RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 147

May 1960

GRADING YELLOW-POPLAR PLANTING STOCK IS IMPORTANT

Two experiments conducted near Statesville, North Carolina, have confirmed the importance of grading yellow-poplar planting stock. Third-year results show that field survival of planted yellow-poplar seedlings is related to root-collar diameter. [1/]

The first study, consisting of 35 field plots of 49 seedlings each, was established in January 1956. Seedlings with root-collar diameters of 0.15, 0.20, 0.25, 0.30, and 0.35 inch were tested. The second study, installed 1 year later, eliminated the 0.15-inch seedlings because they were obviously submarginal, and included 0.40-inch seedlings to extend the test. This installation consisted of 40 plots of 49 seedlings. Both studies are located on fertile bottom land soil on opposite sides of a small stream.

The tests show a much higher level of survival for the 1957 planting than for the 1956 planting for comparable seedling grades (table 1). This is probably because of differences in seedling quality (root weight was only 40 percent of seedling weight in 1956, and 67 percent in 1957), serious frost damage to the 1956 plantation, and more favorable growing conditions following establishment in 1957.

Statistical analysis of the data revealed some significant differences in 3-year survival among grades (table 2). There were no significant differences in height after 3 years, despite the differences in height at planting time. Heights of planted seedlings were greater for larger root-collar diameters in Study No. 2 where frost killing had no effect. Height attained after 1 year was still positively correlated with root-collar diameter. The lack of significance after 3 years indicates that juvenile differences disappear early in the life of the seedlings.

The primary conclusion from these tests is the definition of a minimum size for plantable yellow-poplar seedings. Study No. 1 clearly shows that seedlings below 0.25 inch at the root collar are poorer in survival after 3 years than those 0.25 inch or larger, and seedlings below 0.20 inch are not acceptable. Seedlings in the 0.20-inch grade fall into a marginal class. They are not the equal of larger seedlings, but are not clearly culls. Limstrom, et al. [2/] reported similar results in Ohio, and concluded that the minimum size for planting on dry, exposed sites should be 0.25 inch and the minimum size on moist, protected sites should be 0.20 inch. The results from the Piedmont work agree with Limstrom's findings. For the planting job that includes sites of both types, 0.25-inch seedlings are the minimum size needed to insure good stocking.

1/ Grateful acknowledgement is made to the Furniture, Plywood and Veneer Council and the Duke Power Company for their support of this work, and to Howard J. Doyle for valuable assistance with the field work.

2/ Limstrom, G. A., et al. Planting stock grades for yellow-poplar. Jour. Forestry 53: 28-32. 1955.

Table 1. --Survival and height by root-collar diameter

STUDY NO. 1 (1956)

Root-collar diameter (Inch)	Initial measurements: Survival 6 months	Initial measurements: Planted height	After 1 year: Survival	After 1 year: Height	After 3 years: Survival 1/	After 3 years: Height
	Percent	Feet	Percent	Feet	Percent	Feet
0.15	36	(2/)	22	0.28	29	1.97
.20	74	(2/)	64	.36	67	2.54
.25	83	(2/)	75	.39	77	2.96
.30	84	(2/)	80	.52	81	3.20
.35	84	(2/)	84	.62	82	3.22
Mean	72	(2/)	65	.43	67	2.78
STUDY NO. 2 (1957)						
0.20	95	0.51	91	0.64	91	2.21
.25	96	.67	96	.86	94	2.53
.30	99	.86	98	1.12	98	2.82
.35	99	.92	99	1.30	99	3.37
.40	99	.99	98	1.40	99	3.03
Mean	98	.79	96	1.06	96	2.79

1/ Increased survival during third growing season caused by sprouting of apparently dead seedlings.
2/ Seedlings killed back to groundline by frost.

Table 2. --Statistically significant differences among seedling grades after 3 years in the field

Study number	Grade comparison tested	Attribute tested	Level of significance 1/	Conclusion
1	0.15 vs. larger	Survival	**	0.15 poorer than all larger
1	0.20 vs. larger	Survival	**	0.20 poorer than all larger
1	0.15 vs. 0.20	Survival	**	0.15 poorer than 0.20
1	0.25 vs. larger	Survival	--	0.25 and larger are equal
1	0.30 vs. larger	Survival	--	0.30 and larger are equal
2	0.20 vs. 0.25	Survival	--	0.20 and 0.25 are equal
2	0.20 vs. 0.30, 0.35, 0.40	Survival	*	0.20 poorer than 0.30 and larger
2	0.25 vs. 0.30, 0.35, 0.40 0.30 vs. 0.35, 0.40	Survival	--	No difference among 0.25 and larger
1	All pairs	Height	--	No difference in 3-year height
2	All pairs	Height	--	No difference in 3-year height

1/ ** indicate a highly significant difference; * indicates a significant difference; -- indicates no difference.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 148 June 1960

TIME-TEMPERATURE RELATIONSHIPS OF TEST HEAD FIRES AND BACKFIRES

Time-temperature relations were measured during the course of a preliminary investigation of the thermal characteristics of forest fires. Observations on 5 head fires and 5 backfires in 8-year-old gallberry-palmetto roughs on the Alapaha Experimental Range near Tifton, Georgia, are the basis for this report.

All burning was done on July 22, 1959, between 10 a.m. and 2 p.m., with air temperatures about 90° F. The moisture content of the upper layer of fuels, as measured by fuel moisture sticks, decreased from 12 to 8 percent during the burning period. Winds varied from 1 to 4 miles per hour and the burning index was 1. Fuels, including litter and lower vegetation, averaged 5 to 10 tons per acre. Backfires advanced at the rate of about one chain per hour and head fires at the rate of 10 to 20 chains per hour. Temperature measurements were made at 3-second intervals as the fires (with about a 20-foot run) passed thermocouples located at 1- and 4-foot heights above ground.

Chromel-alumel thermocouples, when used with leads insulated with fiberglass and stainless steel mesh were very satisfactory in these tests. Milliameters were used as measuring devices because they are relatively cheap and are readily wired and transported. Recording potentiometers would serve the purpose better but are expensive and more cumbersome to use in the field.

Composite time-temperature lines for these head and backfires are plotted on the reverse of this sheet. At the 1-foot level, the head fire temperatures rose abruptly to a maximum of about 1600° F. They then fell off, at first sharply, and then at a decreasing rate. The slower moving backfires produced temperatures from 250° to 600° F. at the 1-foot level and maintained this temperature range for several minutes. The second temperature peak associated with backfires occurred when the line of fire had passed the thermocouple, but the flames were still directed at it as a result of wind movement.

At the 4-foot level, head fire temperature peaks barely exceeded 500° F.; backfire temperature peaks at the same level barely exceeded 125° F.

Lindenmuth and Byram[1/] made a comparison of heat factors associated with backfires and head fires in the longleaf pine type. In this type, which was primarily grass mixed and overlain with longleaf needles, their measurements indicated that head fires are cooler near the ground--up to 18 inches--than backfires. Our measurements do not indicate such a relationship for the gallberry-palmetto roughs, at least at the 1- and 4-foot levels. If there is a zone in this type where head fires are cooler than backfires, it is probably within a few inches of the ground.

A plot of temperature against time represents one of a fire's most significant thermal characteristics. By measuring these relationships at different heights above ground, a three-dimensional, quantitative analysis of a fire can be made which in turn

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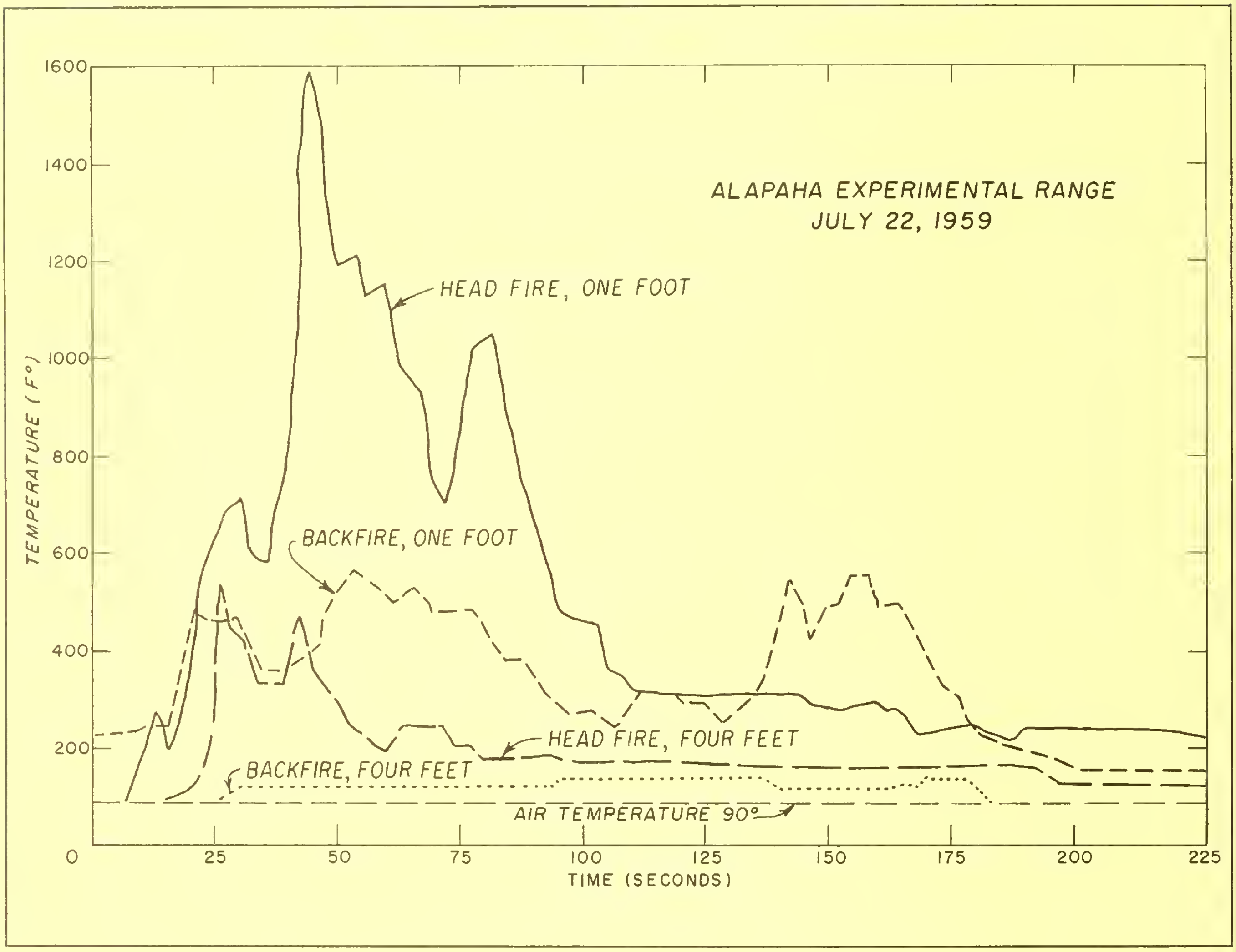
1/ Lindenmuth, A. W., Jr., and Byram, G. M. Headfires are cooler near the ground than backfires. U. S. Forest Serv. Fire Control Notes 9(4): 8-9. 1948.

can be used to rate fuels according to heat yields. Vegetation damage should be closely related to a fire's time-temperature behavior if initial vegetation temperature is taken into account.

Many more fires in different fuels under different weather conditions must be measured before the energy release that takes place in wildfires can be estimated. Detailed and carefully documented studies are now in progress at the Southern Forest Fire Laboratory.



Temperatures developed by 5 head fires and 5 backfires in 8-year-old gallberry-palmetto roughs.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 149 June 1960

FUEL WEIGHTS OF POND PINE CROWNS

Pond pine (Pinus serotina, Michx.) is the most frequent component of the overstory in the fuel types on organic soils areas of coastal North Carolina. Although pond pine stands are characteristically rather open, in blowup fire situations the burning foliage and branchwood contribute significantly to the total energy released.

To determine the weights of these overstory fuels, foliage and branchwood from 20 dominant or codominant trees were measured. Tree diameters ranged from 2.6 to 14.8 inches at breast height. Pine needles were stripped from the branchwood and the two components of the crown were weighed separately. Analysis procedure followed Storey's,[1] except that diameter breast height instead of diameter at base of crown was used as the independent variable.

The contribution of foliage or foliage plus branchwood for individual trees to total ovendry fuel weight can be estimated from the two graphs on the reverse side or from the following relationships:

$$W_{df} = 0.486\ (\text{d. b. h.})^{1.697} \qquad (\underline{A})$$

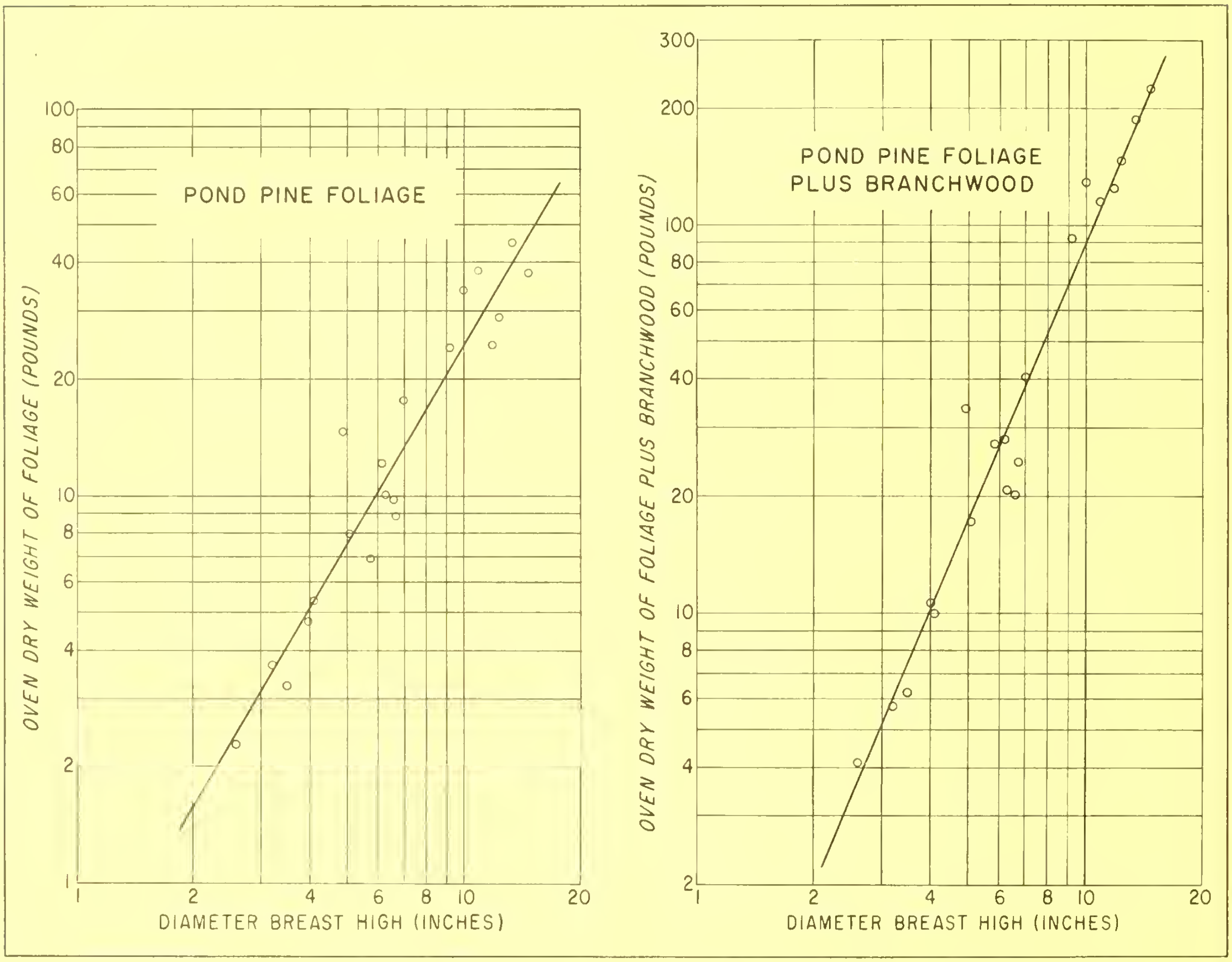
$$W_{dc} = 0.369\ (\text{d. b. h.})^{2.390} \qquad (\underline{B})$$

where W_{df} is weight of ovendry foliage, W_{dc} is the weight of the ovendry foliage plus branchwood, and d. b. h. is diameter breast high outside bark. The coefficient of determination for equation (A) is 0.912 and the standard error of estimate is 28 percent. For equation (B), the coefficient of determination is 0.957 and is 27 percent. Analyses of variance showed highly significant linear dependence between W_{df} and d. b. h. and W_{dc} and d. b. h.

The contribution of the foliage or foliage plus branchwood to total ovendry weight of fuel per unit area can be readily determined. For example, a fuel type was found to have an overstory averaging 20 trees per acre and 10 inches d. b. h. Referring to the curves we find that a 10-inch tree will average 25 pounds of foliage ovendry and 90 pounds of foliage plus branchwood ovendry, giving a mean for the stand of 500 pounds of foliage and 1800 pounds of foliage plus branchwood per acre.

1/ Storey, T. G., Fons, W. L., and Sauer, F. M. Crown characteristics of several coniferous tree species. U. S. Forest Serv. Div. Forest Fire Res. Interim Tech. Rpt. AFSWP-416. 1955.

Suppose further that this fuel type contains 8 tons per acre of understory vegetation and litter--about average for the fuels in the pocosins. If a very hot fire burned in this type and if all foliage and branchwood were consumed, the total fuel weight and resultant total fuel energy released would be increased by about 11 percent. Even in very severe fires, however, it is unlikely that most of the branchwood would be consumed, except in small areas. If the fire were slightly less intense, probably only the needles on the crowns would be consumed. In our example, the total fuel weight and the total fuel energy would be increased by only about 3 percent.



Relation between the ovendry weight of pond pine foliage and d. b. h. Hofmann Forest, N. C.

Relation between the ovendry weight of pond pine foliage plus branchwood and d. b. h. Hofmann Forest, N. C.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 150 October 1960

EARLY RESULTS FROM A GEOGRAPHIC SEED SOURCE STUDY OF YELLOW-POPLAR

After 5 years in a plantation, local yellow-poplar (Liriodendron tulipifera L.) seedlings had better survival than those from several other geographic locations, but average total height did not differ significantly among the various seedling lots tested. Observations and measurements showed that the seedlings of different sources began height growth at different times, correlated with length of growing season, date of last killing frost, and latitude of the source, and also that they stopped growth at different times, correlated with the date of the first killing frost of the source.

Seedlings of sixteen geographic sources are included in the test, which was begun in 1954 at the Bent Creek Experimental Forest near Asheville, North Carolina. A randomized block design with two replications was used; each source was represented once on each block by 64 trees spaced 8 x 8 feet. The two blocks are on cove sites which were cleared just prior to planting. Five-year height and survival results, as well as the results from measurements and observations on seasonal height growth in 1958 and growth initiation in 1959, are presented in this note.

The over-all average survival of seedlings in 1958 was 87 percent, with a range from 79 percent for the two Indiana provenances to 96 percent for the Bent Creek and the northern Georgia provenances (table 1). Differences among the seedling lots were highly significant.

Table 1. --Survival and total height after 5 years, by source

Source	Average survival *	Average total height
	Percent	Feet
Bent Creek, N. C.	96	3.21
Habersham County, Ga.	96	4.23
Jonesboro, Ill.	94	4.76
Calhoun County, Miss.	93	4.54
Orange County, N. Y.	93	5.04
Athens, Ohio	91	3.59
Tucker County, W. Va.	91	3.74
Morgan County, Tenn.	88	4.96
Marietta, Ohio	86	4.73
Henderson County, N. C.	84	4.88
McDowell County, W. Va.	84	5.19
Wake County, N. C.	83	4.18
Dowagiac, Mich.	81	3.04
Madison County, Tenn.	80	5.77
Dexter, Ind.	79	2.96
Cannelton, Ind.	79	5.16

* Survival means were compared by Duncan's Multiple Range Test. The means bracketed by any one line do not differ significantly at the five percent level of testing.

Although average total heights of seedlings were significantly different among the lots tested after one growing season, there were no differences remaining after five growing seasons. Average 5-year heights of seedlings ranged from 3.0 feet for the Dexter, Indiana, source to 5.8 feet for the Madison County, Tennessee, source, with the local seedlings averaging 3.2 feet. Site variation within the blocks, particularly one of them, is considerable and no doubt is responsible in part for the large block times source interaction which tends to mask any actual height differences among the seedling lots.

Five-year heights were quite variable within the different lots of seedlings (fig. 1); ranges varied from 7.2 feet within the Michigan seedlings (c. v. = 53.2 percent) to 19.2 feet within the lot from Henderson County, North Carolina, (c. v. = 68.3 percent). Coefficients of variation ranged from 36.4 percent for the seedlings of Athens, Ohio, source (height range = 7.3 feet) to 68.3 percent for the seedlings of Henderson County, North Carolina, source.

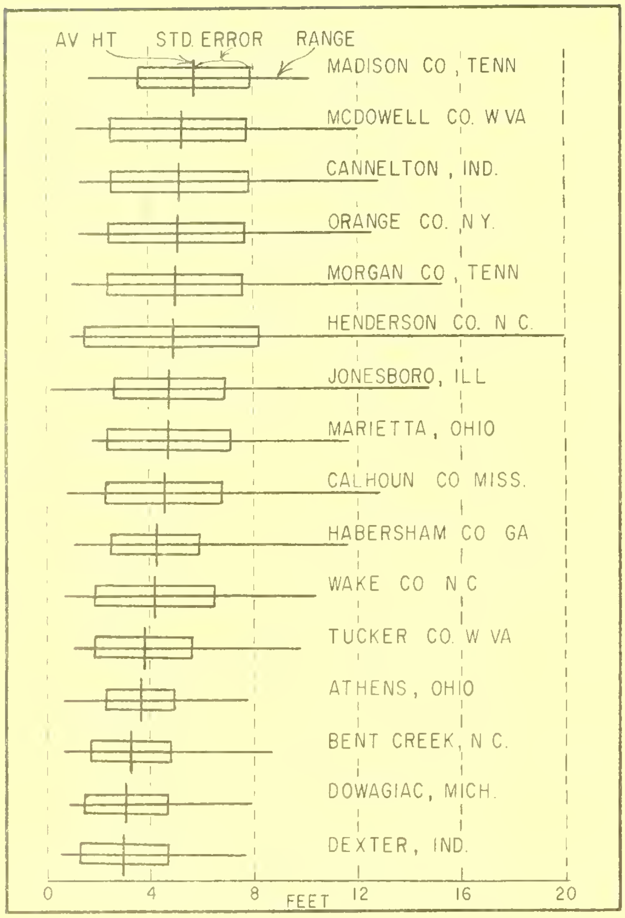

Figure 1.--The averages, ranges, and standard errors of total heights within sources.

Differences in date of growth initiation in 1959 were highly significant; the Mississippi seedlings began growth earliest on April 8, the Athens, Ohio, and the two West Virginia seedling lots began growth latest on April 30, and the local seedlings began growth on April 18. Date of growth initiation was correlated (r = -0.900) with length of growing season (fig. 2). It was also correlated with date of last killing frost (r = 0.808) and latitude (r = 0.575) of the source; the multiple correlation coefficient, including all these independent variables, was 0.902.

Height growth patterns were studied during the 1958 growing season; no trend associated with source was evident. Growth rates increased rapidly from late April, reached a peak in early to mid-June, and dropped to very low rates by mid-July. The date of height growth cessation of seedlings from the different sources in 1958 was significantly correlated with the date of the first killing frost at the seed source (r = 0.518).

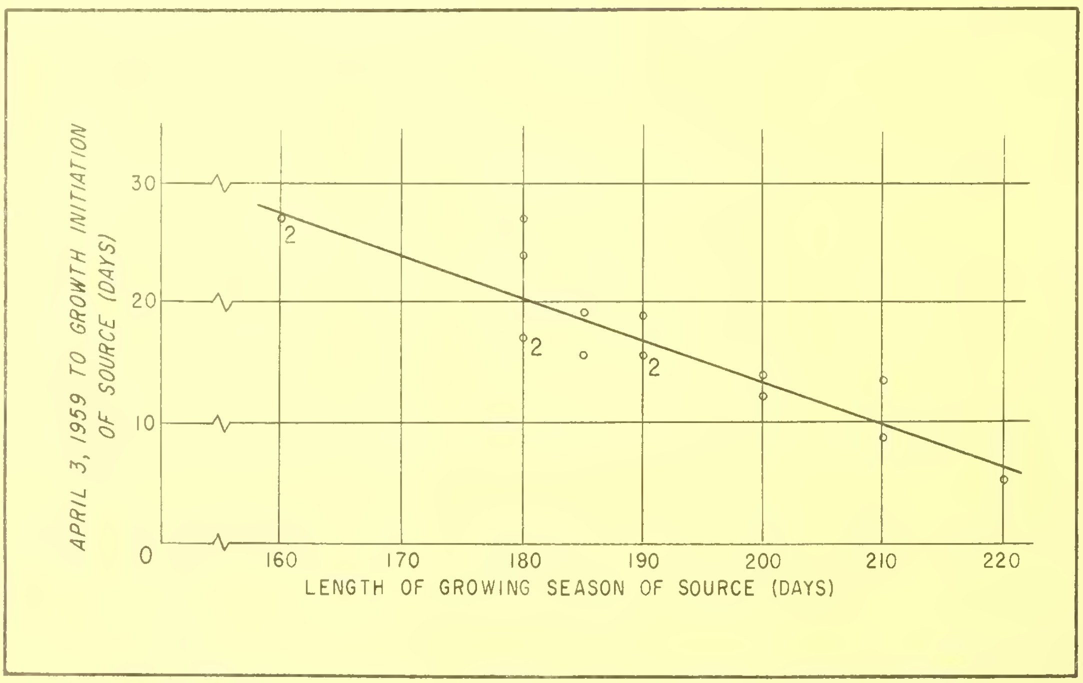

Figure 2.--Regression of growth initiation on length of growing season of source.

Agriculture - Asheville

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 151 October 1960

COUNTING CONES ON STANDING SLASH PINE

A reliable method for estimating the number of cones on standing trees is a useful tool for forest research and management. It is helpful in studies of cone production, stimulation, and protection from insects and disease. It can also furnish the basis for cone crop predictions in stands or larger forested areas.

We found that the cone crop on slash pine trees can be estimated with fair accuracy. On a number of slash pine trees, cones were counted through binoculars and the actual number was determined after felling. Separate counts were made for maturing cones in late summer and for first-year cones (conelets) in the spring. Three observers each counted every tree with hand-held 7 x 50 binoculars and with the binoculars mounted on a tripod. The tripod allowed horizontal as well as vertical adjustment.

The binocular counts were made as suggested by Wenger[1] for loblolly pine. The observer stood with the sun behind him and far enough from the tree so that he could clearly see all of one side of the crown. He then systematically counted all the cones he could see, moving up one side of the crown and down the other. While counting, the observer did not change his position so as not to lose his place in the crown.

The counts were subjected to a conditioned regression analysis with the equation form: $Y = bX$.

In this equation, Y = actual number of cones or conelets,
X = binocular count
b = regression constant.

The analysis showed that:

1. No real difference occurred between counts of two or more observers if 7 x 50 or better binoculars were used.
2. With a tripod mount, more conelets were counted by all observers, even though the precision of the estimate did not improve.

1/ Wenger, Karl F. How to estimate the number of cones in standing loblolly pine trees. Southeast. Forest Expt. Sta. Res. Notes 44. 1953.

The factor b and its standard deviation were calculated for 3 situations of counting with 7 x 50 binoculars:

Object	Binoculars	b	Standard deviation of b
Conelets	held freehand	2.719	0.1225
	tripod mounted	2.428	0.1282
Cones	held freehand	2.244	0.1167

Freehand counting is much faster than counting with tripod-mounted binoculars. A tripod need not be used except when fatigue becomes a factor. If a large number of trees heavily laden with conelets must be counted, greater accuracy will be achieved with the binoculars mounted on a tripod.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 152 January 1961

RESPONSE OF FESCUE TO NATURAL MOISTURE GRADIENT ON AN ARTIFICIAL SLOPE

A study of drainage from a narrow, sloping, enclosed soil model planted to grass (Festuca arundinacea) revealed an interesting growth response to small moisture tension gradients (fig. 1). Although the model was well-watered during a 3-month observation period, growth of the grass was notably more vigorous at the lower end of the model, where a free-draining artificial "water table" was maintained. After 3 months' growth, average length of dominant grass blades decreased from 19 to 12 inches as elevation above the "water table" increased along a 40 percent slope from zero to 10 feet (fig. 2).

In preparing the model, the sandy loam soil was carefully mixed, tamped into place, and thoroughly soaked by sprinkling. After drainage from the model had ceased, small amounts of fertilizer and lime were spread by hand evenly over the surface, and grass was sown on August 12. Subsequent additions to soil moisture were from natural rainfall, which infiltrated readily. Measurements of soil moisture by the nuclear method indicated that the growing grass was subjected to moisture stress which varied with position on the slope despite fairly frequent rainfall. At no time did the average moisture stress as reflected by moisture contents at 9 inches depth exceed the one-third atmosphere percentage. A gradient in plant growth and density, quite obvious to the eye, developed during the period August 12 to October 19. Under the conditions of the experiment, it is most unlikely that the downward migration of nutrients caused this response.

Several workers have reported evidence that small increase in soil moisture stress within and above the field capacity range can cause appreciable reduction in plant growth. McKell, Perrier, and Stebbins 1/ have recently reviewed experimental work on this subject and at the same time showed that orchard grass (Dactylis glomerata) reduced growth rapidly and progressively as soil moisture stress increased from zero to about 3 atmospheres. The present study suggests that small, recurring moisture-tension gradients on natural slopes, undetected by most

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1/ McKell, C. M., E. R. Perrier, and G. L. Stebbins. Responses of two subspecies of orchard grass (Dactylis glomerata subsp. lusitanica and judaica) to increasing soil moisture stress. Ecology 41: 772-778. 1960.

field measurements, may have an appreciable influence on plant growth and development. The interaction of rainfall and drainage by gravity may help to explain the effects observed here. Following rainfall, which effectively cancels all moisture stresses, slow drainage extracts water from the top of the model while maintaining soil moisture at low tensions downslope.

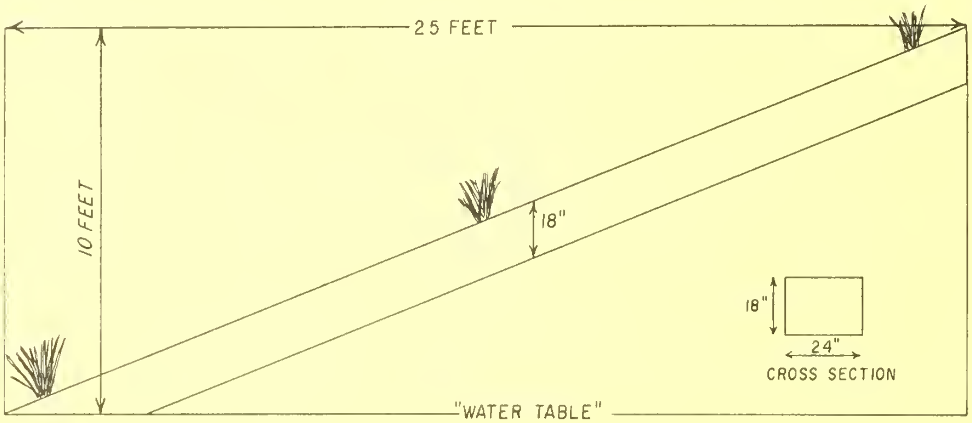

Figure 1. --Diagram of the soil model.

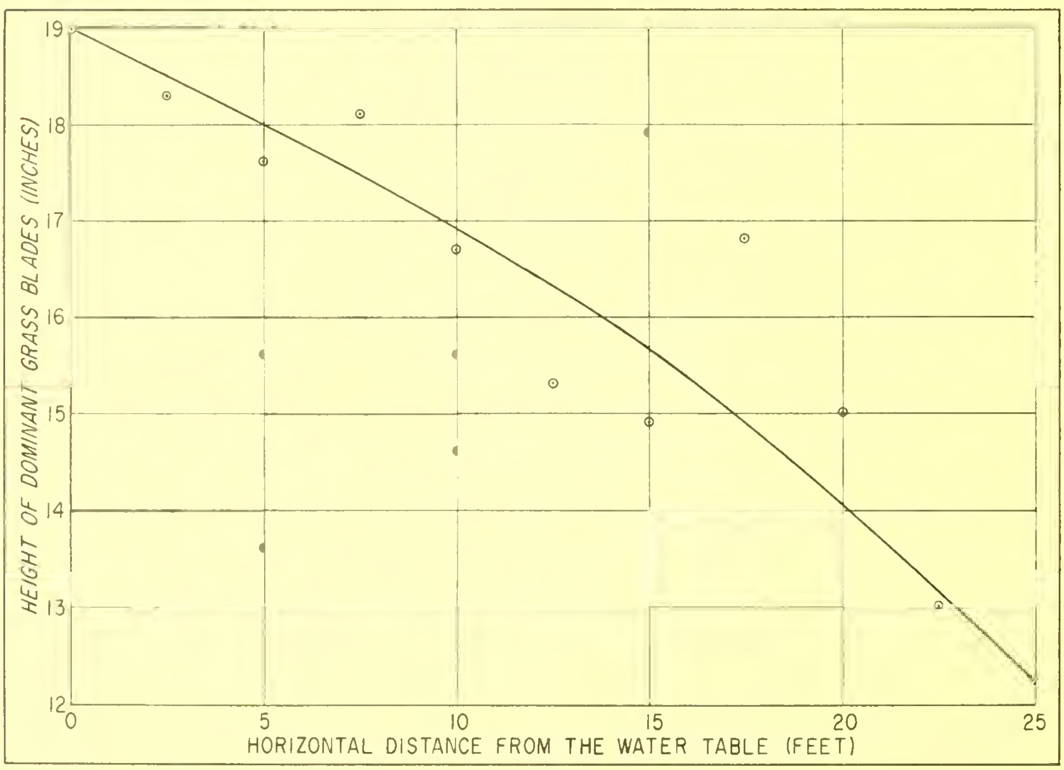

Figure 2. --Three months' growth of grass in relation to distance from the "water table."

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 153 January 1961

PREDATOR INTRODUCTIONS FOR CONTROL OF THE BALSAM WOOLLY APHID ON MT. MITCHELL, NORTH CAROLINA

The balsam woolly aphid, Chermes piceae Ratz., a serious killer of true firs in the United States, was detected on Fraser fir in Mt. Mitchell State Park in 1957.[1] Surveys revealed that 21,600 trees had been killed in 1959 and that countless others were infested.[2] Fraser fir grows naturally on the higher mountain peaks in the southern Appalachians where it has high aesthetic value. It is also valued as a Christmas tree, and its seed and nursery stock are much in demand by Christmas tree growers.

The balsam woolly aphid is about one millimeter in length, wingless, and reproduces in the absence of males. Insecticides have been used with fair success in controlling the aphid in scenic and recreation areas. However, extremely rough terrain, dense stands of fir, and high cost of application limit the use of this treatment.

To provide some degree of aphid control in inaccessible stands, biological methods utilizing two species of insect predators, Aphidoletes thompsoni Möhn and Laricobius erichsonii Rosenh., were started in 1959. These insects were obtained from Germany through the Commonwealth Institute of Biological Control, the Canada Department of Agriculture, and the Agricultural Research Service of the U. S. Department of Agriculture.

The two predators released in 1959 completed their life cycles and overwintered successfully. In 1960, four additional species of predators were released, two from Germany, one from Australia, and one from New England, as well as additional specimens of Laricobius (table 1). Each species will be studied to determine whether it becomes established and its degree of aphid control. As additional species of predators become available they will be released on Mt. Mitchell to aid in the biological control effort.

1/ Speers, C. F. The balsam woolly aphid in the Southeast. Jour. Forestry 56: 515-516. 1958.

2/ Anonymous. Forest insect conditions in the United States, 1959. U. S. Forest Serv., 33 pp., illus. 1960.

Table 1.--Predator liberations on Mt. Mitchell, North Carolina, for control of the balsam woolly aphid

Species	Origin	Received	Released
		1959	
		- - Number - -	
Laricobius erichsonii Rosenh.	Germany	624	619
Aphidoletes thompsoni Möhn	Germany	21,216 (estimated)	8,809
		1960	
Aphidecta obliterata (L.)	Germany	1,300	1,230
Laricobius erichsonii Rosenh.	Germany	1,200	1,100
Neoleucopis obscura (Hal.)	New England	142	142
Pullus impexus (Muls.)	Germany	300	290
Scymnus pumilio (Ws.) [(Flavifrons) (Blkb.)]	Australia	3,400	3,300

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Division of Forest Insect Research

RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 154 May 1961

A SECOND REPORT ON INTERPLANTED SLASH PINE

Data from two interplanted slash pine plantations on the George Walton Experimental Forest were published in 1954.[1] The interplants, converting an approximate 12 x 12-foot spacing to 6 x 12, were one year younger than the initial planting, and were 8 years of age at the time of the report.[2] The interplanting was judged a failure on the basis of the diameter growth of the interplants.

Table 1.--Average number of trees and volume per acre, by diameter classes, for two interplanted slash pine plantations

D. b. h. (inches)	Interplanting		First planting	
	Trees	Volume	Trees	Volume
	Number	Cords	Number	Cords
1	2	--	--	--
2	15	--	2	--
3	39	--	4	--
4	50	--	9	--
5	37	0.73	20	0.42
6	17	.59	31	1.15
7	5	.26	62	3.67
8	1	.07	75	6.25
9	--	--	36	4.09
10	--	--	9	1.28
11	--	--	2	.40
Total	166	1.65	250	17.26

A recent inventory of these two plantations, 15 growing seasons after the interplanting, substantiates the original judgment, not only on the basis of average tree size but also from the standpoint of volume production (table 1).

Crown class observations were included in the re-inventory and show the relative position of the two plantings in the crown canopy (table 2).

Interplants in the larger d. b. h. classes were usually found at the end of rows or next to openings caused by mortality.

Interplanting in one direction would nearly double the number of stems in the plantation. At the present time, however, there are 34 percent fewer interplants than trees of the original planting. The current condition of the 15-year-old interplants is further emphasized by the fact that 64 percent of

1/ Bennett, Frank A. Reduction in growth of interplanted slash pine. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Notes 55. 1954.

2/ Originally the spacing was considered 15 x 15; a thorough check showed it to average closer to 12 x 12.

them are still below merchantable size. Of these trees below 5 inches, 89 percent are suppressed so there will be little ingrowth into merchantable size in the future. Only 37 percent of the merchantable-sized interplants, or 13 percent of the total, are in a position to compete favorably.

As shown in table 1, the first planting has now produced 17.26 cords per acre and the interplants only 1.65 cords.

Table 2.--Percentage of trees in each of the four crown classes by diameter class

D. b. h. (inches)	Crown class							
	Suppressed		Intermediate		Codominant		Dominant	
	Inter-planting	First planting	Inter-planting	First planting	Inter-planting	First planting	Inter-planting	First planting
	Percent							
1	100	100	--	--	--	--	--	--
2	100	100	--	--	--	--	--	--
3	100	80	--	20	--	--	--	--
4	77	46	23	54	--	--	--	--
5	33	17	57	75	10	8	--	--
6	--	--	27	60	73	40	--	--
7	--	--	--	23	79	70	21	7
8	--	--	--	--	71	70	29	30
9	--	--	--	--	55	54	45	46
10	--	--	--	--	--	15	--	85
11	--	--	--	--	--	22	--	78

A. Jay Schultz
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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 155 May 1961

SEEDLING SIZE AFFECTS EARLY SURVIVAL AND HEIGHT GROWTH OF PLANTED CYPRESS

A small plot study on the Santee Experimental Forest near Charleston, S. C., shows that cypress seedlings (Taxodium distichum (L.) Rich.) can be successfully established on some wetland sites when stem diameter is used as a guide to the selection of nursery stock.

One-year-old cypress seedlings used in the study were grown at the West Virginia Pulp and Paper Company nursery near Summerville, S. C., from seed collected in Georgetown County. The planting stock was sorted, according to stem diameter at the upper one-third of the root collar swell, into diameter classes: 0.45-, 0.35-, 0.25-, and 0.15-inch. Seedlings with poorly formed roots or tops, or damaged in any way, were rejected regardless of size. One hundred and fifty trees of each diameter class were outplanted in April 1958 on 24 plots of 25 trees each. Plots were equally divided between two locations previously cleared of lowland hardwoods and enclosed by hogproof fences. The primary difference between areas was that one remained flooded for longer periods than the other following periodic rises of an adjacent small stream.

The soil at each location was a fine sandy loam overlying a sandy clay. Depth to the subsoil averaged about 4 inches on the wettest site and 8 inches on the other. A local SCS technician classified soils at both study areas as Bladen fine sandy loam.

A field examination at the end of the second growing season showed that only the 0.15-inch seedlings survived poorly (table 1). The survival pattern was about the same at both planting locations.

Table 1.--Average survival and height growth of planted cypress by seedling size class at end of the second growing season 1/

Stem diameter (inches)	Survival	Height		
		Initial	After 2 years	Growth
	Percent	Feet		
0.45	100	1.8	3.6	1.8
.35	98	1.5	3.1	1.6
.25	93	1.2	2.7	1.5
.15	55	.6	1.8	1.2

1/ Basis: 150 seedlings per size class.

U. S. Department of Agriculture - Forest Service

Seedling size also influenced height growth. Both the 0.45- and 0.35-inch seedlings grew significantly better than the 0.15-inch trees, and the 0.25-inch trees did almost as well as those of the larger sizes. Location, however, seems to have as great an effect on growth as seedling size. The seedlings on the wettest planting site averaged 1.9 feet in height growth as compared to 1.2 feet on the other area. In fact, all sizes of seedlings on the wettest site grew better than any single seedling grade on the drier location (fig. 1).

From this limited study it appears that 1-0 cypress seedlings with stem diameters 0.25-inch and larger at the upper end of the root collar make good planting stock. Good early survival and growth may be expected from seedlings of these dimensions on first bottom sites adjacent to small streams of the Carolina coastal plain.

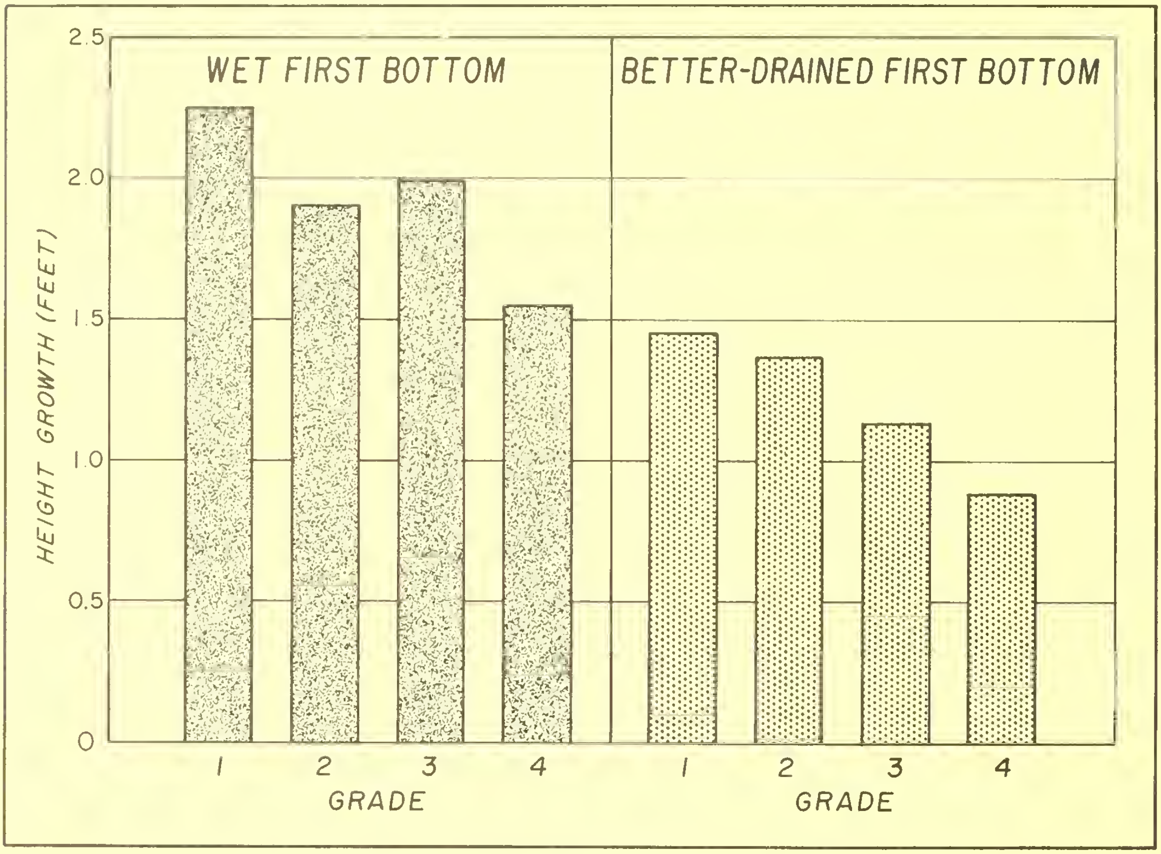

Figure 1. --Two-year height growth of planted cypress seedlings by grade and location.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
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PINE CHAFER BEETLE CAUSES DAMAGE IN THE SOUTHEAST

The pine chafer, Anomala oblivia (Horn.), although native to the southeastern United States, has only recently caused any serious defoliation of southern pines. Several infestations have been reported on loblolly pine plantations in recent years. One occurred near Waycross, Georgia, in 1956 and another south of New Bern in eastern North Carolina in 1957.[1] These infestations persisted for only one year, and there was no apparent damage to the trees. An infestation near Bolton, North Carolina, first reported in 1958, differs from other recent outbreaks in the Southeast in that it has persisted for several years.

This scarabaeid beetle occurs in open, scrubby pine forests from Georgia to New York and westward to Lake Michigan. The details of its biology are unknown in the Southeast, but the general life history is quite similar to that described for central Michigan.[2]

As in Michigan, one generation occurs each year. Adults emerge in the early part of June, feed on pine needles for several weeks, mate, and then lay their eggs in the soil. The eggs probably hatch in 10 to 15 days. The grubs are similar in appearance to white grubs. They feed on the roots of grasses and weeds until cold weather and overwinter at depths of several inches in the soil. Pupation occurs in mid-May, and the adults emerge 2 to 3 weeks later. The adults cause the damage to the trees. The adult female is about 9 millimeters long and light tan in color. The male is 6 to 7 millimeters long, has a greenish bronze head and pronotum, and dark tan wing covers.

In the Southeast, this insect prefers loblolly pine, but in the Bolton area it was also observed feeding on slash, longleaf, and pond pine. In all cases adult feeding occurred on the new growth. A notch is eaten in each needle just above the bundle sheath and the ends of the needles die, giving the tree a reddish, fire-scorched appearance. The bases of the needles usually survive and grow to about one-half their normal length.

In the Bolton area, foresters found the beetle infesting almost every tree on 500 acres of 2-year-old planted loblolly pine in the spring of 1958. By the spring of 1959 the outbreak included 5,000 acres of 2-, 3-, and 4-year-old loblolly and slash pine. By mid-June of 1960 approximately 1,500 acres of

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1/ Nagel, W. P. Pine leaf chafer defoliation on loblolly pine in southern North Carolina. U. S. Forest Serv. Southeast. Forest Expt. Sta. Forest Insect Survey Rpt. 59-2, 3 pp. 1959. (Unpublished.)

2/ Craighead, F. C. Insect enemies of eastern forests. U. S. Dept. Agr. Misc. Pub. 657, 679 pp., illus. 1950.

2- and 3-year-old pine were lightly to moderately defoliated, 1,000 acres suffered heavy defoliation, and the beetle could be found throughout a 20,000-acre area on pine of all sizes. The infestation appears likely to continue in 1961.

The plantations referred to are on a wet site formerly stocked with pond pine. The land was cleared, burned, drained, disced, and then planted to loblolly or slash pine the following season. During the first season the grass and weed cover on newly planted areas was sparse, but it may have served to attract beetles into the area to lay eggs. In succeeding years the grass and weed cover became quite dense and the roots offered a favorable feeding site for beetle larvae. To date no feeding has been observed in 1-year-old plantings, but in the second and succeeding years the adult beetles have attacked the young trees.

When feeding by adults is confined to a single year, there appears to be no cause for concern. It is quite unlikely that tree mortality will occur in plantations that have suffered several defoliations. Repeated defoliation, however, may reduce the height growth of the trees. Where the young trees have to compete with woody shrubs, a severe reduction in height growth as a result of beetle attack might allow the shrubs to overtop the pines and damage the plantations.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

mber 157 June 1961

LOBLOLLY PINE OF NORTHERN PROVENANCE MAY BE BEST FOR PLANTING IN VIRGINIA

The natural range of loblolly pine (Pinus taeda L.) does not extend to the Virginia Piedmont, but it is t major species used for reforestation in that area. There has been no information until recently to ow which geographic sources of seed are best for planting stock. After 15 years, however, the results a small study on the Lee Experimental Forest, Buckingham, Virginia, show that seedlings of northern more local origin may grow faster than southern races, but that the stem form of loblolly pine in genal may be very poor.

In 1945, Dr. Leon Minckler obtained 1-0 loblolly pine seedlings from different geographic areas: rgaw, North Carolina; coastal plain, South Carolina; thoughout Mississippi; and Columbia County, kansas. These seedlings were outplanted during the spring months in plots of 121 trees each with 5 plications at a spacing of about 6 x 6 feet. Height and survival measurements were made in the fall of 45, 1947, 1950, and 1959, when the trees had been in the field 1, 3, 5, and 15 years. Diameter measements were taken in 1954 and 1959. Stem crook and forking were recorded in 1959. Final analyses of ight and volume growth were based on data for 44 trees in the interior of each plot, which left an isolan strip of two rows on all sides. All trees on the plots were evaluated for form.

Seedling survival after 15 years was not significantly different between lots of seedlings, although rvival varied as follows: Arkansas, 93 percent; South Carolina, 77 percent; North Carolina, 83 percent; d Mississippi, 84 percent. Survival differences were significantly different early in the life of the study, after 1, 3, and 5 years in the field, but not after 10 and 15 years.

Damage by diseases and insects was extremely low in all plots.

Heights of seedlings of different geographic origin were significantly different after 1 year in the ld, and Mississippi seedlings were the tallest. However, seedling heights were not significantly differt after 3 and 5 years in the field. In 1959, after 15 years in the field, the heights were significantly ferent, with seedlings from North Carolina taller than those from South Carolina, Mississippi, and kansas (table 1). Trees from Mississippi and Arkansas were the same average height.

able 1.--Average height, diameter, volume, and height over diameter ratio of 15-year-old loblolly pine, by geographic source of seed

ource of seed	Total trees	Height	Height index	Diameter	Diameter index	Volume per tree	Volume index	Height over diameter
	Number	Feet	Percent	Inches	Percent	Cubic feet	Percent	Ratio
rkansas	205	34	100	5.3	100	1.90	100	6.4
lississippi	185	34	100	5.3	100	1.90	100	6.4
outh Carolina	169	35	103	5.3	100	1.96	103	6.6
orth Carolina	183	37	109	5.7	107	2.40	126	6.5

On these four plots, height differences were naturally not very great at the end of 5 years. However, easurements at that time ranked the trees as North Carolina tallest, South Carolina next, Mississippi xt, and Arkansas shortest. At the end of 15 years, North Carolina trees were still tallest, Arkansas ortest, and ranking was unchanged. Thus, the inherent rate of growth may have been established before e end of the first 5-year period after outplanting. This is of importance because foresters often wonder ether growth rates during the early years are a true indication of growth rates later on, and in this nall trial the height-growth trends could have been predicted as well at 5 years as at 15.

Average diameter of trees from North Carolina was significantly greater than that of trees from uth Carolina, Mississippi, and Arkansas after both 10 and 15 years in the field.

Volume of the average tree in the seedling lot from North Carolina was about 26 percent larger than that from Mississippi and Arkansas and about 22 percent greater than that from South Carolina. Although the percentage differences in diameter and height are small, the difference in volume is quite impressive because volume is a function of both diameter and height.

Stem form in all plots was very poor, and only a relatively small percentage (8 to 20 percent) could be placed in Classes 1 and 2 (table 2). There were only 17 straight trees in all plots. Class 1 trees were straight, Class 2 trees had small crooks that would be outgrown before maturity, Class 3 trees had crooks that could be attributed to either glaze or snow damage, and Class 4 trees had severe crooks or were leaning trees. Data on stem crooks were not analyzed statistically because the classification is subjective.

Table 2.--Proportion of trees by straightness class and type of forking, by geographic source of seed

Source of seed	Trees examined	Straightness class			Type of fork	
		1 and 2	3	4	Partial	Complete
	Number	Percent				
Arkansas	534	20	2	78	26	15
Mississippi	404	8	5	87	32	5
South Carolina	456	15	3	82	25	3
North Carolina	513	12	3	85	23	6

There were significantly more trees with complete forks in the Arkansas seedlings than in lots from other areas (table 2). The percentage of trees with partial forks was about the same. Partial forks are spur branches larger in diameter and having a much smaller angle from the vertical than regular branches. The figures for partial forking were not analyzed statistically because the classification is subjective.

Stem taper as indicated by the tree height over diameter ratio did not vary significantly among trees of different geographic source. This ratio has been found to vary sometimes between different races or the progeny of individual trees.

The results of this study after 15 years are in general agreement with those of other loblolly pine studies showing that seedlings of northern geographic sources do better than those of southern origin when planted north of the natural range or in the northern part of the natural range. Similar results were obtained in Maryland by Little and Tepper[1/] and in Illinois by Woerheide.[2/] In addition, the present study shows that the form of loblolly pine may be very poor when planted in the Piedmont region of Virginia and may not produce high quality trees for saw logs or poles. The data on the percent of trees with complete forks indicate that this trait, or some trait that contributes to forking, is hereditary.

In addition to showing that seed of northern latitude is best to plant in the Virginia Piedmont, it is evident from the data that racial selection studies should be evaluated on the basis of tree quality as well as rate of growth and susceptibility to pests to make the comparison complete.

1/ Little, S., and Tepper, H. B. Six-year results from a Maryland planting of loblolly pine from different seed sources. In Sixth Northeast. Forest Tree Improvement Conf. Proc., U. S. Forest Serv. Northeast. Forest Expt. Sta., pp. 26-29. 1959.

2/ Woerheide, John D. Loblolly seed from Maryland best of six sources tested in southern Illinois. U. S. Forest Serv. Central States Forest Expt. Sta. Note 129. 1959.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
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AGE OF STOCK AS A FACTOR IN SURVIVAL AND GROWTH OF LONGLEAF SEEDLINGS

A major problem encountered in regenerating thousands of acres of Carolina sandhills is the high mortality suffered by outplanted longleaf pine. Research results, however, have indicated that mortality can be reduced by planting large, high-vigor seedlings,[1] and that height growth of longleaf pine does not begin until the seedlings are approximately one inch in diameter.[2] These findings suggested the possibility that 2-0 or 1-1 transplant stock would survive and grow better than the 1-0 stock customarily planted. Reported here are first- and fifth-year results of a cooperative study between the U. S. Forest Service and the South Carolina Commission of Forestry to compare the survival and growth of 2-0, 1-1, and 1-0 seedlings after several preplanting treatments and outplanting. The results indicate that little or no practical advantage can be obtained by planting 2-0 or 1-1 stock.

Methods

In January 1955, plots were established at the Manchester and Sand Hills State Forests on deep-sand sites which initially supported stands of scrub oak. Before planting, the sites were treated with a Marden brush cutter followed by deep plowing. Later, scrub oak sprout development was controlled by a basal spray of 2,4,5-T and oil.

The stock planted in each of the three age classes met the minimum requirements for Grade 1 Seedlings.[2] As a test of preplanting procedure, one-half of each age class was foliage clipped to 5 inches and one-half of the 2-0 stock was root pruned to 5 inches. The eight treatments, replicated four times at each forest location, contained 6,400 seedlings. Each surviving seedling was tallied at the end of the first and fifth growing season.

Results and Discussion

Considerable seedling mortality occurred between the first and fifth year due largely to brown spot disease (table 1). A significant number of the surviving seedlings are currently infected and mortality will continue unless

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1/ Shipman, R. D. Planting pine in the Carolina Sandhills. U. S. Forest Serv. Southeast. Forest Expt. Sta. Paper 96, 43 pp., illus. 1958.

2/ Wakeley, P. C. Planting the southern pines. U. S. Dept. Agr. Monog. 18, 233 pp., illus. 1954.

control measures are taken. The difference in early survival at the two planting locations is probably related to a hard freeze that occurred shortly after planting and was more severe at the northerly Sand Hills State Forest location.

Table 1. --Group comparisons of first-year survival and fifth-year survival and height

Group comparison	First-year survival	Fifth-year survival	Fifth-year height
	Percent	Percent	Feet
Age of stock (1-0)	86	69	4.5
Age of stock (1-1)	50	34	5.1
Age of stock (2-0)	57	39	3.5
Location (Manchester State Forest)	73	51	3.8
Location (Sand Hills State Forest)	52	39	4.5
Foliage treatment (Clipped)	63	47	4.0
Foliage treatment (Unclipped)	62	44	4.3
Root treatment of 2-0 stock (Pruned)	53	45	3.2
Root treatment of 2-0 stock (Unpruned)	63	34	3.7

The major conclusion of this study is that planting large seedlings does not necessarily insure good survival and rapid height growth. The group comparison indicates that only 1-0 seedlings produce desirable levels of survival and growth. Other comparisons indicate that the over-all effect of foliage clipping is not appreciable, but the 1-1 stock shows a 24 percent increase in survival when clipped. Root pruning increased over-all survival of the 2-0 seedlings by 11 percent, but reduced height growth by 0.5 of a foot.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
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GROWTH OF FUSIFORM CANKERS ON YOUNG SLASH PINE

The initial 100-percent inventory of all slash pine plantations on the George Walton Experimental Forest, Dooly County, Georgia, showed an average of 5 percent of the trees to be infected with fusiform rust (Cronartium fusiforme). The maximum infection encountered was 16 percent. Ten years later, in 1957, a 6-year-old slash pine plantation showed 31 percent of the trees to be infected with rust. This large, unexpected increase in infection prompted a study to investigate the rate of branch canker growth.

The development of 54 branch cankers on otherwise healthy trees in this 6-year-old plantation was observed over a 3-year period. The cankers were evenly divided into three categories on the basis of initial measurement: A, 0 to 4 inches from stem; B, 5 to 8 inches from stem; and C, 9 to 18 inches from stem. All cankers either entered the stem by the end of the third growing season or died before reaching it, as shown in table 1.

Table 1.--Percentage of branch cankers that infected stem or died before reaching stem, by category and growing season

Growing season	Category A, cankers initially 0 to 4 inches from stem		Category B, cankers initially 5 to 8 inches from stem		Category C, cankers initially 9 to 18 inches from stem	
	Infected stem	Died before reaching stem	Infected stem	Died before reaching stem	Infected stem	Died before reaching stem
			Percent			
First	66.6	5.5	38.9	11.1	0.0	27.8
Second	16.7	5.6	27.7	0.0	0.0	16.7
Third	5.6	0.0	22.3	0.0	50.0	5.5

Sixty-six percent of the cankers in category A reached the stem by the end of the first growing season. At the end of the second year 66 percent of the cankers in category B had reached the stem, while none of those in category C entered it until the third year. Forty-five percent of category C cankers were dead by the end of the second year. Only 11 percent of those in categories A and B died before reaching the stem.

To determine more precisely the distance beyond which cankers were not likely to reach the stem, category C was divided into cankers which were 9 to 13 and 14 to 18 inches from the stem (table 2). Sixty-three percent of the cankers between 9 and 13 inches from the stem had infected it by the end of the third year, while less than 30 percent of those at 14 to 18 inches reached the stem (the remainder of this latter group having died by the end of the second year).

Table 2.--Percentage of Category C branch cankers that infected stem or died before reaching stem

Growing season	Cankers initially 9 to 13 inches from stem		Cankers initially 14 to 18 inches from stem	
	Infected stem	Died before reaching stem	Infected stem	Died before reaching stem
	- - - - - - - -	- - - - - - - - Percent	- - - - - - - -	- - - - - - - -
First	0.0	27.3	0.0	28.6
Second	0.0	0.0	0.0	42.8
Third	63.6	9.1	28.6	0.0

Although the sample on which this study was based is small, some useful conclusions can be drawn. For instance, other researchers have observed that branch cankers more than 15 inches from the stem were of no importance. The present work indicates that 15 inches may be conservative, at least for slash pine.

The important fact is that 28 percent of the branch cankers 14 inches or more from the stem entered it within 3 years, while the majority of those closer infected it within one to three years. Therefore, if a tree is to be kept in the stand for any length of time, it should be pruned of all cankers closer than 14 inches to the stem. As a further safeguard, cankers more than 14 inches from the stem probably should be removed if they are growing on vigorous branches.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
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UNDERPLANTING TESTS IN PINE STANDS

Hardwoods which invade pine stands are not always the most desirable species. Early results of the experiment reported in this note indicate that in the South Carolina Piedmont desirable hardwood species can be established in thinned pine plantations. The ultimate purpose of such plantings would be to produce a soil-improving understory and an older stand of mixed pine and hardwood.

Methods

Yellow-poplar, northern red oak, green ash, and eastern red cedar were planted in a 19-year-old loblolly pine plantation which had recently received a pulpwood thinning from below. The residual pine stand had an average d.b.h. of 5.6 inches and a basal area of 119 square feet per acre. Dominant trees were 40 to 45 feet high. The 1-0 seedlings were planted at a 3 x 3-foot spacing with a planting bar in late March and early April 1960. The soil was a Cecil sandy loam with an A (sandy) horizon ranging from 3 to 7 inches thick. Fertility of the soil was considered low. The A horizon contained 265 pounds per acre nitrogen, 37 pounds per acre exchangeable potassium, 59 pounds per acre exchangeable calcium, 14 to 28 pounds per acre available phosphorus by the Bray No. 2 test, and had a pH of 4.3.

Nitrogen and phosphorus were broadcast on the plots two weeks after planting at rates of 0, 100, 200, and 400 pounds per acre of ammonium nitrate and 0, 200, 400, and 800 pounds per acre of superphosphate. Each plot, 24 x 60 feet in size, contained 20 seedlings of each species. Treatments were replicated four times in a randomized block design.

Survival and height growth were determined for the first growing season. Leaf samples were taken from yellow-poplar and northern red oak for chemical analyses.

Results and Discussion

After one growing season survival was excellent for yellow-poplar, northern red oak, and green ash, but poor for eastern red cedar (table 1). A repeat planting of yellow-poplar and northern red oak in January 1961 also had an excellent initial survival. Growth was extremely variable within plots; some yellow-poplar scarcely grew in height and others grew more than two feet. Growth of yellow-poplar and northern red oak was related to percentage of nitrogen in the leaves. Even at the high fertilizer rate, however, the leaves of yellow-poplar showed chlorosis. Results of other studies at this station indicated that 1.08 percent nitrogen in yellow-poplar leaves is a deficiency level. Therefore, it appears that most of the nitrogen was either taken up by the overstory pine or leached from the root zone. Considering climatic factors, little leaching could have occurred.

Table 1.--Average survival, height growth, and percent foliar nitrogen of underplantings after one growing season in a thinned loblolly pine plantation

Fertilizer		Survival				Height growth				Foliar nitrogen	
Ammonium nitrate (pounds per acre)	Superphosphate (pounds per acre)	Yellow-poplar	Northern red oak	Green ash	Eastern red cedar	Yellow-poplar	Northern red oak	Green ash	Eastern red cedar	Yellow-poplar	Northern red oak
		- - - - - Percent - - - - -				- - - - - - Feet - - - - - -				- - Percent - -	
0	0	99	94	99	43	0.17	0.26	0.10	0.12	0.91	1.68
100	200	96	95	91	40	.15	.24	.10	.10	.96	1.67
200	400	100	94	98	34	.25	.30	.26	.16	.98	1.75
400	800	97	96	98	44	.38	.32	.30	.29	1.08	1.76

Better response to fertilizers would be expected if treatments were made in larger plots. Overstory pine from outside the plots probably removed much of the fertilizer and these nutrients will be deposited outside the plots when the litter falls. Limited tests with slowly soluble fertilizers placed near the seedlings have shown promising results with respect to growth and survival. This method could be used to reduce the uptake of fertilizers by overstory.

The rate of growth the first year or two after planting may not be of great importance and addition of the amounts of fertilizers used here may not be economically justifiable. The experiment does show, however, that excellent initial survival is possible when planting certain hardwood species in a thinned pine plantation.

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RESEARCH NOTES

SOUTHEASTERN FOREST EXPERIMENT STATION

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WEIGHT AND VOLUME OF PLANTATION-GROWN LOBLOLLY PINE[1]

Buying pulpwood by weight, rather than volume, is a sound method of doing business. Weight measurements are convenient, rapid, and do not involve human judgment. They encourage the delivery of freshly-cut wood to the mill and discourage dishonest practices such as rigging empty spaces in truckloads of wood.

A publication by Taras[2] summarized many of the problems involved in wood purchases by weight. He cautioned that variables, such as species, locale, the actual amount of wood in a cord, wood density, and moisture content must all be considered in weight measures.

A study was designed to develop volume and weight tables for loblolly pine plantations in the lower Piedmont of middle Georgia. One hundred and sixteen trees from 12 different plantations were selected at random, cut, measured, and weighed. Trees sampled ranged from 30 to 65 feet in total height, from 5 to 12 inches d.b.h., and from 19 to 24 years of age. The trees were sound, of good form, and representative of all crown classes encountered in a plantation. The field work was done from December 1959 to November 1960.

Tree weights and volumes were recorded to 3.6, 3.0, and 2.0 inch top diameters inside bark. Information from top diameter limits is useful for future growth studies and indicates the increase in yield one might expect from smaller top utilization. Currently, the minimum top diameter accepted by pulp companies is 4 inches (outside bark).

Regression equations were developed for constructing weight and volume tables to various top diameters. The equations for tree weight and volume to a 3.6 inch top i.b. are listed below:

$$\text{Tree weight in pounds} = -72.280052 - 1.145907(D)^2 + 0.25336232(H) + 0.16949407(D)^2H$$

$$\text{Tree volume in cubic feet} = -3.2914302 + 0.069568154(D)^2 + 0.05175864(H) + 0.00125878(D)^2H$$

Where:

D = D.b.h. in inches

H = Total height in feet

Tables 1 and 2 present the weight and volume data from this study. Values are given for top diameters of 3.6 and 2.0 inches. Equations for 3.0-inch tops were computed but were not tabulated.

The weight-volume ratios determined in this study disagree in part with those given by Schumacher[3] and Wahlenberg[4] in that there is a definite increase in green weight of trees with increased tree height. In contrast, Schumacher and Wahlenberg indicate that green weight per cubic foot remains the same or decreases with increased tree height.

1/ In cooperation with the Georgia Forest Research Council.

2/ Taras, Michael A. Buying pulpwood by weight as compared with volume measure. U. S. Forest Serv. Southeast. Forest Expt. Sta. Paper 74, 11 pp., illus. 1956.

3/ Schumacher, F. X. Volume-weight ratios of pine logs in the Virginia-North Carolina Coastal Plain. Jour. Forestry 44: 583-586. 1946.

4/ Wahlenberg, W. G. Loblolly pine. Duke University Press. 603 pp. Illus. 1960.

Table 1.--Weight of wood and bark of individual trees to two top diameters and various total heights (Basis: 116 trees)

TOP DIAMETER 3.6 INCHES INSIDE BARK

D. b. h. (inches)	Total tree height								
	30	35	40	45	50	55	60	65	70
	Pounds								
5	34	56	79	101	124	146	--	--	--
6	77	109	141	172	204	236	268	--	--
7	--	171	214	257	299	342	385	428	--
8	--	--	298	354	409	465	520	576	631
9	--	--	--	464	534	604	674	744	814
10	--	--	--	--	673	759	845	931	1017
11	--	--	--	--	827	931	1035	1139	1242
12	--	--	--	--	--	1119	1242	1366	1489

TOP DIAMETER 2.0 INCHES INSIDE BARK

D. b. h. (inches)	30	35	40	45	50	55	60	65	70
5	72	97	121	146	170	195	--	--	--
6	107	142	176	211	246	281	315	--	--
7	--	194	241	288	335	382	429	476	--
8	--	--	316	377	438	499	560	620	681
9	--	--	--	478	555	631	708	785	861
10	--	--	--	--	685	779	874	968	1063
11	--	--	--	--	829	943	1057	1171	1285
12	--	--	--	--	--	1122	1258	1393	1528

Table 2.--Volume of individual trees to two top diameters and various total heights (Basis: 116 trees)

TOP DIAMETER 3.6 INCHES INSIDE BARK

D. b. h. (inches)	Total tree height								
	30	35	40	45	50	55	60	65	70
	Cubic feet								
5	0.9	1.4	1.8	2.2	2.6	3.0	--	--	--
6	2.1	2.6	3.1	3.6	4.1	4.6	5.0	--	--
7	--	4.1	4.6	5.2	5.8	6.4	6.9	7.5	--
8	--	--	6.4	7.1	7.8	8.4	9.1	9.8	10.4
9	--	--	--	9.3	10.0	10.8	11.6	12.3	13.1
10	--	--	--	--	12.6	13.4	14.3	15.2	16.1
11	--	--	--	--	15.3	16.4	17.4	18.4	19.4
12	--	--	--	--	--	19.5	20.7	21.9	23.0

TOP DIAMETER 2.0 INCHES INSIDE BARK

D. b. h. (inches)	30	35	40	45	50	55	60	65	70
5	1.8	2.2	2.6	3.0	3.4	3.8	--	--	--
6	2.8	3.3	3.8	4.3	4.8	5.3	5.8	--	--
7	--	4.6	5.2	5.8	6.4	7.0	7.6	8.2	--
8	--	--	6.8	7.6	8.3	9.0	9.7	10.5	11.2
9	--	--	--	9.6	10.4	11.3	12.1	13.0	13.9
10	--	--	--	--	12.8	13.8	14.8	15.8	16.9
11	--	--	--	--	15.4	16.6	17.8	19.0	20.1
12	--	--	--	--	--	19.6	21.0	22.4	23.8

The weight and volume tables are applicable to trees in young loblolly pine plantations. To use the tables, diameters and total heights must be measured and recorded. Corresponding weight or volume values from tables 1 and 2 must be used to get at an estimate of total weight or volume of wood in the plantation.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 162 August 1961

CUBIC-FOOT VOLUME TABLES FOR SOUTHERN APPALACHIAN WHITE PINE PLANTATIONS

Some of the earliest successful forest plantations in the United States were those of eastern white pine (Pinus strobus) established about 1900 on the Biltmore Estate near Asheville, North Carolina. Since that time white pine has played an increasingly important role in reforestation in the southern Appalachians. Growth is rapid, the wood is valuable, and white pine blister rust (Cronartium ribicola) and white pine weevil (Pissodes strobi) are less common than in the northern part of the range.

From 1952 through 1960, about 20 million white pine seedlings were planted in the 15 western counties of North Carolina. In 1957, studies were begun to develop volume and yield tables and site index curves for old-field plantations. Tables 1 and 2 are a partial result of these studies; they may be used to estimate cubic-foot volume of white pine trees planted in old fields in the southern Appalachian region. These tables were prepared by regression methods from detailed measurements of 241 sample trees located mainly in North Carolina.

Table 1. --Cubic-foot volumes (outside bark) for white pine plantations

TOP DIAMETER 4.0 INCHES OUTSIDE BARK

D. b. h. (Inches)	Total tree height (feet)															
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
	Cubic-feet															
5	.73	1.05	1.38	1.71	2.03	2.36	2.69	3.01	3.34							
6	1.30	1.77	2.24	2.71	3.18	3.65	4.12	4.59	5.07	5.54	6.01					
7	1.98	2.62	3.26	3.90	4.54	5.18	5.82	6.46	7.10	7.74	8.38	9.02	9.66			
8			4.44	5.27	6.11	6.95	7.78	8.62	9.46	10.29	11.13	11.96	12.80			
9				6.83	7.89	8.95	10.00	11.06	12.12	13.18	14.24	15.30	16.35	17.41		
10					9.87	11.18	12.49	13.79	15.10	16.41	17.71	19.02	20.33	21.63	22.94	24.25
11						13.65	15.23	16.81	18.39	19.97	21.56	23.14	24.72	26.30	27.88	29.46
12									22.00	23.88	25.76	27.65	29.53	31.41	33.29	35.17
13											30.34	32.55	34.75	36.96	39.17	41.38
14													40.40	42.96	45.52	48.08

TOP DIAMETER 3.0 INCHES OUTSIDE BARK

D. b. h. (Inches)	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
4	.64	.85	1.06	1.27	1.48	1.68	1.89	2.10								
5	1.11	1.44	1.76	2.09	2.41	2.73	3.06	3.38	3.70							
6	1.68	2.15	2.61	3.08	3.54	4.01	4.48	4.94	5.41	5.87	6.34					
7	2.36	2.99	3.62	4.26	4.89	5.52	6.16	6.79	7.43	8.06	8.70	9.33	9.96			
8			4.79	5.61	6.44	7.27	8.10	8.93	9.76	10.59	11.41	12.24	13.07			
9				7.15	8.20	9.25	10.30	11.35	12.40	13.45	14.49	15.54	16.59	17.64		
10					10.17	11.47	12.76	14.05	15.35	16.64	17.94	19.23	20.53	21.82	23.12	24.41
11						13.91	15.48	17.04	18.61	20.18	21.74	23.31	24.88	26.44	28.01	29.58
12								20.31	22.18	24.05	25.91	27.78	29.64	31.50	33.37	35.23
13											30.44	32.63	34.82	37.01	39.19	41.38
14													40.41	42.96	45.52	48.08

Table 2. --Cubic-foot volumes (inside bark) for white pine plantations

TOP DIAMETER 4.0 INCHES OUTSIDE BARK

D. b. h. (Inches)	Total tree height (feet)															
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
	Cubic-feet															
5	.60	.89	1.18	1.47	1.75	2.04	2.33	2.61	2.90							
6	1.11	1.52	1.94	2.35	2.76	3.17	3.58	4.00	4.41	4.82	5.23					
7	1.70	2.27	2.83	3.39	3.95	4.51	5.07	5.63	6.19	6.75	7.31	7.87	8.43			
8			3.86	4.59	5.32	6.06	6.79	7.52	8.25	8.98	9.72	10.45	11.18			
9				5.95	6.88	7.81	8.73	9.66	10.59	11.51	12.44	13.37	14.29	15.22		
10					8.62	9.76	10.91	12.05	13.19	14.34	15.48	16.63	17.77	18.92	20.06	21.20
11						11.92	13.31	14.69	16.08	17.46	18.85	20.23	21.62	23.00	24.38	25.77
12									19.24	20.88	22.53	24.18	25.83	27.47	29.12	30.77
13											26.54	28.47	30.40	32.34	34.27	36.20
14													35.35	37.59	39.83	42.07

TOP DIAMETER 3.0 INCHES OUTSIDE BARK

D. b. h. (Inches)	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
4	.48	.66	.84	1.03	1.21	1.39	1.57	1.75								
5	.89	1.17	1.46	1.75	2.03	2.32	2.60	2.89	3.17							
6	1.39	1.80	2.21	2.63	3.04	3.45	3.86	4.27	4.68	5.10	5.51					
7	1.99	2.55	3.11	3.67	4.23	4.79	5.35	5.91	6.47	7.03	7.59	8.15	8.71			
8			4.13	4.87	5.60	6.33	7.06	7.79	8.52	9.26	9.99	10.72	11.45			
9				6.23	7.15	8.08	9.00	9.93	10.86	11.78	12.71	13.63	14.56	15.49		
10					8.89	10.03	11.18	12.32	13.46	14.61	15.75	16.89	18.04	19.18	20.32	21.46
11						12.19	13.58	14.96	16.34	17.73	19.11	20.49	21.88	23.26	24.64	26.03
12									19.50	21.14	22.79	24.44	26.08	27.73	29.37	31.02
13											26.79	28.72	30.65	32.59	34.52	36.45
14													35.59	37.83	40.07	42.31

Weighted regression equations were developed, using the following form:

$$\frac{\text{Cubic-foot volume}}{D^2H} = b_0 + b_1\left(\frac{1}{D^2H}\right)$$

where D = diameter at breast height in inches
H = total height in feet
b with subscripts = coefficients derived from the data.

Table 3 gives the regression coefficients and standard error of the mean volume for the various equations.

Table 3. --Regression coefficients and standard error of the mean volume

Top diameter limit (Inches)	Equation for volume	b_0	b_1	SE mean volume 1/
				Cubic feet
4.0	Outside bark	0.00261366	-0.581077	± 0.667
3.0	Outside bark	0.00258896	-0.184542	± 0.533
4.0	Inside bark	0.00228831	-0.535206	± 0.594
3.0	Inside bark	0.00228620	-0.254526	± 0.500

1/ Standard error of the mean volume = (root mean square residual from weighted regression) $(\overline{D^2H})$.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

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PULPWOOD PRICE TRENDS IN THE SOUTHEAST

The 1960 survey of pulpwood prices in Florida, Georgia, North and South Carolina, and Virginia found rough pine pulpwood averaging $16.45 per cord, a $0.45 increase over 1959. Hardwood prices, on the other hand, fell $0.10 a cord from $13.70 in 1959 to $13.60 in 1960. For the most part, this drop reflects larger purchases of rail and yard wood and less of the higher priced truck wood, even though truck wood prices did decline slightly.

These prices and the others shown in the table (on the reverse) are based on reports covering 67 percent of all rough pulpwood currently purchased in the 5-state area. The term "rough pulpwood" refers to wood with bark from standing trees, as contrasted with peeled wood, sawmill chips, veneer cores, or other wood residues used for pulp. Four price series are shown--one for wood loaded on railroad cars at sidings, one for wood delivered to mechanized pulpwood yards, one for wood trucked to pulpmills, and one for all-wood. The all-wood prices are weighted averages of all rough pulpwood purchases. Since they reflect changes in the proportions and prices of rail, yard, and truck wood purchased, they are applicable to total regional volumes of production or consumption.

Sawmill chips currently make up 11 percent of the total wood fibre used for pulp. The most commonly reported prices for pine chips were $6.10 per ton in 1957 and 1958, $6.25 in 1959, and $6.50 in 1960. Hardwood chips in 1960 were priced at $1.00 to $2.20 a ton below pine chip prices.

Average price of rough pulpwood in the Southeast, by year 1/

(In dollars)

Year	Pine				Hardwood			
	Rail wood 2/	Yard wood 3/	Truck wood 4/	All-wood 5/	Rail wood 2/	Yard wood 3/	Truck wood 4/	All-wood 5/
1938	3.55	--	3.85	3.60	--	--	--	--
1939	3.75	--	4.40	3.90	--	--	--	--
1940	4.00	--	4.60	4.15	--	--	--	--
1941	4.50	--	5.00	4.60	--	--	--	--
1942	5.90	--	6.65	6.00	--	--	--	--
1943	7.15	--	8.00	7.25	--	--	--	--
1944	8.15	--	8.70	8.20	--	--	--	--
1945	8.35	--	9.15	8.45	8.10	--	8.55	8.10
1946	9.90	--	10.75	10.10	9.50	--	10.55	9.70
1947	10.80	--	11.70	10.95	9.70	--	10.55	9.80
1948	11.65	--	12.30	11.70	11.00	--	11.25	11.05
1949	10.85	--	11.80	11.00	10.75	--	11.25	10.80
1950	11.85	--	12.55	11.90	10.70	--	11.50	11.00
1951	13.65	--	14.70	13.85	12.40	--	13.15	12.75
1952	13.70	--	14.70	13.90	12.40	--	13.15	12.80
1953	13.70	--	14.70	13.90	12.35	--	13.15	12.75
1954	13.75	--	14.75	13.95	12.30	--	13.15	12.75
1955	14.15	--	15.05	14.35	12.50	--	13.45	13.05
1956	15.15	--	16.45	15.45	12.90	--	13.90	13.50
1957	15.20	15.40	16.35	15.50	12.65	12.70	13.75	13.35
1958	15.20	15.40	16.10	15.50	12.45	12.50	13.85	13.45
1959	15.60	15.90	16.60	16.00	12.90	12.80	14.25	13.70
1960	16.25	16.35	17.20	16.45	13.15	13.25	14.05	13.60

1/ Per cord of 128 cubic feet of 5-foot wood with bark. Includes dealers' allowances in cases where they are paid. Prices are rounded to the nearest 5 cents.

2/ F.o.b. railroad car.

3/ Delivered to mechanized pulpwood yard.

4/ Delivered to pulpmill.

5/ Weighted average of all wood loaded on railroad cars, trucked to pulpwood yards, and delivered to pulpmills.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 164 November 1961

A STUDY OF LOSSES IN THE 1960 SLASH PINE CONE CROP

Foresters know that the mature pine cone crop of a forest stand commonly represents a small proportion of the initial flower crop, but they are usually unfamiliar with the various factors that cause this reduction during the 18-month period between flower pollination and cone maturation. Information is often published on the percentage of cones surviving, based on a simple ratio of the total number of mature cones to the total original flower crop. Although these data are useful, they do not tell when the losses occurred or the factors involved.

Periodic observations on flower, seed, and cone losses in slash pine, *Pinus elliottii* Engelm., by all known causes were made during a field study of chemical control at Olustee, Florida, in 1959 and 1960. Twenty branches were tagged on each of seven unsprayed check trees on February 26, 1959. At that time, the 140 tagged branches had a total of 332 female flowers. A series of observations were made over a 2-year period and damage and losses to first- and second-year cones were recorded.

The number of sound cones and those damaged, killed, or lost between the post-flowering period and cone maturation are shown in table 1, together with the effects of various causal agents on seed production. The estimates of seed

Table 1.--Losses and damage to 1960-crop slash pine flowers, cones, and seeds during the period from February 29, 1959, to September 13, 1960, at Olustee, Florida

Types of damage or loss	First- and second-year cones 1/	Ratio: cones to total flowers	Average seed loss per cone	Ratio: lost seed to total seed 2/	Ratio: sound seed to total seed 2/
	Number	Percent			
Sound (undamaged)	42	13	0	0	13
Thrips-killed	18	5	100	5	0
Cone rust	27	8	100	8	0
Dioryctria sp.	95	29	3/ 84	24	4
Laspeyresia anaranjada	102	31	4/ 9	3	29
Missing	18	5	100	5	0
Killed-unknown causes	30	9	100	9	0
Totals	332	100		54	46

1/ Based on 332 flowers located on 20 branches of each of seven trees.

2/ Estimated total potential yield of 39,176 full seeds in 332 cones, based on average of 118 sound seed per cone.

3/ Based on 100-percent seed loss in 65 first-year cones and 50-percent seed loss in 30 second-year cones.

4/ Based on average of 11 seed destroyed per cone.

losses are based on the average number of sound seed found in 30 randomly sampled sound cones from the check trees. The average number of full seed per cone was 118, with a sampling error of 9 percent.

DISCUSSION

Even though the cone and seed losses shown in table 1 represent a single example, they give the reader some idea of the relative importance of various destructive agents. Compared with other observations of insect and disease losses of slash pine cones at Olustee, Florida, during the past 4 years, the losses shown would be considered moderate, yet the actual yield of sound seed was only 46 percent of the estimated potential total yield.

As high as 20-percent mortality of female slash pine flowers, killed by *Gnophothrips piniphilus* Cwfd.,[1] has been observed on individual trees. Infection of female flowers by *Cronartium strobilinum* (Arth.) Hedgc. and Hahn is also quite variable from year to year, but in certain localities losses may approach 100 percent.

One of the most significant data in table 1 is the difference between the loss of seed caused by the *Dioryctria* spp. coneworms and the seedworm, *Laspeyresia anaranjada* Miller. The number of cones infested by *Dioryctria* spp. and the seedworm were about the same, but it was estimated that the coneworms caused the loss of nine times as many seeds as the seedworm, or nearly one-fourth of the total potential seed yield.

A fairly high number, i.e., 9 percent, of the cones were killed by unknown causes, mostly during the first year of development. It is known that some of the cones listed as missing were broken off by wind and perching birds when the young conelets and shoots were succulent. Squirrel losses were eliminated by the use of wide aluminum bands around the tree stems.

Seed orchards of slash and other pines are being established throughout the South and some are just beginning to bear sizeable cone crops. Foresters charged with the protection and maintenance of such plantations may find these seed-loss data useful in tentatively estimating future seed yields.

1/ Ebel, B. H. Thrips injure slash pine flowers. Jour. Forestry 59: 374-375. 1961.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

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EXPLORATORY STUDIES ON CHEMICAL CONTROL OF UNWANTED HARDWOODS IN THE SOUTHERN APPALACHIANS

Red maple, sourwood, hickory, rhododendron, and laurel are "problem" species in the Southern Appalachian mountains. The first three are often unwanted because of overabundance, poor quality, and lack of a local market; rhododendron and laurel because they occupy approximately three million acres of land in the Southern Appalachians.[1] Although rhododendron and laurel are shrubs prized for their aesthetic values and should be protected where these values are high, they have no tangible value except where they provide watershed protection. All too often they hamper regeneration of desired species.

Exploratory studies on chemical control of the five species were installed on the Bent Creek Experimental Forest in 1958. Chemicals used were 2, 4, 5-T, sodium arsenite, and 2 soil sterilants, Fenuron and Trysben. This note reports the 3-year results.

2, 4, 5-T

Ten stems each of rhododendron, laurel, red maple, hickory, and sourwood--all less than 8 inches d.b.h.--were treated with a 44 pound ahg.[2] solution of 2, 4, 5-T in fuel oil in February 1958. In addition, five large hickory trees 12 to 16 inches in diameter were treated. Application was made with a tree injector, and incisions were spaced approximately one inch apart. Stem kill and sprouting results are listed below:

Species	Number stems totally killed	Average number sprouts
Rhododendron	2	0
Laurel	5	0
Red maple	8	1.2
Hickory (small)	7	0
Hickory (large)	0	0
Sourwood	7	0.5

Absence of sprouts on rhododendron, laurel, and large hickories is not meaningful because of poor top kill.

1/ Wahlenberg, W.G. From brush to pine; how to convert rhododendron brush areas to stands of white pine timber. South. Lumberman 180(2261): 40-41, illus. 1950.

2/ Acid equivalent per hundred gallons.

Complete sprout control on rhododendron stumps was obtained by spraying them with 2, 4, 5-T in fuel oil. Concentrations used were 8, 16, and 32 pounds ahg.; ten stumps were treated with each concentration. The stumps and root crowns were thoroughly wetted. One test was made during the dormant season and one during the growing season. None of the treated stumps sprouted, while untreated stumps sprouted profusely. One important advantage for this chemical is its nontoxicity to man and animals.

Sodium Arsenite

Rhododendron, laurel, and sourwood were top-killed by sodium arsenite applied with a tree injector at a concentration of 6 pounds of chemical per gallon of solution. Incisions were spaced approximately one inch apart. Ten stems of each species were treated in February 1958. Stem kill and sprouting results were as follows:

Species	Number stems totally killed	Average number sprouts
Rhododendron	10	7.8
Laurel	8	4.8
Sourwood	10	3.6

Four different concentrations of sodium arsenite--6, 3, 1-1/2, and 3/4 pound per gallon of solution--were tested on laurel, rhododendron, and red maple in early May 1958. Ten stems of each species were treated with each concentration. Application was made with an injector. Stem kill was good, but sprouting was heavy on all three species at all concentrations. The most serious disadvantage is the high toxicity to man and animals.

Fenuron and Trysben

Two pelletized chemicals, Fenuron and Trysben, designed to control hardwoods by broadcast application on the ground, were tested on laurel and rhododendron. Application rates as high as 100 pounds of material per acre were used. No damage occurred to either species at any application rate tested.

Economic removal of unwanted trees and shrubs is one of the most serious problems associated with species conversion and stand reproduction. One widely used tool--the tree injector--has proved to be an effective and efficient tool for the control of many single-stemmed species, but it is prohibitively slow on multi-stemmed clumps of laurel and rhododendron. An economic treatment that will top-kill these two species is needed. The treatment need not necessarily control sprouting. The sprouts grow slowly and would not be a serious deterrent to either natural or artificial regeneration of the desirable pine or hardwood species.

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RESEARCH NOTES

SOUTHEASTERN FOREST EXPERIMENT STATION

Asheville, North Carolina

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EPICORMIC BRANCHING ON SYCAMORE

Sycamore stands in the Piedmont are generally unmanaged and little is known of their response to cutting. A recently completed exploratory thinning indicates that degrade from epicormic branching may be related to the residual density after thinning.

The study consisted of 6 unreplicated 1/5-acre plots with 1/2-chain isolation strips located in a 35-year-old sycamore stand on a good bottomland site along the Oconee River in Greene County, Georgia. Sycamore was the dominant species; the associated species were green ash, cottonwood, river birch, boxelder, and other typical bottomland species. Sycamore was favored as the leave species in the cutting, but poorly formed trees and trees of low vigor of all species were removed. Five plots were cut to basal areas of 118, 101, 80, 58, and 33 square feet per acre, and the sixth plot, with 154 square feet, was left uncut. Five trees bracketing the range of diameter and crown classes on each plot were examined for epicormic branches before the cut and during the following 5 years.

Before the cutting, most sycamores were free of epicormic branches for the first 25 feet. After the thinning, epicormic branching was serious only at basal areas of 80 square feet and less, as shown in the following tabulation:

Initial basal area per acre (Square feet)	Residual basal area per acre (Square feet)	Epicormic branches per tree (Number)
137	33	15
133	58	14
129	80	4
202	101	2
142	118	0
154	154	0

While this study was unreplicated and only exploratory in design, it does indicate that dense stands of sycamore can be uniformly thinned to residual densities as low as 80 square feet of basal area per acre without appreciable epicormic branching.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 167 November 1961

LESS GROWTH AND NO INCREASED FLOWERING FROM CHANGING SLASH PINE BRANCH ANGLE[1]

Analysis of data collected in a recent experiment yielded some interesting sidelights. During the spring of 1960, a study of the effect of changing the angle of branches on the stimulation of male and female strobili in young grafted slash pines was begun in the Georgia Forestry Commission's Horseshoe Bend Seed Orchard in Wheeler County. The trees, established by grafting "plus" scions onto potted root stock plants in February 1955, were outplanted in December 1955. The study was conducted during their fifth growing season in the field.

Four treatments, as suggested by Longman and Wareing,[2] were applied to eight clones, replicated three times. Each replication contained four trees. The treatments were applied to branches in whorls in the upper and lower crowns of 96 trees as follows:

Treatment	
I (control)	No treatment. These upturned branches averaged about 65° in their natural positions.
II (90°)	All branches of the two selected whorls were tied down and fixed in a 90° (horizontal) position.
III (120°)	All branches of the two selected whorls were tied down and fixed in a 120° (downward) position.
IV	Each branch of the two selected whorls was fixed in one of the three positions described in Treatments I, II, and III; thus, all treatments were represented in each whorl.

Trees showed no positive response to flowering during the first year of treatment. In the year prior to treatment the clones produced a total of 44 female and no male strobili; after treatment they produced 46 female and 16 male strobili. Although results were meager insofar as effect on strobili production was concerned, a routine analysis of supplementary quantitative information showed distinct differences in amounts of branch elongation in response to different treatments.

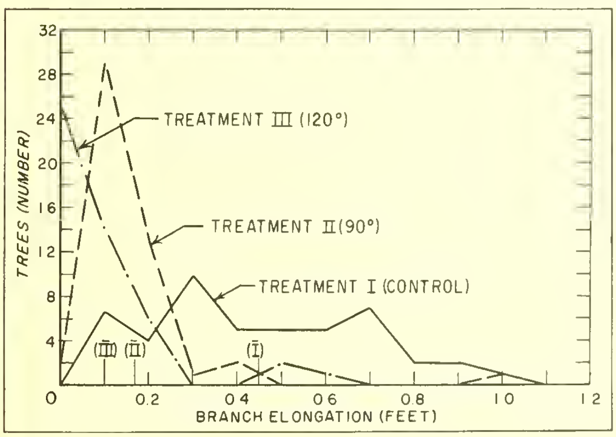

Figure 1a.--Distributions and mean values of branch elongation as influenced by Treatments I (control), II (90°), and III (120°).

Measurements of branch elongation were taken at the beginning of the study (spring, 1960) and again at the conclusion of the study (spring, 1961) as a check of vigor. Pre-treatment measurements recorded shoot-elongation which occurred between the beginning of the 1960 growing season and the start of the study. The post-treatment measurements recorded the amounts of shoot-elongation which occurred during the period of study. Amounts of branch elongation were similar for all clones, and were pooled by treatment for table 1.

These data show that branches in upper and lower whorls elongated 1.24 feet and 0.95 foot, respectively, prior to treatment. After treatment, however, there were marked differences according to treatment and location of the branches in the crowns of the trees.

The data show that both treatment and crown position influenced growth of branches. Also, elongation of branches was controlled by the treatments applied to limbs within the whorls, in that as the angle became larger, elongation decreased, and branches in the upper whorls elongated more than did branches in lower whorls. Clones and

1/ This study was in cooperation with the Georgia Forestry Commission and the Georgia Forest Research Council.

2/ Longman, K. A., and Wareing, P. F. Effect of gravity on flowering and shoot growth in Japanese larch (Larix leptolepis, Murray). Nature 182: 380-381. 1958.

replications showed no differences and therefore were not influencing factors in the growth pattern. No effect on branch elongation was attributable to any other combination of factors.

Mean values for branch elongation in horizontal and downward treatments were less than 50 percent of the means obtained in the control treatment. Although there was some variation in the range of amounts of elongation, very similar mean values were obtained between Treatments I, II, and III, and corresponding subtreatments within Treatment IV (figures 1a and 1b). Branch elongation measurements in Treatment IV strongly indicated that the processes which inhibit branch elongation are contained within the branch and not translocated within the tree. These data re-emphasize that branch elongation is greatly influenced by the degree of down sweep of the branch.

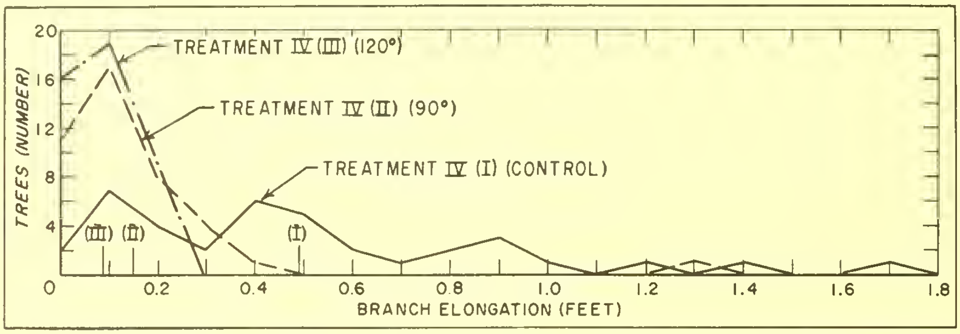

Figure 1b.--Distributions and mean values of branch elongation as influenced by subtreatments (I), (II), and (III) within Treatment IV.

Table 1.--Branch elongation of slash pine trees resulting from changing branch angle

Treatment	Whorl	Branches	Branch elongation	
			Prior to treatment	During treatment
		Number	- - - - - Feet - - - - -	
Control	Upper	57	1.21	0.56
	Lower	71	0.95	0.34
	Total	128	--	--
	Average	--	1.07	0.45
90°	Upper	59	1.24	0.21
	Lower	72	1.00	0.13
	Total	131	--	--
	Average	--	1.11	0.17
120°	Upper	65	1.22	0.13
	Lower	73	0.92	0.07
	Total	138	--	--
	Average	--	1.05	0.10
Mixed whorls (control)	Upper	17	1.31	0.71
	Lower	27	0.89	0.36
	Total	44	--	--
	Average	--	1.06	0.49
90°	Upper	23	1.18	0.22
	Lower	24	1.02	0.08
	Total	47	--	--
	Average	--	1.10	0.15
120°	Upper	23	1.26	0.10
	Lower	24	0.92	0.08
	Total	47	--	--
	Average	--	1.09	0.09
Grand total	Upper	244	--	--
Grand average	Upper	--	1.24	--
Grand total	Lower	291	--	--
Grand average	Lower	--	0.95	--

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 168 November 1961

AIR TEMPERATURE AND GUM YIELD

Many factors affect gum yields from slash and longleaf pines, but air temperature, soil temperature, and evaporation of moisture in the air account for about 90 percent of the variation in yields over a given period.1/ Air temperatures have the greatest effect, and yields increase as the temperature rises.

Weather conditions have an important influence on the best time to start and stop chipping, when to apply makeup streaks, and when to add a few streaks for increased production. Gum will not flow when the weather is cold. For an early- or late-season streak to produce a profitable quantity of gum, the temperature for the 2-week period should average 60° F. or higher. Since weather conditions vary by regions in the naval stores belt, the most effective time to start and stop chipping will vary correspondingly for the many operations ranging from South Carolina to southwestern Louisiana.

A recently completed 3-year study of gum flow and temperature influences in Stone County, Mississippi, indicated that the producing season in southern Mississippi begins around April 1, when the first streak is applied, and normally ends 7 months later (fig. 1). Chipping must be done with consistent biweekly regularity to get a complement of 16 productive streaks for the normal producing season.

It is an accepted belief of producers that longleaf pines yield their greatest volume during the early months of the season. In this study with Mississippi longleaf, the first 4 months of the 7-month season did not yield quite 50 percent of the total annual volume.

Period of Peak Gum Flow

Sometime during each producing season, high daily air temperatures and suitable amounts of rainfall combine to create optimum conditions for rapid gum flow. This period will vary for species and different regions of the belt, but usually lasts from 6 to 8 weeks. In this study, July and August proved to be the period of greatest gum flow for the Mississippi longleaf pine, and 30 percent of the total annual yield was produced during this 8-week period.

For profitable gum production, it is important that gum producers in each region of the belt recognize and take advantage of this period of peak gum flow. If gum yields have been low because of abnormally cold weather

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1/ Harper, V. L., and Wyman, L. Variations in naval stores yields associated with weather. U. S. Dept. Agr. Tech. Bul. 510. 1936.

during April and May, yields can be substantially increased by weekly or 10-day chipping and treating during this period, and if streaks have been missed during the early part of the season, this is the ideal time to apply makeup streaks.

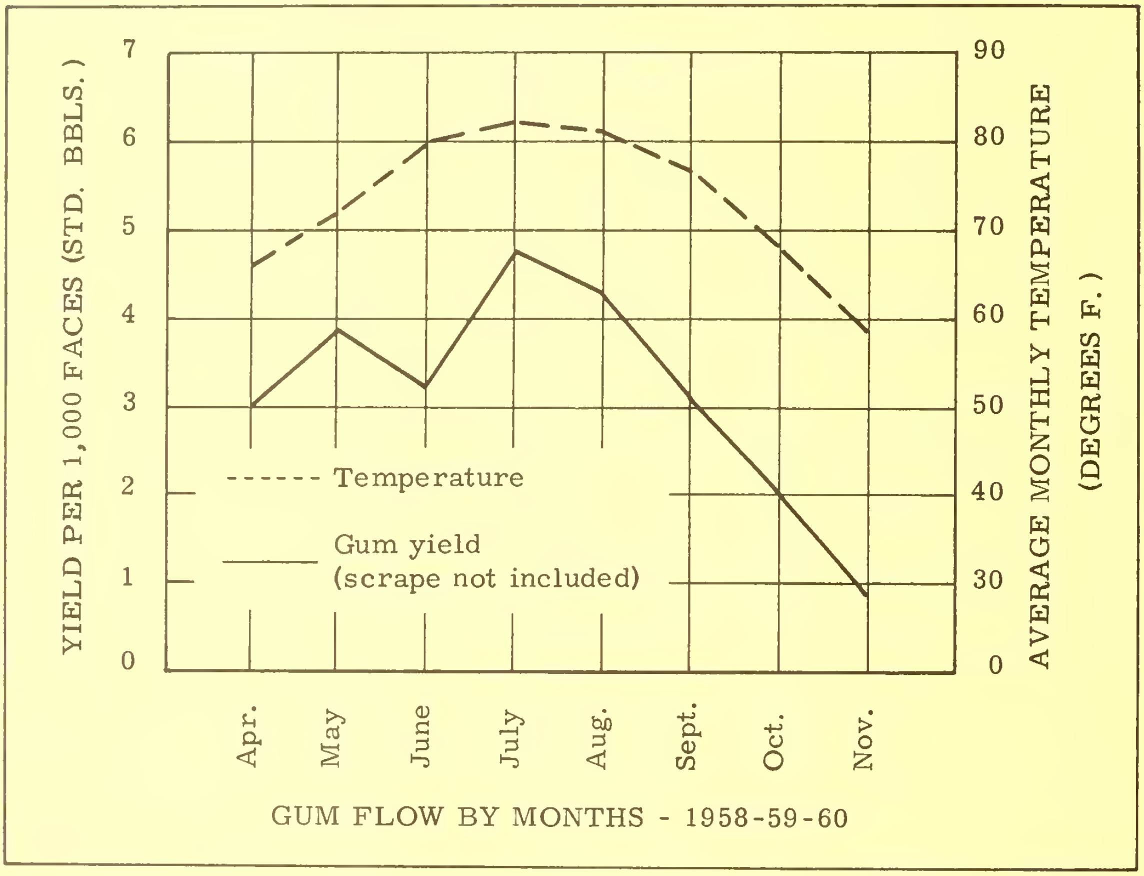

Figure 1. --Average monthly yield trend and air temperatures for 3 years of gum production in Mississippi longleaf pine.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 169 November 1961

WIDE SPACING OF SLASH PINE PRODUCES EARLY GUM AND SAWTIMBER YIELDS

After two pulpwood thinnings and two naval stores cycles, the 26-year-old Stephens slash pine plantation, owned by Holt Walton and located near Cordele, Georgia, carries 10,356 board feet of sawtimber and 7.82 cords of pulpwood on the average acre. Production of this plantation was previously reported at age 18.[1] The 127-acre tract, an abandoned field, was hand-planted in 1935 with native stock taken from nearby intermittent stream bottoms. The spacing at planting was 15 x 15 feet.

The plantation has maintained excellent growth through 26 years (table 1). These data are per-acre averages and are based on the sampling of four 1-acre permanent plots. Not included here are trees less than 4.6 inches d. b. h. representing only 0.3 square foot of basal area per acre.

Table 1. --Stand and volume data per acre at different ages for the Stephens slash pine plantation

Age (years)	Operation	Trees 1/		Average d. b. h.	Basal area	Volume 2/		
		Total	Classed as sawtimber			Saw-timber	Pulp-wood 3/	All trees as pulpwood
		Number	Percent	Inches	Square feet	Board feet	Cords	Cords
13	Inventory	192	29.6	8.5	79.3	1,912	15.6	22.7
18	Inventory	194	71.1	9.8	103.2	6,656	11.2	31.3
19	Thinning	29	80.1	10.4	16.9	4/ 1,275	1.9	6.1
	Residual inventory	165	70.9	9.9	89.0	6,329	9.5	27.4
26	Thinning	42	12.0	8.9	18.5	4/ 394	4.4	5.5
	Residual inventory	118	91.9	11.6	86.5	10,356	7.8	27.5

1/ Nonmerchantable stems (below 4.6 inches d. b. h.) not included.
2/ International $\frac{1}{4}$-inch rule and standard cords.
3/ Including topwood.
4/ Removed as pulpwood.

1/ Hawley, Norman R. Rapid growth of planted slash pine in the middle coastal plain of Georgia. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Notes 32, 1 p. 1953.

Adding the residual volume at 26 years and the volumes cut in thinnings, the plantation has produced 12,025 board feet plus 14.1 cords during its 26 years. Expressing the whole volume as cords, it equals 39.1 cords or a growth of 1.5 cord per acre per year. Board-foot growth has averaged 462 feet per acre annually during the 26 years. For the past eight years the average has been 671 feet. The site index varies over the area but averages about 73 feet (25-year basis).

In addition to the pulpwood cuts, two naval stores cycles have been completed. These operations started at ages 13 and 20, and ran for 6 and 5 years, respectively. A third cycle is now in its first year. No accurate record of gum production has been kept, but based on locally developed yield data,[2/] total gum production for the two cycles is estimated to have been about 8.5 barrels per acre. There have been about 29 faces per acre for each cycle.

For the cuts at ages 19 and 26 years, 16.0 and 17.6 percent of the basal area was removed, respectively. In both cases, the basal area per acre prior to cutting was about 105 square feet. The first thinning was essentially an improvement cut; the second a thinning from below. As a result, most of the residual stand is now sawtimber.

This plantation, with its excellent production of multiple products at an early age, demonstrates the feasibility and profitability of "timber farming" in the middle coastal plain area. The total value of timber and gum products, including the residual stand, is about $485 per acre or an annual gross return per acre of almost $19. (Costs of labor and materials were deducted from gross gum returns, thereby putting this revenue on a comparable basis with stumpage.) This has been accomplished against the usual threats of fire, disease, and insect attacks, none of which has caused serious damage to date. With the discovery of annosus root rot in the plantation 2 years ago, however, it will be interesting to watch future developments in the Stephens Plantation.

2/ Jones, Earle P., Jr. Gum yields of planted slash pine. AT-FA Journal 23(7): 9-10. 1961.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
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Number 170 February 1962

CUBIC-FOOT VOLUME TABLES FOR SHORTLEAF PINE IN THE VIRGINIA-CAROLINA PIEDMONT[1]

Available volume tables for shortleaf pine are based on merchantable height and do not show volumes to the small top diameter limits now used in many areas. Volume tables based on total height are also often preferred because they eliminate the error associated with ocular estimates of merchantable height. The table presented here for natural shortleaf pine is based on total tree height and gives volume estimates for the commonly used 4- and 3-inch d.i.b. tops (table 1).

Volume estimates in table 1 are based on measurement of 302 trees from numerous locations throughout the Piedmont region of Virginia, North Carolina, and South Carolina. The data were analyzed by regression techniques and each state was analyzed separately. Tests of significance on the equations from these separate analyses showed that the three states' data were compatible with one another, and the data from all three were then combined into a single equation.

From the combined data, the following two regression equations were derived to express the cubic-foot volume estimates for either the 4- or 3-inch top d.i.b. in the study area:

$$\text{Cubic-foot volume (4-inch top d.i.b.)} = -.337655 + .002835\ D^2H$$

$$\text{Cubic-foot volume (3-inch top d.i.b.)} = -.127248 + .002837\ D^2H$$

where D is the diameter at breast height and H is total height. Both equations account for about 98 percent of the total variation in the volume per tree.

Slight curvilinearity at the lower end of the estimating curve (D^2H values smaller than 650) made it desirable to fit a curve graphically to that portion of the data. All volume estimates less than 7 cubic feet were slightly affected by this curvilinearity. Volumes in table 1 less than 7 cubic feet were read from this graphically fitted curve rather than computed directly from the regression equations.

1/ Tree measurements for South Carolina were supplied by N. B. Goebel, Forestry Department, Clemson College, Clemson, South Carolina.

Table 1.--Cubic-foot volumes (outside bark) for natural shortleaf pine

D. b. h. (inches)	Total tree height (feet)														
	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
	Cubic feet														
TOP DIAMETER 4.0 INCHES INSIDE BARK															
5	.41	.74	1.15	1.62	2.05	2.47	2.88	3.31	3.73						
6	1.28	1.87	2.47	3.12	3.67	4.33	4.90	5.56	6.20	6.73					
7	2.40	3.21	4.05	4.90	5.76	6.51	7.30	8.00	8.69	9.39					
8		4.80	5.88	6.85	7.83	8.73	9.64	10.55	11.46	12.36	13.27				
9		6.45	7.70	8.85	10.00	11.14	12.29	13.44	14.59	15.74	16.88	18.03	19.18		
10			9.58	11.00	12.42	13.84	15.26	16.67	18.09	19.51	20.93	22.34	23.76	25.18	26.59
11			11.67	13.38	15.10	16.81	18.53	20.24	21.96	23.68	25.39	27.10	28.82	30.54	32.25
12					18.03	20.07	22.12	24.16	26.20	28.24	30.28	32.32	34.36	36.40	38.44
13						23.62	26.01	28.41	30.80	33.20	35.60	37.99	40.39	42.78	45.18
14						27.44	30.22	33.00	35.78	38.56	41.34	44.12	46.89	49.67	52.45
15						31.56	34.74	37.94	41.12	44.31	47.50	50.69	53.88	57.07	60.26
16						35.95	39.58	43.21	46.84	50.47	54.09	57.72	61.35	64.98	68.61
17							44.72	48.82	52.92	57.01	61.11	65.21	69.30	73.40	77.50
18								54.78	59.37	63.96	68.55	73.15	77.74	82.33	86.92
19								61.07	66.19	71.30	76.42	81.54	86.65	91.77	96.89
20									73.37	79.04	84.71	90.38	96.05	101.72	107.39
21											93.43	99.68	105.93	112.18	118.44
22												109.43	116.29	123.16	130.02
23													127.14	134.64	142.14
24													138.46	146.63	154.79
TOP DIAMETER 3.0 INCHES INSIDE BARK															
5	1.15	1.57	1.92	2.32	2.70	3.05	3.42	3.80	4.18						
6	2.00	2.55	3.07	3.68	4.17	4.72	5.25	5.79	6.35	7.02					
7	3.00	3.75	4.45	5.18	5.95	6.69	7.52	8.21	8.91	9.60					
8		5.10	6.01	7.14	8.04	8.95	9.86	10.77	11.68	12.58	13.49				
9		6.60	7.92	9.06	10.21	11.36	12.51	13.66	14.81	15.96	17.11	18.26	19.40		
10			9.80	11.22	12.64	14.06	15.48	16.90	18.31	19.73	21.15	22.57	23.99	25.41	26.82
11			11.89	13.60	15.32	17.04	18.75	20.47	22.19	23.90	25.62	27.34	29.05	30.77	32.48
12					18.26	20.30	22.34	24.38	26.43	28.47	30.51	32.56	34.60	36.64	38.68
13						23.84	26.24	28.64	31.04	33.43	35.83	38.23	40.63	43.02	45.42
14						27.68	30.46	33.24	36.02	38.80	41.58	44.36	47.14	49.92	52.70
15						31.79	34.98	38.17	41.36	44.56	47.75	50.94	54.13	57.32	60.51
16						36.19	39.81	43.45	47.08	50.71	54.34	57.98	61.61	65.24	68.87
17							44.97	49.07	53.17	57.26	61.36	65.46	69.56	73.66	77.76
18								55.02	59.62	64.22	68.81	73.41	78.00	82.60	87.20
19								61.32	66.44	71.56	76.68	81.80	86.93	92.05	97.17
20									73.64	79.31	84.98	90.66	96.33	102.00	107.68
21											93.71	99.96	106.22	112.47	118.73
22												109.72	116.59	123.45	130.32
23													127.44	134.94	142.45
24													138.77	146.94	155.11

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 171 February 1962

TREE AND SHRUB RESPONSE TO RECREATION USE

Forty-two developed camping and picnicking sites on the Cherokee, Nantahala, and Pisgah National Forests were studied to determine area response to recreation use. An important phase of this study involved the measurement of the effects of such use on native vegetation.

Areas selected were 10 or more years old and contained from 1 to 21 family units per site. Unit samples were taken in 280 family units with picnic tables serving as centers for plots with $\frac{1}{2}$-chain radius. All trees and shrubs in these plots were tallied by species, dominance, and diameter. Degrees of insect infestation, disease infection, and decline, except in conifers, were noted for individual trees and shrubs. Insect and disease problems were appraised on a scale from 1 to 3 (none to high); decline was scored on a scale from 1 to 8 (none to death). Only trees and shrubs that occurred 10 or more times in the sample were included in this report.

Data indicated little or no differences in damage, or in insect and disease problems related to size or dominance of the vegetation. Differences between species, however, were consistently large. The following conifers and hardwoods are listed in order of decreasing ability to withstand the impacts of recreation use, as gaged by disease infection, insect infestation, and decline.

Species Ranking

Hardwoods		Conifers
1. Hickories	12. Red maple	1. Shortleaf pine
2. Persimmon	13. American holly	2. Hemlocks
3. Sycamore	14. Sourwood	3. White pine
4. White ash	15. Black birch	4. Pitch pine
5. Beech	16. White oaks	5. Virginia pine
6. Sassafras	17. Black walnut	
7. Buckeye	18. Red oaks	
8. Yellow-poplar	19. Black locust	
9. Dogwood	20. Magnolia	
10. Blackgum	21. Black cherry	
11. Yellow birch	22. Blue beech	

Not reflected in the listing are important group differences between conifers and hardwoods. Conifers were clearly more susceptible to disease and insect attack than were hardwoods--with the possible exception of shortleaf pine and hemlock. Apart from the disease and insect problems, the dense shade produced by conifers apparently induced greater site degradation. White pine had serious disease problems (Fomes annosus) that greatly limit its usefulness in recreation areas. Among the hardwoods only sassafras appears unrealistically ranked. A short-lived species, this tree rarely reaches a position of dominance or codominance and frequently succumbs quickly, and is a poor risk in wooded recreation areas.

Though not shown, three shrubs in the Heath family (Ericaceae)--rhododendron, mountain laurel, and azalea (deciduous)--were important understory components. All three apparently are quite resistant to disease and insects with azalea the most, and mountain laurel the least tolerant to heavy recreation use.

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Project Leader

RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 172 March 1962

DEER BROWSE PLANTS IN LOBLOLLY AND WATER OAK-GUM TYPES OF PIEDMONT GEORGIA

A major problem of forest-game management is in assessing the relative value of major forest types and stand conditions in terms of forage yield and potential. Recent trial sampling in the Georgia Coastal Plain in connection with the Forest Survey has indicated that composition and occurrence of the woody understory component are related to overstory vegetation and that deer browse may be inventoried rapidly, easily, and simultaneously with timber resource inventories.[1] Reported here are the results of further trials in three Georgia Piedmont counties involving two major forest types.

Methods used for the first time in the Georgia Forest Survey provide an excellent means for sampling understory characteristics. In the Forest Survey, timber volumes and other stand characteristics are determined by a variable plot cruise method, and certain understory and regeneration characteristics are determined by using 20 points systematically arranged around randomly located plot centers. Deer browse data were collected at all 20 points surrounding every fifth plot in Jasper, Lamar, and Talbot Counties. Unit samples at each sampling point were taken using a cylindrical plot delineated by projecting a circular milacre surrounding each point upward 4.5 feet. The species occurring in the milacre and producing the greatest quantity of annual growth was considered dominant. This "dominant" species was recorded for each point and summarized for the plot (20 points). Data were analyzed to study differences between and within forest types by sorting observations into deer browse preference classes based on observed browse usage in the Southeast:

1. Preferred--Delicacies or "candy" species. The first species consumed by deer.
2. Staple--Foundation or "bread and butter" species. Constitute the bulk of deer diet on optimum occupied range. High in nutritive value. Provide for normal animal weight gain and reproduction.
3. Emergency--Life-sustaining species. May provide a large part of deer diet on overstocked range. Low in nutritive value and produces little or no animal weight gain. Animal reproduction usually low.
4. Stuffing--Starvation species. Little or no food value. Animals continually lose weight. Animal reproduction very low.

1/ Moore, W. H., Ripley, T. H., and Clutter, J. L. Trials to determine relative deer range carrying capacity values in connection with the Georgia Forest Survey. Southeast. Assoc. Game & Fish Comn. Proc. 1960.

Table 1 compares the frequency distribution of browse preference classes for the loblolly pine and water oak-gum types.

Table 1.--Frequency distribution of browse preference classes by forest type

Forest type	Preferred	Staple	Emergency	Stuffing	Unclassified vegetation	Total sampling points
	- - - - - -	- - - -	Percent	- - - -	- - - - - -	Number
Loblolly pine	37.7	19.2	20.4	16.4	6.3	318
Water oak-gum	54.6	10.8	18.0	5.8	10.8	139

Chi-square analysis indicated that differences in the browse preference class distribution observed between forest types were highly significant. Chi-square analysis also indicated that within-type differences existed. These data, however, were too meager to warrant inclusion.

Collectively, preferred and staple species represented 57 percent of all sampled browse in the loblolly pine type and 65 percent in the water oak-gum type. In the water oak-gum type, however, preferred foods made up a considerably higher percentage of the total than in the loblolly type (55 and 38 percent).

In table 2, it may be seen that only three species--Japanese honeysuckle, sweetgum, and greenbrier--dominated 10 percent or more of the points in either forest type. The high frequency of Japanese honeysuckle and greenbrier, both excellent deer foods, accounts for the high percentage of preferred species in both types shown in table 1.

Table 2.--Frequency distribution of the more abundant browse species in the two major forest types

Species	Browse preference class	Loblolly pine (n = 318) 1/	Water oak-gum (n = 139) 1/
		Percent	Percent
Japanese honeysuckle (*Lonicera japonica* Thunb.)	Preferred	26.7	49.6
Greenbrier (*Smilax* spp.)	Preferred	11.0	5.0
Sweetgum (*Liquidambar styraciflua* L.)	Emergency	10.7	3.6
Blackberry (*Rubus* spp.)	Staple	5.0	5.0
Cane (*Arundinaria* spp.)	Emergency	0.0	9.4
Grape (*Vitis* spp.)	Staple	5.0	1.4

1/ n = total points sampled.

The findings show that the species composition of understory vegetation is clearly related to forest type. Although the sampling techniques used here do not provide actual weight estimates of browse, they do afford qualitative data that may be useful to foresters and game managers in determining the forest types most desirable for deer browse production.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 173 March 1962

A COMPARISON OF ELM SPANWORM OVIPOSITION HABITS IN 1960 AND 1961

To increase the accuracy of forest insect surveys, attention must be given to many details in the ecology of the insect and host. The true value of data collected for a single year may not be known until similar collections are made in succeeding years to corroborate or invalidate the earlier findings.

Recent investigations associated with elm spanworm, Ennomos subsignarius (Hbn.), egg mass sampling have yielded useful information on certain facets of survey techniques.[1]

The spanworm is a polyphagous forest insect, essentially rejecting only yellow-poplar, Liriodendron tulipifera L., and sassafras, Sassafras albidum (Nutt.) Nees, among the hardwoods of the Southern Appalachian Mountains. It oviposits on the underside of branches. Two questions, therefore, emerge from these habits: which host should be sampled in order to ascertain egg mass population levels, and where on the host is the best location for sampling?

If one were to visit the outbreak area, it would appear that the hickories are the choice host for egg sampling; commonly this species is completely devoid of foliage in areas where the red oaks and white oaks have lost little foliage. However, such is not the case. Analysis of data collected in 1960 and 1961 shows that the chances of finding spanworm eggs are significantly greater by sampling the white oaks (group) or red oaks (group), rather than the hickories (table 1).

Curiously, doubling the sample size in 1961 doubled the number of masses on both red and white oaks, but the egg population remained static on hickory. Whether this is a sampling artifact or a biological phenomenon remains an enigma at present.

The spanworm shows a decided preference for oviposition on branches 0.5-inch (± 0.1) in diameter.[1] Three-fifths of the masses can be found here, and roughly a fifth can be found above, and another fifth below, this zone.

A convenient sample unit used in surveys is the 5-foot branch after the branchlets and current year's growth have been removed. By comparing egg deposition in 1960 and 1961, a similarity in foot-section preference becomes evident (table 2). The only notable difference during those years is the direct switch that occurred on the third and fourth feet. Apparently no preference is shown for either of these sections. The data provide a clear picture showing over one-half the egg sample can be found on the third- and fourth-foot sections.

1/ Drooz, A. T., and Solomon, J. D. Elm spanworm egg mass studies. Jour. Econ. Ent. 54: 1060-1061, illus. 1961.

U. S. Department of Agriculture - Forest Service

Table 1.--Two-year comparison of oviposition host preference by the elm spanworm. (The data are from 59 survey plots in Georgia, North Carolina, and Tennessee.)

Host	Egg masses		Mean masses per plot		Standard deviation per plot		Treatment	"t"	
	1960 1/	1961 2/	1960	1961	1960	1961		1960	1961
	Number								
Red oaks	386	625	6.5	10.6	± 10.34	± 18.13	Red oaks versus white oaks	0.425	0.107
White oaks	365	616	6.2	10.4	± 8.82	± 18.74	White oaks versus hickories	2.278*	3.170**
Hickories	237	252	4.0	4.3	± 5.36	± 9.81	Red oaks versus hickories	2.401*	3.894**

1/ Based on a sample consisting of two 5-foot branches from the lower crown of each of two red oaks, two white oaks, and two hickories.
2/ The number of branches sampled from each species was double that of 1960.
* Significant at the 5 percent level for 58 degrees of freedom where "t" = 2.000.
** Significant at the 1 percent level for 58 degrees of freedom where "t" = 2.664.

Table 2.--The distribution of elm spanworm egg masses along a 5-foot branch sample

Location	Foot section				
	1	2	3	4	5
	Percent				
North Carolina and Tennessee					
1960 (654 masses)	7	17	24	28	24
1961 (1,025 masses)	8	17	32	23	20
Georgia					
1960 (741 masses)	5	20	24	32	19
1961 (823 masses)	7	20	28	25	20
All states					
1960 (1,395 masses)	6	18	24	30	22
1961 (1,848 masses)	7	18	30	24	20

At the present stage of survey development, a 5-foot branch sample is the best basic unit for defoliation predictions. It is possible that refinements will increase the prognostic accuracy; a smaller sample--3- or 4-foot--may be adequate.

These studies show the superior value of sampling elm spanworm egg masses on either red or white oaks (groups) in the Southern Appalachian Mountains. For the present, a 5-foot branch should remain the basic sampling unit.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 174 March 1962

INFLUENCE OF TIP MOTH LARVAE ON OLEORESIN CRYSTALLIZATION OF SOUTHERN PINES[1]

Two tip moths, the Nantucket pine tip moth, Rhyacionia frustrana (Comst.), and the pitch-pine tip moth, R. rigidana (Fern.), attack young pines throughout the southern part of the United States. Because these two insect species are found together in nature, and because of the difficulty in distinguishing the larvae, they will be referred to collectively in this paper as Rhyacionia. The injury they cause is inflicted by the larvae boring into the young buds and shoots. In some cases such attack kills back shoots five or more inches during a single generation.

Four principal species of pine grow in the southern United States: shortleaf pine, Pinus echinata Mill.; loblolly pine, P. taeda L.; longleaf pine, P. palustris Mill.; and slash pine, P. elliottii var. elliottii. Only shortleaf and loblolly are generally seriously injured by Rhyacionia. Longleaf pine is not injured and slash pine is considered quite resistant to attack. Wakeley[2] stated that the resistance from attack exhibited by slash and longleaf pine might be related to the free resin flow of these two species.

In making sample collections of infested shortleaf and loblolly pine, an exudation of oleoresin and fecal material was found on the outside of the lesions inflicted by the larvae. This resinous exudation was crystalline in appearance and texture and crumpled easily when pressed between the fingers. Slash and longleaf pine also produce a resinous and sticky exudation from larvae-inflicted lesions. In these latter species, however, the oleoresin does not form into a crusty deposit but remains viscous and sticky.

Two possibilities could explain this consistent difference in physical state of the oleoresin. One is that the oleoresin from loblolly and shortleaf pines normally becomes crystalline in a short period after exposure to the air. The other is that Rhyacionia larvae are able to bring about a rapid crystallization of the oleoresin of certain pines and are ineffective on others.

1/ This research was conducted in cooperation with the Georgia Forest Research Council and the Georgia Forestry Commission.

2/ Wakeley, P. A. Notes on the life cycle of the Nantucket tip moth Rhyacionia frustrana Comst. in southeastern Louisiana. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 45, 8 pp., illus. 1935.

Harris[3] found that mixing small quantities of regurgitated fluid from larvae of the European pine shoot moth, Rhyacionia buoliana (Schiff.), with pine oleoresin caused this mixture to emulsify readily and harden into crystals. This characteristic was not compared for different species of pine, but he concluded that it is possible that susceptibility of certain pines to shoot moth attack may be related to the ease with which oleoresin is emulsified.

To determine if Rhyacionia larvae have a similar effect on the oleoresins of southern pines, a series of twenty tips were cut from each of the four southern pine species just below the bud where larval feeding usually begins. A period of two hours was allowed for an accumulation of oleoresin on the ends of these branches. Nearly full grown, field-collected larvae were placed in the oleoresin on ten branch tips of each tree species. Care was taken to completely immerse the larvae in the oleoresin without injuring them. Each tip with a larva had a corresponding severed tip on the same tree without a larva, to serve as a check.

After a period of 24 hours all tips were checked. In every case the loblolly and shortleaf pines showed a definite crystallization of the oleoresin on the shoots where the larvae had been placed. The slash and longleaf pines exhibited no such crystallization of the oleoresin. Even after 4 days this difference in crystallization between the pine species continued. Although the relative rates of normal oleoresin crystallization between the four southern pines is more rapid in shortleaf and loblolly pines, it must be assumed that the larvae were responsible for the more rapid crystallization because all of the check tips on all species of pine remained resinous.

The phenomenon illustrated by this exploratory study has strong implications related to control of the tip moths in pines susceptible to attack. It may explain the relative resistance these pines sometimes exhibit and thus might be employed in studies to develop resistant strains. Crystallization, or lack of it, may be related to environmental conditions under which trees are growing, such as moisture, soil, fertility, etc., and thus be susceptible to cultural treatment as a form of tip moth control. These and other promising possibilities may be revealed by intensive research on this subject.

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[3] Harris, P. Production of pine resin and its effect on survival of Rhyacionia buoliana (Schiff.). (Lepidoptera: Olethreutidae). Canad. Jour. Zool. 38: 121-130, illus. 1960.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 175 March 1962

FERTILIZED YELLOW-POPLAR SEEDLINGS MAINTAIN GROWTH ADVANTAGE AFTER FOUR YEARS

An earlier report[1] described the first year response of yellow-poplar seedlings to fertilization with three rates (250, 500, and 1,000 pounds per acre) of diammonium phosphate (20-52-0).

Fourth-year height measurements (table 1) indicate that the fertilized seedlings are not only maintaining their growth advantage, but are actually showing increases in height advantage each year over unfertilized seedlings. Similarly, mean height differences among plots fertilized at different rates are seen to increase with age.

Table 1. --Mean total height of yellow-poplar

Year	Fertilizer applied in pounds per acre			
	None	250	500	1,000
	- - - - Height in feet - - - -			
Planted height	0.50	0.50	0.50	0.47
1958	1.01	1.35	2.07	2.41
1959	1.70	2.35	3.62	4.28
1960	2.78	3.90	5.93	7.00
1961	4.13	5.70	8.38	10.21

Analysis of current data yields results similar to those obtained from first-year data. That is, all fertilized trees grew to greater heights than the unfertilized; the two highest fertilization rates gave greater responses than the 250-pound rate, but no significant difference could be detected between the 500 and 1,000 pound treatment rates.

It is unknown at this time how long this trend will continue. The height data obtained thus far suggest that the initial fertilizer treatments are continuing to influence the growth of the trees, presumably in the form of recycled nutrients made available by the decay of tree leaves and weed vegetation on the plots. A covariance analysis of the data used to test this possibility proved inconclusive. Chemical analyses of the fourth-year foliage may shed more light on this question.

Other differences among treatments are becoming apparent. Crowns of trees fertilized at the 1,000-pound rate are closing, and producing enough shade to discourage the invasion of competing vegetation, whereas untreated

1/ McAlpine, R. G. Response of planted yellow-poplar to diammonium phosphate fertilizer. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Notes 132. 1959.

seedlings are crowded by volunteer seedlings of sweetgum and boxelder. Site quality for yellow-poplar has evidently been improved by fertilization, for without it the species is neither vigorous nor able to maintain an advantage over competing species.

An estimate of optimum rate of fertilizer application was calculated by expressing total height as a quadratic function of fertilizer applied. The value obtained, 1,200 pounds of diammonium phosphate per acre, must be considered a rough estimate because it falls outside the range of the fertilizer rates applied. Nevertheless, it should be helpful in planning future plantings of yellow-poplar on well-drained small stream bottoms of the Piedmont. No attempt was made to estimate the economic feasibility of fertilization on the basis of this study.

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in cooperation with

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Agriculture - Asheville

RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 176 June 1962

PRETREATMENT OF EASTERN WHITE PINE SEED[1/]

Screening tests conducted by the Eastern Tree Seed Laboratory at Macon, Georgia, showed that forest tree seeds responded in germination to treatment with several organic compounds. Of the compounds screened, citric acid evoked a special interest because of its direct role as a metabolite and possibly as a growth inhibitor extractor. In order to determine the role of citric acid, a parallel test was carried out with tartaric acid. This acid does not enter the citric acid cycle as a metabolite but is used in an ether extraction procedure for growth inhibitors. This note reports the response of eastern white pine seeds (Pinus strobus L.) to pretreatment with these two organic acids.

A single lot of white pine seed was obtained from the Eastern Tree Seed Laboratory and the following treatments were assigned:

1. Control--dry seed taken directly from storage.
2. Water--seeds soaked 24 hours at room temperature in distilled water.
3. Tartaric acid--seeds soaked 24 hours at room temperature in 100 ppm solution of tartaric acid.
4. Citric acid--seeds soaked 24 hours at room temperature in 100 ppm solution of citric acid.

After these treatments, the seeds were stratified in wet peat at 35° to 38° F. for 0, 30, and 60 days.

Figure 1 shows the percent of full seed germination response of white pine seeds to the various treatments. The very striking effect of stratification is shown for all treatments. Within each stratification level the time response and the total cumulative percent of germination vary with treatment.

The speed of germination of the acid-treated seeds is of interest. Without stratification, the acid treatments remained 1 to 2 weeks ahead of the control and 1 week ahead of the water treatment. At the 30-day stratification level, the tartaric acid showed 11 to 15 percent more germination than all other treatments at 12 to 19 days. This treatment reached an optimum of 81 percent germination at 19 days.

The 60-day stratification level of white pine seeds showed all treatments leveling-off at 17 days of germination with the citric acid treatment reaching germination of 98 percent at that time, a 38 percent increase over the previous week. All treatments showed very rapid germination at 11 days, the citric acid, tartaric acid, and water treatment having 28, 23, and 19 percent more germination, respectively, than the control.

These results indicate that citric acid treatment may make it possible to achieve maximum germination in minimum time, thus reducing the risk of seed loss to predators and giving the nurseryman a more uniform stand.

While no biochemical studies have been made to determine the nature of the behavior of citric acid in pretreatment of tree seed, this study suggests several modes of action.

1. Metabolite--It is known that during stratification much physiological activity occurs. It would seem then that citric acid may stimulate this action by a possible reactivation of the citric acid cycle.
2. Extractant--Seeds soaked in citric acid become bleached as the solution takes on an amber color, indicating the dissolving of various compounds from the seeds. It is conceivable that some of the compounds may be inhibitors; thus, their absence from the seed will speed germination.
3. Buffer--It is known that one of the best stratification media is acid peat. The citric acid would maintain acid conditions which are ideal for stratification.

1/ This study is in cooperation with the Georgia Forest Research Council and the Eastern Tree Seed Laboratory, U. S. Forest Service.

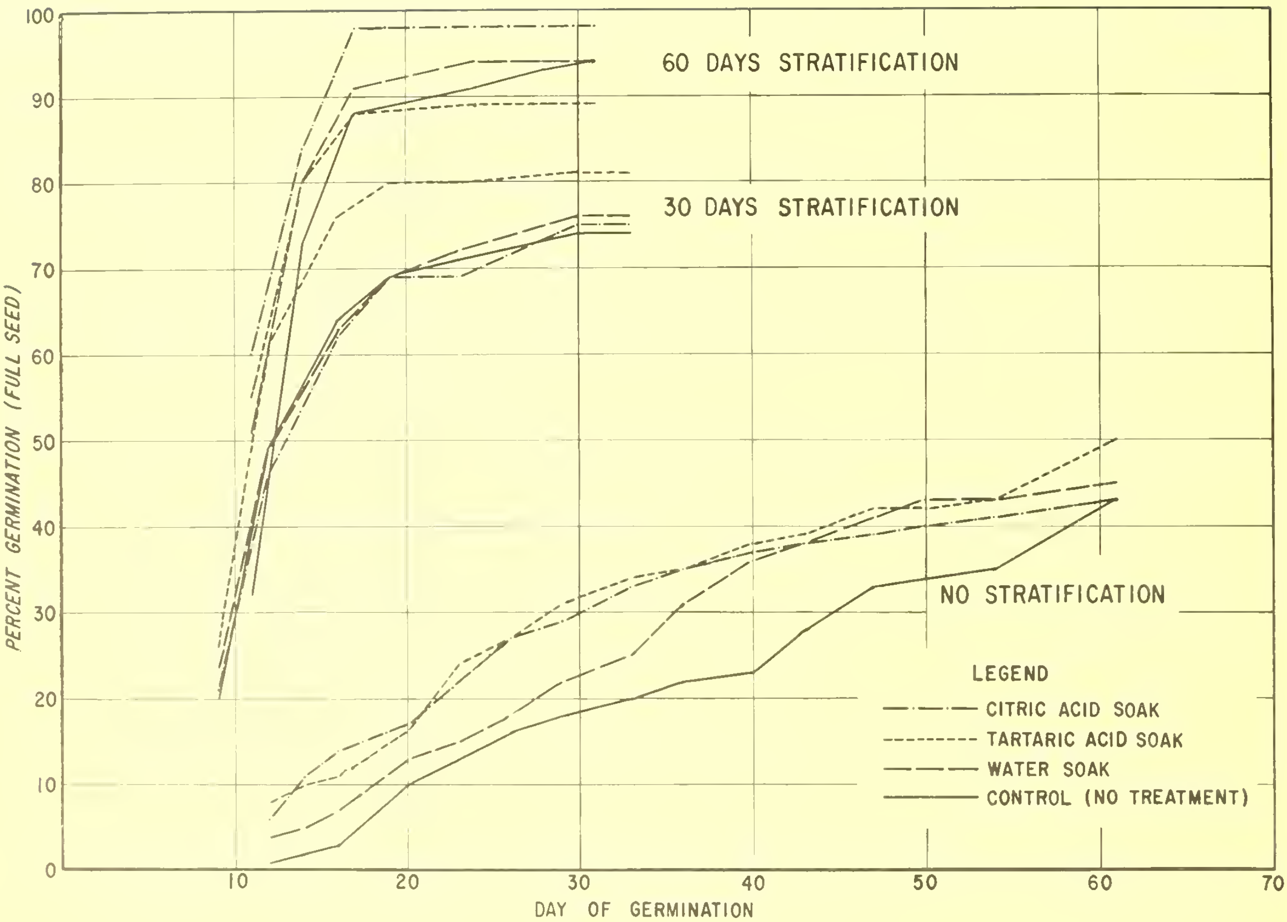

Figure 1.--Germination of white pine seed following various treatments and stratification periods. Germination counts were taken at 2- to 4-day intervals and percentages calculated on a full-seed basis.

Results from studies now in progress with eastern redcedar (Juniperus virginiana L.), loblolly pine (Pinus taeda L.), and baldcypress (Taxodium distichum (L.) Rich.) also indicate that a response similar to that with eastern white pine may be achieved with them. Further work is under way with a number of compounds, including those of the citric acid cycle, to determine their effect upon the germination of several species of forest tree seed.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 177 September 1962

BLACK WILLOW DOMINATES BALDCYPRESS-TUPELO SWAMP EIGHT YEARS AFTER CLEAR CUTTING

Our knowledge of successional relations in tidewater river swamps is scant. In an effort to increase our knowledge, the vegetation in a virgin stand of baldcypress (Taxodium distichum), swamp tupelo (Nyssa sylvatica var. biflora), and water tupelo (N. aquatica) was compared with the new growth in an adjacent 8-year-old clear-cut area in the Chowan River swamp in Hertford County, North Carolina. The soil, a dark brown muck, was 6 to over 10 feet deep, and numerous buried trees made it difficult to measure depth to the sandy clay loam subsoil. Estimates of the organic matter, using the loss by ignition method in four composite samples, ranged from 81.0 to 87.2 percent.

Sampling points in the two areas were located at 1-chain intervals on 15 lines running perpendicular to the swamp-upland border. At each point trees over 15 feet tall were sampled with a prism and the number of trees by species recorded as an estimate of basal area. Shrub and herb layers less than 15 feet tall were sampled in a 5- by 20-link milacre quadrat; the percent crown cover of the plot area by species was recorded. Cover type in the uncut swamp was determined from prism counts; in the clear-cut area, data from both prism counts and the milacre counts were used.

The uncut stand includes a dense overstory of tall, uneven-aged baldcypress and tupelos, with scattered understory trees of the same species and red maple (Acer rubrum) and Carolina ash (Fraxinus caroliniana). Shrubs and most herbs are restricted to raised surfaces, such as logs, cypress knees, and the hummocks around stumps and the tree boles themselves, for the soil is usually flooded throughout the fall, winter, and spring.

Eight growing seasons after the fall and winter high-lead logging operation, most of the clear-cut area is dominated by black willow (Salix nigra) 15 to 25 feet tall and up to 5 inches in diameter. On the 10-chain wide clear-cut strip the over-all stocking of the desirable baldcypress and tupelos was unsatisfactory (table 1).

Within the matrix formed by the black willow stand, smaller communities of different dominant vegetation occur. On limited wet areas cattails are the principal cover type. Occasional clumps of young baldcypress, swamp tupelo, and water tupelo occur where residual seed sources or advanced reproduction were not destroyed by the high-lead skidding operation. The species of shrubs and herbs in the cut and uncut areas are similar, but they attain greater abundance where the forest was clear cut.

Table 1. --Frequency of occurrence of certain tree species 8 years after clear cutting

Species or species group	Origin	Cover type		
		Black willow (32 plots)	Cattail (7 plots)	Baldcypress-tupelo (8 plots)
		- - - Frequency as percentage of plots - - -		
Black willow	Seed	100	57	38
Red maple	Seed	12	29	50
	Seed and sprout	12	29	62
Swamp tupelo	Seed	16	14	25
	Seed and sprout	34	14	38
Water tupelo	Seed	3	43	62
	Seed and sprout	3	57	62
Baldcypress	Seed	16	29	88
Baldcypress and tupelo	Seed	24	71	100
	Seed and sprout	53	71	100

Except in the scattered cattail areas and clumps of tupelo and baldcypress reproduction, black willow is the only tree of seed origin to form the dominant canopy. Vigorous tupelo sprouts are scattered throughout the area but their future value is uncertain because they originated high up on large stumps.

At present the black willows are very vigorous and there is no indication of stagnation. However, the overstory shade of black willow has produced little indication of suppression in the seedlings of other desirable species. How long the dominant stand will persist remains to be seen.

Although stands of black willow normally occur on recently exposed alluvial soils, in this instance a stand became established on a deep organic soil. Apparently the large amount of slash, stumps, logs, and hummocks offered sufficient seedbed for black willow to become quickly established as the high water receded in the spring. Since black willow produces abundant seed crops nearly every May or June, dense stands may result after winter clear cutting.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 178 September 1962

INTERNATIONAL ¼-INCH BOARD-FOOT VOLUME TABLE FOR SHORTLEAF PINE IN THE VIRGINIA-CAROLINA PIEDMONT[1/]

Volume tables for pine based on total height are preferred by most foresters because they do away with ocular estimates of merchantable heights. The first of such tables for natural shortleaf pine in the Piedmont was for cubic-foot volume and was published earlier this year in Research Note 170.[2/] The board-foot volume table presented here is intended to complement the cubic-foot table; both tables were constructed from the same set of tree measurements.

Volume estimates are based on measurements of 258 trees from various locations throughout the Piedmont region of Virginia, North Carolina, and South Carolina. The data from all states were combined and analyzed by multiple regression techniques.

The following regression equation expresses the board-foot volume (outside bark) for a 6-inch top d. i. b. in the study area:

$$\text{Board-foot volume (6-inch top d. i. b.)} = 0.016442D^2H - 41.8778$$

where D is the diameter at breast height and H is total height.

This equation accounted for about 96 percent of the total variation in the volume per tree.

1/ Tree measurements for parts of South Carolina were supplied by N. B. Goebel, Forestry Department, Clemson College, Clemson, South Carolina.

2/ Haney, Glenn P., and Kormanik, Paul P. Cubic-foot volume tables for shortleaf pine in the Virginia-Carolina Piedmont. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Notes 170. 1962.

U. S. Department of Agriculture - Forest Service

Table 1. --International $\frac{1}{4}$-inch board-foot volumes (outside bark) for natural shortleaf pine

(Top diameter 6.0 inches inside bark)

D. b. h. (inches)	Total tree height in feet											
	35	40	45	50	55	60	65	70	75	80	85	90
	Board feet											
8				11	16	21	26	32	37			
9		11	18	25	31	38	45	51	58	65		
10	16	24	32	40	48	57	65	73	81	90	98	
11	28	38	48	58	68	77	87	97	107	117	127	137
12		53	65	76	88	100	112	124	136	148	159	171
13			83	97	111	125	139	153	166	180	194	208
14			103	119	135	151	168	184	200	216	232	248
15			124	143	162	180	198	217	236	254	272	291
16				168	190	211	232	253	274	295	316	337
17				196	219	243	267	291	314	338	362	386
18					251	278	304	331	358	384	411	438
19						314	344	374	403	433	463	492
20							386	418	451	484	517	550

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RESEARCH NOTES

SOUTHEASTERN FOREST EXPERIMENT STATION

Asheville, North Carolina

Number 179 October 1962

SOME HYDROLOGIC PROPERTIES OF THE CECIL AND LLOYD SOIL SERIES IN PIEDMONT FORESTS

Measurements of the hydrologic characteristics of Piedmont forest soils, such as bulk density, percolation, and storage capacities, have been limited in the number of soil series studied and the areas sampled. A soil-site study of Piedmont upland forests in Virginia and North and South Carolina permitted sampling of hydrologic properties for the Cecil and Lloyd series under hardwood and pine-hardwood cover types.[1/][2/]

Sixty-one plots, relatively uniform in soil, litter cover, topography, aspect, and degree of slope were established in stands showing no evidence of recent fire, grazing, erosion, or destructive cutting.[3/] A soil pit was dug at each plot center and 2 core samples were taken from the A_1, A_2, B_1, and B_2 horizons. Samples were processed following a standard procedure.[4/] Physical properties shown in table 1 are based on average values of 4 soil samples per horizon per plot.

The hydrologic properties most conducive to water intake, transmission, and storage attain optimum development in the A_1 horizon. Both the Cecil and Lloyd series show an increase in bulk density and percent clay going from the A_1 to the B_2 horizon. Percolation, detention storage, available water, and sand content decrease with depth. Both series show a reduction in silt content from maximum values in the A_1 horizon to minimum levels in the B_1 followed by a slight increase in the B_2.

Silt content and available water percentages (moisture equivalent minus wilting point) are similar in intra-horizon comparisons of these soils. Available water decreases gradually from about 14 percent in the A_1 to 9 percent in the B_2; this is due to more organic matter in the A_1 horizon.

The wide range in percolation rates shown for the Cecil and Lloyd series is reflected in high coefficients of variation. Detention storage, closely related to percolation, has inter-horizon coefficients of variation which are much less.

Generally, the Lloyd series shows lighter bulk densities, higher percolation rates, larger detention storage values, and a greater amount of total pore space than the Cecil.

1/ Della-Bianca, Lino, and Olson, David F., Jr. Soil-site studies in Piedmont hardwood and pine-hardwood upland forests. Forest Sci. 7: 320-329. 1961.

2/ Soil series classified by: Earl H. Brunger--Virginia; Charles L. Hunt, Charles S. Wilson, and E. O. Brewer--North Carolina; Wallace J. Camp and Huger S. Byrd--South Carolina; Soil Scientists, U. S. Department of Agriculture, Soil Conservation Service.

3/ Additional hydrologic data were collected for 17 other soil series, each represented by 3 or less sampling locations. Data for all series in mimeographed form may be obtained from the Southeastern Forest Experiment Station, P. O. Box 2570, Asheville, N. C.

4/ Hoover, Marvin D., Olson, D. F., Jr., and Metz, L. J. Soil sampling for pore space and percolation. U. S. Forest Serv. Southeast. Forest Expt. Sta. Paper 42, 29 pp., illus. 1954.

Table 1. --Some hydrologic and physical properties of the Cecil and Lloyd soil series in upland hardwood, and pine-hardwood forests of the Virginia-Carolina Piedmont

Soil horizon and number of plots	Statistical variable	Sample depth	Soil separates: Sand	Soil separates: Silt	Soil separates: Clay	Moisture equivalent	Wilting point	Bulk density	Percolation rate	Detention storage	Retention storage	Saturated pore space
		Inches	Percent weight	Percent weight	Percent weight	Percent weight	Percent weight	Grams/cubic centimeter	Inches/hour	Percent volume	Percent volume	Percent volume
CECIL												
A_1	Range	0-2	39-68	20-34	12-28	18.3-55.8	7.9-27.5	0.77-1.30	0.54-104.65	11.6-38.7	28.4-45.4	51.0-69.9
	Mean	[1]0-2	54	27	19	31.3	17.0	1.04	29.27	22.9	36.5	59.4
n = 18	Std. deviation	--	8.6	4.0	5.1	10.3	6.0	0.15	30.90	7.0	5.2	5.3
A_2	Range	2-7	40-67	19-33	14-27	12.4-29.7	3.9-16.3	1.06-1.55	0.04-56.74	7.6-24.6	27.0-40.4	39.4-57.8
	Mean	[1]3.6-5.6	55	24	21	19.2	8.1	1.33	8.83	14.4	33.0	47.4
n = 18	Std. deviation	1.6	6.8	3.4	4.1	4.7	3.2	0.14	14.30	4.9	4.2	5.8
B_1	Range	4-26	42-64	15-24	20-38	16.0-26.2	6.8-15.8	1.28-1.63	0.02-21.52	5.3-15.8	27.0-42.8	36.4-52.0
	Mean	[1]8.5-10.5	53	20	27	19.8	10.3	1.47	2.40	9.2	34.1	43.3
n = 19	Std. deviation	5.4	6.0	2.6	4.9	3.1	2.4	0.11	4.82	2.5	4.7	4.9
B_2	Range	6-38	17-47	12-44	30-57	19.0-33.9	11.5-22.8	1.18-1.58	0.02-6.82	4.2-11.2	33.3-46.7	39.0-59.7
	Mean	[1]12.5-14.5	33	22	45	27.4	18.0	1.40	1.37	7.1	40.6	47.7
n = 19	Std. deviation	7.6	7.5	7.1	6.8	3.7	2.8	0.12	2.00	2.0	5.1	5.4
LLOYD												
A_1	Range	0-2	40-68	16-37	16-31	21.2-45.9	8.8-40.4	0.84-1.08	22.54-121.52	24.1-37.1	28.0-38.9	58.2-67.5
	Mean	[1]0-2	49	26	25	32.1	19.0	0.93	64.88	29.8	33.6	63.4
n = 10	Std. deviation	--	8.6	5.8	4.2	7.5	8.9	0.08	37.63	4.6	3.6	2.8
A_2	Range	2-6	46.61	21-30	18-29	18.7-29.4	6.0-15.1	1.09-1.34	2.34-35.81	11.8-26.8	32.0-42.3	47.4-59.7
n = 10[2]	Mean	[1]2.9-4.9	50	25	25	23.0	10.9	1.21	16.51	18.2	35.5	53.7
n = 9[3]	Std. deviation	1.7	4.7	3.3	3.8	3.6	2.8	0.10	12.43	4.6	3.1	4.5
B_1	Range	4-14	44-56	18-23	24-36	19.9-24.9	9.6-14.6	1.24-1.45	0.14-36.44	7.1-19.4	30.8-44.2	45.3-57.8
	Mean	[1]7.0-9.0	50	20	30	22.0	12.1	1.34	10.86	13.1	36.5	49.6
n = 10	Std. deviation	3.4	4.3	1.6	4.4	1.8	1.8	0.08	11.38	3.8	3.8	4.0
B_2	Range	6-20	21-40	16-27	36-60	21.2-35.2	12.6-23.3	1.23-1.47	0.002-5.15	7.6-14.2	30.6-46.5	44.4-57.7
	Mean	[1]10.7-12.7	30	22	48	28.4	18.6	1.36	1.66	10.4	40.2	50.6
n = 10	Std. deviation	4.4	2.1	3.2	7.3	4.7	4.0	0.09	1.61	2.7	5.1	4.6

1/ Average upper and lower depths of a 2-inch-thick undisturbed soil core.
2/ For the hydrologic properties: bulk density, percolation rate, retention and detention storage, saturated pore space; also, sample depths.
3/ For the physical properties: soil separates, moisture equivalent, wilting point.

RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 180 October 1962

YELLOW-POPLAR SITE INDEX CURVES

Yellow-poplar (Liriodendron tulipifera L.) occurs naturally throughout the eastern and central United States from southern New England west to Michigan and south to Florida and Louisiana. Because of its wide occurrence, yellow-poplar grows under a variety of climatic, edaphic, and biotic conditions. Combinations of these different environmental conditions are associated with several broad physiographic regions such as the central valleys, northern and southern Appalachians, Piedmont Plateau, and coastal plain.

The existing site index curves were constructed for the entire yellow-poplar range.[1/] However, they may not accurately reflect the height-age relationships in certain physiographic regions within the range. This note presents height-age equations and site index curves prepared for the southern Appalachian Mountains and the Piedmont Plateau.

The height-age equation for mountain stands was based on data from 267 sample plots in western North Carolina and northern Georgia. Height-age determinations were made on 4 to 6 dominant and codominant trees on each 1/5-acre plot. The stands ranged in age from 20 to 82 years, and in height from 36 to 134 feet. Site index, or height at the index age of 50 years, ranged from 58 to 123 feet, with an average of 87 feet for all mountain plots. The regression of the logarithm of total height on the reciprocal of age was computed and is expressed in terms of site index:

$$\text{Logarithm site index} = \text{logarithm height} - 9.158\,(1/50 - 1/\text{age}) \qquad (1)$$

Height-age determinations on 117 sample plots in the Piedmont of the Carolinas and Virginia were used to derive equation 2 below. Stands sampled ranged in age of dominants and codominants from 22 to 94 years, while height ranged from 46 to 119 feet. Average site index for the Piedmont plots was 82 feet, ranging from 55 to 122 feet.

The regression of the logarithm of height on the reciprocal of age is expressed in terms of site index as:

$$\text{Logarithm site index} = \text{logarithm height} - 6.503\,(1/50 - 1/\text{age}) \qquad (2)$$

The slope coefficients of equations 1 and 2 were tested and found to be significantly different. This indicates that yellow-poplar height-age relationships are different in the mountains from those in the Piedmont (fig. 1). Accordingly, separate families of site index curves were developed for the two regions (figures 2 and 3). Both sets of curves were compared with Technical Bulletin 356. The mountain curves were significantly different, but the Piedmont curves were not different. In general, Technical Bulletin 356 underestimates site index in the younger ages and overestimates site index in the older ages when applied to mountain stands.

1/ McCarthy, E. F. Yellow-poplar characteristics, growth and management. U. S. Dept. Agr. Tech. Bul. 356, 58 pp., illus. 1933.

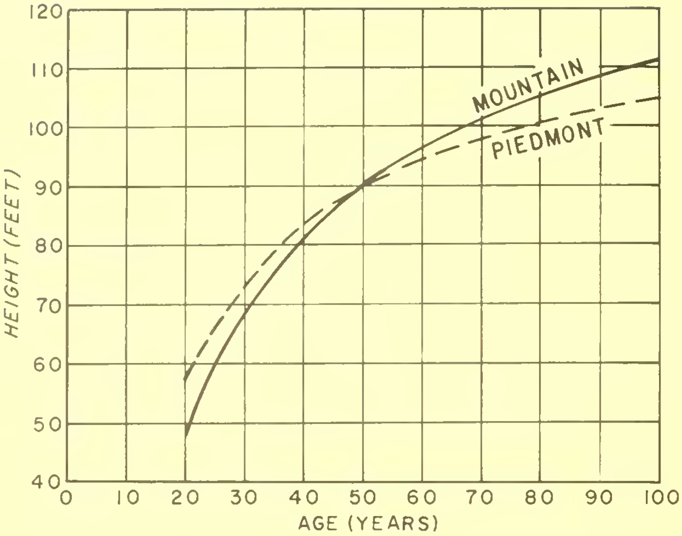

Figure 1. --Yellow-poplar height age curves for site index 90.

It is recommended that the new mountain curves be used in the southern Appalachians. Technical Bulletin 356 curves or the Piedmont curves can be applied with equal accuracy to stands in the Piedmont of the Carolinas and Virginia. However, the Bulletin curves extend only to 50 years of age. In stands older than 50 years the Piedmont curves given here should be used.

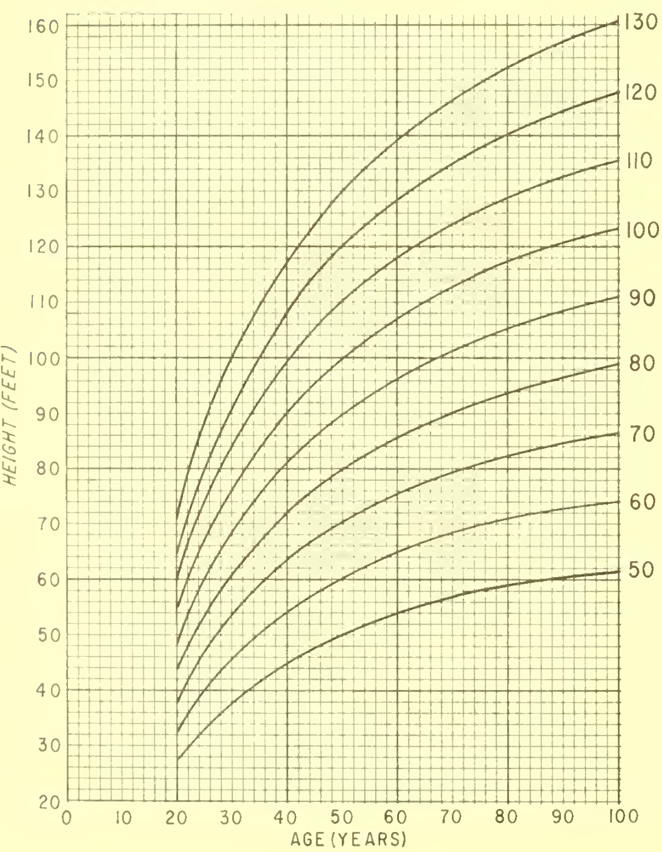

Figure 2. --Site index curves at an index age of 50 years for yellow-poplar in the southern Appalachian Mountains.

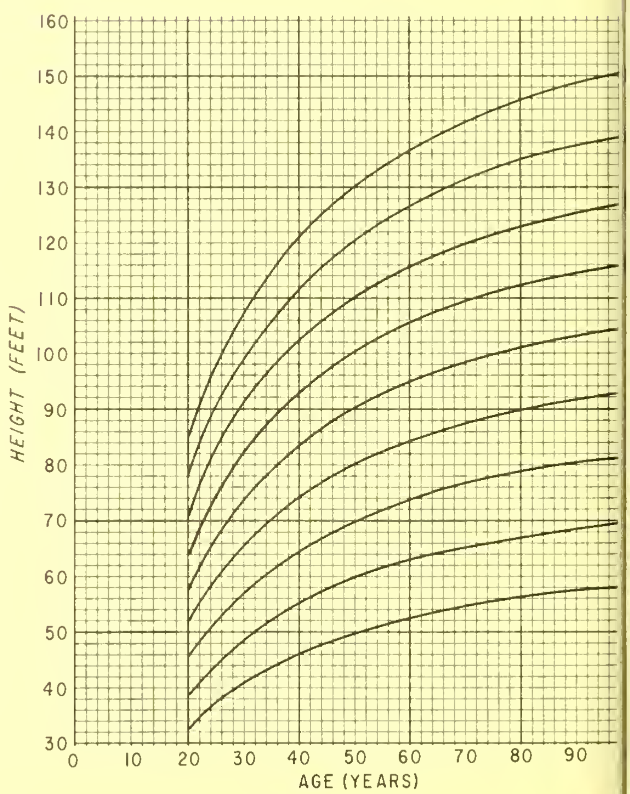

Figure 3. --Site index curves at index age of 50 years for yellow-poplar in the Piedmont of Virginia and the Carolinas.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
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1961 PULPWOOD PRICES IN THE SOUTHEAST

Southeastern pulpmills paid a record $192 million for pulpwood in 1961 with rough bolts averaging $16.55 per cord for pine and $13.50 for hardwood. A mill-by-mill comparison, however, indicates that 1961 prices were $0.10 a cord below those of 1960 for both pine and hardwood. These estimates are based on reports from mills whose pulpwood receipts make up 69 percent of the total in Virginia, North and South Carolina, Georgia, and Florida.

Five-year price trends for rough pulpwood bolts are given in table 1. The four price series shown represent the average prices paid for pulpwood at the points of delivery where the mill took title to the wood from the logger or producer. Freight charges between the rail siding or mechanized yard and the pulpmill are not included.

Pulpwood prices in the Southeast vary by point of delivery and by state. Truck-wood prices are higher than those for wood delivered either to a rail siding or a woodyard. Pine prices steadily increase by state from North to

Table 1.--Average price of rough pulpwood in the Southeast, by year 1/

(In dollars)

Year	Pine				Hardwood			
	Rail wood 2/	Yard wood 3/	Truck wood 4/	All wood 5/	Rail wood 2/	Yard wood 3/	Truck wood 4/	All wood 5/
1957	15.20	15.40	16.35	15.50	12.65	12.70	13.75	13.35
1958	15.20	15.40	16.10	15.50	12.45	12.50	13.85	13.45
1959	15.60	15.90	16.60	16.00	12.90	12.80	14.25	13.70
1960	16.25	16.35	17.20	16.45	13.15	13.25	14.05	13.60
1961	16.25	16.20	6/17.55	6/16.55	12.85	13.15	13.90	13.50

1/ Per cord of 128 cubic feet of 5-foot wood with bark. Includes dealers' allowances in cases where they are paid. Prices are rounded to the nearest 5 cents.

2/ F. o. b. railroad car at spur or siding.

3/ Delivered to mechanized pulpwood yard other than a millyard.

4/ Delivered to pulpmill.

5/ Weighted average of all wood loaded on railroad cars, delivered to pulpwood yards, and trucked to pulpmills.

6/ These prices are not comparable with those of previous years due to revision of the sample of reporting mills. This revision was made to reflect changes in the geographic distribution of pulpwood purchases resulting from recent pulpmill expansion and construction. Comparable 1961 prices based on the original sample are $16.85 for truck wood and $16.35 for all wood.

South. In 1961, for example, pine in Virginia averaged $1.40 less per cord than in Florida. The hardwood price gradient, though not as pronounced or consistent, tends to be the reverse of pine with the higher prices in Virginia.

The all-wood price series are the weighted average of rail, yard, and truck-wood purchases. In recent years, there has been considerable change in pulpwood procurement by these points of delivery (table 2). These changes, however, have had very little effect upon the average price paid for pine because the shift was largely between rail wood and yard wood which are priced very nearly alike. The average hardwood price, on the other hand, has been much more susceptible to these changing delivery patterns. The shift from the higher priced truck wood to the lower priced yard wood offset nearly half the price increase in hardwoods between 1957 and 1961.

Sawmill chips currently make up 12 percent of the total wood fibre used for pulp in the Southeast. The most commonly reported prices paid in 1961 were $6.50 per ton for pine chips and $4.95 for hardwood.

Table 2. --Rough pulpwood receipts in the Southeast by points of delivery [1/]

(In percent of rough pulpwood receipts)

Year	Pine				Hardwood			
	Rail wood	Yard wood	Truck wood	All wood	Rail wood	Yard wood	Truck wood	All wood
1957	47	31	22	100	23	10	67	100
1958	42	33	25	100	18	9	73	100
1959	35	39	26	100	22	22	56	100
1960	36	40	24	100	23	27	50	100
1961	31	41	28	100	18	28	54	100

1/ Based on a sample of mills representing about 70 percent of the total rough pulpwood receipts in the 5-state area.

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RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
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SOUTHERN PINE LUMBER GRADE YIELDS

The lumber yield tables presented here are the result of six separate studies conducted in Arkansas, Florida, Georgia, Mississippi, and South Carolina to develop southern pine log grades.[1] Lumber grade yields by species were analyzed separately, but were combined where differences were negligible. Combined yields for slash and longleaf are shown in table 1 and for loblolly and shortleaf in table 2. So few slash and longleaf logs over 17 inches were found in these studies that no yield table for grade 1 logs was developed.

The lumber yields presented here include 2-inch dimension material, but do not include stress graded material.

Because the results are regional averages, it is unlikely that they will be comparable to yields of any single mill. Individual mill differences, species cut, and products sawed all contribute to yield variation. Hence, if accurate yields for a specific mill or locality are desired, a local mill scale study using standard Forest Service log grades is recommended.

1/ This research note should be used in conjunction with a pocket booklet "Forest Service Standard Grading System for Southern Pine Yard Lumber," USDA, Forest Service, 5 pp., 1962, and a separate research note being published concurrently on "Overruns--Southern Pine Logs."

Table 1.--Green lumber yields for slash and longleaf logs[1]

LOG GRADE II

Log d.i.b. (inches)	Lumber grades											Logs
	B&B	C	D	1C	1D	2C	2D	3C	3D	4C	4D	
	Percent											Number
10	9	22	25	6	25	8	3	2	0	0	0	15
11	11	22	24	6	23	9	3	2	0	0	0	3
12	14	21	23	5	22	10	3	2	0	0	0	19
13	17	20	22	5	21	11	2	2	0	0	0	11
14	20	20	21	5	19	12	1	2	0	0	0	15
15	22	20	20	4	17	14	1	2	0	0	0	9
16	25	18	19	4	16	16	0	2	0	0	0	2
Average	17	20	21	5	22	11	2	2	0	0	0	

LOG GRADE III

Log d.i.b. (inches)	B&B	C	D	1C	1D	2C	2D	3C	3D	4C	4D	Logs
6	1	6	9	3	32	30	18	1	0	0	0	30
7	1	7	10	3	30	31	17	1	0	0	0	27
8	2	7	11	3	27	33	16	1	0	0	0	26
9	2	8	12	3	25	34	15	1	0	0	0	35
10	3	8	14	3	22	35	14	1	0	0	0	23
11	3	9	15	3	20	36	13	1	0	0	0	26
12	4	9	16	3	17	38	12	1	0	0	0	27
13	4	10	17	3	15	40	10	1	0	0	0	19
14	5	10	18	3	12	42	9	1	0	0	0	10
15	5	11	19	3	10	43	8	1	0	0	0	5
16	6	11	21	3	7	44	7	1	0	0	0	1
Average	4	9	14	3	18	39	12	1	0	0	0	

LOG GRADE IV

Log d.i.b. (inches)	B&B	C	D	1C	1D	2C	2D	3C	3D	4C	4D	Logs
6	0	1	2	1	10	43	38	0	5	0	0	12
7	0	1	2	1	9	47	35	0	5	0	0	32
8	0	1	2	1	9	50	32	0	5	0	0	32
9	0	1	2	1	8	53	29	1	5	0	0	36
10	0	1	2	1	7	57	26	1	5	0	0	34
11	0	1	2	1	6	60	23	2	5	0	0	16
12	0	1	2	1	6	65	18	2	5	0	0	10
13	0	1	2	1	5	70	14	2	5	0	0	3
14	0	1	2	1	4	73	11	3	5	0	0	2
15	0	1	2	1	4	77	7	3	5	0	0	1
16	0	1	2	1	3	80	4	4	5	0	0	0
Average	0	1	2	1	7	57	25	2	5	0	0	

1/ Based on curved data from 1956-1959 studies.

Table 2. --Green lumber yields for loblolly and shortleaf logs [1]

LOG GRADE I

Log d. i. b. (inches)	Lumber grades											Logs
	B&B	C	D	1C	1D	2C	2D	3C	3D	4C	4D	
	Percent											Number
17	22	8	5	13	18	15	9	6	4	0	0	23
18	24	8	4	14	17	15	8	6	4	0	0	20
19	25	8	3	15	15	16	7	7	4	0	0	14
20	26	8	3	16	14	16	6	7	4	0	0	5
21	27	8	2	17	12	17	5	8	4	0	0	8
22	28	8	2	18	11	17	4	8	4	0	0	8
23	30	8	1	19	8	18	3	9	4	0	0	3
24	31	8	1	20	7	18	2	9	4	0	0	0
25	32	8	0	21	5	19	1	10	4	0	0	0
26	34	8	0	22	3	19	0	10	4	0	0	1
Average	25	8	3	17	12	17	6	8	4	0	0	

LOG GRADE II

Log d. i. b. (inches)	B&B	C	D	1C	1D	2C	2D	3C	3D	4C	4D	Logs
10	20	11	15	5	25	11	8	1	3	1	0	21
11	20	10	14	6	25	12	8	1	3	1	0	15
12	19	10	13	7	24	13	8	2	3	1	0	32
13	19	10	12	8	24	13	8	2	3	1	0	19
14	18	9	11	9	24	14	8	3	3	1	0	41
15	18	9	10	10	23	14	8	4	3	1	0	32
16	18	9	9	11	23	14	8	4	3	1	0	36
17	17	9	8	12	23	14	8	5	3	1	0	10
18	17	8	7	13	22	15	8	6	3	1	0	7
19	16	8	6	14	22	16	8	6	3	1	0	6
20	16	8	5	14	21	17	8	7	3	1	0	3
21	16	8	4	15	21	17	8	7	3	1	0	0
22	15	7	3	16	21	18	8	8	3	1	0	2
23	15	7	2	17	20	19	8	8	3	1	0	0
24	14	7	1	18	20	19	8	9	3	1	0	2
Average	17	9	8	11	23	15	8	5	3	1	0	

LOG GRADE III

Log d. i. b. (inches)	B&B	C	D	1C	1D	2C	2D	3C	3D	4C	4D	Logs
6	1	3	0	4	46	8	28	3	6	1	0	31
7	1	3	1	4	43	10	28	3	6	1	0	24
8	2	3	1	4	40	12	28	3	6	1	0	35
9	2	3	2	4	37	14	28	3	6	1	0	34
10	3	3	2	4	34	16	28	3	6	1	0	34
11	3	3	3	4	31	18	28	3	6	1	0	42
12	4	3	3	4	28	20	28	3	6	1	0	60
13	4	3	4	4	25	22	28	3	6	1	0	37
14	5	3	4	4	22	24	28	3	6	1	0	48
15	5	3	5	4	19	26	28	3	6	1	0	26
16	6	3	6	4	16	27	28	3	6	1	0	23
17	6	3	7	4	13	29	28	3	6	1	0	16
18	6	3	8	4	10	31	28	3	6	1	0	10
19	7	3	8	4	7	33	28	3	6	1	0	4
20+	7	3	9	4	4	35	28	3	6	1	0	7
Average	5	3	6	4	21	23	28	3	6	1	0	

LOG GRADE IV

Log d. i. b. (inches)	B&B	C	D	1C	1D	2C	2D	3C	3D	4C	4D	Logs
6	1	1	1	1	6	26	38	4	21	0	1	23
7	1	1	1	1	6	26	37	5	21	0	1	31
8	1	1	1	1	5	26	37	6	21	0	1	57
9	1	1	1	1	5	26	36	7	21	0	1	66
10	1	1	1	1	4	26	36	8	21	0	1	68
11	1	1	1	1	4	26	35	8	21	1	1	47
12	1	1	1	1	3	26	35	9	21	1	1	34
13	1	1	1	1	3	26	34	9	21	2	1	42
14	1	1	1	1	2	26	34	10	21	2	1	28
15	1	1	1	1	2	26	32	11	21	3	1	21
16	1	1	1	1	2	26	32	11	21	3	1	23
17	1	1	1	1	1	26	31	12	21	4	1	5
18	1	1	1	1	1	26	31	12	21	4	1	10
19	1	1	1	1	0	26	30	13	21	5	1	2
20+	1	1	1	1	0	26	30	13	21	5	1	4
Average	1	1	1	1	3	26	32	11	21	2	1	

1/ Based on curved data from 1956-1959 studies.

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RESEARCH NOTES
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OVERRUNS--SOUTHERN PINE LOGS

Overrun and underrun data were collected for the four major southern pine species during a series of grade yield studies in the late 1950's in Arkansas, Florida, Georgia, Mississippi, and South Carolina. Each of the 1,491 logs was carefully scaled by the Doyle, Scribner Decimal C, and International $\frac{1}{4}$-inch log rule. All logs were sawed on circle mills and the variations shown are based on green lumber tallies for each log. Only full scale (sound) log data are shown in table 1. The small number of defective logs and their wide variation in overrun militated against their inclusion.

Table 1. --Variations in some log scales compared with green lumber tally of southern yellow pine 1/

Log d. i. b. (inches)	Log rule			Logs
	Doyle	Scribner Decimal C	International $\frac{1}{4}$ inch	
	- - - - - - - - Percent - - - - - - - -			Number
6	+400	+28	-2	89
7	200	26	-2	102
8	130	23	-3	134
9	90	21	-3	162
10	70	19	-4	155
11	50	17	-4	132
12	42	14	-5	167
13	32	12	-5	119
14	26	10	-6	128
15	20	8	-6	85
16	16	5	-7	74
17	12	3	-8	43
18	8	1	-8	42
19	4	-2	-9	22
20	0	-4	-9	16
21	-2	-6	-10	8
22	-4	-8	-11	8
23	-6	-10	-11	3
24	-8	-13	-12	2
Total				1,491

1/ Results shown are based on green lumber tally of sound logs obtained from log grade studies in 1956 and 1959.

These data were analyzed separately by species, location, log grade,[1] and size. Log size proved most important from the practical standpoint. The values shown in the table were read from curves developed from regression computations.

Overrun and underrun are greatly influenced at any mill by the width and thickness of the product, the mill efficiency, and the ability of the sawyer. Since these data are the combined averages of several good mills, it is unlikely that any one mill would happen to get the same results. The values shown indicate what might be expected at a "better than average" mill.

1/ This research note should be used in conjunction with a pocket booklet "Forest Service Standard Grading System for Southern Pine Yard Lumber," USDA, Forest Service, 5 pp., 1962, and a separate research note being published concurrently on "Southern Yellow Pine Lumber Grade Yields."

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