management of ponds, although they occupy a considerable percentage of the flatwoods, and indeed, poorly drained lands comprise a large proportion of forest land in the South. With the increasing value of stumpage and forest land, it is becoming important to manage these wet lands.

In the wet flatwoods of south Florida, six inches in elevation can make a great difference in survival and growth of slash pine seedlings. Before culti­vation, some low-lying sites in south Florida are too wet to grow pines. But if these sites are cultivated for truck crops and then abandoned, the ridges left by cultivation are well enough drained for pine establishment. Two years after such an abandoned field was planted, slash pine seedlings on the ridges averaged 94 per cent survival compared to 26 per cent for the seedlings in the furrows. Seedlings on the ridges averaged thirty-nine inches in height; those in the furrows, twenty-two inches (Langdon, 1956).

Recent Advances in Techniques that Combine Site Preparation and Regeneration

Of special interest to forest landowners since a Treasury Department rul­ing that site preparation costs must be capitalized instead of expensed are the machines that prepare and regenerate sites in one operation. Furrow seeders prepare and seed grassy areas or areas of light brush. Crawler tractors equipped with a plow or disk and a planter prepare and plant in one opera­tion. The versatile Buschmaster has been designed to prepare and plant brushy sites with its front-mounted bulldozer blade and two planters attached behind, each planter operating in a track of the machine (Clepper, 1961).

Summary and Conclusions

To sum up, prescribed fire is being used to prepare grassy areas and areas of light brush for pine regeneration. Prescribed fires are also being used in conjunction with other preparation techniques to further reduce competition
and to facilitate mechanical site preparation and planting. Silvicides are being applied selectively or as broadcast sprays to control hardwoods before pine regeneration. Mechanical equipment is being used to prepare some of the more level sites. Machines capable of preparing and planting or seeding in one operation have been developed.

As a closing point, mention must be made that some of the intensive and expensive site preparation techniques now in use may not have to be used a second time on the same site. In the longleaf-slash pine flatwoods, palmetto eradication is considered to be a one-shot operation, for once destroyed in an area palmetto does not reinvade or reinvades very slowly. Hardwood control may have to be repeated, but in stands that have been converted from low grade hardwoods to pine, or in other pine stands where hardwood invasion is a problem, better stocking and quicker regeneration after harvest should slow reinvasion of the hardwoods. Prescribed burning can control understory hardwoods during the rotation of some even-aged pine stands, thus reducing or eliminating the need for site preparation between rotations.

LITERATURE CITED

Seven years ago, at the third symposium, two full days were spent on the same subject that is to be covered here in thirty minutes — despite the fact that the southwide planting program has grown to over a billion trees annually! This does not imply that few advances have been made in planting and seeding since that meeting seven years ago. On the contrary, marked progress has been made, and it is documented by the specific examples to follow.

Planting

Choice of species

The choice of species for a given site is often one of the first problems confronting the tree planter, and one of the most difficult to resolve satisfactorily. Now, however, guides for classifying planting sites in terms of productivity for various species have been developed for some localities and are being rapidly extended to other areas. This advance in our knowledge of soils will simplify the job of determining what species to plant and what yields to expect on specific sites.

Site preparation

The benefits of site preparation in better survival and early growth of planted pines, particularly in dry years, have been demonstrated repeatedly. Site preparation has more than justified the nominal costs usually incurred.

Methods and techniques for preparing sites are constantly undergoing changes to improve effectiveness and reduce costs. In the dry sandhills of the Southeast heavy machinery that chops the scrub oak and wiregrass is being recommended. On less severe sites furrowing or disking is successful and prescribed burning is still recommended where conditions favor its use.

A new machine that plows a furrow in front and pulls a tree planter in the rear does a good job of site preparation and planting in one operation. These machines are now commercially available.
Hardwoods on pine planting sites are being controlled inexpensively with chemicals applied to single stems by injection or basal spraying, or in girdles and frills, or by area treatment of foliage. Mist blowers permit foliage spraying from the ground at reasonable costs. More spectacular, however, has been the development of aerial spraying by helicopter. Although foliage spraying does not kill hardwoods as effectively as single-stem treatments, it is satisfactory under some conditions and is generally cheaper.

Numerous experiments in recent years have demonstrated that hardwoods underplanted with pine should be deadened soon after planting. Immediate release usually results in better survival and growth of the planted pines, especially in dry years, than delayed release.

The drainage of wet lands is another form of site preparation that is receiving increased attention. Through ditching, these lands are being converted to areas capable of being planted successfully.

**Condition and care of planting stock**

Pruning the roots of seedlings in the nursery increases field survival, especially of longleaf pine, and may check unwanted late-season top growth. Root pruning, however, has not given uniformly good results with all species over several years and in all areas where it has been tested. Further research in this promising development is needed and is being carried on.

Clipping the needles of longleaf pine planting stock has increased survival. Of longleaf seedlings that fail to live through their first summer in the field, most die simply because they dry out. Clipping the foliage cuts down water loss by reducing the amount of needle surface. Like root pruning, however, needle clipping has not always increased survival in all years and all localities.

Most seedlings are still packed and shipped in bales of moss and waterproofed paper or burlap and stored under shelter near the planting site. New developments, however, indicate that this time-honored practice may be in for some changes. At least one state is trying special wire-bound, wrap-around crates. Preliminary results are encouraging, and so are those from tests of polyethylene bags.

Recent studies have shown that baled seedlings which have been stored in earth pits for at least six weeks will survive as well when outplanted as those seedlings stored by conventional methods. Storage in pits appears practical when cold storage space is limited or when shelters with heating and watering facilities are not available. The method is cheap and the bales require no care.
Depth of planting

Numerous studies in recent years have shown that planting seedlings slightly deeper than at root collar improves survival, especially in dry years. Results have been so convincing that deep planting should now be standard practice. With longleaf, however, special care is needed to prevent covering the bud.

Protection

Insects and disease are still killing many planted trees or reducing their growth. Nevertheless, progress is being made in developing effective and economical control of these pests. For example, recent studies have shown that areas cut in July or earlier and planted the next winter will have very few pine weevils by the following spring. If it is essential to plant within six months after pines are harvested, losses from weevils can be reduced by dipping the planting stock in chemicals. Water suspensions containing 1.0 per cent of dieldrin or the gamma isomer of BHC, or 2.0 per cent water emulsions of aldrin or heptachlor, are effective. The BHC suspension should only be used as a top dip, since the chemical is toxic to seedling roots. Seedlings may be completely immersed for brief periods in the other chemicals.

Tipmoths may not affect survival, but they can be very damaging to planted trees even in the first year. DDT has given such variable and inconsistent results that it is not yet generally recommended. Systemics are currently receiving widespread attention in the control of numerous pests. A recent study indicates that one year of protection from attacks by the Nantucket pine tipmoth can be obtained by applying ten grams of thimet to the base of one-year-old loblolly pines. Granular thimet was applied by hand in late winter before the trees started growth. All treated trees remained free of attack throughout the year, while nearby untreated trees were heavily infested. Thimet is highly toxic to mammals and should not be used without proper precautions. Because of this danger and the preliminary nature of the test, wide-scale use of this systemic for tipmoth control is not yet being recommended.

Brown spot and southern fusiform rust are probably the two major diseases that southern pine planters are concerned with. Although no new measures can be recommended for general use in controlling these diseases, recent research indicates that antibiotics have promising possibilities. For example, acti-dione, applied as a basal spray, has controlled white pine blister rust and may be equally effective in controlling our fusiform rust.
Tree improvement through genetics can also lead to a practical solution of these disease problems.

Tree planters who have had trouble with rabbits may be interested in the results of recent screening tests of various repellents. The most effective formulations were endrin or zinc in emulsions of latex, wax, or asphalt; nicotine sulfate in latex emulsion; and lime-sulphur in asphalt emulsion. Only zinc and lime-sulphur are being recommended for general use because endrin and nicotine are toxic to humans.

Seed and nursery practices

Numerous improvements have been made in the collection, storage, testing, and treatment of seed, and in nursery practices. A few of the more significant ones are worth at least brief mention because they affect the cost of producing nursery stock, and ultimately planting costs.

Nursery soil fumigation is now common practice because it has been proven effective in controlling nematodes and weeds. Bigger seedlings resulting from fumigation have also been reported. Several chemicals are effective as fumigants, but methyl bromide is generally recommended.

Treating seed in the nursery with bird and rodent repellents, as for direct seeding, is an innovation in nursery practice. This new method of pest control eliminates costly shotgun patrols.

Stratification of seed in polyethylene bags has been a new development and is especially useful for small lots of seed.

Direct Seeding

The development of techniques for direct seeding pine is probably the most spectacular advance in reforestation in the South in recent years. The breakthrough was the discovery of effective bird and rodent repellents.

Repellents

In discussing direct seeding let us first consider what is new in repellents. Tests have shown that Anthraquinone and Arasan–75, two standard bird repellents, can be used at lighter, more economical rates than were originally deemed reliable. Anthraquinone should be applied at the rate of fifteen pounds per hundred pounds of seed. Because it is nonirritating, it is recommended for hand seeding even though it is slightly more expensive than the Arasan compounds. Arasan–75 should be used at a 10 per cent concentration
or ten pounds per hundred pounds of seed. Arasan, which is a nonwettable formulation, should always be used at a 15 per cent rate. It contains less thiram and does not adhere as firmly as the wettable Arasan-75.

Endrin, which protects against rodents, should be blended with the bird repellent unless it is known that birds will be the principal seed predators — as in nursery sowing and possibly in early fall direct seeding of longleaf pine. Where rodent populations are known to be light, one pound of Stauffer’s Endrin 50W, which contains 0.5 pound effective endrin per hundred pounds of seed, provides ample protection. Where rodents are numerous, the concentration of Endrin 50W should be two pounds per hundred pounds of seed.

An adhesive is, of course, essential for holding the repellent to the seed. Two good stickers are Flintkote C-13–HPC asphalt emulsion and Dow latex 512R.

In recent screening tests of new chemicals several have shown good repellency and possess other desirable characteristics. Liquid Arasan, an experimental Dupont product, is easy to apply and eliminates dust, but additional work is needed to develop an effective sticker for it. Methyl Tuads has also been effective, and because it is the undiluted form of the active material, the rate of application possibly can be reduced below the 10 per cent level, thus lowering the cost of seed treating.

Systemics are also being tested as repellents, but none can yet be recommended. Some have been ineffective, and others are too toxic for field use.

**Seeding methods**

Seed may be sown from the air by fixed-wind aircraft or by helicopter. Both have been very effective for seeding large areas quickly and cheaply.

On the ground, seed can be broadcast by hand or drilled by various types of machine seeders. In all these methods some form of site preparation, usually diskling, has been found necessary or desirable for good germination and survival. Machine seeders that combine site preparation with seeding in one operation are constantly being improved. One machine that has aroused widespread interest is the H–C furrow seeder, which plows a furrow and sows the seed in one operation. Spacing is good and less seed is needed than in most other methods.

Various hand seeders for spot sowing have been developed and some are commercially available. A new one made and tested in north Mississippi has a modified fire-rake attached at one end and an efficient seed metering device. It does a good job of spot preparation and seed dropping in one simple operation.
In most seeding to date seed has been sown on the ground without covering. This is still recommended on most sites. Recent work in west Florida, however, shows that seed should be slightly covered on the dry sandy soils of that area.

Seed storage and stratification

On seed storage and stratification it is now recommended that seed be stored in sealed containers at 10 per cent moisture content or less and at sub-freezing temperature; that slash be stratified for thirty days, loblolly sixty days, and shortleaf pine forty-five to sixty days. There are, however, exceptions to these rules for stratification, because fresh slash seed may germinate promptly with no stratification and fresh loblolly may germinate almost as rapidly with thirty-day as with sixty-day stratification.

Conclusion

Most of the developments mentioned here are discussed in more detail in recent publications of the Southern and Southeastern Forest Experiment Stations, in Tree Planters' Notes, and in various professional and trade journals. Forest Service publications are available upon request, and one may receive them regularly by asking to be placed on the mailing list. Tree Planters' Notes is an especially useful and up-to-date publication that should be read regularly by all tree planters, direct seeders, and nurserymen.

Discussion

Question: Has there been any systematic effort to have these chemicals approved by the medical profession before they are used, in order to avoid possible harmful effects to human beings?

Mr. Muntz: If the chemicals to which you are referring are the antibiotics and systemics, I do not know that any clearance by medical authorities is necessary or has been done by the people testing them in disease control and direct seeding work. As I indicated, however, none has yet been recommended for general use, with the exception of thimet for control of insects in cottonwood.

Question: In direct seeding, when you use the hand spot seeders, how many seeds do you put out per spot?

Mr. Muntz: Hand seeders vary from simple, homemade tubes through which any number of seeds may be dropped to those that have
metering devices which control the number of seeds dropped by pulling a plunger to release them. They can be designed to release one, two, three, or more seeds. If 30 per cent germination is anticipated, then three seeds per spot should be sown to have, theoretically, every spot seeded with at least one seedling. Sowing rate should, of course, be based on your own past experience with germination and initial establishment of seedlings.

Question: Could you not do nearly as well by distributing the seed by hand and then stepping on it?

Mr. Muntz: It can be done that way, but then frequently the seeds will bunch or not go where intended, and there is not good control over spacing. Also, if you take time to be sure you drop only three seeds, this takes longer than it would using the efficient little hand seeder. The one I described has a rake for clearing a small spot; the seeds are dropped in one simple operation, and the operator steps on them as he goes to the next spot.

Comment: (H. L. Williston) With regard to the use of chemicals mentioned previously, it is my understanding the chemical companies have studied the toxicity of them and their possible danger to human beings. I suggest that if you want to use them check with the manufacturers on proper procedure.

Regarding the hand seed spotter, the one we have used distributes three to five seeds per spot; it has been our experience that we tend to get 100 per cent survival on some spots and complete failure on others. We believe, however, that the rake feature of the seeder is highly important, especially in north Mississippi because of heavy hardwood rough. It takes a little more than kicking a spot with your heel. Also, when unskilled workers are used, if they are allowed to decide how many seeds to drop, they may be quite wasteful.
Invasion of pine sites by undesirable hardwood species has become a major land-management problem in the South. The control of hardwoods for the establishment or release of established conifers is essential in widespread areas. Unfortunately, in much of our southern pine region nature favors forests in which certain hardwood species predominate. If we desire to grow pure stands of pine, some means will have to be found to interrupt the natural climax trend. It is understood that we are speaking of sites on which we should be growing pine and not our bottomland and cove sites on which we can and probably should be growing high quality hardwoods.

There are two broad considerations that should be made in planning a program of hardwood control. First is that in which the primary objective is the release of already established stems of desirable form and species, and second, one in which a complete stand conversion is desired. Both of these objectives will have to be met on most forest properties. They will probably require different approaches but in some cases can be met with the same prescription. So it becomes apparent that no one overall prescription can be made to fit all conditions found in the southern pine forest. Thus, it follows that each forest manager must write a prescription for each of his stand conditions. In the past this has not been too difficult because he had only a limited number of choices. However, a forest manager now has more tools from which to choose, and the problem now is choosing the right tool to do a specific job. In choosing a tool for a hardwood control problem there are a number of considerations that have to be made. A few of these considerations are: (1) the final objective of the treatment, (2) the site being dealt with, (3) the size of the competing vegetation, (4) the species, (5) size of the tract, and (6) the funds available to do the job.

In thinking of the control of competing vegetation one must consider two broad fields: first, a broadcast type treatment and, second, an individual stem treatment. Considerable research has been done along both of these lines in the past. Under the broadcast system probably the first attempt was the use of a controlled fire. This has the advantage of being cheap, and large
areas could be treated in a relatively short time. However, it was not a permanent treatment, and it was necessary to repeat the treatment every three or four years. Then there were and still are conditions that do not lend themselves to this type of treatment. In some places there may not be enough fuel to carry a fire as hot as is necessary to get the job done. The shortcomings of fire and the advent of 2,4,5-T brought about the use of foliage application for control of large numbers of stems per acre. This was accomplished at first by the application of high volumes of herbicide solution per acre. From the high volume-low concentration method of ground application we went to the low volume-high concentration aerial application. Now with the development of tractor-mounted mist blowers ground equipment is being used to apply low volume-high concentration treatment.

The treatment of individual stems has received most of the attention of research workers in the past. Probably the reason was that this was a very obvious need and could be handled much simpler than an overall treatment. The ax has been used as a tool to girdle unwanted trees. This was too slow, so a mechanical girdler was developed. Both gave good top kill, and on the larger trees the results were good. However, on the smaller diameters these efforts were getting good top kill with very little root kill. This led to the use of chemicals applied to the girdle or frill, or in some cases applied in cups at the base of the tree. Another method of individual stem treatment is the basal spray treatment in which the penetration of the bark is accomplished by the carrier of the herbicide rather than by some mechanical method. The shortcomings of these treatments, such as high cost of the basal spray and the sprout problem of the girdle, led to widespread use of the tree injector, which applies the herbicide to the base of the tree with penetration accomplished by the tool itself. This will give an idea of how far we have come in this field and in which direction we are heading.

The control of undesirable hardwoods in coniferous stands has been a major problem for forest managers in the past, but now with better stumpage prices and high labor costs it has become more acute. It is important that a forest manager not only maintain his growing stock at a high level but it must be of the desired quality and species. To give an idea of how acute this problem really is, last year a committee from the Southern Weed Conference sent out questionnaires to eighty-three industrial or “company” foresters located throughout the South in an effort to determine the current status of the use of herbicides in southern forestry. This survey indicated that of the 33.5 million acres of southern timberland controlled by companies, 600,000 acres received chemical weed-tree control, 330,000 acres were treated mechanically, and 200,000 acres were control-burned. This represents an expen-
diture of eight million dollars for weed-tree control by southern timber industries last year. There is a great deal of research now being conducted on weed-tree control, but the need is great for more. There is a need for basic research on the use of herbicides. There is also a need for applied research, not only on chemicals, rates, and carriers, but on technique. The sad truth about this type of research is that a lot of industries are ahead of the research agencies. This points out the urgent need of more research on how this south-wide problem can be met.

The ideal solution to the problem would be for some chemical company to develop a herbicide that would be very effective on all species of hardwood but would not damage pine. This could be applied in low volumes per acre during any season of the year. However, this is not the case. There are now herbicides that are considered better than the techniques developed for their use. The truth of the matter is that no one treatment will solve all of the problems.

Let us take a look at some of the conditions with which the forest managers of the South will be concerned. First and probably the simplest to control is the condition in which there is a high overstory of undesirable hardwoods with an understory of desirable pine. This can be handled by simply removing the overstory of hardwood. Another condition similar would be that in which there is the undesirable hardwood overstory but where the understory is also undesirable but is being held back by the overstory. Here the problem becomes a job of complete stand conversion. If the overstory is removed and no control is applied to the understory, the situation is much worse than in the beginning — and this very thing has been done on many acres over the South. There must be control of the understory before the overstory is removed! This calls for two treatments, one for the understory which will have to be a broadcast treatment due to the number of stems, and a second treatment for the overstory, which could be an individual stem treatment or an aerial application. The big question is the time to treat one and how long before the other should be treated.

A third condition that is common occurs where the overstory is of a desirable species and the understory needs to be removed before desirable reproduction can be established. All of these conditions must be met and proper technique, chemical, rate, and application prescribed before full benefits can be reaped from our pine forest. So the forest manager's job not only becomes recommending the treatment but also prescribing the order in which hardwood control will be most effective. There is another consideration that most persons fail to see — the part that soil moisture plays in hardwood control. This can be looked at in two ways: first is that the increased growth on the
desirable species may pay for the control job, and second is how soil moisture will influence the effectiveness of the treatment.

From the above discussion it becomes apparent that the hardwood control problem must, in most cases, be broken down into two separate problems, the control of the overstory (trees about three inches d.b.h. and larger) and the control of the understory (trees up to about twenty feet high). First, let us consider overstory control. In the past this has been limited to girdling with or without chemicals, frilling with chemicals, and the application of chemicals at the base of the tree in cups. All have been used with some degree of success. Two of the latest methods of overstory control are aerial application of herbicides and tree injection of herbicides. Both of these have their place and both have some advantage over the ones listed above. Since my experience has been limited as far as aerial application is concerned, I shall limit my discussion to the use of the tree injector for control of undesirable hardwoods.

The principle of injection is to place the herbicides in contact with living cells of the tree. Penetration of the bark is made by the cutting bit of the injector. This differs from basal spray in which the penetration is made by the oil carrier. It also differs from frill application in that it is not necessary to make overlapping notches in a continuous ring around the trunk of the tree. In the summer of 1959 a series of plots were installed and treated with the injector in an attempt to answer some of the questions arising from general use of this tool. The foremost questions were: which chemical to use, what to use as a carrier, and what concentration of chemical and carrier to use. Table 3 shows the chemicals, carriers, and concentrations tested along

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Carrier</th>
<th>Rate</th>
<th>Per cent Kill</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-ester, nonemulsifiable</td>
<td>oil</td>
<td>40 lbs. per 100 gals.</td>
<td>99</td>
</tr>
<tr>
<td>T-ester, nonemulsifiable</td>
<td>oil</td>
<td>20 lbs. per 100 gals.</td>
<td>97</td>
</tr>
<tr>
<td>D &amp; T-ester, nonemulsifiable</td>
<td>oil</td>
<td>40 lbs. per 100 gals.</td>
<td>97</td>
</tr>
<tr>
<td>D &amp; T-ester, nonemulsifiable</td>
<td>oil</td>
<td>20 lbs. per 100 gals.</td>
<td>95</td>
</tr>
<tr>
<td>T-amine</td>
<td>water</td>
<td>40 lbs. per 100 gals.</td>
<td>98</td>
</tr>
<tr>
<td>T-amine</td>
<td>water</td>
<td>20 lbs. per 100 gals.</td>
<td>96</td>
</tr>
<tr>
<td>D &amp; T-amine</td>
<td>water</td>
<td>40 lbs. per 100 gals.</td>
<td>97</td>
</tr>
<tr>
<td>D &amp; T-amine</td>
<td>water</td>
<td>20 lbs. per 100 gals.</td>
<td>93</td>
</tr>
<tr>
<td>T-ester, emulsifiable</td>
<td>water</td>
<td>20 lbs. per 100 gals.</td>
<td>65</td>
</tr>
<tr>
<td>T-emulsifiable acid</td>
<td>water</td>
<td>20 lbs. per 100 gals.</td>
<td>89</td>
</tr>
</tbody>
</table>
TABLE 4. Percentage kill of the four major species injected by various chemicals (both rates combined).

<table>
<thead>
<tr>
<th>Species</th>
<th>T-Ester nonemul-sifiable</th>
<th>D &amp; T-Ester nonemul-sifiable</th>
<th>T-Amine</th>
<th>D &amp; T-Amine</th>
<th>T-Ester emul-sifiable</th>
<th>T-Emul-sifiable Acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red oaks</td>
<td>95</td>
<td>96</td>
<td>97</td>
<td>97</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>Post oak</td>
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<td>100</td>
<td>99</td>
<td>99</td>
<td>72</td>
<td>90</td>
</tr>
<tr>
<td>Sweetgum</td>
<td>100</td>
<td>98</td>
<td>100</td>
<td>98</td>
<td>77</td>
<td>100</td>
</tr>
<tr>
<td>Hickory</td>
<td>97</td>
<td>100</td>
<td>96</td>
<td>94</td>
<td>76</td>
<td>94</td>
</tr>
</tbody>
</table>

with the results expressed as per cent kill. Table 4 gives the per cent kill of the four major species by various chemicals, with both rates combined. The species composition of the plots was as follows: 34 per cent southern red oak, 40 per cent post oak, 10 per cent sweetgum, 9 per cent hickory, 7 per cent miscellaneous species. The number of injections per tree depended on the size of the tree. An attempt was made to space the jabs one inch apart. After the data were tabulated, it was found that 1.5 jabs were made for each inch of stem diameter measured 4.5 feet above ground level (d.b.h.). This experiment has been repeated during the dormant season, but the final evaluation has not been made. However, the one year's results seem to follow the same pattern as the plots treated in June.

From the above work and from additional work in the field it appears that the tree injection method is here to stay. Last year 252,000 acres of the 600,000 acres of company-owned timberlands receiving chemical treatment were treated with the injector. From this it appears that company foresters are satisfied with the injector. But the questions are "Can it be improved?" and "Where do we go from here?" To me it seems necessary to find if herbicides can be applied in a concentrated form with an injector. If this can be done, it will eliminate the big job of mixing herbicide and carrier before going to the field. A special tool will have to be developed that will apply small quantities of concentrate, say down to 0.33 ml. per injection. A series of plots have been installed to test this idea, and at the end of one growing season the 0.33 ml. concentrate per injection of the amine salt of 2,4,5-T looks good. This is a step in the right direction.

The control of competing vegetation in the understory is a much more difficult problem than control in the overstory. This is because there are many more stems per acre and they are of a smaller diameter. In the past the control of the understory vegetation has been limited to fire, high volume
foliage spray, and basal spray. All have a place and all have been used with some degree of success. Fire, of course, is not selective and in some cases this may limit its use. High volume foliage application has the problem of applying forty to fifty gallons of total solution per acre, and the per acre cost of basal application has limited its use. Aerial application has been used for this job but usually has to be from a second application, since the overstory has first to be removed before the herbicide can reach the lower vegetation.

TABLE 5. Per cent kill of hardwood and pine, mist blower application.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Lbs. of Acid per acre</th>
<th>Gals. of Solution per acre</th>
<th>Carrier</th>
<th>Percent Kill¹</th>
<th>June 1959 Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trinoxol 4</td>
<td>4</td>
<td>5</td>
<td>oil</td>
<td>56</td>
<td>41</td>
</tr>
<tr>
<td>Trinoxol 2</td>
<td>2</td>
<td>5</td>
<td>oil</td>
<td>56</td>
<td>18</td>
</tr>
<tr>
<td>Trinoxol 2</td>
<td>2</td>
<td>3</td>
<td>oil</td>
<td>42</td>
<td>0</td>
</tr>
<tr>
<td>Weedone 2,4,5-T 4</td>
<td>4</td>
<td>5</td>
<td>oil</td>
<td>44</td>
<td>50</td>
</tr>
<tr>
<td>Weedone 2,4,5-T 2</td>
<td>2</td>
<td>5</td>
<td>oil</td>
<td>49</td>
<td>0</td>
</tr>
<tr>
<td>Weedone 2,4,5-T 2</td>
<td>2</td>
<td>3</td>
<td>oil</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>ACP-M654 4</td>
<td>4</td>
<td>5</td>
<td>water</td>
<td>85</td>
<td>67</td>
</tr>
<tr>
<td>ACP-M654 2</td>
<td>2</td>
<td>5</td>
<td>water</td>
<td>48</td>
<td>23</td>
</tr>
<tr>
<td>ACP-M654 2</td>
<td>2</td>
<td>3</td>
<td>water</td>
<td>34</td>
<td>6</td>
</tr>
<tr>
<td>ACP-M414 2</td>
<td>2</td>
<td>5</td>
<td>oil</td>
<td>64</td>
<td>20</td>
</tr>
<tr>
<td>GC, 2,4,5-T 4</td>
<td>4</td>
<td>5</td>
<td>oil</td>
<td>75</td>
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<tr>
<td>GC, 2,4,5-T 2</td>
<td>2</td>
<td>3</td>
<td>oil</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>Weedar 2,4,5-T 4</td>
<td>4</td>
<td>5</td>
<td>water</td>
<td>33</td>
<td>0</td>
</tr>
<tr>
<td>Weedar 2,4,5-T 2</td>
<td>2</td>
<td>5</td>
<td>water</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td>Weedar 2,4,5-T 2</td>
<td>2</td>
<td>3</td>
<td>water</td>
<td>23</td>
<td>0</td>
</tr>
</tbody>
</table>

¹ Complete top kill, no resprouts.
² Species included red oak, post oak, hickory, and sweetgum in almost equal number.
³ Loblolly pine and shortleaf pine.
The need for ground equipment that would apply effectively and economically low volume (three to five gallons per acre) of herbicides for hardwood control in coniferous stands has led to the development of tractor-mounted mist blowers. The primary objective of the mist blower is the removal of dense stands of small hardwoods (up to twenty feet in height) which often exist as understories in coniferous forests. The idea of foliage application of herbicides is not new. However, we usually think of foliage application as high volume (forty to fifty gallons per acre) with low concentration. In mist blowing we are thinking of low volume (three to five gallons per acre) with high concentration.

With the development of the mist blower there are many questions on methodology that need to be answered. Some of the questions are which chemicals will give the best results, at what rate should they be applied, what should be used as a carrier, what volume of total solution to apply to get good coverage, and when during the growing season to spray for best results.

In an attempt to answer some of these questions a fairly intensive program of research has been launched in cooperation with Amchem Products, Inc., on the use of the mist blower. The following is a two-year progress report on the first of this work.

Table 5 shows the effect on hardwood and pine expressed as a per cent kill of the various chemicals, rates, carriers, and total volume of solution.

There are many additional problems or questions that need to be investigated. Work has already started on some of them: (1) the effects of soil moisture on per cent kill; (2) the effect the density of the brush has on the total volume necessary to obtain good coverage; (3) how the portable mist blower fits into this program; (4) whether we can go below two pound acid equivalent per acre and maintain good per cent kills.

This has been a rather general discussion of the use of the mist blower and tree injector for hardwood control. However, some conclusions have been drawn from this work. Keep in mind that the mist blower work is a two-year progress report; the results may differ after the third and final evaluation.

From the injector work:

1. When an ester form of 2,4,5-T is used it is best to use oil as a carrier.
2. Good control of post oak, red oak, hickory, and sweetgum can be obtained using twenty pounds acid equivalent per hundred gallons of solution when applied in June.
3. Good control of the above species can be obtained using the combination of 2,4-D and 2,4,5-T at the rate of twenty pounds total acid equivalent per hundred gallons of solution when applied in June. (Ten pounds 2,4-D and ten pounds 2,4,5-T.)
4. The amine form of 2,4,5-T or the combination 2,4-D and 2,4,5-T in water will give good control at the twenty-pound rate when applied in June.

From the mist blower work:

1. There was no significant difference between the two-pound treatments and the four-pound treatments, both at five gallons of total volume.

2. Overall there was no significant difference between the three-gallon treatments and the five-gallon treatments; however, by individual chemicals both nonemulsifiable ester and the emulsifiable acid were significantly better at the five-gallon total volume of solution.

3. At the four-pound-in-five-gallon rate the emulsifiable acid was highly significantly better than all the rest of the chemicals and the amine 2,4,5-T was highly significantly poorer.

4. At the two-pound-in-five-gallon rate the emulsifiable acid was highly significantly better and nonemulsifiable ester was significantly better, while the amine 2,4,5-T was again significantly poorer.

5. At the two-pound-in-three-gallon rate both the emulsifiable acid and the amine 2,4,5-T were significantly poorer.

So it appears, at the present time, we are heading for more widespread use of the injectors for control of the overstory and possibly the use of concentrates in a special injector. For control of the understory we can look for more use of mist blowers, both tractor-mounted and portable.

Discussion

Question: How did costs compare between girdling and injecting to kill overstory hardwoods? How about the frill?

Mr. Starr: Using the Little Beaver and applying a herbicide in the girdle, our costs have run from $6.00 to $6.50 an acre to girdle from sixty to eighty square feet of basal area of overstory hardwoods. Our injection costs have run a little higher—from $7.00 to $9.00 an acre. The frill cost is slightly higher than the Little Beaver girdling, or $6.50 to $7.00 an acre.

SELECTED REFERENCES


RECENT ADVANCES IN CONTROL OF COMPETING VEGETATION


THINNING PRACTICES IN SHORT-ROTATION STANDS

J. W. JOHNSON, Union Bag-Camp Paper Corporation

In the early fall of 1960 the Union Bag-Camp Woodlands Research Department became interested in determining, if possible, the specific forest management techniques, or regimes, or practices, that would fit within the general framework of our management system and return the maximum volume or value or both from forest lands. Our forest management system is rather straightforward, and there is considerable information readily available on the silvics and silviculture of slash pine, our primary species. We may or may not have succeeded in determining the optimum management practices. We did, however, shed a good bit of light on the subject of thinning practices for short-rotation forest management. I pass the results of these analyses, along with our ideas and opinions about them, on to you.

The background for our interest in optimum management techniques and maximum volume and value production from our land is the pulp and paper mill in Savannah that produces an average of about 2,400 tons of paper daily, consuming about 3,500 cords of wood in the process. Roughly 80 per cent of our raw material consumption is pine, and at our Savannah Division we manage some 800,000 acres of pine-productive land out of a total of 1,100,000 acres, all within the lower coastal plains of South Carolina and Florida, and the lower and middle coastal plains of Georgia.

Some years ago we decided that a clear-cut-and-plant system of forest management, using a thirty-year rotation, would assure maximum productivity of our pine-productive lands. We have been operating under this system for the past five years, we like it, and we will continue on about the same scale as at present for the foreseeable future. Located as we are in the heart of the slash pine region, we have concentrated and undoubtedly will continue to concentrate on this species in our planting program.

There are a couple of points which I would like to clarify before getting on with the subject. First, let me substitute tree size for length of rotation and entitle the subject “Thinning practices for small-product management,” rather than “short-rotation management,” if for no other reason than that my short rotation may be your medium, or vice versa. Secondly, I do not
want to be put in the position of having to defend small-product forest management, although I think this can be done. Let me say only that it is a system that is being used on a fair-sized segment of the Southern Pinery, with satisfactory results. Described here is our exploration and evaluation of practices that will produce optimum results when stands are managed for small products.

Our approach to the evaluation of management practices for a system of clear cutting and planting on a thirty-year rotation involved detailed analyses of existing growth and yield table information. The tables used came from the University of Florida Research Report No. 3, entitled “Growth and Yield of Slash Pine plantations in Florida,” by Robert L. Barnes. Published in 1955, this report shows growth and yield of planted slash pine in terms of site quality (which is average height of dominants at Age 25), age, and original spacing or numbers of trees per acre. It has, since its publication, been widely accepted as authoritative for slash pine plantations in north Florida, and its practical use has been extended well beyond the confines of that state by foresters in need of information such as it contains.

As convenient for our purposes as was the information in Research Report No. 3, we did not set about the detailed analysis of the data without considerable examination of their possible applicability to the coastal plains of Georgia and lower South Carolina as well as North Florida. Fortunately, we had available detailed mensurational information on over one hundred plots in slash pine plantations in Georgia and Florida, through a cooperative study with the Cordele Research Center of the Southeastern Forest Experiment Station on optimum stand densities for slash pine plantations. Figure 7 shows the location of these plots. This cooperative study will eventually yield more certain information on optimum management practices for slash pine plantations than we have come up with here. We think, however, that it will verify our work, which is less exact but also less time consuming. At any rate, comparison of our field information on average d.b.h. and numbers of stems per acre with average diameters and average survival at various ages from Barnes’ Research Report No. 3 revealed that his tables are applicable enough to our plantation conditions in the lower and middle coastal plains of Georgia to be used without modification. Figures 8 and 9 indicate the applicability of the tabular information to our conditions. We went ahead with our analysis of the yield tables on this basis.

There is one major gap, however, in the present status of information on slash pine silviculture: nowhere are we able to find information on the possible changes in rates of growth or production following intermediate cut-
tings in stands of merchantable sizes. Data are available on growth rates of slash pine following precommercial thinnings; in fact, we have five-year growth information from precommercial thinning studies on our own Union Bag Experimental Forest, but there are no similar results following

Figure 7. Location of slash pine plantations used to check survival and average diameters as shown in University of Florida Research Report No. 3 (1955).
thinning in stands that have reached usable sizes under conditions of normally heavy stocking. Fortunately, we were able to get around this deplorable absence of information by manipulating and arranging Barnes' growth and yield data and by making certain inferences that we believe will stand the test of reason and logic. Since this is the basis for our conclusions concerning thinning in slash pine stands being managed for small products, let me describe our arrangement and use of Barnes' data.

Our older plantations are for the most part on land of about Site Quality 65 (this corresponds, we have found, to a Site Index of about 80), and our plantation spacing is and has for many years been 6 x 10 feet, which is most closely approximated in Barnes' tables by the 8 x 8-foot spacing. Now as to the actual arrangement of Barnes' information for our use, we found it desirable to construct models to describe the development and production of slash pine plantations of a given initial spacing and site quality. For example, we modeled from Barnes' report the survival, average d.b.h., and volume yield for a plantation with an original spacing of 8 x 8 feet, or 681

![Figure 8. Comparison of average d.b.h. by age, as predicted from University of Florida Research Report No. 3 (1955) and as measured in check plantations.](image-url)
trees per acre, on land of Site Quality 65. The model shows numbers of stems per acre, average d.b.h., and total volume per acre in trees 4.5 inches d.b.h. and larger, by five-year intervals from Ages 15 to 30. These figures were verified for our locations and conditions, as shown earlier.

The basic model can be added to, from another table of Research Report No. 3, to show average d.b.h. and total production for the same age intervals and site quality, but with different numbers of stems per acre at Age 15. All of this is shown in Figure 10. There is no way of determining from the basic data of Research Report No. 3 how or when numbers of stems per acre were reduced. By one means or another, such as wider initial spacing, heavier mortality, or perhaps thinning, the plantations have come to Age 15 with fewer stems per acre than would be the case with an original 8 x 8-foot spacing and normal mortality. And since there are fewer stems per acre at Age 15 in the lighter stand than at Age 30 in the stand modeled in the top line, we can safely assume negligible mortality in these lighter stands between the fifteenth and thirtieth years. The information for the stand of two hundred stems per acre at Age 15 is emphasized because

Figure 9. Comparison of survival as predicted from University of Florida Research Report No. 3 (1955) and as measured in check plantations.
it is used as an example of our analysis of growth and production following thinning.

Suppose we thinned the stand modeled in the top line back to two hundred stems per acre at Age 20 and carried it on to Rotation Age 30 with no further treatment. We would remove 269 stems; and average d.b.h. of the 200 remaining stems immediately after the thinning would be 7.2 inches, since a cut of this magnitude would have to be spread over the small range of diameters that are normally found in uniform stands such as slash pine plantations. Now, over the ten years between thinning and harvest cutting, the residual stems would grow to an average diameter of at least 8.6 inches, which would have been attained if no thinning had been done. They would not, however, grow to the 10.2-inch average diameter of a thirty-year-old stand that received no thinning but that came up to Ages 15 and 20 with a stand density of only 200 stems per acre. We reasoned that the maximum average d.b.h. that could be reached at Age 30 by the thinned stand could be calculated by adding the rate of diameter growth from Age 20 to Age 30 of the 200-stems-per-acre stand to the average d.b.h. of the residuals imme-

Site Quality 65
8 x 8 foot spacing
Initial stems per acre: 681

Figure 10. Model of plantation productions at various ages, in terms of numbers of trees, average d.b.h. in inches, and cord volumes. From University of Florida Research Report No. 3 (1955).
Adiately after thinning in the thinned stand. This rate of d.b.h. increase is 1.5 inches (10.2 inches – 8.7 inches). Added to the 7.2-inch average of the residual stand at Age 20, the maximum average d.b.h. at Age 30 would be 8.7 inches. Summing up, our reasoning is that, if we thin at Age 20 to 200 stems per acre, we will have a stand to be harvest cut at Age 30 with a maximum average diameter of 8.7 inches or a minimum average diameter of 8.6 inches.

This is a sobering revelation. We have gone into a stand, reduced its basal area by nearly 60 per cent, and in ten years time gained a maximum of only one-tenth of an inch in average diameter over what we would have had if we had left the stand untouched. The example presented is not unique. Similar models can be constructed for any combination of site quality, initial spacing, and age, with generally comparable results. If, for example, initial spacing and management technique remain the same, but Site Quality is 50 instead of 65, the average d.b.h. at Age 30 is a maximum of 7.2 or a minimum of 7.0 inches. There are several instances where the calculations give nonsensical results—where maximum average d.b.h. is smaller than minimum average d.b.h. While this might be expected in view of the heavy-handed manner in which the basic data was handled, it really is not important. The important thing is that nowhere can we demonstrate much of any acceleration in diameter growth as a result of heavy thinnings, much less moderate or light thinnings, over periods as long as ten years.

Volume production for a given site quality in the uniform slash pine plantations of the Southeast is for all practical purposes a function only of average d.b.h. and number of trees per acre. Consequently, the evaluation of thinning practices in terms of total cord production is relative to the average diameters produced. There may be minor differences in total production with different commercial thinning regimes; for example, in the Site Quality 65 initially spaced 8 x 8 stand that was modeled, total production at Age 30 with no thinning is 449 stems or 45.5 cords per acre. The most productive thinning regime for the thirty-year rotation, calculated as described, is an intermediate cut at Age 25 to four hundred stems per acre, for which total production from the two cuts is a maximum of 47.8 or a minimum of 45.3 cords. There is not much here to choose from!

There really is not anything new in all these results. Many foresters have realized that slash pine does not respond well to release, particularly if it has been grown in moderately dense stands for the first twenty or twenty-five years of its life. The species will not stagnate, like black willow, except perhaps on the very poorest sites, but it cannot be expected to respond to cultural treatments such as thinnings as promptly or to the degree that we
would like. While this peculiarity of slash pine silvics may have been known, it has been rather consistently ignored, at least in recent popular forestry publicity. Without question, the typical thinning operation that removes four to six cords of wood from well-stocked stands is nothing more than an interim minor recovery of capital from the forestry enterprise. This is a fine objective in itself, as I shall indicate in greater detail. Such thinning, however, must not be expected to stimulate growth of the residual stand or total production. We simply cannot demonstrate any real increase in total volume production, or even average size of trees, from commercial thinnings in slash pine stands being managed on short rotations for small products.

Total volume production, of course, is only part of the story. We have not yet reached the point of having to produce the ultimate cubic foot of wood from our lands, with no regard for the economics involved. Moreover, the forest lands that are being subjected to small-product management are almost without exception portions of larger businesses rather than independent economic entities in themselves, which may call for a different attitude toward their production. At any rate, it all points to the fact that thinning in small-product forest management must be evaluated in terms of dollars rather than cords.

One fairly straightforward way of going about this evaluation is through use of a standard compound interest formula to calculate the net present worth of a series of permanent periodic incomes, as determined from analyses such as we made of Barnes' yield tables. We have assumed certain costs of regeneration and management and certain values for the production of the land. In connection with evaluations of management regimes that include thinning, we have taken into account the recovery and theoretical reuse of capital through thinning ahead of the rotation age, thus crediting the entire venture with the benefits that come from more rapid turnover of this capital.

At any rate, the financial evaluations made of various management practices within a basic thirty-year rotation for small products indicated some advantage from relatively heavy thinnings at Age 20 as compared with no thinning. The example stand used here—Site Quality 65, initial spacing 8 x 8 feet—shows the highest net present worth under a management regime that calls for thinning at Age 20 to 200 stems per acre, followed by the harvest cutting at Age 30. Actual net present worth figures do not mean much, since they will vary with the figures of costs, value, and interest rate that are used in the computations. Within the framework of assumptions that we made, thinning to 200 stems per acre at Age 20 and harvest cut-
ting at Age 30 results in a net present worth that is $12.00 per acre greater than the net present worth for the management regime that harvest cuts at Age 30 with no thinnings having been made.

This all applies, please recall, only to slash pine. I do not know how loblolly plantations would react to intermediate cutting treatments; we do not have information available in the form needed for similar analyses and evaluations. My personal opinion is that loblolly will respond more readily to release and, therefore, that thinnings prior to harvest cutting in small-product rotations will result in more favorable volume and/or value production than in slash.

Moreover, keep in mind that the stands that have been modeled, analyzed, and evaluated are plantations. This is what we at Union Bag-Camp are interested in, since our pine-productive lands in South Carolina, Georgia, and Florida are scheduled to be managed eventually in the form of plantations. I believe, however, that short of extremely low or extremely high stocking, there will not be a great deal of difference between planted and natural slash pine stands. Plantations will be more uniform in diameter and of course in spacing, but my feeling is that the volume differences between the merchantable portions of plantations and natural stands of slash will not be particularly great. Natural stands of slash will react much the same as plantations to intermediate commercial cuttings, and consequently, the results of this analysis of plantation growth and yields will apply, at least relatively, to natural as well as planted stands.

Before summing up, let me emphasize that the intermediate cuttings have been commercial rather than precommercial thinnings, with the result that the stands have been rather tightly stocked for some time ahead of the thinning. If thinnings could be made earlier, I am sure diameter growth response would be greater. We have demonstrated on our Experimental Forest near Savannah that dense natural stands of ten-year-old slash pine will respond in diameter growth, although not in volume growth, to heavy precommercial thinning over the first five years following thinning. If commercial intermediate cuttings could be made in stands that are now of precommercial sizes, the evaluation of thinning practices might change. I am of the opinion that we are fast approaching that day—that we are close to being able to make efficient use of trees that are now of unmerchantable sizes.

In summary, the information presented here indicates that commercial thinning cannot be expected to increase total wood production in slash pine plantations being managed on short rotations for small products. Heavy thinnings five or ten years before harvest cutting may increase the net
present worth of such stands, however, and therefore should be given serious consideration. In short, commercial thinning in small-product forest management can be accepted, rejected, or simply deferred on the basis of mill requirements, net present worth evaluations, cost or availability of raw material from other sources, or general business conditions. Silvicultural considerations involving growth and total volume production are definitely secondary, in view of the manner in which splash pine responds to intermediate cutting treatments, and need not complicate the overall management picture.

Discussion

Question: In your example, when you reduced the number of stems per acre to about 200 at Age 20, how much volume did you remove then and how much did you have left at Age 30?

Mr. Johnson: When we reduced the stand at Age 20 to 200 stems per acre, we cut 269 stems and removed 18.8 cords. In the ten years between Age 20 and Age 30, the residual volume on the area grew back to a maximum of 22.2 cords or a minimum of 20.2 cords per acre, a very narrow range. That, added to the 18.8 cords we removed earlier, gave us a total volume production of a maximum of 41 cords or a minimum of 39 cords per acre.

Question: Was your maximum yield obtained when you thinned at Age 20 to 400 stems per acre?

Mr. Johnson: For that particular stand, yes, although the difference was so small it was completely insignificant. Actually, the figures show we obtained our maximum yield when we thinned at Age 25 back to 400 stems per acre and then harvest cut at Age 30.

Question: Is it your aim not to do any thinning at all until you clearcut at Age 30?

Mr. Johnson: That depends, as I said earlier, on whether your mill has enough wood, whether you can buy wood from outside sources, or whether you are afraid of *Fomes annosus*. It depends on all of those factors rather than on any silvicultural factors. In short, as far as this analysis shows, you do not need to worry about silviculture if you are going to grow small products on a short rotation of about thirty years.

Question: If at Age 30 you could buy wood on the open market in suf-
icient quantity, what would you do? You would have to do something, because if you did not, your stands would probably stagnate. Would you not then be forced either to thin or clearcut and buy possibly cheaper wood on the market?

Mr. Johnson: In this situation we might consider intermediate cuttings a great deal more seriously. I believe that as stand age increases some form of release must be given residual trees, if they are to live and develop as they should. I do not believe that they would stagnate, not in the sense commonly used in forestry terminology. Their growth, however, might be so little that you probably should do something about it.
Our company has a stated forest management policy of striving to produce the maximum of high quality sawtimber and poles and at the same time the greatest cubic-foot volume. This is consistent with the thinking that the forest should produce the maximum dollar value per acre per year. Such a policy might seem a compromise, but data presented here would show that it is not.

The direct application of the data and ideas contained in this paper are to loblolly pine stands in southeastern Arkansas and northeastern Louisiana. Some of the concepts, however, may have application to other areas of the South.

Why should we thin? Are we apt to lose cubic-foot volume if we thin between ages 17 and 35? W. G. Wahlenberg (1960) cited fourteen authors concerning yields resulting from loblolly pine thinning. The majority of them indicated that we will not diminish yields by thinning. None suggest not thinning after Age 35. Three separate intensive studies at Crossett show after ten years no decrease in mean annual cubic-foot yield resulting from thinning.

Yield table authors concur that measurements of uncut stands are the best data available at the present time for planning forest management. When comparable data are available from thinned stands, they will replace the yield tables from uncut stands. Much growth information is available now. As an example, William F. Mann, Jr. (1952) reported that loblolly pine showed a declining periodic annual growth at Age 28; however, it was greater than the mean annual cubic-foot growth, which was still rising at Age 44. Subsequent measurements of the Maxwell plots and others at Urania showed similar trends of continued high growth rates at even greater ages. H. H. Chapman (1953) also reported a rising mean annual growth rate up to Age 36, which was as far as he had carried the data for his thinned plots at Urania. All reports for loblolly pine on good sites have indicated a decrease in cubic-foot volume growth after Age 35, if no thinning was done.
Density of wood should also be considered here, since forest yields are being measured by weight, as pulp mill people know and landowners are learning. Despite other factors that have an influence, the specific gravity of the average cubic foot of wood grown increases with age of the timber. H. L. Mitchell and P. R. Wheeler (1959) reported the results of sampling throughout Mississippi for wood density by means of increment cores. They produced a curve relating age to average specific gravity for three sections of the state. At the same time, trees were felled and the correlation of the specific gravity of the core with that of the average for the whole tree was established. Results were reported by H. E. Wahlgren and D. L. Fassnacht (1959). Mitchell and Wheeler also illustrated the well-established relationship of pulp yield with specific gravity of wood. These three factors are put together in Table 6 to produce what might be called the “pulp yield index,” which is a percentage expression of the increase in yield from a cubic foot of wood beginning at 1.0 for the average fifteen-year-old tree. This would show a 10 per cent increase in the pulp yield per cubic foot of wood from a sixty-year-old tree compared to that of a fifteen-year-old tree.

**TABLE 6. Pulp yield indices for loblolly pine at various ages.**

<table>
<thead>
<tr>
<th>Age</th>
<th>Core Specific Gravity Central Mississippi¹</th>
<th>Tree Specific Gravity²</th>
<th>Av. Oven-Dry Weight, lbs. per cu. ft.</th>
<th>Pulp Yield¹ lbs. per cu. ft.</th>
<th>Pulp Yield Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>.462</td>
<td>.447</td>
<td>27.89</td>
<td>13.18</td>
<td>1.000</td>
</tr>
<tr>
<td>20</td>
<td>.478</td>
<td>.454</td>
<td>28.33</td>
<td>13.40</td>
<td>1.016</td>
</tr>
<tr>
<td>25</td>
<td>.490</td>
<td>.460</td>
<td>28.70</td>
<td>13.59</td>
<td>1.030</td>
</tr>
<tr>
<td>30</td>
<td>.506</td>
<td>.466</td>
<td>29.08</td>
<td>13.79</td>
<td>1.045</td>
</tr>
<tr>
<td>35</td>
<td>.516</td>
<td>.471</td>
<td>29.39</td>
<td>13.94</td>
<td>1.057</td>
</tr>
<tr>
<td>40</td>
<td>.525</td>
<td>.475</td>
<td>29.64</td>
<td>14.07</td>
<td>1.067</td>
</tr>
<tr>
<td>45</td>
<td>.533</td>
<td>.478</td>
<td>29.83</td>
<td>14.16</td>
<td>1.073</td>
</tr>
<tr>
<td>50</td>
<td>.541</td>
<td>.482</td>
<td>30.08</td>
<td>14.29</td>
<td>1.083</td>
</tr>
<tr>
<td>55</td>
<td>.549</td>
<td>.485</td>
<td>30.26</td>
<td>14.38</td>
<td>1.090</td>
</tr>
<tr>
<td>60</td>
<td>.556</td>
<td>.488</td>
<td>30.45</td>
<td>14.48</td>
<td>1.098</td>
</tr>
</tbody>
</table>

²From Wahlgren and Fassnacht, 1959.
The pulp yield index concept, applied to the growth figures published by the Forest Service in *Miscellaneous Publication 50*, will increase the age of culmination of mean annual growth to forty years. Applied to the growth data of managed stands such as the Maxwell plots, it shows that pulp yield reaches a peak at over fifty years of age. Today more and more growth information is becoming available from permanent plots in managed stands. Taking into account thinning and wood density, the so-called pulpwood rotation should not be less than fifty years to maximize pulp yield from a property (Table 7). This approach was presented by C. G. McLaren (1960).

**TABLE 7.** Pulp growth in pounds per acre per year for various stand ages.
Basic data from Mann (1952) for Maxwell plots U-5, U-55, and U-56.

<table>
<thead>
<tr>
<th>Age at End of Period</th>
<th>Annual Growth Periodic</th>
<th>Mean</th>
<th>Pulp Yield lbs. per cubic foot</th>
<th>Total Pulp Production M-lbs.</th>
<th>Annual Growth in Pulp Yield Periodic</th>
<th>Mean</th>
<th>lbs. per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>years</td>
<td>cubic feet</td>
<td>cubic feet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>—</td>
<td>94</td>
<td>13.31</td>
<td>22.5</td>
<td>—</td>
<td></td>
<td>1,250</td>
</tr>
<tr>
<td>23</td>
<td>161</td>
<td>108</td>
<td>13.51</td>
<td>33.1</td>
<td>1,720</td>
<td>1,439</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>181</td>
<td>121</td>
<td>13.71</td>
<td>46.0</td>
<td>2,580</td>
<td>1,643</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>145</td>
<td>125</td>
<td>13.89</td>
<td>56.4</td>
<td>2,040</td>
<td>1,709</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>141</td>
<td>127</td>
<td>14.08</td>
<td>68.8</td>
<td>2,066</td>
<td>1,764</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>157</td>
<td>130</td>
<td>14.15</td>
<td>80.1</td>
<td>2,260</td>
<td>1,820</td>
<td></td>
</tr>
</tbody>
</table>

@ 80 Cubic Feet per Standard Cord

The value of a product is substantially affected by the cost of producing it. If one assumes equal rates of growth for an unthinned thirty-year-old stand and a thirty-year-old stand thinned throughout its life, there could be a difference of $2.00 per cord in favor of the thinned stand in the cost of cutting and hauling the total volumes produced. If there were a mean annual growth rate of 1 1/2 cords in each case, there would be an additional value of $3.00 per acre per year, as a result of larger average size of wood produced by thinning.

An examination of the data published on thinning loblolly pine will reveal that moderate thinnings will produce a volume totaling about half of the mean growth by Age 30 in well-stocked stands. The value of this harvested volume should be enough to return the cost of establishment and the annual management charges at reasonable rates of interest. Using the growth rate above, one faces the alternate choices of how to invest his profit, residual volume of the twenty-three cords of pulpwood remaining,
for the decades ahead. By growing this stand we can obtain a greater
growth than has been averaged to this point, and we can look forward to
a decade of a large amount of sawlog ingrowth. It is entirely feasible to
realize 10,000 board feet Doyle at Age 40.

In the application of thinning practice there are two primary considera-
tions—intensity of thinning and type of tree cut. Although each will be dis-
cussed separately, in application each substantially affects the other.

Thinning studies installed at Crossett eleven years ago in twenty-year-old
second-growth clearly indicate our lack of understanding of the extent of
the level of stocking that will produce maximum growth. The stands were
initially cut back to a range of seventy to one hundred square feet of basal
area per acre. Plots were added after five years to spread the range from
55 square feet to 130 square feet. After a second five years (now at Age
30) some plots were added with basal areas as low as thirty square feet in
an effort to relate residual stand density to periodic growth:

<table>
<thead>
<tr>
<th>Residual Basal Area (per acre) at Age 25</th>
<th>Periodic Annual Growth (per acre) Age 25 to 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square Feet</td>
<td>Cubic Feet</td>
</tr>
<tr>
<td>55</td>
<td>180</td>
</tr>
<tr>
<td>70</td>
<td>165</td>
</tr>
<tr>
<td>85</td>
<td>166</td>
</tr>
<tr>
<td>100</td>
<td>186</td>
</tr>
<tr>
<td>115</td>
<td>142</td>
</tr>
<tr>
<td>130</td>
<td>125</td>
</tr>
</tbody>
</table>

On site index 90 the length of bole that has developed free of green
limbs in the range of basal areas from 70 to 100 square feet is as follows
on 150 crop trees per acre:

<table>
<thead>
<tr>
<th></th>
<th>Dead Limb Length 1949</th>
<th>Dead Limb Length 1959</th>
<th>Increase in Potential Clear Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinned from above</td>
<td>29.1</td>
<td>38.7</td>
<td>9.6</td>
</tr>
<tr>
<td>Thinned from below</td>
<td>27.6</td>
<td>40.1</td>
<td>12.5</td>
</tr>
</tbody>
</table>

Young stands then should be thinned at least to a moderate degree to
maintain cubic foot growth and can be reduced to 70 square feet, while still
cleaning up to 2½ logs at Age 30. Poles and piling sixty feet long and greater
can be produced on this site by Age 50; however, it is obvious that a growth of three inches in ten years must be maintained to reach the necessary diameter. This growth rate has been achieved on the crop trees even in the heaviest stocking for the past thirty years but will be difficult to maintain for the next twenty years.

Now, with two or more potential Grade One logs in sight on at least eighty trees per acre, we may thin to a reasonably heavy degree consistent with maintaining both cubic foot growth and board foot growth at the maximum. It would seem best to thin back to a basal area of about eighty square feet per acre, but with latitude to cut more heavily if original stocking were poor and low quality trees were developing. Basal area is used as the measure of stocking to guide the marking because it is easy to check and can be interpreted with consistency. In use it conveys the idea of space required for best growth on the best trees.

The best trees are the straightest and cleanest of the dominants, which have the capacity to continue good growth in competition with the rest of the stand. In young stands, Age 20 to 30 years, the practice of thinning heavily from above so that the intermediates with smaller knotty boles may develop into quality crop trees simply does not work out that way.

For example, in the thinning study just noted, half of the plots were cut moderately from above; the others were thinned from below. One hundred and fifty crop trees per acre were selected for detailed measurements at the time of the first cut at Age 20. On the plots thinned from above 46 per cent of the crop trees were intermediates and 39 per cent were classed as co-dominants. Ten years later only 29 per cent of the original stems were suitable to be carried on as crop trees. At Age 30 it was obvious that new crop trees must be chosen, and the best eighty per acre were tagged. On the plots thinned from below, 98 per cent were taken from the original 150 per acre. On the plots thinned from above, half of the crop trees had to be selected from other than the original 150. Most of the original intermediate crop trees were cut in the thinning at Age 30, since they were hopelessly behind the dominant stand.

The Southern Forest Tree Improvement Committee has used the term “dysgenic” to describe the practice of thinning heavily from above in the dominant class to favor smaller trees of the intermediate class. However, some light cutting in the dominant class has merit, provided it is thought of as crown thinning for the benefit of the rest of the dominant and co-dominant stand. Diseased, malformed, and forked trees may be removed, provided residual basal area is not lowered to the point where cubic foot growth may fall off and if thinning from below is the basic approach.

The first of the intermediate sawlog cuts can be made at Age 35 to 40
when stems of poorest quality may be removed among the dominants, coupled with a follow-up thinning of pulpwood-size material from below. One must always be guided by the concept of growth on a unit of area, however, rather than on individual trees and should also seek to maintain suitable stocking of the best trees. The development of a layer of quality lumber on a tree bole in a given length of time requires that good diameter growth be maintained. With the butt log clean at Age 25 and a diameter of eight to nine inches on the best eighty trees per acre, continual thinning is needed to add eight inches of clear wood by Age 50.

Suitable operational plans must be put into effect to accomplish these goals. Young stands need thinning every five years and should be identified and located so that this cycle may be effected. As the stands reach small sawlog size, the thinning practice may be extended to every ten years. Thinning delayed may cause a drop in annual growth, since more of the growth is put on shorter stems that have fallen behind in competition. One should bear in mind that the practices outlined apply to well-managed stands; areas long overdue for thinning or of poor original stocking will require different treatment.

In summary, thinning is mandatory to maximize the total forest yield in pulp or quality lumber, and in dollars. Thinning should begin when the stand is large enough to obtain an operable cut from below. Cutting in the dominants at an early age should be very light and confined to removal of diseased and deformed trees. Thinnings should be planned and frequent to keep the stand in the range of maximum growth and to maintain good increment on the best trees.

Research has in recent years made known a great deal about the development of loblolly pine. It remains for forest managers to put that information together to fulfill best the objectives of their organization.

Discussion

**Question:** You said the first thinning was made when you could get an operable cut from a low thinning. About when is that on site index 80 land?

**Mr. Kennedy:** It is approximately Age 20 in second growth.

**Question:** You mentioned precommercial thinnings and gave a slide showing one. At what age was it made?

**Mr. Kennedy:** It was made at Age 14 in an old field, naturally seeded stand.

**Question:** (continued) By precommercial you mean you did not utilize any of the wood?
Mr. Kennedy: True. I used this to illustrate the point that all of us feel we should thin one way or the other.

Question: (continued) What size were these trees at Age 14?
Mr. Kennedy: The 1,000 best crop trees were about four inches in diameter. The smaller trees were to be taken out and none were merchantable.

Question: (continued) Some old field stands are very dense, but seldom or never have I seen one with 1,000 stems per acre at Age 14. In south Arkansas I would think that at Age 14 some of these old field stands would be big enough to utilize for pulpwood. Is that not true?
Mr. Kennedy: In this case there were 3,500 stems per acre at Age 14 over quite an extensive area. We laid out plots, and on some chose the best 1,000 stems per acre and cut out some. On the other plots we let nature cut them out. It is true that trees fallen behind among the other 2,500 were passing out at a very rapid rate at this age.

Question: In 1946, when Professor Walter Meyer took the Yale students to Crossett, the talk at the Crossett Company was selection cutting and all-aged management. Today you showed pictures of even-aged management. Would you say that even-aged management has an important place in the Crossett Company’s operations?
Mr. Kennedy: In the fall of 1951, at a Society meeting in Biloxi, the manager of the Crossett Forestry Division stated that we were aiming towards even-aged management.

LITERATURE CITED

RECENT ADVANCES IN PINE GENETICS

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University of Florida

While forest genetics is by no means a new area of research, the wide popularity of this field in the United States has developed since about 1950. Interest has largely paralleled and, to a considerable extent, been stimulated by the tremendous increase in artificial regeneration. Whereas full advantage of improved strains or hybrids is possible only through seeding and planting, genetic improvement under natural regeneration systems is limited to the avoidance of dysgenic practices.

Reports of European work in forest genetics, such as Lindquist's book (1948), the progress of Australians in improvement of exotic conifers, and the organization of groups like the Southern Forest Tree Improvement Committee may be credited with the awakening of a wider interest in tree improvement. As foresters and landowners became aware of the possibilities of genetic improvement of forest planting stock, a rapidly expanding demand for applied genetic principles was created. Of course, no improved strains or superhybrids were available, and in fact the residue of basic knowledge of the genetics of forest trees was soon outrun.

In the South tree improvement research prior to this period was limited to a few seed-source studies such as the well-known one at Bogalusa, most recently reported by Bercaw (1955), scattered trials of species hybrids, and the early work at Lake City, Florida, on high-yielding naval stores trees. For both applied tree improvement and more basic genetic studies it was readily apparent that much information was needed in related fields. The older studies often presented more new questions than they answered. Results indicate that geographic races of southern pines exist, but what are the limits of these races? Genotypes can be preserved through vegetative propagation—how is this best and most economically accomplished with southern pines? Insects and diseases reduce cone crops and add to the difficulties and expense of breeding programs—what insects and diseases, and how may they be controlled? Can the disadvantage of long tree generations be short cut by stimulating early cone production? And perhaps most important of all from a genetics viewpoint—what characteristics of forest
RECENT ADVANCES IN PINE GENETICS

69

trees are inherited and to what extent? Still expanding research programs were initiated throughout the region to find the answers to these and other questions. It should not be implied that all of them are genetic problems nor that geneticists are responsible for all of this activity. However, the wide interest in forest genetics and the persistent quest for answers on the part of those involved in tree improvement certainly catalyzed much research in related fields.

Just what has all this activity accomplished? So far as I know, no one in the South is about to release a super strain of pines to solve all of our planting problems. There are still innumerable questions for which answers are not available or are only vaguely apparent. However, many real and significant advances have been made. In the area of service functions many problems have been at least partially resolved. While it is still not possible to root pine cuttings with any degree of certainty, adequate methods of grafting have been developed. By way of illustration, I would estimate that over 1,000 acres of grafted pine seed orchards have been established in the South. For example, 430 acres, largely slash pine, have been planted by industries in the University of Florida Cooperative Forest Genetics Program. Good cone crops of larger trees can be stimulated (Halls and Hawley, 1954; Wenger, 1953, 1954), and P. E. Hoekstra and F. Mergen (1957) have shown that, given proper growing space and treatment, slash pine trees less than ten years old will produce cones. We are still, however, a long way from understanding the internal physiological balances which control the initiation and development of reproductive organs. Insect pests attacking pine cones, some of them scarcely noted before intensive breeding programs were initiated, have been studied and considerable progress in control measures has been made (Allen and Coyne, 1956). Cone rust, another organism which concerned us little in previous years, is being intensively investigated (Matthews, 1959).

Geographic Variation

However important these developments may be, their main purpose is to allow the tree breeder to do his job more effectively. What advances have been made that may be properly classified as genetic? Genetics is, to a considerable extent, merely a study of variation—variation within a tree or a clone, variation among trees growing on the same site, geographic variation, variation between parents and their progeny. Geneticists carefully observe variation and attempt to clarify the reasons for its occurrence. One important source of variation of forest tree species is that attributed
to geographic origin. Numerous seed source studies have been established in the South and are beginning to produce interesting results. As might be expected, results of different tests often appear conflicting. For example, H. J. Derr and H. Enghardt (1960) concluded on the basis of data from a twenty-three-year-old plantation established near Alexandria, Louisiana, that geographic races of slash pine are not well defined in respect to rate of growth or fusiform rust susceptibility and suggest that seed from throughout the range may be used with confidence. A different view is expressed by G. L. Switzer (1959), reporting on an eleven-year-old study in north Mississippi. Slash pine seedlings from six sources were used in the Mississippi study, with eastern and more coastal sources performing more poorly than western and inland sources.

This disagreement between two slash pine plantings, both outside the natural range of the species, illustrates the care that must be taken in interpretation of experimental results and emphasizes the point that, in research, what often appears to be wasteful duplication of efforts is frequently valuable replication. Closer comparison of the two reports reveals that the different results may perhaps be reconciled. All of the sources planted at Alexandria were from coastal counties or counties adjacent to coastal counties, except one Georgia and one Florida source, both of which are located near the neck of the Florida peninsula. Even in this study the average volumes produced by the more interior Georgia source and two of the western sources were substantially higher than the Florida and Carolina sources (five cords), although the differences were not statistically significant. This may indicate that, to find different races of slash pine, we need to check sources from the coast inland rather than stretching out along coastal areas.

This is in somewhat general agreement with a study reported by A. E. Squillace and John Kraus (1959), although their report is based on only three years growth after out-planting. In the latter study slash pines originating in an apparently optimum climatic zone for the species are outgrowing other sources in seven areas in Georgia and Florida, with somewhat poorer performance of lots from the north or south of this zone. These results suggest (and later remeasurements indicate a continuing trend1) that inherent variation in growth rate exists and that moderate increases in growth may be obtained by proper choice of seed source.

We can expect that many of the apparent inconsistencies of various seed-source trials will be clarified by the Southwide Seed Source Study (S.F.T.I.C.,2 1952, 1956). This study is designed to outline broadly seed

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1 A. E. Squillace, personal communication.
2 Southern Forest Tree Improvement Committee.
collection zones for the major southern pines. More detailed studies will serve to fill in the gaps. The Southwide Seed Source Study has already furnished valuable data and further results are soon to be released. P. C. Wakeley (1959) has reported differences in fifth-year survival for all four species, although not in all locations or all planting series. For example, in adjacent tests in Pearl River County, Mississippi, differences in survival of loblolly pine sources from the same average annual temperature zone do not approach significance, while sources representing three different temperature zones vary significantly in average survival. Other tests in this study have also indicated highly significant differences in average height of longleaf, slash, and loblolly pines attributable to geographic origin.

Provenance is also of importance for other characteristics than survival and growth rate. The Texas Forest Service has for several years been testing loblolly pine sources for drought resistance (Zobel and Goddard, 1955). The Lost Pines area has produced trees that are generally more drought resistant than other sources, although this is not uniformly true of all trees or locations within the general area. While work toward development of a highly resistant strain is continuing, early tests have indicated a satisfactory growth rate (Goddard and Brown, 1959) and enough improvement in survival under droughty conditions to warrant general seed collection from the Lost Pines area. Seedlings were produced on a commercial scale last year for the first time.

Another characteristic which may be related to geographic origin of seed is resistance to fusiform rust. In an exploratory test of loblolly pine sources conducted by Louisiana State University in Washington Parish, the local seed source had a significantly higher incidence of fusiform rust than other Louisiana and Arkansas sources. Differences in fusiform rust infection are also appearing in the Southwide Seed Source Study (Henry, 1959). In the relatively near future we may be no longer restricted by the rule-of-thumb that the best seed source for all purposes is the local source. By careful consideration of all factors, it may well be possible to achieve improvement in one or more characteristics through proper selection of seed origin.

Variation in Wood Characteristics

Another approach to the study of variation is the careful observation of differences that occur in the woods, both within the same stand and over wide geographic areas. This can be no better exemplified than by the intensive studies that have been made of natural variation in wood characteristics.

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3 A. B. Crow, personal communication.
Most emphasis has been placed on study of wood specific gravity and tracheid length. While there is no single set of wood specifications that would be ideal for all wood and pulp uses, these two affect so many of the qualities of the manufactured products to be of importance both for timber utilization and from the point of view of the paper maker (Dadswell et al., 1959). Several studies have related these wood characteristics to various paper qualities, particularly various tests of paper strength, and to pulp yield (Dadswell et al., 1959; Besley, 1959; Mitchell and Wheeler, 1959; Institute of Paper Chemistry, 1960). H. L. Mitchell (1958), for example, has used specific gravity and net tree volume to express yield in terms of dry weight per tree.

It is well known that wood characteristics vary over a considerable range within one tree. Specific gravity, for example, increases from the pith outward, with a striking difference between the central core of juvenile wood with six to ten annual rings and the outer mature wood (Zobel et al., 1959). Specific gravity also decreases toward the crown. These well-established relationships should be taken into consideration in the future by those responsible for forest management plans, as they could well have significant bearing on such things as thinning practices, rotation age, etc.

Surveys of variation in wood characteristics within a stand or in different geographic areas are usually based on wood samples taken with large increment borers, so that numerous trees may be sampled without destroying them. Because of within-tree variation, there was some question of the validity of these small samples for characterizing the wood of an entire tree. However, it has been amply established that wood samples taken at breast height are adequate. The correlation between breast-height samples and the entire bole for specific gravity, tracheid length, and a number of secondary characteristics of pulp and paper are of a high order, permitting accurate estimates of the qualities of the entire bole (Institute of Paper Chemistry, 1961).

On the basis of such surveys definite geographic trends in specific gravity and tracheid length have been indicated. Samples taken during the last resurvey of the Mississippi forests show that specific gravity of shortleaf and loblolly pines increases from northwest to southeast (Mitchell and Wheeler, 1959). B. J. Zobel et al. (1960) have reported geographic variation of specific gravity and tracheid length in other portions of the range of loblolly pine. Rather distinct differences were noted between these wood characteristics on Piedmont and coastal plain sites. In general, the denser wood and longer tracheids are produced on coastal plain sites. There is also a general trend for decreasing density and tracheid length toward the north in both physiographic regions. A very notable exception is found in wood from
the Eastern Shore counties of Delaware, Maryland, and Virginia, particularly in regard to tracheid length. Loblolly pines in this area appear to have significantly longer tracheids than from similar areas across the Chesapeake Bay.

Such differences, of course, might be attributed to various environmental factors, but this is not entirely the case. R. K. Strickland (1960) studied variation in specific gravity and tracheid length in twenty-one- and twenty-two-year-old loblolly pine plantations near Athens, Georgia, containing trees of nine seed origins from Maryland to Texas. These data show increasing specific gravity with the more northern and western seed sources. The trends indicated are not in agreement with those (Zobel et al, 1961) based on samples taken in stands at the various geographic locations. However, in the Georgia study no distinction was made between coastal plain and Piedmont sources. There is one striking point of agreement. Trees of Eastern Shore origin planted in the Georgia Piedmont had longer tracheids and higher specific gravity than trees of the local Georgia Piedmont source.

Inheritance Studies

While the amount of variation found is of considerable biological interest and indicates that improvement is possible, actual genetic gain is limited by the portion of these observed variations that can be passed on to the progeny of selected parents. Currently, several experiments are being conducted to determine the extent that this is possible for numerous important tree characteristics.

Published reports on inheritance are mostly based on data from relatively young trees and, of course, should be accepted with some reservation. There are reports of differences among progenies of individual slash pine trees in such characteristics as growth rate (Greene et al, 1957), crown width (Barber et al, 1955), and resistance to fusiform rust (Barber et al, 1957). Differences in growth and crown form have also been found in loblolly pine progeny tests (Goddard et al, 1959). Mergen et al (1955) have shown that gum yield and related characteristics vary, depending on the individual tree source. There are good indications, based on progeny performance, that tracheid length (Echols, 1955; Jackson and Greene, 1957, 1958) and wood specific gravity (Fielding and Brown, 1960) are moderately to strongly inherited.

Many reports of this type based on progeny performance merely indicate that there is some genetic control over the characters in question. If the studies are well designed and properly executed, this is certainly a valid
conclusion. However, it is obvious that most, if not all, of the above mentioned qualities are subject to substantial environmental influence. Therefore, the question arises as to how much of the variation observed is due to heredity, to environment, and to the interaction between the two. A term being used more and more frequently in tree improvement circles is "heritability." This is simply the ratio of genetic variance to total variance. More strictly, narrow sense heritability is the portion of total variance that can be transferred through sexual reproduction and is, to a large extent, dependent on additive gene action. By carefully planned breeding experiments and refined statistical techniques, total variance can be partitioned into components attributed to environmental factors, additive gene action, dominance, and various types of epistasis. Heritability estimates are obtained from analysis of variance and covariance of progeny groups or from other statistical methods, such as correlation or regression analysis. Such methods are required because of the nature of variation in most economically important characteristics. According to genetic theory, characteristics which vary in a quantitative manner are affected by many genes with a small individual effect, and such characteristics are usually subject to quite large environmental influence.

Very sensitive partitioning of variance into the several genetic and environmental components often requires F₂, F₃, or back-cross generations. Obviously such experiments are generally lacking in forestry. There are, however, methods available which estimate heritability from first-generation progenies, although they do not allow for a fine breakdown of genetic effects. Regardless of how refined or crude the estimate may be, in the strictest sense the estimates apply only to the material on which they are based. Obviously, if the environmental variation is increased, the total variance is increased and the heritability estimate is decreased. The heritability ratio is increased when environmental variance is held to a minimum.

What then is the purpose of heritability estimates? In the first place, they give an indication of the relative genetic influence of various characteristics. If heritability estimates indicate that only 5 or 10 per cent of total variance for a character is genetic, you can anticipate great difficulty in genetic improvement of that character. On the contrary, high heritability would suggest the possibility of considerable genetic improvement by selection without even progeny testing. For example, analyses of F₁ progeny of slash pine selected for superior gum yield indicate a heritability of 55 per cent (Squillace and Dorman, 1959). If a clonal seed orchard of this material had been established at the time the trees were selected, progeny would now be avail-
able capable of producing approximately 55 per cent higher gum yield than average. An orchard made up of only the clones proven best could increase this yield by an additional 50 per cent. Heritability estimates also indicate which of numerous possible breeding methods give promise of greatest improvement and furnish a valid basis of formulating selection indexes when several characteristics need to be considered simultaneously.

A number of these somewhat cruder heritability estimates for various forest tree characteristics are now available and many more can be expected in the future. Taken out of context, these estimates mean little. If someone states that loblolly pines grow three feet per year, for this to have meaning one would also need to know the age of the trees, something about the climate and soil, and the source of the seed, among a number of pertinent factors. Similarly, for heritability estimates to have meaning, such information as method of computation, age of material, type of parents, relationship of material, etc. should be included. For example, in one study (Squillace and Bingham, 1959) the heritability of juvenile height growth of western white pine was estimated as about 15 per cent. This was controlled pollinated material, parents selected for resistance to blister rust, and the estimate based upon analysis of variance among and between groups having common parents. This information is primarily useful to the tree breeder, as it tells him that for genetic improvement of growth rate with the material in question he will have to rely on very careful and sensitive progeny tests. Mere selection of the more vigorous trees is not likely to prove fruitful, as the environmental variance obscures the better genotypes for improved growth rates. This one report should not be construed to indicate the possibilities for improvement of growth rate in western white pine as a whole and certainly should not be interpreted as representative of pines in general.

Regardless of the limited application of heritability estimates and the care that must be taken in their interpretation there is quite a wide interest in the findings concerning tree species. In a recent review article Zobel (1960) has prudently refrained from citing exact heritability figures and has simply indicated the reported estimates as strong, moderate, or weak. He indicates that estimates of strong heritability have been obtained for tracheid length, height growth, forking, and several other characteristics of coniferous species. Specific gravity and diameter growth in some studies have been classified as moderate in heritability, while root form and resistance to tip moth attack appear to be inherited weakly. Such reports are encouraging and give promise of considerable genetic improvement. However, reports from different studies will vary widely; even different methods of calcula-
tion of the same basic data will produce different estimates, and each esti-
mate really applies only to the population for which the material used repre-
sents a valid sample.

Future Outlook

What, then, can be expected from the thousand or so acres of clonal seed
orchards now established throughout the South? Moderate improvement
in several characters will probably be obtained even in untested orchards,
if they were carefully selected for among the clones making up the orchard.
For example, if spiraled and forked boles were stringently avoided among
the original selections, there should be considerably fewer such trees among
the progeny of the orchard than are commonly encountered in a plantation.
Careful selection for long tracheids, or for high gum yield, should achieve
comparable or even better results. For most characteristics, however, sub-
stantial improvement is most likely to come through genotypic selection—
that is, through progeny testing. In this manner improvement in growth rate,
crown form, specific gravity, and many other characteristics may be made.

Further improvement through a second round of selection among seed
orchard progeny should also be very fruitful. In fact, some consideration
is being given to the possibility of using progeny tests as seed orchards,
although there are several procedural matters to be overcome. Regardless,
however, of whether seedling progeny or a second round of clonal orchards
are used, there is every reason to believe that highly improved strains, largely
based on current selection, can be developed.

It should be pointed out, however, that the more characteristics for which
improvement is attempted, the smaller the degree of improvement in each
characteristic that is likely to be obtained. Therefore, we must very carefully
choose the qualities for which we intend to breed. General quality and im-
proved yield should be the ultimate criteria. At best, the progenies of tree
selections that have been made in the past few years will not reach the market
until thirty or forty years from now.

I cannot competently anticipate technological or sociological changes that
may affect the pulp and other wood-using industries a half century hence.
Breeding for highly specialized characters, such as specific pulping qualities
currently desired, appears to be a large gamble. It seems likely, however, to
assume that there will still be a market for wood. Therefore improved yield,
including both growth rate and specific gravity, should be desirable for many
products. Similarly, improved bole quality seems a safe bet, as this affects
quality and yield of products as well as harvesting efficiency. There are, no
doubt, other qualities of sufficient general importance to warrant consideration. On the other hand, both undue specialization and attempts to produce an all around "perfect tree" should be avoided with the general purpose southern pines.

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When this topic was assigned to me I was somewhat shocked. My whole forestry career has revolved around growing sawlog crops of southern pine timber. The implications of this question sounded like pure heresy. However, upon reflection I realized that hundreds of southern foresters have condemned to death southern pine sawlog forestry. Having rid themselves of the problems and headaches which seem to attend the lumber industry, they are going about their business of growing short-rotation timber crops. Can sawlog forestry be buried? It may be that it has more than just a breath of life remaining.

For our purposes “sawlog forestry” will be defined as management practices which will produce a final timber crop of trees large enough to provide the sawlog requirements of southern pine band sawmills. This would imply a management rotation of fifty to sixty years, producing large numbers of quality sawlogs in trees grown up to a twenty-four-inch diameter at breast height during this time. At present, this type of forest management is being carried out on tens of millions of acres of timberland in the South. Actually it is multiple product management with pulpwood, fence posts, and barn poles produced in early thinnings. Intermediate thinnings, beginning at thirty years, may produce small sawlogs, pulpwood, utility poles, and piling. At the end of the rotation high value sawlogs and large utility poles are the primary products. Through this whole rotation sawlogs are the big volume product and upon sawlog prices depend the major earnings of the forest.

The question at hand is whether or not this type of forest management will continue in the future. Already several million acres of southern woodlands are being dedicated to short-rotation management with the final timber crop to be harvested in thirty to thirty-five years. Some of this land formerly was rundown forest or farm land now being regenerated as a vigorous young pine forest. In other cases large holdings of timbered lands supporting sawlog stands are being converted to young, pulpwood forests. This has been the picture, especially in the Southeast, where large acquisitions have been made by the pulp and paper industry. Recent purchases of timberlands have
been made on an inflated sawlog market with extremely high prices paid for sawlog-size trees. It has been necessary to liquidate these stands to assure a reasonable reduction of the investment and to return these lands to an income producing status as soon as possible.

Will this trend to short rotations be followed all over the South in the next two decades, or will large acreages be carried on the longer rotations as in the past? The answer to this is bound up in ownership patterns and the objectives of these owners. Industrial owners will base practices on the necessity for providing the raw material for owned manufacturing facilities, either those present or those planned for the future. The pulp and paper industry, with primary interest in a secure future wood supply, will favor the short rotation at least until this future supply is assured. The land-holding segment of the lumber industry will continue to grow trees on a long rotation to provide their sawlog requirements. Other land-holding industries, owning lands for other primary purposes such as mineral exploitation, will grow the products for which they have the best markets and will be influenced by these markets. Many private landowners, large and small, will be governed largely by the best return on their investment. Again, this will be based primarily upon available markets and the competition of these outlets. If more than one market is available, they will be influenced by that returning the highest dollar for the trees sold. In the past there have been small sawmills in every neighborhood and pulp mills only in scattered locations. Very recently there has been a shrinking of transportation limits for pulpwood procurement. This has made the pulpwood market more restricted in area than in the previous decade. Also, competition in lumber markets has forced better lumber manufacture with the result that “peckerwood” mills are fast disappearing and substantial medium-sized mills (ten million board feet per year) and larger will be producing the South’s lumber. This concentration of production is establishing a much more stable source of lumber than that which developed immediately after World War II.

Fifty-two per cent of the Southern Pine Association’s member sawmills do not own land and rely upon timber grown on private as well as government lands for their current log supply. The private landowners, who provide the greatest potential source of future sawlogs, will continue their interest in growing sawlogs only if the timber market promises reasonable returns from their land investment. Multiple-product forestry, which provides a variety of markets, will be most attractive to the private owner who has no plant investment. He will not be subject to the economic ups and downs of a single industry. In growing trees on the so-called sawlog rotation he will be able to sell his trees for the best competitive price at any time. With a
short rotation his market is limited to pulpwood, small poles, and low-value sawlogs. The addition of clear, uniform, dense wood on the tree bole after the first thirty years will be of far greater significance for lumber, poles, veneer, and pulp in future markets than it is today. The emphasis will change in general forest management from maximizing gross wood volume growth to achieving the highest values in quality wood volume.

The real key to the future of sawlog forestry is the lumber industry itself. Will it be a vigorous industry two decades from now, or will it wilt on the vine? A study of trends in the past thirty years indicates that lumber has been replaced in many of its historic uses by other materials which are either superior for the use, cheaper to produce, or both. Lumber sheathing has been replaced by plywood, fiberboard, and other large panel materials which are quick and inexpensive to install. The strength added to framing by lumber sheathing is not deemed important in much modern house construction. Concrete slabs and tile floors have replaced floor joists and wood flooring. Metal and moulded plastic have replaced wood in house trim and window sash. Asphalt shingles and even aluminum sheets are being used for exterior siding on houses. Pre-poured concrete steps have replaced wooden house steps. In school and industrial buildings masonry and steel construction have replaced wood framing, partitions, and floors.

Will this trend continue? Recent events indicate it may be reversed. The lumber industry has roused itself from its long complacency and has begun to take action. Natural wood has all of the inherent characteristics best suited for construction purposes, if it is manufactured, merchandised, and applied most effectively. Wooden floors have a resiliency much more restful than concrete and tile. Many factory specifications now call for wooden floors so that workers will tire less easily. Recently, modern wooden windows, built without counterweights, have been regaining their old markets. Laminated beam structures are replacing steel girders and costly masonry in schools, industrial buildings, public auditoriums, and churches. New construction methods have replaced ceiling joists and lumber with heavy roof decking, which can serve both purposes at once very efficiently. Better paint applications are overcoming the time-honored complaint that wooden siding is expensive to maintain. Wood siding and wood sheathing proved their value in many houses which survived the hurricanes of recent years while brick veneer and fiberboard sheathed homes were demolished. Aluminum siding loses its attraction when dented and pockmarked by hail which bounces harmlessly off wooden houses.

What has created these changes? The lumber industry has realized the depth of its problems. Unlike the other big industries, which are composed
of a dozen or so companies, the lumber industry is made up of thousands of individual organizations. The largest single company commands less than 5 per cent of the market. The industry has been too individualistic and unorganized to recognize competition anywhere but within its own ranks, and this has been a major reason for loss of markets to other products. Now, through necessity and with the guidance of industry organizations, a semblance of order is taking shape. More stringent quality requirements for lumber products are being promoted by the industry. Effective policing of quality standards is resulting in a better product offered to the customer. Lumber men are talking in terms of stress-rating and guaranteed low-moisture content to assure superior framing material. Architects are being provided with technical assistance by trade organizations. A national wood promotion campaign is selling the American people the idea of building a home of enduring beauty and utility rather than a mere house. New and better uses for lumber will continue to be offered the public.

Will these obviously revitalizing activities assure a substantial future lumber industry? Sales are half the battle, but they are worthless without supporting production. Let us examine the lumber manufacturing business. Basically the industry is using the same machinery and techniques used sixty years ago. Improvements in power for manufacturing and mobile equipment for logging and lumber handling were borrowed from other industries. In the South the manpower requirement is extremely high per dollar of sales. With ever rising labor costs and equipment expenses the industry must seek new techniques. Highly efficient refinements in equipment have been imported from Europe. However, a real breakthrough is essential to the future health of the southern lumber industry. Automatic controls, electronic “sawing” of lumber, new lumber drying systems, better antistain and decay treatment of lumber, even desirable qualities of strength and durability added by chemical treatment are very real possibilities. When and how soon? Already several automated mills have gone into action. Electronic sawing is still a dream but seems no more illogical than television would have seemed twenty-five years ago. An imaginative approach to lumber manufacturing is essential during the next ten years.

Another step tending to perpetuate the sawlog market and lumber industry will be more efficient methods of logging the raw material. The logging cost is a substantial part of lumber production costs. Growing trees to an economical logging size may be a key to better stumpage earnings for pulpwood as well as sawlogs. The future logger will move the whole tree in sections or in tree length to a concentration point where material will be cut out, sorted, and sent to the most profitable market. New types of equipment, designed
for logging and not adapted to logging, will produce more volume at less cost. A variety of wheeled skidders are appearing to compete with traditional crawler tractors. Rubber is replacing steel and high-speed mobile units are replacing low-speed equipment. Each year tree sawing equipment becomes lighter and more powerful. Airflow cars and helicopters may soon replace automobiles and log trucks in rough terrain. The logging superintendent of 1970 will carry a slide rule in his pocket along with his wrench and wire pliers.

Assuming the ability of the lumber industry to produce desirable products, will there be a demand for these products forty and fifty years hence? To determine this, a number of broad economic studies have been made in recent years to show trends and probabilities. Recently an attempt was made to analyze them in order to give top management a picture of lumber sales potential in the distant future. These reports included the Stanford Report, portions of *Timber Resources for America's Future* by the United States Forest Service, an appraisal of *Timber Resources Review* by Professor John A. Zivnuska, comments on *TRR* by A. Z. Nelson, forest economist, and a review of *Timber Resources for America's Future* by Professor Lee M. James. One solid fact seemed evident in all of these reports—that there will be a lot more people living in these United States forty years from now. Obviously they will need housing and other facilities which could be constructed largely of wood. Therefore, future demand for lumber should be greater than it is today. It is indicated that 50 per cent of the future lumber requirement of the nation will come from the South. However, when one tries to relate broad statistical surveys to local conditions a generation hence, one is dealing with evasive information. Alf Nelson has described these attempts to foresee lumber's future as “The Great Guessing Game.” With no intent to belittle the value and validity of these surveys, I discovered that I could find little absolute economic basis for either discouraging or encouraging continued growth of trees on sawlog rotations for harvest in the years beyond today's markets.

With this in mind, how can the forest manager make long-term recommendations for timberland management objectives and practices? Although these may differ with each individual timberland owner, the primary objective of all owners will be to earn the highest yield per unit of investment. The measure of yield for sawtimber, pulpwood, water, and recreation will vary in physical form but all can best be expressed in the universal commodity, dollars. Foresters like to talk of timber yields in terms of stumpage values. Usually this is an average value for all trees of certain grades and species regardless of location. A more realistic stumpage value would be
based upon the difference between price of the forest product delivered to a manufacturing plant and the cost of delivering it there from the stump. Many companies base timberland acquisition prices on this concept, giving full value to transportation savings. Beyond the wood product stumpage values of the trees themselves are the recreational, water, and soil conservation assets which have real dollar values for both public and private land owners. For diverse reasons such as these, timber values will vary markedly for different owners and from locality to locality. Obviously some of these factors are temporary in nature and will change in relative value before a new crop of trees can be grown. It is interesting to note that at a recent meeting of forest researchers, representatives of the pulp, pole, lumber, and particle board industries were asked to describe their ideal tree. In essence they indicated that this would be an eighteen-inch pine, straight and clear of knots for fifty feet of height.

Who will be growing sawlogs in the future, assuming a good market for quality sawlogs? As mentioned before, large acreages of southern pine timberlands are being managed on short rotation with the intent to clearcut at thirty to thirty-five years and replant the next crop. Many sawlog stands are being liquidated and young even-aged forests are being established on an area-control basis. When these new, forester-grown stands reach management-dictated maturity, will they be clearcut or will they be carried a few more years? If the economic situation at the time will provide outside stumpage at a lower price than the total cost of company-grown wood, the latter probably will be grown for an extended period. By such default, short-rotation forestry may be extended into “sawlog” forestry. Also to be considered is the economic fact that many trees are just beginning to acquire real value as sawlogs and poles at age thirty-five. It is interesting to note that one pulp and paper company has extended the rotation of thirty-five-year-old planted pine to fifty years with the intent to realize maximum dollars from sale of sawlog and pole stumpage. While these trees are adding this extra value, they continue to serve as insurance for the wood supply of the owners’ nearby pulpmill.

The timber-owning members of the lumber industry will continue to grow trees of sawlog size and quality if convinced of the future of their industry. In doing so, great emphasis will be placed on quality growth for the products to be sold. For example, present SPIB grading rules call for six growth rings per inch in dense dimension stock. A quality tree for today’s needs is a straight tree meeting this density requirement and also containing small, tight knots. A large, clear-surfaced log may have relatively little value if it
is open-grained and has knots just below the bark. Clear lumber will always command a premium price, but the price differential between C and Better and No. 2 Common pine will be less than it has been in the past.

The bread and butter of the southern pine lumber industry will be the structural material. Stress rating has become very important in the sale of southern pine framing and structural timbers. Often the central core of the tree stem will be open-grained while the bulk of the wood adjacent meets density standards. This may be controlled by maintaining relatively dense stands and slow growth until the tree reaches about eight inches d.b.h. This can be followed by rather heavy thinnings which will provide sufficient space to allow the maximum rate of tree growth commensurate with density standards. Another means of producing structural material may be the lamination of boards cut from the outer, denser portion of the tree. A third possibility could be the development of a greater proportion of dense summer wood, up to 50 per cent, by summer-time irrigation or by relatively wide spacing which reduces competition for water during the critical summer months. This would require a revision of present ring-width density standards. A fourth solution to the problem of growing strong wood efficiently and quickly may be found in the cultivation of genetically superior trees.

Very likely, future yield tables of stands managed for specific objectives will reveal much greater yields than those previously produced in unmanaged natural stands. These desirable qualities themselves will command a relatively higher earning for the tree than is the case today. Also very likely, with managed growth, sawlog rotations can be reduced by ten to fifteen years. Forest experiment stations have been leaders in studies of these possibilities, and their findings should be heeded.

To summarize, the lumber industry is awakening to the need for a tremendous sales effort backed up by better lumber products manufactured at a lower cost. This need is being handled through a national wood products promotion campaign, stricter lumber quality controls, and better and more efficient production from the stump to customer delivery. Lumber is regaining old markets through imaginative use of new and improved manufacturing techniques. Better technical information on wood properties and uses is being offered the customer. The lumber industry is on the threshold of a revival. How can the forester, serving this industry and the landowners dependent upon it, most effectively provide the future raw material—sawlogs? Timber growing is a long-term proposition, with earnings deferred for an extended period of time while invested capital is piling up interest
charges. Despite the fact that the individual forester may be long gone from the local picture at the end of the rotation, he cannot use snap judgment or employ “cure alls” in planning for this future.

As a profession we have a grave responsibility to plan for a rather uncertain economic future. We have measured what has been done in the past and too often use this information alone in mapping the future. However, we must work from a sound basis but not be unduly conservative. We must be imaginative enough to grasp the possibilities of the future and optimistic enough to apply them in our planning for this future. Mistakes will be made in the process of achieving our goals. We know that Mother Nature has made amends for many a forester’s errors and will continue to assist in the future. Nothing is cut and dried in forestry. We are dealing with many intricately interwoven variables over which we have relatively little control. The forest manager must gather together the facts available, apply his knowledge of all management techniques, analyze research developments for possible application, and add a good measure of forestry common sense. From this combination will evolve the forest management practice which will be the heritage of foresters a generation hence.

Even a forester growing trees for other primary crops will find the saw-log market an excellent hedge when he is unable to move profitably his reserve of pulpwood-sized timber. A healthy lumber industry will be the insurance for the long-term investment in land, trees, imagination, time, and sweat. Southern pine sawlog forestry is very much alive and will continue to thrive in the future!

Discussion

**Question:** In talking with architects, insurance executives, and construction people on the merits of wood, particularly laminated arches and heavy construction timbers, the question of building codes and insurance rates inevitably arises. What is the lumber industry doing about these obstacles to wood construction?

**Mr. Bruce:** A recent publication of the National Lumber Manufacturers Association describes tests made last year in San Antonio where steel beams and timber structures placed side by side were subjected to great heat as would occur in a serious fire. The result was that the steel lost its strength properties and crumbled, while the wooden structures charred but did not burn or fall apart.
The industry is very much awake to the problem of bad publicity which wood has had in the past. The fire on the aircraft carrier in New York was extremely bad publicity for lumber. It was quickly countered by pointing out that much of the fire that consumed lumber was paint burning.

The industry is constantly working to improve wooden structures of all sorts from the standpoint of protection from fire. In recent years much effort has been put in telling this story to architects, building code authorities, and others. There have been many changes all over the country in building code regulations, and now more and more lumber is being allowed in construction.

**Question:** A 1961 study made in the Baton Rouge area revealed that over 75 per cent of the market for 2 x 4's and 2 x 6's has been taken over by Douglas-fir since 1948. How far can the southern pine industry afford to let this condition go?

**Mr. Bruce:** Douglas-fir lumber has gone about as far as it can go in capturing the markets formerly held by southern pine. As a result of a tremendous demand immediately following World War II, thousands of small mill operators all over the South bought timber and mismanufactured it into low grade 2 x 4's. Very soon southern pine had a bad name in many communities right in the southern pine belt. Favorable shipping rates enabled the Douglas-fir dealers to get their lumber into our markets competitively, but it was distaste for the poor lumber manufactured in the South that was largely responsible for the opportunity for western woods to move into our markets.

Many factors are operating today to eliminate the small sawmills in the South. The sooner they are gone, the sooner we will have a chance to win back our full market. Well-manufactured southern pine 2 x 4's have stress ratings which cannot be equaled by West Coast lumber. That is the key to the situation. We have to find what the market demands and then meet the demand, not try to force use of an inferior product. I think we'll find tremendous changes in the market place in the next ten or fifteen years. For example, laminated 2 x 4's are a good possibility and may have a place.

**Question:** I've been wondering about this Douglas-fir invasion of the South. One, do the southern pine people really know how much Douglas-fir lumber has invaded the South? Two, do the Doug-
las-fir people know how much the Douglas-fir lumber has invaded the South? Thirdly, do we foresters know of the extent to which Douglas-fir has taken over the southern pine market? I think the answer to this last is that we do not. I do not; I have never seen any figures on it. My theory is that the southern pine people are afraid to let people know how much Douglas-fir lumber has come into the South, and the Douglas-fir people would rather keep it quiet in order to go on with their invasion.

Mr. Bruce: In answer to the first question, I can assure you the southern pine producers know how much of their market has been invaded by West Coast lumber and the southern quality mills are actively trying to reinvade that same market. In the past few years the Southern Pine Association has been active in selling building code authorities on the use of guaranteed dry moisture content in framing material. That is aimed at West Coast lumbermen who ship the bulk of their 2 x 4’s green. They arrange with the railroads to hold a carload of lumber on a siding for a month or so until it is sold. When that car arrives in the South, the moisture content of the lumber has dropped considerably. The material they are shipping is inferior to our quality material, i.e., that which is being produced by our good substantial mills and which has been kiln-dried down to 19 per cent or less moisture content.

The Douglas-fir people of course realize the extent of their invasion. That information is available. But as for the southern pine people being afraid to let the people here in the South know that fir is taking over, I do not believe that is true. In sales campaigns today they are stressing guaranteed moisture content of kiln-dried, well-manufactured lumber. I would say that attempts to sell building code authorities on this idea have been very successful where pushed. Miami, Florida, not long ago adopted a code that required 19 per cent moisture content for construction lumber. The West Coast is up in arms because that ruled out their lumber. If they could sell kiln-dried lumber they could compete, but when they do kiln-dry it their costs go out of sight compared with ours.

Comment: (H. J. Balcom) Since the Federal Housing Administration established their dry lumber requirement for FHA loans, lumber yards in most communities have been stocking kiln-dried western woods in 2 x 4 dimension. I think this is true for one
reason only: It comes straight, it stays straight, and this speeds up erection of a house. If the southern pine people could produce a straight 2 x 4 that would stay straight in the dealers hands, it would be all right.

Mr. Bruce: I appreciate your remarks. If southern pine structural material is made from straight trees, it will stay straight if properly manufactured. Too often the logs from which it is made are inferior logs. That is what I mean when I say we have to grow a quality product in the future. We cannot meet competition with lumber from the crooked log that has compression wood.

In our operation we have a problem in trying to provide enough 2 x 4's to satisfy the lumber yards we serve. We buy some excellent material from relatively small operations down in the longleaf pine country south of us. They are excellent 2 x 4's, they stay straight, and they are made from relatively small, dense trees. What I am saying is do not give up; we are going to provide you with a better product in the future.
Cellulose forestry in the South is not only the key to the future—it is the future. Concerted efforts to produce maximum per acre yields of pine cellulose are accepted as routine practice today in the Southeast. If present trends continue, and there is every indication that they will, short-rotation pine management will eventually be adopted throughout the South.

Perhaps the trend is not yet apparent to many. From Alabama westward, stands of quality sawtimber still exist, and in many places pulpwood operations are considered only as scavengers of sawlog tops and thinnings. This is an arrangement which I do not believe will continue indefinitely. As the large timber is liquidated, pulpwood consumption rises, and the rural labor force decreases, pulp mills will pay higher stumpage for better timber. Improved cuts mean more producer mechanization, increased pulp yields at the mill, and will provide an incentive for small landowners to harvest younger timber and to plant new crops.

Average size of pine trees in the Southeast has for the past three decades been steadily decreasing. Today the pulpwood and log buyers compete often for the same timber. In southeast Georgia the outlet for sawtimber appears to be disappearing. In fact, most sawmill owners state that wood chips from their waste material have been their margin of profit for some time.

With at least twelve pulpmills vying for open-market pine stumpage in southeast Georgia, prices per cord average almost double those of other regions. As stumpage prices in a given locale become prohibitive, some mills move procurement activities into higher freight zones where cheaper wood can be purchased. But the higher average rates still obtain in the old area and eventually will prevail in the new area of activity.

The very forces now at play are making intensive forest practices not only possible but imperative. In this area of keen competition even the small landowner has joined in the game. His woodlot is now worth protecting and regenerating, as he may still live long enough to harvest at least a portion of another crop from his “set-out pine saplings.” The 1960 forest survey for southeast Georgia, covering almost eight million acres of forest land, unlike
other survey units, shows that very little difference exists between per-acre volumes on industrial holdings and small, privately owned forest lands.

Total growth in this area is steadily increasing, but total pine drain is keeping apace. A tremendous annual ingrowth is occurring and average tree size appears to have become stabilized. Predictions for the future are optimistic for industries using small wood. It is expected that growth will continue to increase, but with pulpwood drain in the South also expected to increase from some twenty-two million cords to forty million cords by 1975, and perhaps in excess of seventy million cords by the year 2000, it is apparent that growth and drain will do well to keep in balance.

The Southeast is now virtually operating in a pulpwood economy. It is too late to control production of present wood-using plants to allow growth to build upon poorly stocked stands or to permit timber to again attain large average diameters. The South’s ability to grow pine cellulose must be fully exploited if we are to attract the maximum potential investments of an expanding pulp and paper industry. Similarly, provisions must be made now to supply cellulose for chemicals and the various forms of pressed and laminated lumber products of the future.

Pulp and paper mills in Georgia alone, with a replacement value in plants and equipment of over one-half billion dollars, rank high in the industrial economy. Tree farming to raise the cellulose for feeding this burgeoning giant is revitalizing the agricultural economy and is here to stay.

Most of the South has the basic ingredients necessary for short-rotation pine management. Accessible woods, excellent transportation, good forest sites, tree species which attain rapid growth rates in even-aged stands, and keen competition for small timber make short rotations attractive. The Gulf South has all of these but perhaps the latter—and that will come.

Industrial foresters must bear the responsibility for taking the initial steps in preparation for the “cellulose era.” Brunswick Pulp and Paper Company, with other southeastern industrial landowners, has committed itself to growing maximum yields of pine cellulose on short rotations. The decisions which have been shaping Brunswick’s forest management policies were not made lightly. For fifteen years we have slowly but surely been moving toward this ultimate plan.

Brunswick’s primary objectives in adopting short-rotation pine management are three-fold:

1. To enable us to use more of what we now have.
2. To reduce effectively the future delivered cost per cord of wood consumed.
3. To prepare adequately the way for future mill expansions.
It was necessary initially to recognize that the physical control of manageable site factors and stand conditions would assume very practical significance in assuring maximum future yields on short rotations. The promptness with which each new stand is reproduced and the control maintained over stand density are of paramount importance. This led to the adoption of a pine plantation program in which the pine working group is being regulated on the basis of redistributing age classes on a twenty-five-year average rotation.

Brunswick began experimentally planting cut-over pine lands in 1947. Rough, freshly cut sites presented a host of problems. First attempts made amidst competing vegetation did not fare well.

Scalping the turf ahead of the planting machine was tried. Initial survival improved but growth did not. On less well-drained sites such plantings looked dismal. This was followed by a more complete form of preparation—planting beds were harrowed to provide cultivation and better undergrowth suppression. Initial survival and early growth became significantly better.

It was evident that competition for soil moisture became severe on the dry sites. Encroachment of ground cover from untreated strips between beds became objectionable on wet sites and heavy soils. The exceptional results obtained on four early plantations which had been completely harrowed—even though with inadequate equipment—soon became apparent. Today no further proof is needed when we compare the twelve-year harrowed planting with eleven-year-old trees planted with no preparation on the same soil and site quality.

Four years ago we established a controlled experiment to study effects of site preparation on initial survival and subsequent growth of slash pine planted at various spacings and on sites of different qualities. After two years the effects of site preparation on height growth and survival are highly significant over effects of scalping and no treatment. Effects on early height growth are most pronounced on well-drained sites. After three growing seasons the plots which were completely harrowed on this well-drained site average 4.9 feet in height, scalped plots average 1.9 feet, and plots with no site treatment 2.2 feet.

Site preparation and tree planting by prescription is now standard practice at Brunswick. After adequate site preparation each area is planted with the proper species at a prescribed spacing. Tree spacing prescriptions vary from 6 x 10 feet to 10 x 12 feet. Fewer trees must be planted on prepared, dry sites if early favorable growth rates are to be maintained till the stand becomes merchantable.

Adequate site preparation varies with site requirements. The development
off-set harrows has made complete undergrowth suppression possible. Since experience has proven that too little preparation in many cases can be more costly than complete preparation, or no better than no preparation, all cut-over pine sites are now completely harrowed using D-7 and D-8 caterpillar tractors with eleven- and thirteen-foot harrows. Planting beds are then constructed on all but the drier sites with D-4 tractors and Rome bedding harrows.

Another but more limited phase of Brunswick's program consists of reclaiming nonproductive lands and converting other forest types to pine plantations. Water control and/or heavy land-clearing techniques are used to obtain the full productive potential of these better soils. Results are astounding as some of our three-year-old plantations clearly show.

Basic management techniques are prescribed for each forest area as soil profile and drainage class dictate. Long-range growth predictions and cutting schedules are now based on soil-site data and vastly improved natural and planted stand yield tables. Dr. T. S. Coile, forest consultant, and Professor F. X. Schumacher, Duke University, are to be thanked for these valuable contributions to southern forestry. A soils survey of all Brunswick's holdings by Dr. Coile makes possible this positive approach to intensive forest operations on an extensive scale.

The adoption of this type of land management program has enabled us to more than double annual pine removals and currently provide 71 per cent of mill pine requirements. The first objective—to use more of what we now have—has already more than adequately been fulfilled.

Also, in keeping with this objective, Brunswick has begun a suppressed-pine pulpwood operation. In this experimental operation we are successfully cutting small trees to a minimum top diameter, inside bark, of less than two inches. Production by a seven-man crew, plus foreman per five-day week, averages seventy-five to eighty cords delivered to the mill. Even considering 8 1/2 per cent less solid wood content than regular wood, delivered cost is slightly less than that for regular wood if no stumpage is charged.

It is a simple operation adapted equally well to salvage thinnings from dense, young stands or to prelogging mature stands. Trees are bucked in place, hand-loaded onto carts, and the load quickly transferred to pallets with jammer and slings. Plans are being made to obtain about 25,000 cords annually from company lands alone.

Utilization of small, suppressed trees opens up an entirely new concept of management. Thinnings from below are now practical without reducing basal area of growing stock and borrowing from the future. Remaining stands of uniformly large trees will make possible more economical harvest-
ing operations followed by greatly reduced site-preparation cost. No longer
need this type wood be pushed into windrows. It can and must become a
significant source of cellulose.

Financial analyses of various alternatives for Brunswick's position show
that intensive plantation management will furnish not only the lowest stump-
age cost but, more important, also the cheapest delivered cost per cord of
wood consumed. Delivered price should be credited with all intangible
values originating in the woods.

Delivered price expressed in rough cords is incomplete if costs in terms
of solid wood content are disregarded. Also, delivered price should be
credited with proper savings due to regularity of wood arrivals and resultant
savings in storage and rehandling. During 1960, 55 per cent of all wood
consumed by Brunswick was delivered directly into the system. Improved
pulp quality and yields of pulp and by-products from fresh wood contribute
further to lowered pulp costs. These savings must be properly reflected in
the cost of wood which includes the cost of forest management. It is only
in the woods that such savings can be created.

Brunswick has determined that plantations managed on short rotations
can be the key to greater mill profits. Had not Brunswick been forward
looking and made investments in its forests to grow cellulose for the future,
new mill construction to double present plant capacity would not now be
in progress.

The South must also make an investment in its future to insure maximum
industrial growth based on full use of its greatest natural resource. Potential
forest production will be realized only if prompt action is taken by all land-
owners to utilize properly the two elements of greatest value in timber man-
agement—time and space. Thus, prompt land regeneration and proper
growing space utilization are of utmost importance.

Discussion

**Question:** In scarifying land preparatory to planting, what is the cost
of site preparation?

**Mr. Anderson:** Specific figures are hard to give because we have so many
different conditions. Our lowest cost per acre is for a pal-
metto flatwood site which has no debris on it and just has
to be burned. It can be harrowed for about $5.30 per acre.
Our most costly site preparation, which makes up only a
minor portion of our annual preparation, runs as high as
$40.00 an acre. Our average cost last year was about $15.00
an acre for overall site preparation.
In complete site preparation, do you have studies old enough to indicate at what age rate of growth of trees on an unprepared site evens up with growth on a completely prepared site?

The way it looks right now, it is going to take a long time for it to balance out. There is no doubt in our minds that if trees are to be grown on short rotations, particularly in our area with the ground cover we have and the droughty condition of the sandy soils, you must have some site preparation.

Referring to use of two-inch wood for pulpwood, you said that, excluding stumpage, the cost of bringing it to the mill was comparable. What would this cost be?

No stumpage is charged. We are producing this wood from our own lands and will continue it until we get the program developed and cost figures assembled. We feel some stumpage could be paid, but not full stumpage as for regular round wood. The small wood is really a waste product.

On the small wood operation, are you attempting to thin for increased growth or are you just removing future mortality?

We are salvage thinning simply to remove what otherwise would be normal mortality.

About how many stems per acre do you leave?

In our present dense 20- to 30-year old slash pine stands, the ones we plan to concentrate these operations in, we would leave from 200 to 240 stems per acre. Many of these stands have as high as 1,000 stems to the acre, but the potential crop trees will number 200, 240, or 250. The rest are suppressed trees.

On the small wood, mill people have always told us they did not like it because it broke up in the debarkers, jammed in the slats, and caused them to stop the machinery and spend considerable time getting it out. How have you solved this problem?

That is true, that happens when you mix small wood with large wood. What we do now is save up production of small wood for a week or two and run it all at night when the barking drums are usually down for maintenance. The drums are run a little more slowly than for regular wood, but they do a good job and the small wood goes through the
regular system with the other wood. We have been promised that separate facilities just for small wood will be installed, once we prove to management that we can effectively log and produce the wood as we are doing now.

Question: Would you unreservedly recommend that all southern pine timberland owners go to a pulpwood rotation?

Mr. Anderson: No, I do not say that. There will always be some large timber and some people will always be growing it for specialty products. There will always be a demand, I think, for a limited amount of what we call today true lumber. I believe, however, that most products for an expanding population must be mass produced—houses and so on. With labor rates going up in the construction industry and others as well, eventually most forest land in the South will, in my opinion, be used for short-rotation fiber production.

Question: You mentioned that Brunswick produced 71 per cent of its wood requirements this past year on company lands. Would you care to comment on whether this is the trend or will you buy more or less outside wood in the future?

Mr. Anderson: Well, we will buy more because we are doubling our present plant capacity, but I think the trend is for mills to be able to draw on their own lands for at least 50 per cent of their wood requirements. This is to keep prices from getting so high that paper products will go right off the market and be replaced by plastics or something else.
Much of the current intensity of forest practice is directed toward the culture of subclimax forest types, attempting to maintain these types at high-productive levels, largely in pure, even-aged stands.

This is the natural consequence of the recognition by the wood-using industries that the qualities of certain tree species are in great economic demand, and hence these trees will surely be grown in large supply. To some extent, perhaps, it is unfortunate that many of the highly regarded forest types are subclimax; our southern pines, for example, and Douglas-fir, yellow poplar, etc. But, on the other hand, these relatively intolerant species, representative of the earlier stages of ecological succession, have the very characteristics of seed supply, vigor, and growth rates that lend themselves to mass production.

So what is the problem? Certainly these species can be mass produced with comparative ease. Witness: over two million acres of conifer plantations, principally *Pinus radiata* (Monterey pine) and the southern pines in Australia, New Zealand, and South Africa, and almost another half million acres in Chile. The ease with which these forests are established, managed, and logged, as well as the high value of the products, reflects tremendous economic benefits to these countries. Many of these exotic forests are in their second and third rotation, being regenerated by natural means.

Witness, further, the century-old monoculture of pure teak in India. One of my students had this reminder: "No account of monocultures could be considered complete without reference to the great forests of the French Landes. Many parallels could be drawn between the history of these forests and those of our southern states, except that the Landes are more extreme in every respect: in their fire-hazard; the poverty of the soils; the almost complete destruction of the forests through felling, fire, and grazing by the end of the eighteenth century; and the extreme paucity of the flora. Yet today the Landes carry 2½ million acres of highly productive, closely utilized, and skilfully managed pure, even-aged maritime pine (*Pinus pinaster*), much of it in the second and third rotation."
Other examples of the presumably successful mass production of single species can be cited; yet, there is apprehension among many foresters. This is summed up, perhaps, by J. J. DeGryse who, in viewing the extensive planting of *Pinus radiata* in New Zealand, stated: "These forests are extensive monocultures, and the susceptibility of monocultures to insects and diseases has become axiomatic. The fact that until now no serious widespread damage has occurred is nothing short of a miracle."

Now this is a sobering thought, echoed by many, repeating the philosophy of the German forester, Karl Gayer, nearly a century ago, who forcefully spoke against the culture of pure stands and advocated stands of mixed species. Gayer, of course, could point to the unfortunate example of the "Saxon spruce sickness" to support his views. Since this has been so frequently cited as a classic example of what might happen by the violation of ecological principles, it may be worthwhile to refresh the memory of this experience.

Monocultures of spruce (*Picea abies*) were initiated by Cotta in the lowlands of southeastern Germany at the beginning of the nineteenth century (so that there is now a century and a half of experience and data upon which to draw). Pure stands of spruce were vigorously advocated on the basis of high financial returns from spruce pulpwood and sawlogs. It may be noted here that spruce, with a mean annual volume increment of 120 cubic feet per acre at 140 years on first quality sites is by far the most productive of the native European species, exceeded only by the introduced Douglas-fir.

Initially these stands grew quite well, but from 1870 to 1920 there was a gradual reversion from this policy, largely stimulated by Gayer, who could point to the increasing frequency of insect attacks and to striking losses in increment by "soil deterioration." More recent studies of this experience have shown that, although there was a very definite "spruce sickness," it was a result of very definite soil and site conditions—such that spruce should not have been introduced into the lowlands in the first place. And, all this time, in the natural spruce zone above 2,000 feet, monocultures of this species remained generally healthy and productive. This experience in Saxony should demonstrate not the evils of monoculture but very clearly the possible dangers of introducing a species into an unsuited environment. It has been mainly this unhappy experience that has given monoculture a bad name.

Now let us return with this thought to the vast conifer plantations in Australia, New Zealand, and South Africa, species introduced into new environments. The phenomenal growth of these species has been ascribed to a number of factors: the absence of indigenous insects and diseases, the relatively milder and more oceanic climate of the southern hemisphere, and
the utilization of longer day-lengths and growing seasons than in the native northern habitat. Nevertheless, these very factors which increase timber yields may also increase the magnitude of potential losses in the event that insects and diseases do become established. So it becomes necessary to insure against epidemic buildup by such devices as strict import quarantines and inspection and the maintenance of a permanent forest biological survey. Happily, so far, no catastrophes have occurred.

One cannot conclude, then, that the introduction of trees into new environments is necessarily bad. And here re-examination of our concepts of natural ranges must begin. Monterey pine, insignificant in its native California, produces timber at prodigious rates in many other parts of the world. Even our slash pine on the best sites of its native habitat cannot measure up to the maximum rates for slash pine in New Zealand, *four degrees further away* from the equator, or in Queensland, *four degrees nearer* the equator. To equate “conditions for optimum growth” with “natural range” is to ignore the fact that a species is restricted, not by climatic factors alone, but by the whole environmental complex, and this is unique for each species.

As soon as management intrudes, at whatever level, a new set of conditions, good or bad in effect, is created. Factors previously limiting at the reproductive level may be controlled in a seed orchard, factors inhibiting germination and early survival may be controlled in a nursery, or site preparation may eliminate the strictures of competition. Keep in mind, however, that these effects can also be adverse. For example, the elimination of certain shrubs to permit the introduction of Monterey pine in New Zealand thereby also eliminated the host plant of an innocuous looping caterpillar, which viciously retaliated by attacking the pine. The damage, however, has not been too severe and is being contained by suppressive measures.

Much as might be learned from the experience with forest monotypes in other parts of the world, we do not want to dwell on them too long, for our immediate concern is: how vulnerable will be monotypes of species native to a region?

None will question the direction in which we are going. We are definitely headed toward the mass production of several species in the South, mainly slash pine and to a lesser extent, loblolly. Both of these species are transitional throughout most of their ranges, even though they have grown in essentially pure, even-aged stands for centuries. The maintenance of these types at high productive levels will require a variety of cultural treatments: site preparation through fire, chemical, and mechanical means; probably artificial regeneration, perhaps fertilization, and certainly a more complete removal of the vegetative material from the site. What, then, might be the
long-term consequences of such successive cropping and of the cultural practices required to maintain these species?

In the first place, there is the constant threat of insects and diseases. But keep in mind that even if no new pest arises to plague us, and even if those we have remain at endemic levels, we can still expect a greater impact on our intensively cultured forests than ever before, because we will be more conscious of these losses and of the greater values involved. An example of this is the uneasiness with which we view the increasing reports of damage by *Fomes annosus*. Mass production, in itself, is not to be blamed. We can and do have *annosus* in even small, isolated slash pine stands. But the more slash pine we plant and the more we thin, the more opportunities we will have to incur such losses.

It is entirely possible that new pests will arise, and native species can be quite vulnerable to introduced pests. Our few examples are classic and overwhelmingly impressive: all of our chestnut and many of our elms have been wiped out by imported fungi. As the eminent forest pathologist, George Hepting, points out, “... do not think this cannot happen to the southern pines ... it could happen to anything that grows.” Some of our common pests may also become provoking; they already have. In addition to *Fomes annosus* we observe that the spread of littleleaf disease of shortleaf pine is accentuated by the replacement of hardwoods by pine in the Piedmont. We wonder, too, why we are now finding tipmoths on the tops of eighty-foot trees where they were not supposed to be. Surely we must look for the buildup and spread of damaging pathogens, especially the soil-borne diseases.

Some are eager to bestow our pest problems on the tree geneticists, with the full expectation that pest-resistant strains will be developed. Although we can expect a certain measure of success in this direction, we must be aware of what a tremendous job it will be. As Hepting points out, about 75 per cent of all plant breeding for agricultural crops is for disease resistance, making it a continuous job of breeding resistant strains of plants for constantly changing strains of pests.

While we are on the subject of tree improvement, is it not possible that our very successes may, paradoxically, lead to our greatest hazards? As we develop tree strains with desired wood properties and growth characteristics, we will concurrently be restricting the genetic base; that is, we will become more dependent on relatively uniform genetic stock. Here, then, we must exercise extreme caution, for this could lead to monoculture with a vengeance, unless we are so naïve as to believe that we can breed a tree that is perfect in all its properties, including absolute resistance to all pests.

I wonder if one of the difficulties that we will encounter with monocultures
will be one that is not really generic, but one of application. Once the decision is made to mass produce a species—say, slash pine—we foresters will enter into the game most enthusiastically and, being fully aware of the economies of scale, will be carried away by our momentum. We purposefully disregard variations in conditions, even though they may be adverse. One forester stated, when questioned about variations in plantation spacing, that he could not vary spacing by small changes in soil, that for an eighty-acre hilly site, for example, where soils may vary from top to bottom of the slope, he tries to strike an average. Now this will reduce planting costs and lead to the breaking of all records for acres planted, but I foresee painful problems ahead if we continue to culture our forests on the basis of broad averages.

However, as we mature we will recognize significant variations and act accordingly. I do not suppose there is any part of our nation where site conditions for tree growth are as uniform over broad areas as in the South. But even here, and even with a species such as slash pine whose requirements are not too fastidious, we recognize quite significant and variable yields associated with relatively minor site differences.

In this connection, it is the practice with the southern pines in Queensland, Australia, to carry out a soil survey and analysis prior to planting; this may well serve as a model. It is known that the most critical factor in the soils concerned is the total phosphate content and that the minimum levels for healthy growth of slash and loblolly are 115 and 160 p.p.m., respectively. By surveying and demarcating deficient areas, it has become established practice to bring the soil up to the optimum response-level by superphosphate applications immediately following planting.

On the other hand, there may be combinations of conditions where it may not be possible or may be too costly to maintain a healthy and productive monoculture. One such may be the Florida deep sands and the deep-phase Norfolk and Lakeland sands of the Carolinas. According to reports, these soils have always supported scattered longleaf pine with oak scrub. Under the prevailing precipitation and internal soil-drainage regime, it seems highly unlikely that these soils could, merely by a change of species, be brought to carry a high order of productivity. Experience with tobacco crops and tree nurseries on these soils has shown their low base-exchange capacity and the extreme rapidity with which amending nutrients are leached out. With the elimination of the hardwood leaf litter and the concentration of the more acid pine needles, the result could well be progressive leaching and deterioration.

What I am trying to say is that, as we discard our worship of the average,
we will refrain from planting slash pine, or any single species, on every acre. This is the real lesson to be learned from Saxony.

Monocultures, of course, present a concentration of risks. What are the alternatives? Obviously, one way to scatter risks is to grow forests of intermixed species. Unfortunately we have yet to find an intimate mixture that is suitably productive and valuable. The only protection afforded by mixed stands, when exposed to virulent exotic pathogens, is the rather cheerless comfort that something will be left when the epidemic has run its course.

Another way to scatter risks is by species diversification by blocks. It is now the policy in New Zealand to establish single species-age class blocks of less than about two hundred acres. This will require careful matching of sites with species requirements and emphasizes the urgency to explore the possible use of alternate species, not only among the pines, but other genera as well.

One can enumerate many disadvantages and possible consequences of forest monotypes, pointing out the potential effects of insects and diseases, the possibility of reducing soil fertility, the restricting of the genetic base, and yet, the advantages of monocultures are so many, that I am personally kindly disposed toward them. The risks may be high—so may be the rewards. A concentration of risks affords a concentration of control. We must be constantly vigilant to the dangers before and as they arise, so that ameliorative action can be firmly taken. So too, we must be flexible, for if we should prove to be wrong or if our remedies be too costly, we can revise our practices accordingly.

Discussion

Question: Do you think we are making a mistake in eliminating low-grade hardwoods from pine stands?

Mr. Chaiken: That, in my opinion, depends on the soil. For some soil types I am in agreement with eliminating all hardwoods. I think on some sites we can maintain a healthy and productive monoculture without whatever contributions hardwoods would make, by adding artificially as the need arises the nutrients that are required. I think we can provide them at a lower cost than trying to grow hardwoods and pines in combination, especially when the hardwoods are of a lower value and growth rate than the pines.

On other sites, such as in the Piedmont, the elimination of hardwoods may be a mistake because of the lack of nutrients
which hardwoods provide and because of their contribution to soil structure. This will not be easy to provide artificially. I think it will largely be a matter of equating costs with productivity. On some sites I am sure we are going to find that it is too costly to maintain a monoculture.

I am personally disturbed about the future of some of our pine plantations on the deep sands. They are doing well early in life, but I think we are going to see that competition among the trees for moisture and nutrients will become more severe and that many of our pine stands on deep sands are going to deteriorate and be not nearly as productive as expected. This should be of considerable concern to all of us because we are concerned with how much we are going to be able to grow on those sites. This does not include all of the sands, but only the deep sterile ones. It will be particularly evident in the Florida deep sands and on the oak ridges of the sandhills in the Carolinas.

**Question:** We have talked about three pine species—loblolly, slash, and longleaf. What about shortleaf growing in pure or mixed stands? It seems to me that the people who grow shortleaf like to grow it mixed. What do you think about it?

**Mr. Chaiken:** I don’t know how it might be in Arkansas. I can speak only for North Carolina, especially the Duke Forest, where for the past thirty years we have grown intermixed species in almost all combinations. On those soils loblolly outgrows shortleaf two to one. It is not only that shortleaf does not grow well in competition with loblolly; it makes the loblolly poor, because if the two species are alternated in rows or plots, the loblolly pines are adjacent to the shortleaf rows. Since the loblolly outgrows the shortleaf and the latter does not help prune the former, loblolly which is grown adjacent to shortleaf is very rough in that area.

**Question:** *Fomes annosus* has been mentioned by several speakers. In north Louisiana we are discovering the extent to which we have it, and we are finding damage on all species. How does damage to slash pine compare with that on other southern pines?

**Mr. Chaiken:** This subject is being thoroughly investigated in a southwide survey. Results of earlier surveys showed that slash pine was more susceptible than loblolly. This was planted slash pine
that had been thinned. Loblolly is susceptible, presumably, but we do not really know. In our area there has not been the planting and thinning of loblolly as with slash pine.

*Question:* (continued) Are there any recommended treatments at this time?

*Mr. Chaiken:* *Fomes annosus* has been a problem for many years in other parts of the world, especially in Europe. Some control has been achieved, but it is apt to be quite expensive. I wonder if we can solve this problem by growing slash pine on short rotations without thinning.

*Question:* Not much has been said about longleaf pine. Everybody seems to favor slash. Is it not true that longleaf would be best for monoculture, that it is resistant to nearly all pests?

*Mr. Chaiken:* I am glad you mentioned that. Last week I visited a company in west Florida that has just begun to plant longleaf pine, not in mixtures but in blocks. Formerly, they planted slash. I think this is one possibility, since longleaf is more resistant to pests than either loblolly or slash. We really do not know, because we have not planted much longleaf and have not grown it long enough to see what might happen.

*Question:* When you begin to get bad effects from monoculture on the site where soil structure may deteriorate, how will you know it? Will it be fairly obvious to the naked eye?

*Mr. Chaiken:* I think so. In our experience with slash, loblolly, and long-leaf pines in the sandhills of the Carolinas we found that they grew well for the first few years and then we could see the deterioration quite markedly. I would like to reiterate that a change of species is not going to make the very poor sites highly productive. We will have to accept the fact that we have them and that they are not going to produce much. Also, we would not be able to improve them much, while we may cause them to deteriorate in soil structure.
WHO'S GOING TO USE ALL THIS WOOD?

SAM GUTTENBERG, Southern Forest Experiment Station
U. S. Forest Service

As our economy limps into the '60's, some disheartened foresters are conjuring up visions of excessive wood supplies. Are they right? I hope to provide a basis from which to draw your own conclusions.

To begin with, appraisals made while business is off are likely to be unduly pessimistic. The Survey Research Center at the University of Michigan has repeatedly shown that consumer’s buying intentions react sharply to expected shifts in income. And industry shelves planned capital expenditures as business chills.

No matter how prudent such adjustments may be, it does not follow that forest investors should do likewise. We are decades behind in stand treatments that are required for expanded operations in future markets and that would be profitable.

But before turning to the future let us look at the current situation. Markets for sawlog products have been hurt much more than those for pulpwood, poles, and piling. In part, buyers may still remember the poorly manufactured southern pine lumber of the years immediately following World War II. Business conditions are also a factor, but less so than our inadequate timber stands.

Local and regional shortages of quality pine and hardwood timber have contributed to our loss of markets. While consumers want dimension more than boards, pine lumbermen have not been able to meet fully the shift in demand. The timber that is available today just will not yield large proportions of what the Southern Pine Inspection Bureau regards as dimension. Scarcity of prime pine timber often prevents mills from supplying the lucrative special order and export business.

Much of the market that has been lost in recent years can be charged off to insufficient investment in southern forestry thirty to forty years ago. Such investments could have provided southern lumbermen with the kind of timber that would enable them to outsell Douglas-fir today. And the periodic increases in the minimum wage might have been easier to live with. Recent history does not point to excess wood supplies so much as it does to lack of a balanced growing stock capable of supplying salable timber.
The Forest Survey has shown that the South has finally begun to increase its pine timber supplies. The turning point for hardwoods still lies ahead. Furthermore, rough and ready appraisals based on inventory totals can be deceiving. Southwide, growing stock averages about eight cords per acre, more than half hardwood. This volume includes at least two cords of hardwoods which, though theoretically convertible to pulpwood bolts or crossties, have not been marketable southwide in the past and are not likely to be in the foreseeable future. In addition to these two cords, there is more than a cord of sound wood per acre in cull trees.

The woods would be better off without this material—getting rid of it would be a blessing. Worst of all, loggers continue to favor these trees for further growth by concentrating their cutting on good trees. Industrial usage of this kind of material is not likely to occur soon enough to do much good. These problem trees are growing far more rapidly than they are being cut. For the most part, it will take a sizeable investment to turn the wasted growing space over to more worthy timber.

Even if the quality of today's growing stock were as good as we might wish, it takes timber to grow timber. Trees are both factory and commodity. An industry cannot flourish, if its factories are used without adequate provision for replacement and expansion. In the South more than twelve cords per acre would probably be needed to maintain annual one-cord harvests of all forest products—veneer and sawlogs, poles and piling, and pulpwood. The question then is, "Who's going to use all this growth?"

The markets of a particular year or decade are a singularly inappropriate index of the demand for forest products thirty to fifty years hence. People will continue to use timber if it is offered in convenient forms at competitive prices. Our population will continue to grow for some time to come. One of the few mandates of the Good Book that mankind follows assiduously is "go forth and multiply." The latest estimate is three hundred million Americans in the year 2,000—twenty-five million more than expected a few years ago. But how much wood these people will use is not entirely a matter of projecting historical trend lines. Let us look at the record of wood consumption in Figure 11. It covers the whole United States from 1920 through 1960, forty-one years. The major products are shown in per capita use in cubic feet.

The pessimists would extend the sawlog trend to oblivion. Though the thumping 24 per cent decline in per capita consumption between 1950 and 1960 looks bad, let us not be hasty. Those who slavishly fit trend lines overlook two key factors: that economic history never really repeats itself and that human ingenuity can create new markets faster than old ones are lost.

Take history first; note the outstanding peaks and troughs on the sawlog
Figure 11. National per capita consumption of selected forest products.
portion of the chart. The first peak coincides with the building boom of the 1920’s, the abyss with the great depression. The second peak represents the huge lumber demand during World War II. In contrast, the trends for pulpwood and veneer consumption are not only upward but are less affected in years when the nation’s business is off.

Variation in application of human ingenuity is the main reason for differences in consumption patterns. Some segments of the forest products industry have used more of it than others. While sawmill men have been largely content to make standard lumber, the pulp and veneer industries have been in hot pursuit of more business. Not content to drift along with standard items, these industries have invested heavily in product research and development and until recently have grown even in bad times.

The pulp industry shared in developing cellophane and rayon. It progressively bettered corrugated and board packaging materials, multiwall bags, and other paper specialties to take markets away from packaging made of wood, glass, burlap, and cotton. Growers of cotton helped by insisting on parity pricing.

But new-won markets can be lost to still other competitors. The petrochemical and aluminum industries, among other high-powered contenders, are cutting in on the paper business and may slow the rise in per capita pulpwood consumption below the rate that prevailed between 1935 and 1955.

One of paper’s biggest competitors is itself. More than a fourth of our annual output of paper products is derived from about nine million tons of waste paper. Imagine the increased demand for pulpwood, if we could make virgin pulps more economical than waste paper! This development may result from rising living standards, though it will be rough on P-TA and Boy Scout paper drives.

The favorable veneer and plywood trend is barely under way. Manufacture of softwood plywood has increased seven-fold since 1946. Most of the development has been with Douglas-fir. Recent advances in gluing and processing, together with on-site benefits from using plywood in construction, suggest that the upward trend has yet to find a peak. Even southern pine plywood is a possibility as more efficient utilization techniques are developed. Should the United States Forest Products Laboratory make further improvements on edible wood, the nation may some day sit down to a dinner of planked steak—and if we do our job it will be a southern pine prime.

But what of lumber? Will the consumption continue downward? I think there is room for doubt. There is evidence that lumbermen have finally discovered the operating principle used successfully by pulp and veneer people. Recent developments in edge-glued lumber panels, paper-overlaid lumber,
laminated 2 x 4’s and timbers, plus an awareness that specialties are also good, suggest an upswing. These products are steps in the right direction. The ideal place to make lumber more economical, durable, and satisfying is at the mill. The more completely the item is factory-finished, the less opportunity is there for nail knockers and paint slurpers to mangle it on site. Various types of unit structures provide opportunities for circumventing fast-buck artists who give wood a bad name.

Wood in its original state has many advantages over reconstituted fiber boards. Wood bonded to paper, aluminum, steel, and plastics could improve over-all product utility and thereby increase lumber consumption. As I see the sawmiller of the future, he will still be making the lumber that we know today but perhaps only as a sideline. His main revenue could well be from cutting a wide range of special items.

Foresters can aid industrial efforts for increasing national wood consumption. Wood can lose out through prejudice or lack of knowledge on the part of potential consumers. If the local school board is planning a new building, get in touch with it and ascertain whether a properly designed wood structure is competitive—all costs considered. Should the church vote for a new edifice, help to evaluate the possibilities of laminated wooden arches and heavy roof timbers. Who knows? We might even line our concrete and brick offices with wood panelling and lay a resilient wooden floor to spare our fallen arches. There is hardly need to belabor the advantages of keeping wood competitive. Expanding rather than contracting wood consumption is most likely to bring widespread benefits to all concerned with forests and timber.

A projected national consumption of eighty billion board feet of lumber and one hundred million cords of pulp products in the year 2,000 may be conservative. Projections are based on historical trends of consumption and population growth, and the past is often an understatement of the future. Furthermore, projectionists must analyze the strengths and weaknesses of the industry they are estimating for, and their findings permit the industry to take action that will upset the prediction—actions that might otherwise be long delayed or not taken at all.

In the South it should be possible to stimulate demand to the point where, once again, timber buyers will be chasing timber growers. Figure 12 shows that pine types of the South cover five times as much acreage as do the Douglas-fir types of western Oregon and Washington. It also shows that the fir types have twice as much sawtimber volume as the pine types—and, of course, on one-fifth the acreage. This concentration of timber is an advantage for fir lumbermen. But time is on our side. Currently, pine sawtimber volume
growth is three times that of fir. Moreover, it takes two to three times as long for western trees to reach usable size from seed. Even if one includes all fir acreage and allows for conversion of old growth to young timber, southern pine would still lead in growth.

There are still other reasons for supposing that, as the supply of old Douglas-fir dwindles, southern pine will again become pre-eminent. Pine’s location in respect to national and international markets is better. Managed pine stands start producing clear wood at the age of twenty to thirty years, but typical natural fir stands two to four times as old and from twenty to twenty-four inches in diameter are still limby from the ground up. Since management costs are also less than in the West, we should become the nation’s main source of clear wood in the decades ahead. Firms with stands of quality pine timber should be in excellent position to take advantage of future markets.

We have an edge in hardwoods too. The West hardly matters in acreage or volume, and the North’s advantage in acreage and volume (Figure 13) is no real handicap for the South. About two-thirds of our 101 million acres in hardwood types occur on soils where many species reach optimum development. It is on this acreage that there is money to be made in growing prize

Figure 12. Acreage and volume in the Douglas-fir and southern pine region.
hardwoods. Imports are maintaining a premium for clear wood. The luans, cativo, and other foreign species are filling much of the present demand for cream, while our timber fills mostly the demand for skim milk. Hardwoods comparable to the woods run of today are not likely to have much place in the future. In hardwood as in pine, management efforts need to be concentrated on the better sites. The relatively small proportion of southern acreage that is too poor for growing commercial timber is often valuable for production of water and game. The increasing demand for water, recreation, and wildlife may enable some owners to earn respectable returns per acre from multiple-use management. A few land managers have already put multiple-use into practice.

The rewards inherent in the South's natural and economic advantages will not fall into our laps. By hard work, imagination, and perseverance others in less favored areas could overcome our natural assets. One thing seems certain: southern foresters will have to be as zealous in making wood products competitive as in growing good raw material. Forest research will have to contribute to logging and processing efficiencies and product development.

Our objective is not to grow timber without limit. We want timber to have

![Figure 13. The nation's hardwood resources by region.](attachment:image.png)
value, so that we will be paid for growing it. At the same time, if we are to expand consumption, wood products must be priced more favorably than substitute materials. In a word, we are seeking an elusive optimum. Taking the long look at future prospects for the South, is there really much chance of overinvestment in timber growing anytime soon?
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