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# Long-Term Research Does Pay Off

## A Summary of the Southern Station Experience

Margaret S. Devall and Virgil C. Baldwin, Jr., Compilers

## SUMMARY

Descriptions and summaries of completed and ongoing long-term research studies (those in existence for 5 or more years) conducted by scientists of the USDA Forest Service's former Southern Forest Experiment Station (now part of the Southern Research Station) are presented in this report. The array of data bases at the Southern Station includes forest surveys, genetics studies, watershed experiments, silviculture studies, and many other subjects. The purpose of this publication is to inform the public of the successful long-term research, accomplished and ongoing, at the Southern Forest Experiment Station and to encourage scientists from other institutions to utilize the data that have resulted from this research.

## ACKNOWLEDGMENTS

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# INTRODUCTION

Long-term studies make valuable contributions to forestry and related fields. Most natural resource research organizations and scientists agree that long-term research is essential, yet few carry out studies that continue for more than a few years because of the special problems involved. Some of these problems are: (1) required continuous funding is difficult to justify based only on intermediate and expected results; (2) intermediate results are sometimes not publishable, especially in scientific journals; (3) field research plots and detailed records and data files must be meticulously maintained and preserved; (4) there is a higher probability of catastrophic losses to research study plots, etc., in long-term studies than in short-term studies; (5) many scientists who initiate long-term studies are unable to complete them due to reassignment, transfer, promotion, or retirement; and (6) the professional standing and financial rewards of scientists are primarily based on publication of research results, not maintenance of studies. Therefore, a strong and continuing commitment of support by the research organization and dedication by the principal investigators and supporting personnel are absolutely necessary for the initiation and successful completion of long-term studies.

The USDA Forest Service's Southern Forest Experiment Station (presently Southern Research Station[1]) has supported numerous long-term research studies since its establishment in New Orleans, LA, in 1921. Consequently, the Southern Station possesses numerous large data sets. Many are from long-term studies of timber growth and yield, but long-term studies on a number of other topics have also been carried out. Particularly noteworthy is the enormous data set amassed from recurring forest surveys, encompassing all of the timberland of the Midsouth States, Puerto Rico, and some of the U.S. Virgin Islands. Another example is the Southwide Seed Source Study, with repeated observations on hundreds of thousands of southern pines in carefully controlled plantings across the entire Southern United States. The array of data bases at the Southern Station also includes watershed experiments, silvicultural studies, and many other topics. The long-term studies of the Southern Station have been invaluable. Conclusive solutions to some vital problems concerning forests could not have been developed without data from these carefully controlled field experiments that were continued for many years-some for more than half a century. In some cases, studies established for one purpose have been invaluable in dealing with problems not of concern when the study was initiated. The Southern Station continues to encourage the maintenance of existing long-term studies and the establishment of new ones consistent with the staff's mission and the practical constraints of budget and personnel levels. In most cases, data from long-term studies are maintained permanently, with adequate documentation, for use by scientists in the future. And most data sets are in machine-readable format.

The purpose of this publication is to inform the public of the successful long-term research, accomplished and ongoing, at the Southern Station and to encourage scientists from other institutions to utilize the data that have resulted from this research. Thus, the public benefit from the Southern Station's research can be greatly expanded.

Anyone wishing to use data from the studies described herein should contact the scientist or project leader involved with each study of interest, if known, or contact the Southern Research Station, Office of Planning and Applications, 200 Weaver Boulevard, P.O. Box 2680, Asheville, NC 28802 (phone 704/257-4304) for referral to the appropriate scientist. Requests for information on studies from Range Management for Southern Pine Ecosystems or Sewanee should be sent to the Office for Planning and Applications because these research work units are closed. After the potential user has consulted with the scientist in charge of a study, a cooperative agreement can be arranged but is not absolutely necessary. There is no charge for these data; however, unless a cooperative effort is practical where both parties benefit, all costs pertaining to the transfer of data must be borne by the recipient.

The first section of this publication contains descriptions of the studies with a list of the major publications that resulted from each study. The second section includes a summary of each study. If no publications exist, the establishment record or progress reports are listed. Page numbers are given with each study summary and description so the reader can quickly refer from one section to the other. Readers interested in specific species or subjects can refer to the index to find the appropriate studies.

All of the research work units of the Southern Station are not represented here nor are all of the ongoing long-term studies described. In some units, the scientists do not carry out long-term studies. In other units, descriptions of some studies could not be accurately completed or preliminary data could not be released at this time. For this publication, a long-term study is defined as one that has been in existence for 5 or more years and for which the intent is, or was, to make repeated measurements over a period of years.

[1] In January 1995, the Southern Forest Experiment Station and Southeastern Forest Experiment Station combined to form the Southern Research Station with headquarters in Asheville, NC. In this publication, the former Southern Forest Experiment Station will be referred to as the Southern Forest Experiment Station or Southern Station.

# STUDY DESCRIPTIONS AND PUBLICATIONS

## ENVIRONMENTAL IMPACTS OF AND ECOSYSTEM RESPONSES TO VEGETATION MANAGEMENT IN SOUTHERN FORESTRY

### The Impacts of Competition on Loblolly Pine: a Regional Assessment of the Competition Omission Monitoring Project (COMProject; See summary, p. 104.)

A common study design was installed at 14 locations throughout the South to track the growth of loblolly pine (*Pinus taeda*) established under 4 competition conditions that represent the corner extremes of a pine-growth response surface where the independent variables are woody competition and herbaceous competition. The treatments during the first 4 years were: (1) total control; (2) control of woody competition; (3) control of herbaceous competition; and (4) no control after roller chopping or clearing. During the first 5 years, treatment rankings for greater growth in height, diameter, and volume of loblolly pine were: (1) total control; (2) herbaceous control; (3) woody control; and (4) no control. With total control, pine volume after 5 years averaged about five times more than with no control. Woody and herbaceous control increased volume by an average of 68 and 173 percent, respectively, showing the greater average influence of herbaceous competition during this period. Both height and diameter can be increased with vegetation control, but diameter is influenced more. Growth reductions by competitors vary by site and intensity of competition.

This study is being conducted through cooperation among the Southeastern Forest Experiment Station,[2] Auburn University Silvicultural Herbicide Cooperative, Virginia Polytechnic Institute and State University, Louisiana Tech University, International Paper Company, Packaging Corporation of America, Potlatch Corporation, Scott Paper Company, Union Camp Corporation, Georgia Pacific Corporation, Willamette Industries, and E.I. DuPont de Nemours and Company. An investigator from each of these cooperating agencies, institutions, and companies is responsible for research activities at one of the study locations.

[2] In January 1995, the Southeastern Forest Experiment Station and Southern Forest Experiment Station combined to form the Southern Research Station. In this publication, the former Southeastern Forest Experiment Station will be referred to as the Southeastern Forest Experiment Station.

#### Major Publications Or Progress Reports

Cain, M.D. 1988. Competition impacts on growth of naturally regenerated loblolly pine seedlings. Res. Note SO-345. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 5 p.

Cain, M.D. 1989. A simple competition assessment system associated with intensive competition control in natural loblolly-shortleaf pine seedling stands. Southern Journal of Applied Forestry. 13: 8-12.

Miller, J.H.; Zutter, B.; Zedaker, S.M. [and others]. 1987. Region-wide study of loblolly pine seedling growth relative to 4 competition levels after 2 growing seasons. In: Phillips, Douglas R., comp. Proceedings of the 4th biennial southern silvicultural research conference; 1986 November 4-6; Atlanta, GA. Gen. Tech. Rep. SE-42. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 581-591.

Zutter, Bruce. 1988. 1986 growing season results of HB-4F studies (COMP). Res. Note 88-8. Auburn, AL: Auburn University Silvicultural Herbicide Cooperative. 14 p.

### The Impact of Mechanical Site Preparation on the Continued Forest Productivity of Piedmont Soils (See summary, p. 104.)

The effects of rootraking on the properties of soils (study 1) as well as varying intensities of mechanical site preparation (study 2) have been under investigation for 9 years on Piedmont soils. Periodic sampling and analyses of nutritional and physical variables have revealed a general trend in elevated levels of available nutrients at a higher soil pH for 2 years after treatment followed by a period of declining levels at a lower pH. Much phosphorus and other macronutrients are concentrated in windrows. Surprisingly, bulk density tends to decrease and macropore space to increase in the first few years after mechanical treatments. Apparently, most changes in the nutritional and physical properties of these soils are associated with root death after harvesting and subsequent decomposition.

Study 2 is being conducted through cooperation with M. Boyd Edwards, Southeastern Forest Experiment Station, who is measuring pine growth and vegetation development.

#### Major Publications Or Progress Reports

Banker, R.E.; Miller, J.H. 1983. Mechanical site preparation impacts on soil and plant competition in the

Piedmont. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 45 p. On file with: Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Banker, R.E.; Miller, J.H.; Davis, D.E. 1983. First-year effects of rootraking on available nutrients in Piedmont Plateau soils. In: Jones, Earle P., ed. Proceedings of the 2nd biennial southern silvicultural research conference; 1982 November 4-5; Atlanta, GA. Gen. Tech. Rep. SE-24. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 23-25.

Miller, J.H.; Edwards, M.B. 1984. The effect of varying intensities of site preparation on the soil resource. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 26 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Miller, J.H.; Edwards, M.B. 1985. Impacts of various intensities of site preparation on Piedmont soils after 2 years. In: Shoulders, E., ed. Proceedings of the 3rd biennial southern silvicultural research conference; 1984 November 7-8; Atlanta, GA. Gen. Tech. Rep. SO-54. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 65-73.

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**Understory Succession and Overstory Growth in Longleaf Pine Small Pole Stands Following Fire, Mechanical, and Chemical Treatments (See summary, p. 105.)**

The average height, d.b.h., volume, and basal area of longleaf pine (*Pinus palustris*) stands on unburned plots significantly exceeded the average measurements for each of three burning treatments. The difference between unburned and burned stands in total volume continues to widen from 202 ft³/acre in 1980 to 341 ft³/acre in 1983 to 479 ft³/acre in 1986 to 574 ft³/acre in 1989. Supplemental hardwood control treatments have not affected any measure of pine growth in any measurement period, though midstory hardwoods (>1.5 inches in d.b.h.) on untreated check plots reached an average of 340 stems and a basal area of 15.5 ft²/acre.

From 1983 to 1989, on plots without supplemental treatments, biennial spring burns reduced the density of midstory hardwoods from 5.1 to 1.6 ft²/acre and summer burns from 4.0 to 1.9 ft²/acre. Winter burns allowed a slow increase in midstory hardwoods from 8.7 to 10.4 ft²/acre. Over the first 10 years of the study, burning led to substantial shifts in composition of understory biomass. On unburned plots, both woody and litter biomass increased whereas herbaceous vegetation declined. On burned plots, herbaceous biomass increased. The significant effect of burning on total biomass was due to differences in dead organic litter. Total living green biomass was not significantly affected by the three burning treatments, and there was little difference in biomass components among the three seasons of burn.

**Major Publications Or Progress Reports**

Boyer, William D. 1983. Growth of young longleaf pine as affected by biennial burns plus chemical or mechanical treatments for competition control. In: Proceedings of the 2nd biennial southern silvicultural research conference; 1982 November 4-5; Atlanta GA. Gen. Tech. Rep. SE-24. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 62-65.

Boyer, William D. 1985. Understory succession and overstory growth in longleaf pine small pole stands following fire, mechanical, and chemical treatment. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 59 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Boyer, William D. 1987. Volume growth loss: a hidden cost of prescribed burning in longleaf pine? Southern Journal of Applied Forestry. 11(3): 154-157.

Boyer, William D. 1988. Understory succession and overstory growth in longleaf pine small pole stands following fire, mechanical, and chemical treatment. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 46 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Boyer, William D. 1990. Understory succession and overstory growth in longleaf pine small pole stands following fire, mechanical, and chemical treatment. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 84 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

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**Longleaf Pine Regeneration Trials (See summary, p. 106.)**

Knowledge derived from these regional tests of the shelterwood systems of natural regeneration of longleaf pine (*Pinus palustris*) has been utilized in the development and application of the method. The tests have provided useful information on: periodicity of cone production from year to year and place to place; seedling establishment; seedling survival and growth, both when the shelter-wood overstory was removed and when the parent overstory was retained; techniques for monitoring and predicting seed crops; and techniques for conducting regeneration surveys.

### Major Publications Or Progress Reports


Boyer, William D. 1977. Stocking percent and seedlings per acre in naturally established longleaf pine. Journal of Forestry. 75(8): 500, 505, 506.

Boyer, William D. 1979. Mortality among seed trees in longleaf pine shelter-wood stands. Southern Journal of Applied Forestry. 3(4): 165-167.

Boyer, William D. 1979. Regenerating the natural longleaf pine forest. Journal of Forestry. 77(9): 572-575.

Boyer, William D. 1979. The shelter-wood system for natural regeneration of longleaf pine. In: Proceedings, National silviculture workshop; 1979 September 17-21; Charleston, SC. Washington, DC: U.S. Department of Agriculture, Forest Service, Division of Timber Management: 124-128.

Boyer, William D. 1987. Annual and geographic variations in cone production by longleaf pine. In: Proceedings of the 4th biennial southern silvicultural research conference; 1986 November 4-6; Atlanta, GA. Gen. Tech. Rep. SE-42. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 73-76.

Croker, Thomas C., Jr.; Boyer, William D. 1975. Regenerating longleaf pine naturally. Res. Pap. SO-105. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 21 p.


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### Escambia "Farm Forty" (See summary, p. 106.)

This study, which was begun in 1947, is a management demonstration in an understocked 40-acre tract of second-growth longleaf pine (*Pinus palustris*). The management goal for this tract has been to produce high-quality logs and poles on a 60-year rotation using low-cost natural regeneration methods that include patch shelter-wood and group selection. Initial sawlog volume averaged 3,559 foot board measure (fbm)/acre (International 1/4-inch). In 1987, 40 years later, sawlog volume averaged 6,417 fbm/acre, an increase of 2,858 fbm/acre over the 1947 inventory. During the 40-year period, removals included 4,370 fbm/acre of logs and poles, plus an additional 239 $ft^3$/acre in pine pulpwood and posts. By 1987, over one-half (22 acres) of the tract had been naturally regenerated to longleaf pine and supported stands ranging from grass-stage seedlings to small poles. Nearly all the 1987 sawtimber volume was on the 18 acres not yet regenerated, so each of these 18 acres carried an average of about 14,000 fbm of sawtimber and poles. Hardwoods averaged 330 $ft^3$/acre, about 17 percent of total volume, with 58 percent in the 5-inch d.b.h. class or larger.

Management costs for the 40-acre tract were confined mostly to prescribed burning, marking trees for cut, and some control of cull hardwoods. The tract was prescribed burned 10 times during the 40-year period for brush control, hazard reduction, and seedbed preparation.

### Major Publications or Progress Reports


Boyer, William D.; Farrar, Robert M. 1981. Thirty years of management on a small longleaf pine forest. Southern Journal of Applied Forestry. 5(2): 73-77.

Croker, T.C. 1953. Results of good management seem like woodland magic. Southern Lumber Journal 57(10): 76.

Croker, T.C., Jr. 1953. Returns from a longleaf pine woodland. South. For. Notes 83. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. [not paged]

Croker, Thomas C. 1950. Small longleaf tract shows profit. Forest Farmer. 10(2): 12.

Croker, Thomas C., Jr. 1950. Wide faces boost gum yields. Forest Farmer. 9(11): 14.

Croker, Thomas C., Jr. 1950. Wide faces boost gum yields. Naval Stores Review. 60(31): 22-23.

Croker, Thomas C., Jr. 1951. An annual tree crop. Forest Farmer. 10(8): 9.

Croker, Thomas C., Jr. 1951. Tree crop box score-it answers grower's questions. Alabama Lumberman. 3(5): 18-19.

Croker, Tom. 1954. Seven years of management on the Escambia farm forest forty. The AT-FA Journal 17(2): 14.


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### Timing of Scrub Oak Control (See summary, p. 107.)

This study was conducted to determine whether seedling age at time of release from overtopping hardwoods is an important factor in the development of longleaf pine (*Pinus palustris*) regeneration. Seedling growth was retarded by overtopping hardwoods (mostly scrub oaks), and the largest seedlings at age 10 were those released first. The impact of hardwood competition was much greater on poor than on average sites. Seedlings released at age 1 on poor sites were three times larger at age 10 than similar unreleased seedlings, and seedlings released early on good sites were only 50 percent larger than similar unreleased seedlings.

Seedling survival was better on average than on poor sites, regardless of release treatment. Apparently, fire was the major direct cause of seedling mortality. In years without fire, annual mortality averaged about 1.4 percent, regardless of site conditions and release treatments. Mortality from fire is apparently related to seedling size, degree of brown spot (*Scirrhia acicola*) infection, and release status. The risk of mortality from fire was greatest among unreleased seedlings on poor sites, so early seedling release is most important on poor sites, especially if these sites are to be burned.

Seedlings responded to release with increased growth, even when release was delayed as long as 8 years. Seedlings released at ages 1 and 2 grew significantly better than unreleased seedlings during the first year after release. Those released at a later age generally did not show a significant response until the second year after release.

Apparently, 12 percent of the longleaf pine seedlings were inherently resistant to brown spot disease and were never more than lightly infected during the course of the study, although close-neighboring trees were severely infected. A follow-up examination when trees were 24 years old indicated that brown spot-resistant individuals had an average height advantage of 8 ft over the more brown spot-susceptible trees. The disease-resistant longleaf pines were clearly the dominant members of the new stand.

The differences in seedling size associated with early and delayed release from overtopping hardwoods were highly significant at age 10, with the trees released at age 1 being five times as tall as trees released at age 8. However, a reexamination of study plots when trees were 31 years old revealed that the growth of stands released late caught up with those released early. Timing of release from overstory hardwoods no longer had any significant effect on stocking, average height and d.b.h. of trees, or basal area and volume of stands.

### Major Publications or Progress Reports


Boyer, William D. 1972. Brown-spot resistance in natural stands of longleaf pine seedlings. Res. Note SO-142. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 4 p.

Boyer, William D. 1974. Impact of prescribed fires on mortality of released and unreleased longleaf pine seedlings. Res. Note SO-182. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 6 p.

Boyer, William D. 1975. Timing overstory removal in longleaf pine. Journal of Forestry. 73(9): 578-580.

Boyer, William D. 1985. Timing of longleaf pine seedling release from overtopping hardwoods: a look 30 years later. Southern Journal of Applied Forestry. 9(2): 114-116.

Gaines, Edward M. 1950. Scrub oak helps longleaf seedlings on deep sand. South. For. Notes 69. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. [Not paged].

Gaines, Edward M. 1951. Scrub oak as a nurse crop for longleaf pine on deep sandy soils. Alabama Academy of Science Journal 22: 107-108.

Walker, L.C. 1954. Early scrub oak control helps longleaf pine seedlings. Journal of Forestry. 52(12): 939.

Walker, L.C. 1954. Release longleaf seedlings early. Southern Lumberman. 189: 2369.


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### Aerial Application of Three New Silvicides to Longleaf Pine Regeneration Areas

**(See summary, p. 107.)**

The purpose of this study was to determine if two new formulations of 2,4,5-T (butoxy ethanol ester and emulsifiable acid) are as effective as an older formulation (emulsifiable amine) for controlling hardwoods while causing less damage to longleaf pine (*Pinus palustris*) seedlings. The recommended formulation of 2,4,5-T was most effective in controlling oaks (*Quercus* spp.), with no more damage to pines than any other formulation tested. About 18 percent of the first-year longleaf pine seedlings sprayed with a silvicide were dead 1 year after treatment, compared to less than 3 percent of the older longleaf seedlings.

Twenty years after treatment, the ester-treated and untreated control plots in each of four 40-acre compartments were reexamined. Although the number of longleaf pines per acre was the same for both treated and untreated stands, the chemical release treatments resulted in trees having a diameter averaging 10 percent greater in size, 17 percent greater in height, and 40 percent more in merchantable volume than trees in the untreated stands. The volume difference represents about an 8-year growth advantage for treated stands.

In 1985, soils on these study sites were sampled by the U.S. Environmental Protection Agency for presence of dioxin residues.

#### Major Publications or Progress Reports

Farrar, Robert M. 1961. Aerial application of four silvicides in south Alabama. In: Proceedings of the southern weed conference; 1961 January 18; St. Petersburg, FL. Champaign, IL: Weed Science Society of America; 14: 198-201.

Michael, J.L. 1980. Long-term impact of aerial application of 2,4,5-T to longleaf pine (*Pinus palustris*). Weed Science. 28(3): 255-257.

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### Longleaf Pine Seed Production
**(See summary, p. 108)**

This study was conducted to explore factors affecting cone production by longleaf pine (*Pinus palustris*) and the long-term variability in, and relationship between, pollen and cone production. The date of peak flowering by longleaf pine is closely associated with air temperature. In this study, heat sums above a threshold of 50 °F accumulated from January 1 accounted for nearly all the year-to-year variation in flowering date. The heat sum required for peak pollen shed declined with later flowering dates. Air temperatures in the immediate environment of the flowers were the principal determinant of the rate of flower development. Both male and female flowers developed concurrently and reached a peak at the same time. Seventy percent of the variation in heat sums preceding peak pollen shed resulted from tree-to-tree differences, which ranged from 11,300 to 16,100 degree-hours.

Though most trees in a stand will reach peak pollen shed within a period of several days, some trees consistently shed pollen early and others late-so much so that in most years there will be little, if any, overlap in pollen shed between early and late flowering trees within a stand. The heat requirements for flowering are apparently an inherent characteristic of individual trees.

#### Major Publications or Progress Reports

Boyer, W.D.; Woods, F.W. 1973. Date of pollen shedding by longleaf pine advanced by increased temperatures at strobili. Forest Science. 19(4): 315-318.

Boyer, William D. 1973. Air temperature, heat sums, and pollen shedding phenology of longleaf pine. Ecology. 54(2): 420-426.

Boyer, William D. 1974. Longleaf pine cone production related to pollen density. In: Kraus, John, ed. Proceedings of a colloquium on seed yield from southern pine seed orchards; 1974 April 2-3; Macon, GA. Macon, GA: Georgia Forest Research Council 8-14.

Boyer, William D. 1978. Heat accumulation: an easy way to anticipate the flowering of southern pines. Journal of Forestry. 76(1): 20-23.

Boyer, William D. 1981. Pollen production and dispersal as affected by seasonal temperature and rainfall patterns. In: Franklin, E. Carlyle, ed. Pollen management handbook. Agric. Handb. 587. Washington, DC: U.S. Department of Agriculture: 2-9.

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## GENETICS OF SOUTHERN PINES

### A Seed Source Study and Progeny Test of Select East Coast Loblolly Pines
**(See summary, p. 108.)**

Earlier seed source tests had demonstrated that loblolly pine (*Pinus taeda*) from the Atlantic coast outperforms local loblolly pine in southern Arkansas. Further testing was indicated, using the progeny of plus tree selections, which should give greater improvement than could be expected from trees of the "woods run" or nonselect seed sources that had been previously tested. A study was installed at two sites in Arkansas and one in Mississippi to test the performance of progeny of 38 open-pollinated plus tree seed orchard sources from coastal counties of North and South Carolina along with those of two woods-run sources from the same areas. Progeny of a woods-run source and a mixed seed lot from a plus tree seed orchard in southern Arkansas were also tested. The study design was a randomized block with 5 replications and 64 trees per plot (Grigsby 1973).

After 13 years, the Atlantic coast selections were outperforming the woods-run trees of Carolina or Arkansas origin as well as the Arkansas orchard trees in the Arkansas planting. After 11 years, the advantage of the coastal sources was not as apparent at the Mississippi site. These results substantiate the value of planting loblolly pine seeds from the Carolina Coastal Plain in southern Arkansas (Schmidtling 1987).

#### Major Publications or Progress Reports

Grigsby, H.C. 1973. A seed source and progeny test of select east coast loblolly pines in southern Arkansas. Gulfport, MS: U.S. Department of Agriculture,

Forest Service, Southern Forest Experiment Station. Study plan. 11 p. On file with: Southern Forest Experiment Station, 701 Loyola Avenue, Room T-10210, New Orleans, LA 70113.
Schmidtlng, Ronald C. 1987. A seed source and progeny test of select east coast loblolly pines in southern Arkansas. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 15 p. On file with: Southern Forest Experiment Station, 701 Loyola Avenue, Room T-10210, New Orleans, LA 70113.

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## Thirty-Six Seed Sources of Loblolly Pine Tested in Southern Arkansas
(See summary, p. 109.)

In a sizable provenance test in 1957, loblolly pine (*Pinus taeda*) was planted in southern Arkansas on lands of the Ozan and Fordyce Lumber Companies (now owned by Potlatch and Georgia Pacific Corporations). Since the first few years after planting, researchers at the USDA Forest Service's Southern Forest Experiment Station have collected and analyzed data from the plots, and personnel of the two companies have maintained the plantings. Thirty-six rangewide seed sources of loblolly pine are represented in each of eight blocks, four in Hempstead County, and four in Cleveland County. Each plot (36/block) contains 49 trees surrounded by 2 buffer rows. Spacing averages 6 by 7 ft in Hempstead County and 8 by 8 ft in Cleveland County (Wells and Lambeth 1983).

After 25 years, trees from some eastern seed sources of loblolly pine averaged 8 ft taller than local Arkansas trees. Trees from most of the range seemed well adapted to the climate of southern Arkansas, although those from near the gulf coast were poorly adapted. Damage from fusiform rust caused by *Cronartium quercuum* f. sp. *fusiforme* fungus was negligible, but the western trees were more resistant than those from eastern sources. Forest managers can weigh the considerable potential gain against possible risk when choosing seed sources for planting loblolly pine in southern Arkansas (Wells and Lambeth 1983).

### Major Publications or Progress Reports

Grigsby, H. C. 1977. A 16-year provenance test of loblolly pine in southern Arkansas. In: Proceedings, southern forest tree improvement conference; [Dates unknown]; Gainesville, FL. Gainesville, FL: [Publisher unknown]: [Pagination unknown].
Wells, 0.0.; Lambeth, C. C. 1983. Loblolly pine provenance test in southern Arkansas-25th year results. Southern Journal of Applied Forestry. 7(2): 71-75.

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## The Effects of Intensive Culture and Wood Quality on Growth and Yield of Longleaf, Slash, and Loblolly Pines
(See summary, p. 109.)

The majority of forest managers do not consider planting longleaf pine (*Pinus palustris*) because of its slow early growth rate compared to slash (*P. elliottii*) and loblolly (*P. taeda*) pines. However, many foresters believe that the long-term growth rate of longleaf pine is superior to that of the other two species. The present study was undertaken to compare the relative growth rates and yields of longleaf, slash, and loblolly pines in a 25-year-old intensive-culture experiment (Schmidtlng 1986).

One-year-old seedlings of the three species were bar-planted at 10- by 10-ft spacings in 1960. The design was a split-plot, randomized complete block with four replications. Each block consisted of 15 plots, with 5 plots each of the 3 pine species, and 100 trees per plot. A different cultural treatment was applied to each plot within the 5-plot areas for each species: cultivated but not fertilized, cultivated with 100 lb per acre of fertilizer, cultivated with 200 lb per acre of fertilizer, cultivated with 400 lb per acre of fertilizer, and control. After 9 years, all three species grew better on the fertilized plots, with loblolly pine benefiting the most and longleaf pine lagging far behind. After 25 years, the effects of intensive culture were still striking in all three species. The most important change was in relative performance of longleaf pine compared to slash and loblolly pines. Height of all three species was equal at the lowest fertilizer levels, but longleaf pine performed better than the other species at the highest levels of fertilizer. Thus, longleaf pine is apparently a desirable species to plant. It is naturally resistant to fusiform rust and southern pine beetles and is used for many forest products because of its high quality (Schmidtlng 1986).

### Major Publications or Progress Reports

Schmidtlng, R.C. 1984. Early intensive culture affects long-term growth of loblolly pine trees. Forest Science. 30(2): 491-498.
Schmidtlng, R.C. 1984. Species and cultural effects on soil chemistry in a southern pine plantation after 24 years. In: Proceedings, 3rd biennial southern silvicultural research conference; 1984 November 7-8; Atlanta, GA. Gen. Tech. Rep. SO-54. New Or-

leans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 573-577.
Schmidtlng, R.C. 1986. Relative performance of longleaf compared to loblolly and slash pines under different levels of intensive culture. In: Proceedings, 4th biennial southern silvicultural research conference; 1986 November 4-6; Jackson, MS. Gen. Tech. Rep. SE-42. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 395-400.
Schmidtlng, R.C.; Amburgey, T.L. 1977. Growth and wood qualty of slash pines after early cultivation and fertilzation. Wood Science. 9: 154-159.
Schmidtlng, Ronald C. 1973. Intensive culture increases growth without affecting wood qualty of young southern pines. Canadian Journal of Forest Research. 3: 565-573.
Wolters, Gale L.; Schmidtlng, Ronald C. 1975. Browse and herbage in intensively managed pine plantations. Journal of Wildlife Management. 39(3): 557-562.

**Yield, Stabilty, and Fusiform Rust Comparisons for Single and Multi-Family Blends of Slash Pine and Loblolly Pine (Includes studies 50-1401-4.1 through SO-1401-4.3; see summaries, p. 110-111.)**

Southern pine plantations are often establshed with seedlngs grown from seeds produced by seed orchards. Seed orchards are composed of ramets from many improved famiIes, and the seeds from all ramets are mixed together during collection. This process creates a complex blend of seeds from many different famiIes, with the proportion of seeds contributed by a given family determined by the family's current seed production in the orchard. This practice is not a rational deployment strategy but is done for convenience in seed collection and handlng. There is a need for deployment strategies based on some definable goal, such as minimizing the potential risk to seeds from diseases and pests. These mixing experiments were designed to provide forest managers with the kind of information needed to make decisions regarding the optimum deployment of improved trees (Nance 1984a, 1984b, 1984c).

A series of plantings of half-sib famiIes from commercial seed orchard clones was establshed, with famiIes of loblolly pine (*Pinus taeda*) mixed together in various proportions (Study SO-1401-4.1). The objectives of the study are to determine the yielding abilty of representative famiIes of loblolly pine in both pure and mixed family plots, to develop a working model for predicting the yields of mixed plots based on a knowledge of the yields of each family in pure plots, to compare the performance of row-plot mixtures with that of single random mixtures (blends) for mixtures of up to six famiIes, to develop, if possible, a working model to predict pure-plot and mixed-plot yields in large plots based on family performance in small row plots, and to compare the yield stabilty of pure versus mixed plots. Plantings were establshed in two locations: the Harrison Experimental Forest in Mississippi and on Crown Zellerbach land near Bogalusa, LA. There are 4 test plantations, each with 4 blocks and 30 test plots per block: 10 pure plots, 18 binary mixtures (9 mixtures, 2 proportions), 1 blend, and 1 row mix. Height and fusiform rust stem cankers caused by ***Cronartium quercuum*** f. sp. ***fusiforme*** fungus were measured after the 1st and 2nd growing seasons in the field, and height, stem cankers, d.b.h., and crown length were to be measured after the 3rd, 4th, 5th, 6th, 8th, 10th, and 12th growing seasons (Nance 1984b, 1984c).

A simiIar study (SO-1401-4.2) was establshed for slash pine (*P. elliottii*) in 1984. Two test plantations were establshed on the Harrison Experimental Forest. The first test spacing was 2 by 2 m, replcated three times, and the second test spacing was 2 by 1 m, replcated four times (Nance 1984c).

A third study in the series (SO-1401-4.31, designed to develop a strategy of seed deployment for pine seed orchards, was installed in the Ouachita Mountains of Oklahoma. North Carolna and Arkansas loblolly pines were planted in pure 100-tree plots in 3 different seed mixtures: 25 percent Arkansas-75 percent North Carolna, 50 percent Arkansas-50 percent North Carolna, and 75 percent Arkansas-25 percent North Carolna. Another objective of this study is to reduce the potential risk of using loblolly pine seeds from North Carolna in Arkansas (Nance 1984a).

**Major Publcations or Progress Reports**

Nance, Warren L. 1984a. Mixing eastern and western seed sources of loblolly pine in Oklahoma plantings. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 3 p. On file with: Southern Forest Experiment Station, 701 Loyola Avenue, Room T-10210, New Orleans, LA 70113.
Nance, Warren L. 1984b. Yield, stabilty, and fusiform rust comparisons for single and multi-family blends of loblolly pine. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 3 p. On file with: Southern Forest Experiment Station, 701 Loyola Avenue, Room T-10210, New Orleans, LA 70113.

Nance, Warren L. 1984c. Yield, stability, and fusiform rust comparisons for single and multi-family blends of slash pine. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 3 p. On file with: Southern Forest Experiment Station, 701 Loyola Avenue, Room T-10210, New Orleans, LA 70113.

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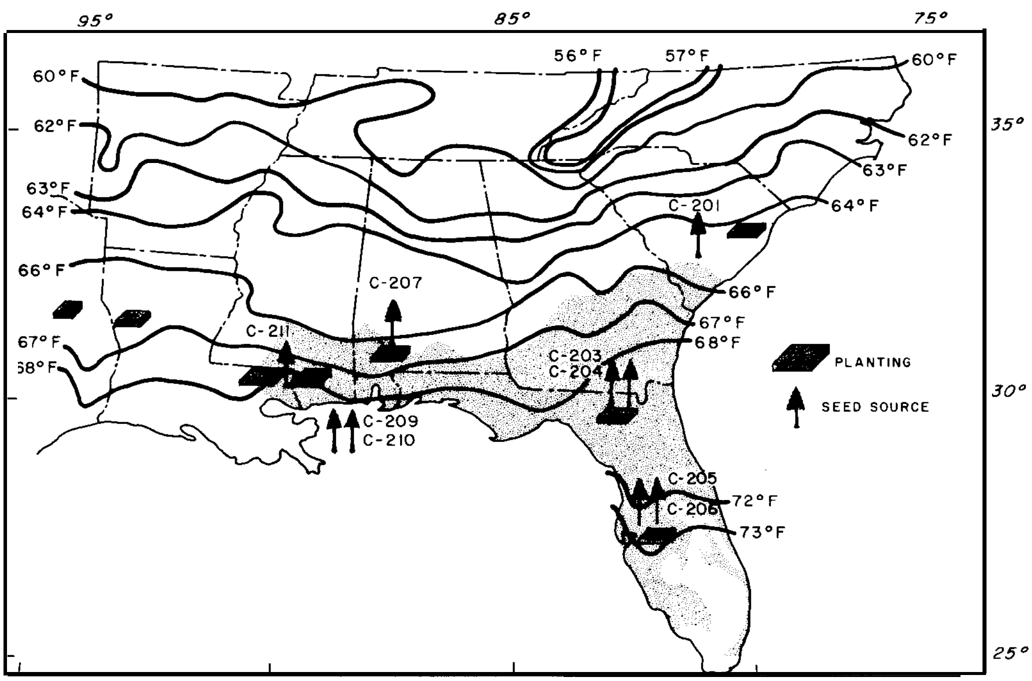
**Southwide Pine Seed Source Study**
**(See summaries, p. 111-113.)**

How far can southern pine seeds be planted from the orchard in which they were collected? Where is the best place to obtain seeds for planting at a specific site? When seed orchards are being established, what should be known about the geographic origin of the parent trees? There are several practical questions regarding southern pine seed sources for which answers have long been sought. Some provenance tests were established before 1950, but none sampled the entire range of a species, so the information from these studies was limited.

The Southwide Pine Seed Source (SPSS) study was proposed and undertaken at the First Southern Conference on Forest Tree Improvement in 1951. The study was sponsored by the southern forest tree improvement committee through its subcommittee on geographic sources of seeds. The species studied were longleaf pine (*Pinus palustris*), slash pine (*P. elliottii* var. *elliottii*), loblolly pine (*P. taeda*), and shortleaf pine (*P. echinata*). The objective of the SPSS study was to determine to what extent inherent geographic variation in the four pine species is associated with geographic variation in climate and physiography. The resulting information was intended for use in mapping the zones in which it is practical to move seeds from orchard to planting site (Committee on Southern Forest Tree Improvement 1956; Wells 1969).

The plantations for all four species were established in 1952-53 from seeds collected in 1951. The droughts of 1953 and 1954 depleted or destroyed many of the original longleaf and shortleaf plantations, so new plantations for those species were established in 1956-57 from seeds collected in 1955. The seed sources in a replacement plantation paralleled as closely as possible the source of the original plantation (Wells 1969).

In the SPSS slash pine study, there were six seed sources representing the northeastern and western extremities of the range and a more southerly portion of the range than was included in any earlier study (fig. 1). Nine plantations were established, from eastern Texas to southern North Carolina and from central Georgia to south Florida. Three plantations were located outside the range of slash pine (Koretz 1987). The study indicated that trees of the northeast Florida-south Georgia provenance do not survive planting quite as well as those from the western part of the species' range. There is also evidence that within the species' range, differences in growth rates are not due to geographic source of seeds. However, north of the range of slash pine, western trees outgrew eastern trees in some plantings. Thus, slash pine seeds from anywhere north and west of south-central Florida are suitable for planting within the natural range of the species. In the North or West or on adverse sites, north



and west provenances may be preferable. No geographic difference in rust resistance was found. The study suggests that within each provenance much more individual variation is present than is variation among populations. Hence, the traits of the individual parent trees may be more important than the geographic origin if climate or site is not adverse. Seeds from orchard trees, which have been rigorously selected, should be superior to wild stand seeds, regardless of location or site. Because many slash pine plantations were established with seeds of the northeast Florida-south Georgia provenance, plantations grown from seeds of even unknown geographic origin should be good sources of seeds for orchard trees (Snyder and others 1967).

The SPSS longleaf pine study included 15 seed sources representing the greater part of the species' range, with a noticeable gap between south Florida and central Georgia. Thirty-seven plantations were successfully established from southeastern Virginia to eastern Texas and from northeastern Alabama to the central gulf coast. The seed sources and plantings were grouped into six series designed to test specific hypotheses. In two series, seed sources from the east-west extremes of the range were evaluated, and in two other series, seed sources from the north-south extremes were evaluated. In the remaining two series, differences in soil properties were evaluated (Koretz 1987). Trees from southern Florida seeds performed poorly at all locations where those seeds had been planted, but trees from three central gulf coast seed sources performed well throughout the Coastal Plain. Figure 2 shows the zone within which trees from gulf coast seeds have performed better than those from other sources. West of central Louisiana, seeds from west of the Mississippi River performed better. There is no advantage in moving seeds north more than 4 °F of annual mean temperature, and there are various combinations of seed sources and plantings to be avoided. Genetic differences between sandhill and nonsandhill ecotypes were too small to be important (Wells and Wakeley 1970).

The SPSS loblolly pine study included 15 seed sources representing the major portion of the range. Eighteen plantations were established from eastern Maryland to east Texas and from central Arkansas and Tennessee to south Georgia and Louisiana. The seed sources were grouped into two series, with one series representing the major portion of the range and the other series being restricted to a mostly continental east-west transect from North Carolina to Arkansas. The study demonstrated that in most locations it is best to use local seeds, but there are some exceptions. In Tennessee, loblolly pine from the eastern part of the range performed considerably better than that from the adjoining Southern States. In areas where fusiform rust caused by ***Cronartium quercuum*** f. sp *fusiforme* fungus is a problem, rust-resistant loblolly

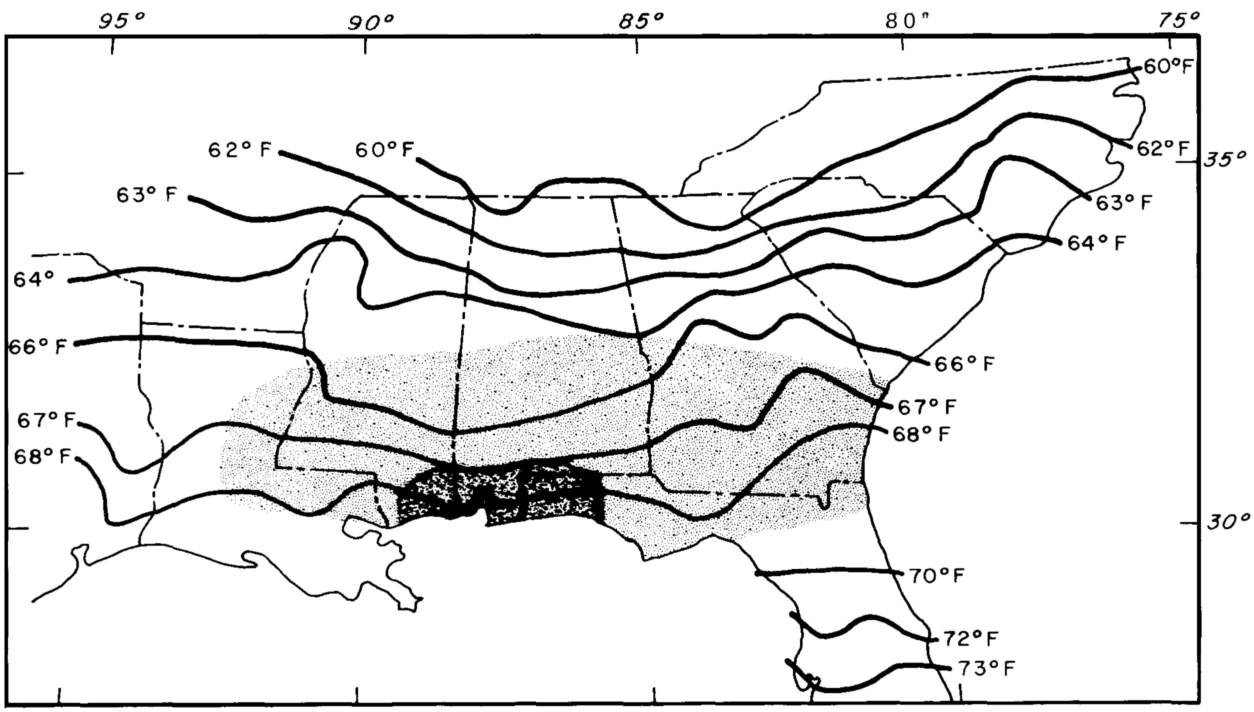



Figure 2.— ***The optimum seed collection area (hatched) for plantings of longleaf pine to be made within the stippled area. Isotherms of average annual temperature are shown (Wells and Wakeley 1970).***

pine from Livingston Parish, LA, performed better than loblolly pine from local seeds (Wells 1983). Since the 10th year data were published (Wells and Wakeley 1966), results of this study have been helpful to persons wanting to move seeds or planting stock. The later measurements confirm the trends observed in the earlier measurements (Wells 1983).

In the SPSS shortleaf pine study, seeds from 23 sources located throughout the species' range were planted at 40 locations. There were a latitudinal, a longitudinal, and an intermediate series of sources and plantings (Wells 1979). A map of seed collection and planting zones for shortleaf pine was prepared based on results of the study (fig. 3). The major findings of the study were as follows: east of the Mississippi River, trees from the seed sources farthest south tend to grow faster than those from northern sources as far north as northern Mississippi; trees from the most northern sources are far superior to those from near the northern edge of the natural range; and, in the center of the range, seeds can be moved freely on both sides of the Mississippi River (Wells 1979).

Although the adage "local seeds are best" has long been helpful to southern tree planters, the study indicated that, in some areas, considerable genetic gain can be realized by moving seeds fairly long distances. In other instances, especially near the northern limit of a species' range, no improvement over the local seeds seems possible (Wells 1969).

### Major Publications or Progress Reports

#### Southwide Pine Seed Source Study (SPSS)


Committee on Southern Forest Tree Improvement (Subcommittee on Geographic Source of Seed). 1952. Working plan for cooperative study of geographic sources of southern pine seed. 35 p.

Committee on Southern Forest Tree Improvement (Subcommittee on Geographic Source of Seed.) 1956. Supplement No. 1 to the original working plan of September 12, 1952, for the Southwide Pine Seed Source Study. 110 p.

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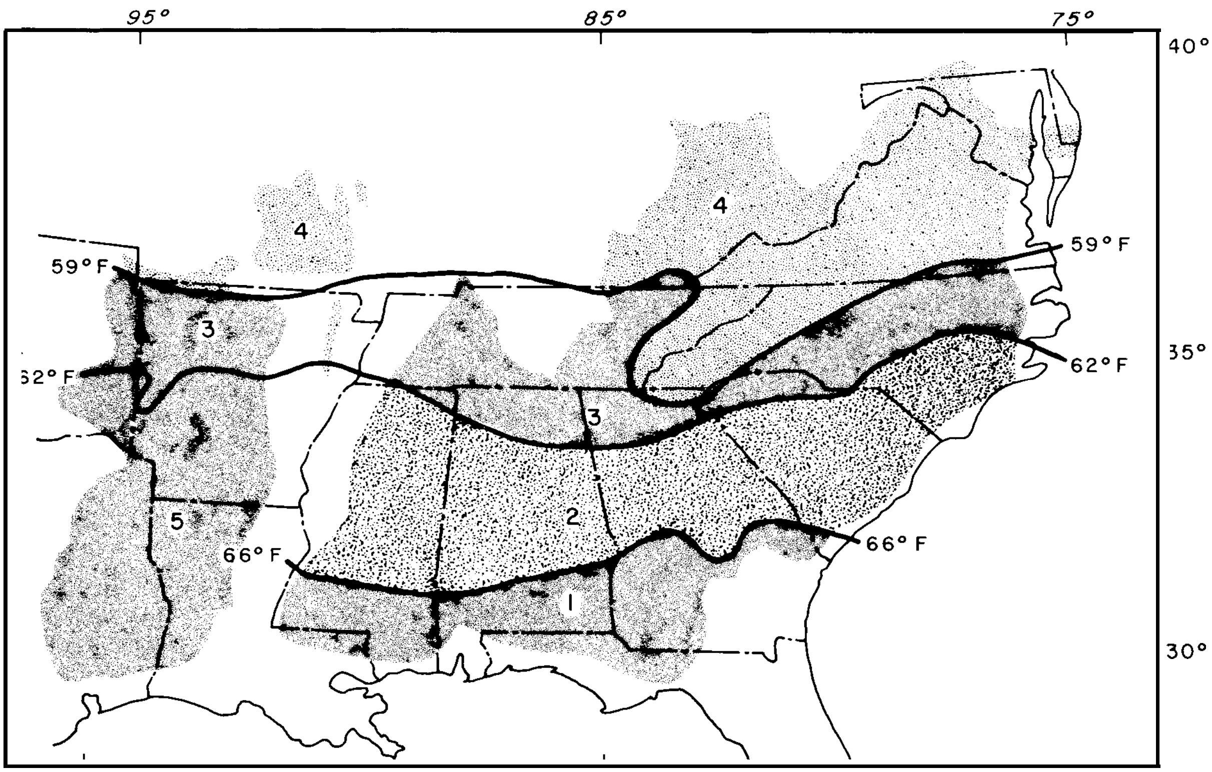


Figure 3.—*Seed collection and planting zones for shortleaf pine. Seeds for plantings in zones 1 or 2 should be collected in zones 1 or 5. Seeds for zone 5 should come from zone 5. Seeds for zone 3 can come from either zone 2 or 3 or the northern half of zone 5. Seeds for zone 4 and beyond should be collected in zone 4 (Wells and Wakeley 1970).*

3rd southern conference on forest tree improvement; [Location unknown]; [Dates unknown]; New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 49-54.

Henry, B.W.; Hepting, G.H. 1957. Pest occurrences in 35 of the Southwide Pine Seed Source Study plantations during the first three years. New Orleans, LA, and Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern and Southeastern Forest Experiment Stations: 7 p.

Koretz, J. 1987. Southwide Pine Seed Source Study. Unpub. Ms. On file with: RWU 4107, U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, New Orleans, LA.

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Wells, 0.0. 1969. Results of the Southwide Pine Seed Source Study through 1968-69. In: Proceedings, 10th southern conference on forest tree improvement; [Location unknown]; [Dates unknown]. [Place of publication unknown1: [Publisher unknown]:117–129.

Wells, 0.0. 1983. Southwide Pine Seed Source Study at 25 years. Southern Journal of Applied Forestry. 7(2): 63-71.

## SPSS-Loblolly Pine

Nance, W.L.; Wells, 0.0. 1981. Site index models for height growth of planted loblolly pine (*Pinus taeda* L.) seed sources. In: Proceedings, 10th southern conference on forest tree improvement; [Location unknown]; [Dates unknown]. [Place of publication unknown]: [Publisher unknown]: 86-96.

Wells, 0.0. 1983. Southwide Pine Seed Source Study—loblolly pine at 25 years. Southern Journal of Applied Forestry. 72(2): 63-70.

Wells, 0.0. 1985. Use of Livingston Parish, Louisiana loblolly pine by forest products industries in the Southeast. Southern Journal of Applied Forestry. 9(3): 180-185.

Wells, 0.0.; Wakeley, PC. 1966. Geographic variations in survival, growth, and fusiform-rust infection of planted loblolly pine. Forest Science Monograph. 11. 40 p.

## SPSS-Longleaf Pine

Wells, 0.0.; Wakeley, P.C. 1970. Variation in longleaf pine from several geographic sources. Forest Science. 16(1): 28-42.

## SPSS-Shortleaf Pine

Wells, 0.0. 1979. Geographic seed source affects performance of planted shortleaf pine. In: Proceedings, symposium on the management of pines of interior South; [Location unknown]; [Dates unknown]. [Place of publication unknown]: [Publisher unknown]: 48-57.

Wells, 0.0.; Wakeley, PC. 1970. Variation in shortleaf pine from several geographic sources. Forest Science. 16: 415-423.

## SPSS-Slash Pine

Snyder, E.B.; Wakeley, P.C.; Wells, 0.0. 1967. Slash Pine Provenance Tests. Journal of Forestry 65(6): 414–420.

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## Control Pollinating to Determine Efficient Methods of Breeding Longleaf Pine for Brown Spot Resistance (See summary, p. 113.)

The original study was initiated in 1978 by E.B. Snyder and A.G. Kais. It was based on previous genetic experiments conducted by Snyder and H.R. Derr. In particular, the study (SO-4153-3.10) was a wind-pollinated progeny test of more than 500 longleaf pine trees (*Pinus palustris*). Tests were established on the Harrison and Palustris Experimental Forests near Gulfport, MS, and Alexandria, LA, respectively. Most of the tested trees were native to and growing in the vicinity of Bogalusa, LA. Following extensive measurements and analyses of growth and diseases, the poorest trees were culled from the test plantings, thus producing first-generation-seedling seed orchards. Many questions were raised during the analyses about the correct or optimal procedures for culling as well as for selecting specific trees for breeding the next generation.

The following questions formed the motivation for the present study, which was installed in 1982-83. Where brown spot needle blight (caused by the fungus *Scirrhia acicola*) is a problem, should longleaf pine be bred for general or specific adaptiveness? Where brown spot is not a problem, should longleaf pine parents be selected with or without disease pressure? With or without disease pressure, do parents or offspring make better parents? Currently, all the data have been collected for this study, and efforts are underway to organize these data into a Statistical Analysis System (SAS) data library. When complete, the library will contain data from both generations of this longleaf pine breeding population. Quantitative genetic analyses will be made in hope of answering the proposed questions as well as others that have recently surfaced. Recent questions pertain more to the genetic control of the grass stage and how new molecular technologies may help eliminate this problematic characteristic from improved longleaf pine. Answers to these questions concerning breeding and genetic problems should allow researchers of the USDA Forest Service and other tree breeders to continue the genetic improvement of longleaf pine.

## WOOD PRODUCTS INSECT RESEARCH

### Evaluation of Chemicals used to Control Subterranean Termites (Includes studies SO-4502-4.102, 4.104, 4.105, 4.151 through 4.155, 4.158, 4.161, 4.163, 4.168, 4.173, 4.176, 4.177, and 4.603; (see summaries, p. 114-122.)

Subterranean termites are found in every State of the United States except Alaska, and drywood termites exist along the southern rim of the United States. Termites play an important role in forest ecology by recycling deadwood on the forest floor (fig. 4) and thereby

Figure 4.-A live elm tree infested with Formosan subterranean termites. Termites do not infest live trees in most parts of the United States.

enriching the soil (Haverty 1977). Most buildings in the United States are so constructed that termites can easily attack the wood (fig. 5) unless a termite preventive or control is used (Mauldin 1983). The USDA Forest Service Wood Products Insect Research Laboratory at Gulfport, MS, is the only laboratory in the Nation exclusively devoted to the study of insects that attack wood products (fig. 6) (Johnston 1967). Scientists at the laboratory have conducted many long-term studies to determine the effects of various chemicals used as soil treatment for control of termites (fig. 7). Because the studies and the methods used are so similar, they are combined here.

Studies of subterranean termite control were begun on the Harrison Experimental Forest in southern Mississippi during the late 1930's. Later studies were begun on sites in other States to determine the influence of soil type, climate, and termite species on the duration of protection (Johnston 1967). Aldrin, benzene hexachloride, chlordane, DDT, dieldrin, heptachlor, toxaphene, and other chemicals were tested shortly after being developed.

The standard board and stake methods were used in many of the experiments. In the board method, chemicals are sprinkled on the surface of a 17-inch$^2$ area that has been cleared of leaves and debris. After the chemicals have soaked into the soil, a 1- by 6- by 6-inch sap pine board is laid on the soil surface in the center of the treated area and weighted with a brick. Termites have to penetrate the treated soil to attack the board. Treatments are usually distributed in a randomized block design with 10 replications. Boards that decay are replaced with new ones.

Chemical treatments being evaluated by using the stake method also are distributed in a randomized block design with 10 replications. Three methods using stakes designed to simulate treatment around the foundation of buildings are used. In the first method, a hole 15 by 19 inches and 12 inches deep is dug, and the chemical is applied to the soil as it is being returned to the hole; after the soil is replaced, the stake is set. In the second method, after a hole 15 by 10 inches and 12 inches deep is dug, half the chemical is poured into the hole, the soil is replaced, and the stake is set; then the remaining chemical is applied at the soil surface. In the third method, four 12-inch-deep holes are made with a crowbar, equidistant from a stake, in a 2-ft sample area. The chemical is divided equally and applied to the four holes.

With the introduction of the organic phosphate, carbamate, and pyrethroid insecticides as termite controls, a modified ground-board technique, the concrete slab method, was introduced in 1967. Because of leaching or degradation in sunlight, these chemicals could not be fairly evaluated using the standard board and stake methods. These insecticides would be used under and around buildings in a protected environment

Figure 5.—*Severe subterranean termite damage underneath a large commercial building.*

Figure 6.-Japanese *pest control personnel visiting the **Gulfport** termiticide tests at the Harrison Experimental Forest.*

(Beal 1984). With the modified ground-board technique, leaves and debris are removed to expose soil in a 24-inch$^2$ area. A 21-inch$^2$ wooden frame is placed in the cleared area, and a trench 2 inches deep and 2 inches wide is dug inside and adjacent to the frame. The insecticides are applied over a 17-inch$^2$ area in the middle of the surrounding trench. A vapor barrier is placed over the treated area, and concrete is poured over the area to a depth of 1 inch and into the trench to form a simulated house slab, with a 1- by 4-inch-diameter plastic tube placed in the center of the treated area. The vapor barrier is later removed, and a sap pine block is placed in the tube, which is covered. The experiment is installed as a randomized block design, and each treatment is replicated 10 times.

Chemicals were mixed with fuel oil or water and tested at various concentrations. Study areas were visited annually or semiannually, and boards and stakes were carefully examined for termite attack. When 50 percent of the boards or stakes of a replication became damaged by termites, the treatment was considered a failure and closed.

The experiments demonstrated that some of the insecticides tested are highly effective against subterranean termites (Smith 1969). Some concentrations of some of the chlorinated hydrocarbons tested still gave 100-percent control after 20 years or more (Johnston and others 1971). The chlorinated hydrocarbons aldrin, chlordane, dieldrin, and heptachlor were very effective in the studies in southern Mississippi and at the nationwide sites. More recently, other chemicals have also proven effective for termite control in Mississippi and at other nationwide test sites (Mauldin and others 1987a, 1987b).

### Major Publications or Progress Reports


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Anon. 1984. Gulfport searches for new termite technology. Pest Control 52: 20-24. (This article was written by Roger Standly of Morgan & Myers Public Relations firm with information furnished to him by all the scientists in RWU-4502.)

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Figure 7.—*Gulfport employee Janet Terry screening potential termiticides in the laboratory*

meeting of the International Research Group on Wood Preservation-working group Ib: Biological Problems; 1986 May 26-30; Avignon, France. Stockholm, Sweden: IRG Secretariat; Document IRG/WP/1294. 9 p.

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**Evaluation of Selected Insecticides as Soil Treatments for Control of *Coptotermes formosanus* Shirake, the Formosan Subterranean Termite, on Midway Island (See summary, p. 122.)**

Although the Formosan subterranean termite, ***Coptotermes formosanus,*** is one of the most destructive species of termites in the world, currently recommended insecticides have not been evaluated against field colonies of this species. Field studies of other termite species in Panama indicate that increased rates of insecticide are needed in a tropical environment.

In 1981, a study was installed on Sand Island on Midway Atoll near the western end of the leeward Hawaiian Islands to determine the effectiveness of various insecticide formulations applied to soil to prevent penetration of the Formosan subterranean termite through soils (fig. 8). Chlordane, chlordane-heptachlor combination, Dursban, Ectiban, heptachlor, N-2596, Oftanol, Pounce, and Tiovel were applied to the soil in concentrations varying from 62 to 1,000 p/m. A modified stake test method was used, with 10 replications per treatment randomly distributed over the experimental area. (See termiticide studies in the United States at the beginning of this section.) When termites penetrated the treated soil in 50 percent of a particular treatment, it was considered a failure.

In 1989, chlordane, heptachlor, and Termide applied to the soil at 250, 500, and 1,000 p/m and aldrin applied at 250 and 500 p/m remained 100 percent effective. Termite attack of wood in both untreated control plots and termiticide-treated plots had increased since the last annual examination. Twelve treatments were closed because the soil in five or more replications was penetrated by termites.

### Major Publications or Progress Reports

Mauldin, Joe K.; Jones, Susan C.; Beal, Raymond H. 1987. Soil termiticides: a review of efficacy data from field tests. In: Proceedings, 18th annual meeting of the International Research Group on Wood Preservation-working group Ib: Biological Problems; 1987 May 17-22; Honey Harbor, Canada. Stockholm, Sweden: IRG Secretariat; Document IRG/WP/1323. 20 p.

### Testing of Insecticides for Use as Soil Treatments for the Control of Subterranean Termites-Republic of Panama (See summary, p. 123.)

The gradual curtailment of the production of chlorinated hydrocarbons for the control of subterranean termites in the United States has made necessary the evaluation of other insecticides. Insecticides that have successfully killed or repelled termites in laboratory tests must be evaluated in the field before they can be considered effective controls. Some of these insecticides have been installed in field tests in Chiva Chiva, Panama, on lands controlled by the U.S. Army Tropic Test Center.

The objective of this study is to determine the effectiveness of various formulations of insecticides (two formulations of Dursban, [M-4504 and M-4548], six concentrations of Pydrin and Ectiban, five concentrations of Oftanol, and three concentrations of Termide) when applied to the soil to prevent penetration of sub-

Figure 8.—*A view of a typical termiticide field test.*

terranean termites through the soils in this tropical area. Oftanol was tested by the standard concrete-slab method and Termide by the standard ground-board method. (See termiticide studies in the United States at beginning of this section.) Dursban M-4504, Dursban M-4548, Ectiban, and Pydrin were tested by the concrete-slab and ground-board methods. Ten replications of each treatment were distributed over the study area in a randomized fashion. Inspections were made annually. When treated soil in 5 of the 10 replications was penetrated by termites, the treatment was considered a failure.

In 1985, termites were very active, and 24 treatments had been attacked by termites (*Heterotermes* spp. and *Coptotermes* spp.). The only treatments that were 100 percent effective were 0.25 percent chlordane under the concrete slab; 1.0 percent chlordane in both methods; and 0.125, 0.50, and 1.0 percent Termide in the ground-board method. By 1987, the effectiveness of 0.125 percent Termide in the ground-board method and 0.25 percent chlordane in the concrete-slab method had been reduced to 70- and 90-percent control, respectively.

### Major Publications or Progress Reports


Kard, Bradford M.; Mauldin, Joe M.; Jones, Susan C. 1989. Evaluation of soil termiticides for control of subterranean termites. Sociobiology. 15(3): 285-297.

Mauldin, Joe K.; Jones, Susan C.; Beal, Raymond H. 1987. Soil termiticides: a review of efficacy data from field tests. In: Proceedings, 18th annual meeting of the International Research Group on Wood Preservation-working group Ib: Biological Problems; 1987 May 17-22; Honey Harbor, Canada. Stockholm, Sweden: IRG Secretariat; Document NO. IRG/WP/1323.20 p.


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### Isolation, Characterization, and Identification of Biologically Active Components from Termite-Resistant Woods 1978 (See summary, p. 123.)

Researchers in this study are investigating extractive components of woods that contain substances detrimental to subterranean termites. Biologically active compounds obtained from woods naturally resistant to termite attack may be useful in the development of new types of wood preservatives to replace currently used termiticides whose toxicity and environmental effects are in question. The chemical constituent responsible for the resistance of wood may act as a repellent or be distasteful to termites but is not toxic to the insects. Chemical characterization of the extractives would be valuable because some extractives or synthesized compounds with similar structures could be used to protect susceptible wood from termite attack.

The overall objective of this study is to obtain information on the feasibility of preventing termite damage by choosing naturally resistant woods or using extractive constituents of the woods as wood preservatives. The specific objectives are to fractionate, isolate, characterize, and identify the extraneous components of the wood extracts that are detrimental to the termites. A limited number of native and tropical wood species were selected for detailed investigation of their extractive components. The antitermitic properties tested include toxicity, repellency, antifeedant, and antiprotozoan characteristics.

Components of the wood extracts are separated for bioassay and identification by column or thin-layer chromatography. A 1-mL aliquot of the test solution (extract, fraction, or isolate) is applied to absorbent paper, and the paper is put in a container with 25 termites. Condition of the termites is checked at 24 and 72 hours and biweekly for 4 weeks. The test solution is considered as toxic if the termites die in less than 10 days, as possibly a stomach poison if the termites die between 7 and 14 days, and as possibly a repellent, antiprotozoan, or antifeedant material if the termites die between 2.5 and 4 weeks. If the termites have eaten the test sample, the antifeedant property is ruled out.

### Major Publications or Progress Reports


Adams, R.P.; McDaniel, C.A.; Carter, F.L. 1988. Termiticidal activities in the heartwood, bark/sapwood and leaves of *Juniper-us* species from the United States. Biochemical Systematics and Ecology. 16(5): 453-456.

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Carter, Fairie Lyn; Beal, Raymond H. 1982. Termite responses to susceptible pine wood treated with antitermitic extracts. International Journal of Wood Preservation. 2(4): 185-191.

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Carter, Fairie Lyn; Mauldin, Joe K. 1981. Responses of *Reticulitermes flavipes* to extracts from nine antitermitic hardwoods. Material and Organismen. 16(3): 175-188.

Jones, Susan C.; Carter, Fairie Lyn; Mauldin, Joe K. 1983. *Reticulitermes flavipes* (Kollar) (Isoptera: Rhinotermitidae) responses to extracts from six Brazilian woods. Environmental Entomology 12(2): 458-462.

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**Evaluation of Chemicals Used as Soil Treatments for Control of Subterranean Termites-Panama Canal Zone**
**(See summary, p. 124.)**

Since construction of the Panama Canal in the early 1900's, subterranean termites have damaged the canal facilities and nearby military installations. In 1943 and 1946, tests began on Barro Colorado Island, Panama, to determine the effectiveness of various chemical formulations for use as soil treatment for control of subterranean termites and to evaluate many chemicals in a tropical environment. During 1952-53, the termite control studies were expanded in the Cunmdu Jungle at Fort Clayton, Panama, and in 1963, more tests were installed nearby (fig. 9) (Beal 1981).

Two standard field test procedures were used to evaluate the effectiveness of various chemical treatments, the standard stake method and the standard ground-board method. Each concentration of each chemical was replicated 10 times in a randomized complete block. The stake or board was southern pine or some other termite-susceptible wood that was inspected annually to determine if termites had penetrated the treated soil. The treatment was considered a failure when termites had penetrated the soil in 5 of the 10 replications. Materials tested included aldrin, benzene hexachloride, copper ammonium fluoride, chlordane, DDT (various concentrations and formulations), dieldrin, heptachlor, pentachlorophenol, sodium

Figure 9.—*Gulfport employees Nelly Rich and Eldon Mallette preparing a test plot for evaluation of potential termiticides.*

arsenite, sodium fluorosilicate, and trichlorobenzene (Beal 1981).

Dieldrin (1.0 percent) applied to the soil as a water emulsion was still 100 percent effective 27 years later when the study was closed. Aldrin, chlordane, and heptachlor were still 100 percent effective when the tests were terminated after 16 years (Beal 1981).

### Major Publications or Progress Reports

Beal, Raymond H. 1981. Termite control studies in Panama. Res. Note SO-280. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 6 p.

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## DISEASES OF SOUTHERN PINES

### Lab and Field Testing for Growth and Brown-Spot Resistance of Longleaf Pine Progeny (See summary, p. 124.)

A recently developed inoculation technique can be used to screen longleaf pine (*Pinus palustris)* for resistance to brown-spot needle blight caused by the fungus *Scirrhia acicola*. Employing this technique could reduce the time necessary for field testing from 4 years to 1 year or less. Although laboratory screening cannot replace field testing, it can be used for preliminary screening and can reduce the scope of field testing. This would bring about reduced costs for progeny testing and could expedite the detection and release of promising longleaf selections. A study was begun in 1976 to test, evaluate, and correlate the laboratory and field techniques used to detect resistance to brown spot in longleaf pine and to evaluate the growth of and resistance to this disease in promising longleaf parents and their progeny for use in future breeding programs (Kais 1976).

After 5 years in the field, 30 open-pollinated families of longleaf pine were evaluated for survival, resistance to brown spot, and growth. The groups included 5 resistant families previously tested and 25 untested families. The field design consisted of a split plot with whole plots (families) replicated five times. Families were represented by 2 rows of 10 seedlings each in each block. One-half of the seedlings had been pruned of all inoculated fascicled needle tissue at the time of outplanting (Kais and Bey 1982).

The correlation coefficient between greenhouse infection and infection following outplanting was 0.641. Families with the highest infection in the greenhouse tended to be highest in the field, and those with the lowest infection in the greenhouse were lowest in the field. After 5 years, family survival ranged from a low of 38.0 percent to a high of 92.0 percent, with an overall mean of 65.2 percent. Infection by brown spot ranged from a low of 34.7 percent to a high of 80.4 percent, with an overall mean of 57.4 percent. Growth of the progeny was generally slow. Root-collar diameters ranged from 1.67 to 3.72 cm, with an overall mean of 2.25 cm, and only 51.3 percent of the seedlings had begun rapid height growth. The study confirmed the disease resistance of the 5 previously tested families and demonstrated that 5 of the 25 previously untested families were superior in disease resistance and growth capability. The study closed in 1982, but the families will continue to be monitored for disease resistance and exceptional growth selection (Kais and Bey 1982).

### Major Publications or Progress Reports

Kais, A.G. 1976. Lab and field testing for growth and brown-spot resistance of longleaf pine progeny. Study plan SO-2208-10.20. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 7 p.

Kais, A.G.; Bey, C.F. 1982. Lab and field testing for growth and brown-spot resistance of longleaf pine progeny. Study plan SO-2208-10.20. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 12 p.

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### Control of Brown-Spot Needle Blight on Outplanted Longleaf Pine Seedlings by Stimulation of Rapid Height Growth (Study SO-2208-10.26; see summary, p. 125.)

Longleaf pine (*Pinus palustris*) seedlings go through a period of root and foliar development referred to as the "grass stage." Young needles of plants in the grass stage are easily infected by the fungus *Scirrhia acicola*, which causes brown-spot needle blight disease. This disease delays growth, promotes further infection, and may kill the seedling. Once the seedlings begin height growth, the effects of the disease diminish rapidly, so silvicultural techniques that permit the initiation of rapid height growth by seedlings would be valuable. Four factors (or combinations of these factors) that affect the early rapid height growth of outplanted longleaf pine seedlings are seedling size, brown-spot needle blight, weed control, and nutrition (Kais 1979).

To study the effects of these four factors and the interaction among them on the growth of longleaf pine, two field tests were established. Both experiments were set up as a $2^4$ factorial with a randomized complete block design with five blocks. The variables measured included survival, percentage of infection, diameter growth, and height growth (Kais 1979).

Benomyl root-dip treatments provided significant control of needle blight (fig. 10). Once the disease was under control, fertilization was the most important single factor in the stimulation of growth. However, fertilization along with herbicide treatment provided significantly greater increases in growth. In one test, 76 to 85 percent of the seedlings were in active height growth (greater than 10 cm) after the second year, and in another test, 90 to 98 percent of the seedlings were in active growth after the second year. Survival and mean stem length of seedlings were also significantly increased by the combined fertilizer-herbicide treatment along with brown-spot control. Plot volume index (a value combining survival and growth) was significantly affected by the combined fertilizer-herbicide treatment (Kais 1984).

### Major Publications or Progress Reports


Kais, A.G. 1979. Control of brown-spot needle blight on outplanted longleaf pine seedlings by stimulation of rapid height growth. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan SO-2208-10.26. 9 p.

Kais, A.G. 1984. Control of brown-spot needle blight on outplanted longleaf pine seedlings by stimulation of rapid height growth. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Final Report SO-2208-10.26. 32 p.

Kais, Albert G.; Cordell, Charles E.; Affeltranger, Charles E. 1986. Nursery application of benomyl fungicide for field control of brown-spot needle blight (*Scirrhia acicola* (Dearn.) Sigg.) on longleaf pine (*Pinus palustris* Mill). Tree Planters' Notes. 37(1): 5.


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### The Effect of a *Pisolithus* Ectomycorrhizal Root-Dip Treatment on the Survival and Growth of Brown-Spot Infection in Select Longleaf Pine Families (See summary, p. 125.)

*Pisolithus tinctorius* (*Pt*) ectomycorrhizae have been shown to stimulate both the survival and growth of

Figure 10.—*Three-year-old longleafpines. The row on the right was treated with benomyl to control brown spot needle blight.*

longleaf pine (*Pinus palustris*) seedlings. Several questions have arisen because of this finding. Do select individual families from cross-pollination studies differ in their inherent ability to be infected with the ectomycorrhizae of *Pt*? Can a dip treatment at the time of outplanting infect longleaf pine seedlings more effectively than *Pt* inoculation of seedlings while they are growing in nursery beds? How long will *Pt* ectomycorrhizae persist on inoculated seedlings in both the nursery bed and in the field? A study was conducted to provide answers to these questions. Objectives of the study were: to evaluate different longleaf pine families for susceptibility to infection by ectomycorrhizae of *Pt;* to evaluate the effects of *Pt* ectomycorrhizae on the survival and growth of, and infection by, brown spot needle blight in the different longleaf pine families; to evaluate a *Pt* dipping method for the inoculation of longleaf pine with ectomycorrhizae; and to determine the persistence of *Pt* ectomycorrhizae on longleaf pine seedlings (Kais and others 1983).

Two field tests involving 15 longleaf pine families were evaluated. Both of the tests were designed as split plots. Test 1, with bare-root seedlings, had 4 blocks; and test 2, with seedlings grown in tubes, had 20 blocks. Paired seedlings were dip-treated with either a *Pt* ectomycorrhizae slurry or plain water before being set out. Longleaf pine seedlings were successfully inoculated with *Pt* ectomycorrhizae in the nursery seedbed. The *Pt* ectomycorrhizae persisted on infected seedlings after planting in the field. Machine-planted seedlings proved to be superior to hand-planted seedlings in survival and growth and in retention and persistence of ectomycorrhizae on the seedlings (Kais and others 1986a, 1986b).

### Major Publications or Progress Reports


Kais, A.G.; Cordell, C.E.; Affeltranger, C.E. 1983. The effect of a *Pisolithus* ectomycorrhizal root-dip treatment on the survival, growth, and brown-spot infection of select longleaf pine families. Study plan. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 5 p.

Kais, A.G.; Cordell, C.E.; Affeltranger, C.E. 1986a. Benomyl root treatment controls brown-spot disease on longleaf pine in the Southern United States. Forest Science. 32(2): 506-511.

Kais, A.G.; Cordell, C.E.; Affeltranger, C.E. 1986b. The effect of a *Pisolithus* ectomycorrhizal root dip treatment on the survival, growth, and brown-spot infection of select longleaf pine families. Final report. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 24 p.

Kais, Albert G.; Snow, Glenn A.; Marx, Donald H. 1981. The effects of benomyl and *Pisolithus tinctorius* ectomycorrhizae on survival and growth of longleaf pine seedlings. Southern Journal of Applied Forestry. 5(4): 189-195.


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### Forest-Site Evaluation of Fusiform Rust in Mississippi (See summary, p. 126.)

Fusiform rust, caused by the fungus *Cronartium quercuum*, is a serious management problem in southern forests. It is especially harmful to slash pine (*Pinus elliottii*) and loblolly pine (*P. taeda*). To study conditions affecting the incidence of fusiform rust, nine plantations of slash pine were established in 1974 in Hancock, Harrison, and Jackson Counties in coastal Mississippi. The study areas were selected to represent a wide range of potential site hazards conducive to the development and spread of fusiform rust. Seedlings were hand planted in 25 rows, with 30 trees per row. Seedlings from one of three seed sources were planted in each row, with seven replications of each seed source. The variables studied included climate; seed source; soil properties; pine growth; fungus and host phenology, including year of origin of gall, year of discovery of gall, height of gall above ground, distance of branch galls from the stem, fate (year of gall death, tree death, and year that branch galls spread into the main stem), abundance of aeciospore-producing galls and telia, and number of basidiospores trapped; and the spatial relationships of oaks to the plantations (Froelich and Snow 1986).

The amount of fusiform rust infection varied considerably by year from 1974 through 1978 (fig. 11), depending on frequency of rain or nights with prolonged high relative humidity. Large but inconsistent differences were recorded in annual infection among sites due to a combination of factors. Apparently, climate, seed source, soil properties, and pine growth were not related to site hazard in this study. The major controlling factors for hazard in each area were the relationships of oaks to the pine plantation, including how near the oaks were to, and, in which direction the oaks were from, the plantation and the total number of oaks (Froelich and Snow 1986).

### Major Publications or Progress Reports


Froelich, R.C.; Nance, W.L.; Snow, G.A. 1983. Size and growth of planted slash pines infected with fusiform rust. Forest Science. 29: 527-534.

Froelich, R.C.; Snow, G.A. 1986. Predicting site hazard to fusiform rust. Forest Science. 32(1): 21-35..

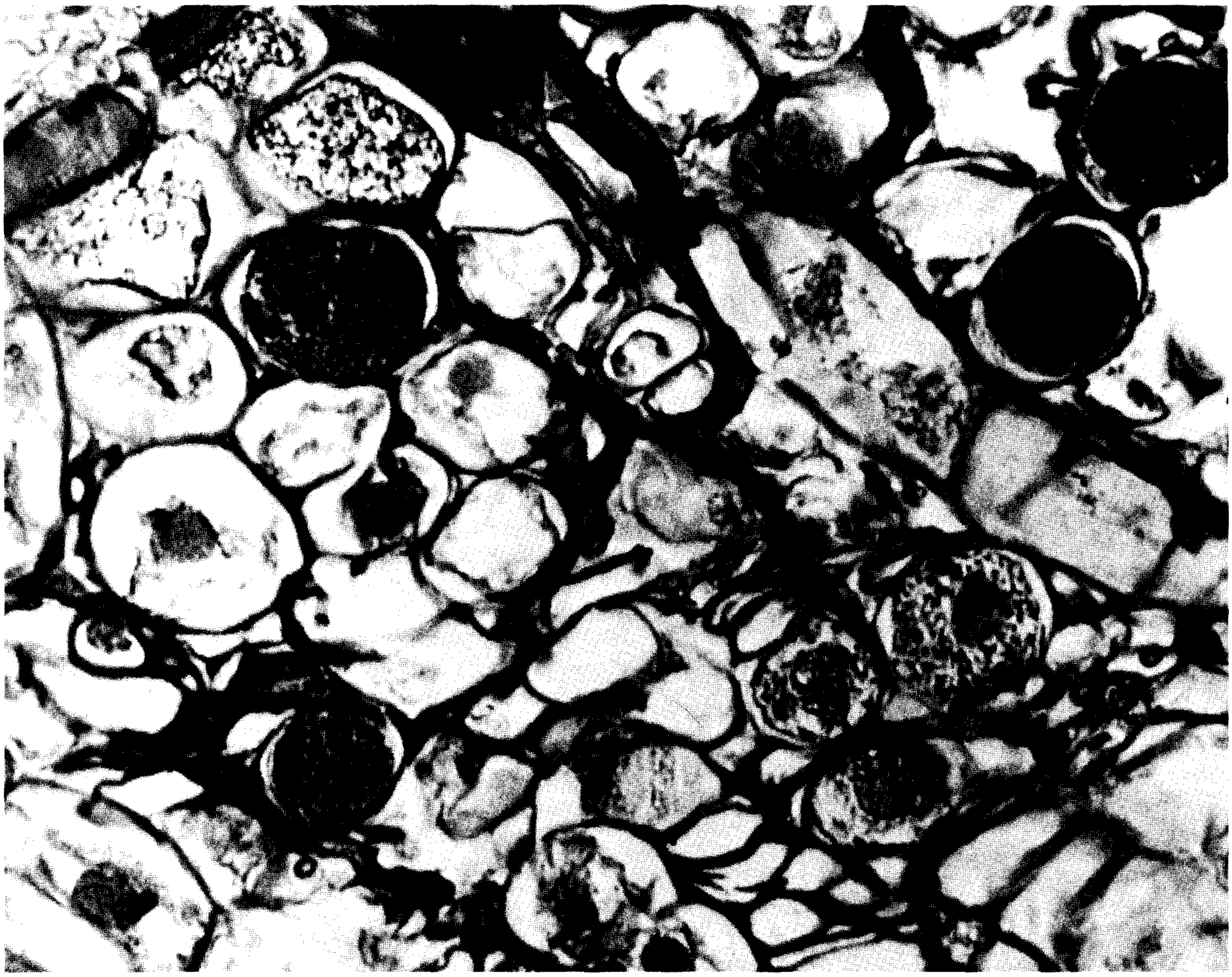

Figure 11.— *Magnification of fusiform rust fungus in a pine gall.*

**Reaction of Loblolly Pine Diallel Families to Cultures of Fusiform Rust**
**(See summary, p. 126.)**

Loblolly pine (*Pinus taeda*) seeds from certain geographic seed sources are resistant to fusiform rust caused by the fungus, *Cronartium quercuum* f. sp. *fusiforme*. Livingston Parish, LA, is an important source for rust-resistant loblolly pine seeds, and trees grown from these seeds perform well throughout much of the southern pine region. However, seedlings grown from bulk seed collections vary in susceptibility to different sources of fusiform rust inocula. Thus, a need existed to evaluate potential breeding stock from the Livingston Parish area with an array of different inocula to identify and maintain adequate genetic resistance (Snow and others 1982).

In this study, seedlings of 43 control-pollinated pine families were inoculated with 5 sources of fusiform rust. The seedlings were grown from seeds produced in a diallel crossing experiment with 10 loblolly pines in Livingston Parish. The percentage of trees with galls and the form of galls on infected trees were assessed. Differences in pine families, inocula, and the interaction of pine families with inocula were identified. The most accurate separation of inocula was achieved with gall form. The variable response of full-sib pine families to different inocula underscores the need to evaluate potential breeding stock with different rust inocula. Progeny from some parents were rather stable in response to the various sources of inocula. These trees may be valuable as testers in future breeding programs (Snow and others 1982).

The original trees of this study are being maintained as "grafts" on the Harrison Experimental Forest in southern Mississippi. All are considered valuable for future genetic studies and as sources of rust-resistant and rust-susceptible material for tree breeding.

### Major Publications or Progress Reports


Snow, G.A.; Nance, W.L.; Snyder, E.B. 1982. Relative virulence of *Cronartium quercuum* f. sp. *fusiforme* on loblolly pine from Livingston Parish. In: Heybroek, H.M.; Stephan, B.R.; von Weissenberg, K., eds. Resistance to diseases and pests in forest trees: Proceedings of the third international workshop on the genetics of host-parasite interactions in forestry; 1980 September 14-21; Wageningen, the Netherlands. Wageningen: Centre for Agricultural Publishing and Documentation: 243-250.

Snow, Glenn A. 1985. A view of resistance to fusiform rust in loblolly pine. In: Goyer, Richard A.; Jones, John P., eds. Insects and diseases of southern forests: 34th annual forestry symposium; 1985 March 26-27; Baton Rouge, LA. Baton Rouge, LA: Louisiana Agricultural Experiment Station: 47-51.


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## Determining the Virulence of *Cronartium quercuum fusiforme* on Loblolly Pine Plantations in and Near Madison County, Florida (See summary, p. 127.)

Loblolly pine (*Pinus taeda*) seed sources in Livingston Parish, LA, have shown a high level of resistance to *Cronartium quercuum* f. sp. *fusiforme*, which causes fusiform rust, at many locations in the Southeastern United States. An exception to this finding was recently observed in a research study in Madison County, FL, where Livingston Parish trees were very susceptible to the fusiform rust fungus.

The purpose of the current work is to determine if the fusiform rust population is more virulent to Livingston Parish stock in the Madison County area than it is to stock in other areas. Six separate field plantings of loblolly pines representing several seed sources were established in northern Florida. In the fifth growing season, the trees had moderate to high rust infection.

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## Screening of Rust-Free Slash Pine Trees in Intensively Cultured Plantations for Resistance to Fusiform Rust (See summary, p. 127.)

Experimental trees in a study of the effects of weeding, drainage, irrigation, and fertilization on the growth of slash pine (*Pinus elliottii*) in central Louisiana became heavily infected with fusiform rust, which is caused by the fungus *Cronartium quercuum*. By the end of the sixth growing season, 67 to 96 percent of trees on individual plots were infected. Because rust-free trees in these plots are likely to produce rust-free progeny, a study was carried out to determine the relative resistance of selected individuals from the study to fusiform rust and to preserve the germ plasm of at least 20 individuals of good form and growth rate that show a high degree of resistance to fusiform rust when screened at the USDA Forest Service's Forest Pest Management Resistance Screening Center at Harrison Experimental Forest, MS (Shoulders and Snow 1988).

In 1983, 20 rust-free trees with good form and growth rate were selected to be cloned; 1 or more successful grafts have been obtained from 19 of the trees. Progeny from these and other disease-free trees will be tested, and parent trees with good potential for transmitting fusiform rust resistance to their progeny will be protected as a source of seeds and scions. In 1986, wind-pollinated seeds were collected from 18 trees, including 6 trees that had been cloned, 10 trees with rust-free boles, and 2 trees that had stem galls. A composite sample of seeds was also collected, including seeds from 2 cones of each of 20 individuals. In a routine screening for rust resistance, six seedlings from six of these seed lots were superior to those in the resistant slash pine check at the Forest Pest Management's Resistance Screening Center in both resistance index and percentage of galled trees (Shoulders and Snow 1988).

### Major Publications or Progress Reports


Shoulders, Eugene; Snow, Glenn A. 1988. Screening of rust-free slash pine trees in intensively cultured plantations for resistance to fusiform rust. Study plan and establishment record. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 44 p.


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## The Effects of Benomyl on Genetically Improved Longleaf Pine (See summary, p. 128.)

Notable early height growth and control of brown-spot needle blight caused by the fungus *Scirrhia acicola* have been obtained on longleaf pine (*Pinus palustris*) seedlings in the field following treatment with benomyl. Also, control-pollinated tests of elite x elite longleaf pine trees have yielded superior progeny. These results suggest that the use of benomyl and genetically superior seed sources could result in significant gains in the survival and growth of longleaf pine. A study was conducted to determine if benomyl is equally effective on 69 families of longleaf pine having various levels of resistance to brown-spot needle blight. Effectiveness of the fungicide was evaluated on the basis of brown-spot infection and growth differences between treated and untreated seedlings (Lott and others 1982).

Longleaf pine seedlings in two different tests (A and B) were treated with benomyl or a clay control and then planted at the Harrison Experimental Forest in southern Mississippi in 1982. Test A consists of 40 wind-pollinated families, and test B consists of 24 cross-pollinated and 5 wind-pollinated families. Both tests have a paired plot design with five blocks of their respective families, two treatments per family, and eight seedlings in each row plot.

Height growth, survival, and infection were recorded after growth in 1982, 1983, and 1984. Significant differences in growth were noted for test A families after 14 months, and significant differences in brown spot infection were noted for test B families after greenhouse inoculations (Lott and others 1982). The mean survival was 88.7 percent for benomyl-treated seedlings and 73.9 percent for untreated seedlings. The mean brown-spot infection rate was 16.4 percent for treated seedlings and 67.6 percent for untreated seedlings. Mean stem length was 17.9 cm for treated families and 9.3 cm for untreated families. In addition, 50.5 percent of seedlings from treated families had begun height growth, but only 22.1 percent of those in untreated families had (Kais and others 1984).

The severe infection encountered in these tests has emphasized the efficacy of benomyl for field control of brown-spot needle blight of longleaf pine and has confirmed the inverse relationship of brown-spot needle blight to the survival and subsequent growth of the species (Kais and others 1984).

### Major Publications or Progress Reports

Kais, Albert G.; Lott, Larry H.; Hamaker, J.M.; Griggs, M.M. 1984. The effects of benomyl on genetically improved longleaf pine. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 15 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Lott, Larry H.; Hamaker, James M.; Kais, Albert G.; Bey, Calvin F. 1982. The effects of benomyl on genetically improved longleaf pine. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Establishment record and progress report. 14 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

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### Control of Brown-Spot Needle Blight on Longleaf Pine Seedlings by Benlate Root-Dip Fungicidal Treatment (See summary, p. 128.)

Longleaf pine (*Pinus palustris*) seedlings are very susceptible to brown-spot needle blight, caused by the fungus *Scirrhia acicola*, during the first 3 years after planting in the field. Infection during this time can inhibit growth for 10 years or more or kill the seedlings. When height growth begins, the seedlings become resistant to further infection. Consequently, control of the disease during the first 3 years after planting is very important. Soil-drench and root-dip treatments with Benlate (benomyl) have controlled brown-spot needle blight on longleaf pine seedlings in the field. Apparently, the fungicide is translocated systemically within the seedlings, thus preventing infection. Application of the fungicide to seedlings before planting is feasible, practical, and environmentally safe (Kais and others 1978).

The objectives of this study were to test the effectiveness of Benlate root-dip fungicidal treatment for the control of brown-spot needle blight over a wide geographic area in five Southern States, to determine the optimal dosage rate of the fungicide and to determine the duration of effective control Seedlings obtained from nurseries in Alabama, Florida, Georgia, Louisiana, and Mississippi were dip-treated with nine levels of Benlate and then planted in the field in high-hazard areas in their respective States. The experimental design was a randomized complete block with nine treatments. There were 6 blocks, 1 row for each treatment, and 25 trees per row. Seedlings were planted 3 ft apart in rows 10 ft apart, with blocks being separated by 20-ft buffer zones. Height growth, survival, and percentage of infection were measured yearly during the month of November.

A supplemental study was initiated in 1981 in four of these States, with the same objectives as the original study and, in addition, to determine whether the field survival and growth of longleaf pines could be improved by the utilization of *Pisolithus tinctorius* (*Pt*) ectomycorrhizae. The design of the supplemental study was similar to that of the original study, except that half of the seedlings had been inoculated with *Pt*. After 3 years in the field, significant differences in survival due to benomyl treatment were evident at all four of the planting sites. And with the exception of the Alabama site, significant differences in tree survival could be attributed to *Pt* inoculation (Kais and others 1985).

### Major Publications or Progress Reports

Kais, Albert G.; Cordell, Charles E.; Affeltranger, Charles E. 1978. Control of brown-spot needle blight on longleaf pine seedlings by Benlate fungicide-dip treatment. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 9 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Kais, Albert G.; Cordell, Charles E.; Affeltranger, Charles E. 1985. Control of brown-spot needle blight on longleaf pine seedlings by Benlate fungicide-dip treatment. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Final report. 9 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Kais, Albert G.; Cordell, Charles E.; Affeltranger, Charles E. 1986. Nursery application of benomyl fungicide for field control of brown-spot needle blight (*Scirrhia acicola* [Dear-n.] Sigg.) on longleaf pine (*Pinus palustris* Mill). Tree Planters' Notes. 37(1): 5.

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### Major Factors of the Successful Growth of Longleaf Pines in the South (See summary, p. 129.)

Longleaf pine (*Pinus palustris*) seedlings pass through a preliminary period of root and foliar development referred to as the "grass stage." This condition is under genetic control, although it is strongly influenced by environmental factors. Some factors, such as low soil fertility, vigorous competition, and brown-spot needle blight infection, which is caused by the fungus *Scirrhia acicola*, could delay initiation of height growth for up to 15 or 20 years. This study was conducted to measure the effects of ectomycorrhizae, weed control, and fertilizer on the growth and survival of longleaf pine in plantations with high and low rates of infection by brown-spot needle blight and to quantify the effectiveness of a chemical fungicide in controlling this disease in longleaf pine plantations provided with different cultural treatments (Kais and others 1984).

Longleaf pine was planted in five different locations within its natural range (Louisiana, Mississippi, Alabama, South Carolina, and Florida). At each of 5 sites, 18 plots consisting of 6 different treatments in each of 3 complete blocks were laid out. Each plot measured 90 by 54 ft (0.1116 acre) and contained 81 trees in 9 rows of 9 trees. Rows were 10 ft apart, and trees were 6 ft apart within rows. Each measurement plot was 70 by 42 ft (0.0674 acre) in size and contained 49 trees in 7 rows of 7 trees each (Kais and others 1986).

Survival rates at all five sites were poor. Maximum survival rates usually occurred on *Pisolithus tinctorius-infected* seedlings that had been treated with benomyl before being planted on scalped rows. These results suggest that competition control plus disease control were best for stimulating survival. Fertilizer applications stimulated survival only when competition was controlled.

These plots are being maintained for demonstration in a longleaf pine technology transfer program.

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### Impact of Fusiform Rust in Southern Pine Plantations (See summary, p. 130.)

Although fusiform rust, caused by the fungus (*Cronartium quercuum* f. sp. *fusiforme*), is the most serious disease of loblolly (*Pinus taeda*) and slash (*P. elliottii*) pines, its true impact throughout the South, or its impact on individual forests, has not been determined. Therefore, a study was begun to determine the effects of fusiform rust over time on the stocking and volume yields of individual slash and loblolly pine plantations. The secondary objectives of the study are to determine if resistance can be overcome by unusually favorable climate, to determine if fungicides applied for 3 or 4 consecutive years after planting in the field will protect plantations from serious infection, and to define climatic factors involved in years when rust is especially prevalent (Froelich and Snow 1977).

Paired plots were established to quantify the effects of fusiform rust on the productivity of slash and loblolly pines. Disease was controlled with fungicides on three high-hazard sites for fusiform rust. On two low-hazard sites, fusiform rust mortality was simulated by removing trees mechanically according to disease progress curves. There were 5 replications, with 300 plots and 80 trees per plot. Yields of rust-resistant slash and loblolly pines were compared with those of trees more susceptible to the disease (Froelich and Snow 1977).

### Major Publications or Progress Reports

Froelich, R.C. 1988. Determining the effects of fusiform rust on forest productivity. In: Economic and social development: a role for forests and forestry professionals. Proceedings of the 1987 Society of American Foresters national convention; 1987 October 18-21; Minneapolis, MN. Bethesda, MD: Society of American Foresters: 68-71.

Froelich, R.C.; Miller, T.; Belanger, R.P. 1988. An evaluation of methods for assessing impacts of pests on forestry productivity. In: Ek, Alan R.; Shifley, Stephen R.; Burk, Thomas E., eds. Forest growth modelling and prediction. Proceedings of the IUFRO conference; 1987 August 23-27; Minneapolis, MN. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 458-466. Vol 1.

Froelich, R.C.; Snow, G.A. 1977. Impact of fusiform rust in southern pine plantations. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 16 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Nance, Warren L.; Froelich, Ronald C.; Dell, Tommy R.; Shoulders, Eugene. 1983. A growth and yield model for unthinned slash pine plantations infected with fusiform rust. In: Jones, Earle P., Jr., ed. Proceedings of the 2nd biennial southern silvicultural research conference; 1982 November 4-5; Atlanta, GA. Gen. Tech. Rep. SE-24. Asheville, NC: Southeastern Forest Experiment Station: 275-282.

## Use of Top-Cross Testers to Evaluate Loblolly Pines for Resistance to *Cronartium quercuum* f. sp. *fusiforme* (See summary, p. 130.)

Selection of pine trees that produce progeny that are resistant to the fungus *Cronartium quercuum* f. sp. *fusiforme* is one of the first phases in establishing seed orchards for producing rust-resistant stock. Selection is usually done by collecting wind-pollinated seeds from candidate trees and testing the seedlings for resistance by artificial inoculation or in plantations in high-rust-hazard areas. Substantial gains have been made in rust resistance with this method of selecting resistant parents, and improved stock is being produced for most areas of the South where fusiform rust is a serious problem (Snow and others 1983).

This study was begun to screen several loblolly pine (*Pinus taeda*) trees for use as top-cross testers for rust resistance and to assess the potential of using top-cross testers to evaluate parent trees for rust resistance. Testers were evaluated using 10 candidate trees, with the progeny being exposed to 5 sources of inoculum in 2 greenhouse tests and 2 field tests. The performance of each tester will be compared with that of the other testers for use in detecting differences in resistance among candidate trees and for determining the stability of these trees when encountering various sources of inocula in greenhouse and field tests (Snow and others 1983).

### Major Publications or Progress Reports

Snow, G.A.; Matthews, F.R.; Nance, W.L.; Foster, G.S. 1990. Effects of pollen source on loblolly pine resistance to *Cronartium quercuum* f. sp. *fusiforme*. Forest Science. 36(2): 304-312.

Snow, G.A.; Nance, W.L.; Matthews, F.R.; Foster, Sam. 1983. Use of top-cross testers to evaluate loblolly pines for resistance to *Cronartium quercuum* f. sp. *fusiforme*. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 11 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

## An Evaluation of Loblolly Pine from East Texas for Resistance to Fusiform Rust (See summary, p. 131.)

During the 1960's, loblolly pine (*Pinus taeda*) trees from east Texas that were free from fusiform rust (caused by *Cronartium quercuum* f. sp. *fusiforme* or *C. quercuum* f. sp. *echinata*) were cloned and placed in the clone bank at the Harrison Experimental Forest in southern Mississippi. A breeding plan was carried out with the clones to produce seeds for a 10 by 10 diallel. Some of these seeds were used in the study to attain the following objectives: to rank 21 control-pollinated pine families of Texas loblolly pine in order of their susceptibility to 4 single-gall cultures of *C. quercuum* f. sp. *fusiforme* and 1 culture of *C. quercuum* f. sp. *echinata*; to compare the resistance of these families to that of loblolly and shortleaf (*P. echinata*) pines from bulk seed sources in southern Mississippi; to examine the possible interaction of pine families with rust inocula, which, if found, will be evidence of pathogenic variation among the rust inocula; to determine if inocula from round or long galls on field-infected trees tend to cause galls of a similar shape on inoculated seedlings; to correlate the results of artificial inoculation with field infection at a high-rust-hazard site; and to plant the rust-free survivors from the inoculation experiments to establish a seedling orchard for a future source of rust-resistant stock (Snow and others 1985).

Two Texas loblolly pine trees produced progeny with higher resistance to *C. quercuum* f. sp. *fusiforme* than all others tested. One Texas loblolly pine tree had high resistance to *C. quercuum* f. sp. *echinata*, and the others varied in susceptibility to this form of the fungus.

### Major Publications or Progress Reports

Snow, Glenn A.; Lott, Larry A.; Barnett, James P. 1985. An evaluation of loblolly pine from east Texas for resistance to fusiform rust. Gulfport, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 9 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

**Relation of Mycorrhizae on Longleaf Pine to Brown-Spot Needle Blight (See summary, p. 131.)**

This was the original study designed to determine the effects of *Pisolithus tinctorius* and benomyl on outplanted longleaf pine (*Pinus palustris*) seedlings. The study was established at two different locations in southern Mississippi in December 1976.

Benomyl-treated seedlings had significantly less infection by brown-spot needle blight, caused by the fungus *Scirrhia acicola*, during the first 5 years of the test than did the untreated seedlings. *Pisolithus tinctorius* (*Pt*) ectomycorrhizae had no apparent effect on the incidence of disease. Benomyl alone had a greater effect on stimulating root-collar diameter, stem length, rapid height growth, and plot volume index than did *Pt* ectomycorrhizae. In the case of *Pt* ectomycorrhizae, growth stimulation occurred only with the two highest levels of the benomyl The combined treatment of benomyl and *Pt* ectomycorrhizae resulted in a significant gain in both survival and growth.

Although this study is closed, the trees are measured periodically for growth and diameter.

### Major Publications or Progress Reports

Kais, A.G.; Snow, G.A.; Marks, J.S. 1981. The effects of benomyl and *Pisolithus tinctorius* on survival and growth of longleaf pine seedlings. Southern Journal of Applied Forestry. 5(4): 189-195.

## MULTIRESOURCE MANAGEMENT OF NATURALLY REGENERATED UPLAND FORESTS IN THE MIDSOUTH

**Growth and Development of Well-Stocked, Natural Even-Aged Stands of Loblolly Shortleaf Pine Under Different Thinning Methods (See summary, p. 132.)**

Beginning in the 1930's, the development of natural, well-stocked, second-growth loblolly (*Pinus taeda*)-shortleaf (*P. echinata*) pine stands in the West Gulf region was encouraged by organized fire protection, the adoption of cutting practices that provided for leaving a seed source, and improved low-grade hardwood control techniques. With an increasing interest in managing these young, well-stocked stands, a study was started in 1949 in south Arkansas and north Louisiana to investigate the effects of type and intensity of thinning on the growth and yield of young, even-aged stands of loblolly-shortleaf pine.

The thinning types and intensities are the following: thinning from above and below to 70, 85, and 100 $ft^2$ per acre; starting at a residual basal area of 70 $ft^2$ and increasing the residual density by 5 $ft^2$ until 105 $ft^2$ is reached; thinning according to the judgment of the timber marker; and thinning from below to 55, 115, and 130 $ft^2$ per acre. Most thinning was started at stand age 20, but nine plots were first thinned at stand age 25.

The plots have been inventoried and thinned, if warranted, every 5 years. Hardwoods have also been periodically controlled by chemical or mechanical methods. Until 1959, detailed measurements were done on only a portion of the plot trees. Subsequently, most trees have had complete measurements.

The study is still active, and measurements were last made during the dormant season of 1989-90.

### Major Publications or Progress Reports

Bassett, J.R. 1966. Periodic cubic growth in natural loblolly stands near Crossett, Arkansas. Res. Note SO-37. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 4 p.

Bassett, J.R. 1966. Thinning loblolly pine from above and below. Res. Note SO-44. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 3 p.

Bassett, J.R. 1967. Pole production in natural loblolly stands near Crossett, Arkansas. Res. Note SO-58. New Orleans, LA: U.S. Department of Agriculture,

Forest Service, Southern Forest Experiment Station. 5 p.
Burton, J.D. 1980. Growth and yield in managed natural stands of loblolly and shortleaf pine in the West Gulf Coastal Plain. Res. Pap. SO-159. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 23 p.
Murphy, P.A.; Farrar, R.M., Jr. 1984. Effects of different thinning regimes on growth and inventory of 50-year-old loblolly-shortleaf pine stands. In: Shoulders, E., ed. Proceedings of the 3rd biennial southern silvicultural research conference; 1984 November 7-8; Atlanta, GA. Gen. Tech. Rep. SO-54. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 241-246.
Murphy, P.A.; Farrar, R.M., Jr. 1988. Basal area projection equations for thinned even-aged forest stands. Canadian Journal of Forest Research. 18: 827-832.

**Crossett "Farm Forestry Forties"**
**(See summary, p. 132.)**

In 1937, timber management was begun in two 40-acre tracts of mostly pine in southern Arkansas to determine if selection management could be used to rehabilitate cut-over stands while providing a periodic return to the landowner. One tract was well stocked and the other was poorly stocked.

During the first years, all competing midstory and overstory hardwoods were removed from the stands, and light improvement cuts were begun to promote the growth of the residual trees and establishment of pine reproduction. Understory hardwoods were also controlled periodically. The improvement cuts removed only a portion of growth; thus, stocking was increased. After 15 years, full stocking was reached, and annual sawlog production reached 400 fbm (Doyle rule) per acre. The well-stocked stand needed only some remedial measures to increase stocking.

Over the first 41 years of the study, the poorly stocked stand produced 16,300 fbm (Doyle rule) per acre, and the initially well-stocked stand produced 16,900 fbm per acre. Selection management is a viable and low-cost alternative for rehabilitating cut-over, understocked loblolly (*Pinus taeda*)-shortleaf (*P. echinata*) pine stands.

**Major Publications or Progress Reports**

Baker, J.B.; Bishop, L.M. 1986. Crossett demonstration forest guide. Gen. Tech. Rep. R8-GTR 6. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region. 53 p.
Reynolds, R.R.; Baker J.B.; Ku, T.T. 1984. Four decades of selection management on the Crossett farm forestry forties. Bull 872. Fayetteville, AR: University of Arkansas, Division of Agriculture, Agricultural Experiment Station. 43 p.

**Methods of Cutting and Reproduction**
**(See summary, p. 133.)**

This study was conducted to compare the regeneration and growth and yield of stands composed of both pines and hardwoods subjected to four reproduction cutting methods: clearcut, heavy-seed-tree, selection, and diameter-limit. All four methods provided adequate regeneration to establish or maintain well-stocked pine stands. (If overstory and midstory hardwoods are removed at the beginning of management and the understory hardwood component is periodically controlled mechanically, chemically, or by fire, low-quality hardwoods should be no problem.)

During the 36-year study period (1942–78), heavy-seed-tree and diameter-limit cutting methods produced significantly more cubic-foot volume than did selection and clearcutting, and clearcutting produced significantly less board-foot (Doyle rule) volume. Intermediate thinnings were not done on the plots that received clearcut and heavy-seed-tree treatments. Because many trees on the clearcut areas are just now (1993) reaching sawlog size, board-foot volume pro-. duction on all treatments will probably equalize as time goes on.

**Major Publications or Progress Reports**

Baker, J.B.; Murphy, P.A. 1982. Growth and yield following 4 reproduction cutting methods in loblolly-shortleaf pine stands-a case study. Southern Journal of Applied Forestry. 6: 66-74.
Grano, C.X. 1954. Re-establishment of shortleaf-loblolly pine under 4 cutting methods. Journal of Forestry. 52: 132-133.

**Recovery and Development of Understocked Loblolly-Shortleaf Pine Stands and Suppressed Trees (See summary, p. 133.)**

Plots in two uneven-aged loblolly (*Pinus taeda*)-shortleaf (*P. echinata*) pine stands were cut back to stocking levels of 10, 20, 30, 40, and 50 percent to simulate cutover, understocked stands in an effort to determine the recovery period required for the stands. One stand was on a good site (Site index [SI] = 90 ft, age 50), and the other was on a medium site (SI = 75 ft, age 50). As a rehabilitation treatment, all hardwoods 1 inch or larger in groundline diameter were injected with herbicide. The plots were reinventoried 2 and 5 years later.

During the 5-year rehabilitation period, the understocked stands changed dramatically. Average increases in stocking level, basal area, and pulpwood and sawlog volume were 40, 155, 160, and 355 percent for the good site and 35, 110, 125, and 220 percent for the medium site, respectively.

Projections of the time required for understocked stands to reach 60 percent or an acceptable stocking level indicate that stands having at least 15 to 25 percent stocking or 5 $ft^2$/acre of basal area can reach an acceptable stocking level in 15 years or less.

### Major Publications or Progress Reports

Baker, J.B. 1989. Recovery and development of understocked loblolly-shortleaf pine stands. Southern Journal of Applied Forestry. 13: 132-139.

McLemore, B.F. 1983. Recovery of understocked, uneven-aged pine stands and suppressed trees. In: Jones, E.P., Jr., ed. Proceedings of the 2nd biennial southern silvicultural research conference; 1982 November 4-5; Atlanta, GA. Gen. Tech. Rep. SE-24. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 226-229.

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### Growth and Wildlife Habitat Suitability of Pine-Hardwood Mixtures (See summary, p. 134.)

From 1983 to 1985, annual production of total forage, including woody plants, legumes, vines, and forbs, did not differ by treatment in test plots that were cut back to the following percentages of pine to total basal area: 50, 70, 90, and 100. After hardwood regeneration was killed in 1985, annual production of ground-level vegetation was generally greater on the 100-percent pine plots than on the pine-hardwood plots. Forage production typically did not differ among the pine-hardwood mixtures during any year. Acorn production per oak tree was not different among treatments. In 1988, percentage of cover of ground-level and shrub layers was greatest in the 100-percent pine plots. Cover of midstory and canopy layers was greatest in the 50- and 70-percent pine plots, favoring wildlife species dependent on these layers.

The 5-year growth data from tree overstory measurements were used to examine the relationship between basal area growth and various site and stand variables for pine and hardwood trees. Separate analyses were made for each species. A comparison was also made between distance-independent measures and a distance-dependent measure of competition (area potentially available or APA). The APA did not make any additional statistical contribution to regressions of basal area growth of trees in the presence of other variables.

### Major Publications or Progress Reports

Murphy, P.A.; Farrar, R.M., Jr.; Willett, R.L. 1989. Individual tree growth relationships in pine-hardwood mixtures. In: Waldrop, T.A., ed. Proceedings of pine-hardwood mixtures: a symposium on management and ecology of the type; 1989 April 18-19; Atlanta, GA. Gen. Tech. Rep. SE-58. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 181-188.

Wigley, T.B.; Willett, R.L.; Garner, M.E.; Baker, J.B. 1989. Wildlife habitat quality in varying mixtures of pine and hardwood. In: Waldrop, T.A., ed. Proceedings of pine-hardwood mixtures: a symposium on management and ecology of the type; 1989 April 18-19; Atlanta, GA. Gen. Tech. Rep. SE-58. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 131-136.

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### Precommercial Thinning and Management of Natural Loblolly-Shortleaf Pine Stands for Rapid Sawlog Production (See summary, p. 134.)

This study was conducted to demonstrate a proven and recommended precommercial thinning technique in dense, even-aged loblolly-shortleaf pine stands and to investigate the production of sawlog-sized pines in an abbreviated time period by use of commercial thinning techniques. Analyses of fire effects and tree variables following winter prescribed burns demonstrated that diameter and height growth during the year after burning showed statistically significant negative correlation with increasing crown scorch. Measurements of flame length and associated stem-bark char and subsequent analyses revealed that height of stem-bark char underestimated flame length. Therefore, the use of stem-bark char as a substitute variable for flame length, particularly to estimate fire intensity, is not recommended.

An evaluation of individual tree growth from ages 8 to 12 showed that loblolly pine (*Pinus taeda*) generally outgrew shortleaf pine (*P. echinata*) in both thinned and unthinned plots. From ages 12 to 14, loblolly pine generally grew better than shortleaf pine on the thinned plots, but there was no statistical difference on the unthinned plots. Despite growth differences, shortleaf pine will probably continue to exist in the maturing stand.

### Major Publications or Progress Reports

Cain, M.D. 1983. Precommercial thinning for the private, nonindustrial landowner: a methodology report. In: Jones, E.P., Jr., ed. Proceedings of the 2nd biennial southern silvicultural research conference; 1982 November 4-5; Atlanta, GA. Gen. Tech. Rep. SE-24. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 200-205.

Cain, M.D. 1984. Height of stem-bark char underestimates flame length in prescribed burns. Fire Management Notes. 45(1): 17-21.

Cain, M.D. 1985. Prescribed winter burns can reduce the growth of 9-year-old loblolly pines. Res. Note SO-312. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 4 p.

Cain, M.D. 1990. Incidental observations on growth and survival of loblolly and shortleaf pines in an even-aged stand. Southern Journal of Applied Forestry. 14: 81-84.

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### Objective Regulation of Uneven-Aged Loblolly-Shortleaf Pine Stands in Arkansas (See summary, p. 135.)

Results covering 5 years have been obtained from the initial nominal 5-year cutting cycle of 16 loblolly (*Pinus taeda*)-shortleaf (*P. echinata*) pine stands. Various structures of different basal areas, maximum diameters, and *q* values (the ratio of the number of trees in successive diameter classes) were imposed on the 16 stands to investigate the efficacy of this method for regulating these stands. Competing hardwoods were controlled with herbicides. During the growth period, basal area growth ranged from a negative 0.2 to 3.4 $ft^2$/acre, merchantable volume growth ranged from 20 to 111 $ft^3$/acre, and sawtimber growth ranged from 134 to 528 fbm (Doyle rule)/acre. Development of reproduction was adequate in most cases.

### Major Publications or Progress Reports

Farrar, R.M., Jr.; Murphy, P.A. 1989. Objective regulation of selection-managed stands of southern pine-a progress report. In: Miller, J.H., comp. Proceedings of the 5th biennial southern silvicultural research conference; 1988 November 1-3; Memphis, TN. Gen. Tech. Rep. SO-74. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 231-241.

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### Unmanaged Stands (See summary, p. 135.)

Eight inventories were taken between 1937 and 1983 to document long-term stand dynamics and succession in unmanaged cut-over pine stands. In 1983, 76 percent of the total merchantable cubic-foot volume and 83 percent of the sawlog cubic-foot volume was pine, but pines have virtually disappeared from the sawtimber class. Oaks are the predominant hardwoods in the sawtimber class, and nonoak hardwoods are most common in the subsawtimber class. In the past two decades, periodic annual increment of pines has dropped dramatically, and hardwood growth has not concomitantly increased. These dynamics classically illustrate the transition of southern upland forests from pine to hardwood in the absence of disturbance.

### Major Publications or Progress Reports

Baker, J.B.; Bishop, L.M. 1986. Crossett demonstration forest guide. Gen. Tech. Rep. R8-GTR 6. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region. 53 p.

Cain, M.D. 1987. Survival patterns of understory woody species in a pine-hardwood forest during 28 years without timber management. In: Proceedings of the central hardwood forest conference VI; 1987 February 24-26; Knoxville, TN. Knoxville, TN: University of Tennessee: 141-147.

Guldin, J.M.; Baker, J.B. 1985. Dynamics and development of a once-cutover, unmanaged loblolly pine stand in southeastern Arkansas. In: Shoulders, E., ed. Proceedings of the 3rd biennial southern silvicultural research conference; 1984 November 7-8; Atlanta, GA. Gen. Tech. Rep. SO-54. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 198-202.

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### Cutting Cycle Study (See summary, p. 136.)

Selection management over a 29-year period (1938–66) demonstrated that cutting cycle length had no effect on volume production. Merchantable volume growth was 84 $ft^3$/acre, and periodic annual growth was 430 fbm (International 1/4-inch rule)/acre. Harvests for the period averaged 314 and 26 fbm (International 1/4-inch rule)/acre/year for pine and hardwood, respectively. Average annual per-acre cordwood harvests were 0.35 and 0.17 cord for pine and hardwood, respectively.

### Major Publications or Progress Reports

Farrar, R.M., Jr.; Murphy, P.A.; Willett, R.L. 1984. Tables for estimating growth and yield of uneven-aged stands of loblolly-shortleaf pine on average sites in the West Gulf area. Bull 874. Fayetteville, AR: University of Arkansas, Arkansas Agricultural Experiment Station. 21 p.

Murphy, PA.; Farrar, R.M. 1982. Interim models for basal area and volume projection for uneven-aged loblolly-shortleaf pine stands. Southern Journal of Applied Forestry. 6: 115-119.

Murphy, P.A.; Farrar, R.M. 1982. Sawtimber volume predictions for uneven-aged loblolly-shortleaf pine stands on average sites. Southern Journal of Applied Forestry. 7: 45-50.

Reynolds, R.R. 1959. Eighteen years of selection timber management on the Crossett Experimental Forest. USDA Tech. Bull 1206. Washington, DC: U.S. Department of Agriculture. 68 p.

Reynolds, R.R. 1969. Twenty-nine years of selection timber management on the Crossett Experimental Forest. Res. Pap. SO-40. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 19 p.

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## Effects of Fertilization and Release on the Diameter Growth of Overstocked Poletimber Oak Stands (See summary, p. 136.)

Fertilizer applications of a nitrogen and phosphorus combination were broadcast at two levels to individual oaks *(Quercus* spp.) in stands that had received thinning or no thinning treatments. Both levels of fertilization increased diameter growth of oaks in thinned and unthinned stands. Maximum response to fertilization occurred during the first and second years after treatment. Response continued through the sixth year for white oaks and through the eighth year for red oaks. A significant diameter growth response to thinning occurred during the third growing season after treatment for red and black oaks and during the fifth growing season for white oaks. From this point, the rate of annual diameter growth for all oaks in thinned stands increased annually through the 10th year.

### Major Publications or Progress Reports

Graney, D.L. 1982. Response of red oaks and white oaks to thinning and fertilization in the Boston Mountains of Arkansas: 7-year results. In: Muller, R.N., ed. Proceedings of 4th central hardwood forest conference; [Dates unknown]; [Location unknown]. Lexington, KY: University of Kentucky: 64-78.

Graney, D.L. 1987. Ten-year growth of red and white oak crop trees following thinning and fertilization in the Boston Mountains of Arkansas. In: Phillips, D.R., ed. Proceedings of the 4th biennial southern silvicultural research conference; 1986 November 4-6; Atlanta, GA. Gen. Tech. Rep. SE-42. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 445-450.

Graney, D.L.; Pope, P.E. 1978. Fertilization increases growth of thinned and unthinned oak stands in the Boston Mountains of Arkansas. Res. Note SO-243. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 4 p.

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## Effects of Intermediate Cutting and Fertilization on Understory Development in Ozark Highland and Boston Mountain Poletimber Oak Stands (See summary, p. 137.)

In unthinned stands, total oak (*Quercus* spp.), ash *(Fraxinus* spp.), and cherry (*Prunus* spp.) reproduction averaged more than 4,000 stems per acre; but fewer than 400 stems per acre were taller than 1 ft and only 4 stems exceeded a height of 4.5 ft. After 5 years, the number of reproduction stems taller than 4.5 ft ranged from 100 per acre in unfertilized stands receiving a light overstory thinning to 300 per acre in fertilized stands receiving medium to heavy thinning treatments. Black cherry (*P. serotina*) and ash accounted for more than two-thirds of the stems taller than 4.5 ft and were the only species to exceed 10 ft in height growth during the 5-year period. Fertilization had no effect on the height growth of trees in established oak reproduction, but increased 5-year heights of trees in ash and cherry reproduction by 1 to 2 ft.

### Major Publications or Progress Reports

Graney, D.L.; Rogerson, T.L. 1985. Development of oak, ash, and cherry reproduction following thinning and fertilization of upland hardwood stands in the Boston Mountains of Arkansas. In: Shoulders, E., ed. Proceedings of the 3rd biennial southern silvicultural research conference; 1984 November 7-8; Atlanta, GA. Gen. Tech. Rep. SO-54. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 171-177.

Graney, D.L.; Rogerson, T.L. 1985. Growth of oak, ash, and cherry reproduction following overstory thinning of upland hardwood stands in the Boston Mountains of Arkansas. In: Proceedings of the 5th central hardwood forest conference; 1985 April 15-17; Urbana-champaign, IL. Urbana-Champaign, IL: University of Illinois, Department of Forestry: 4-10.

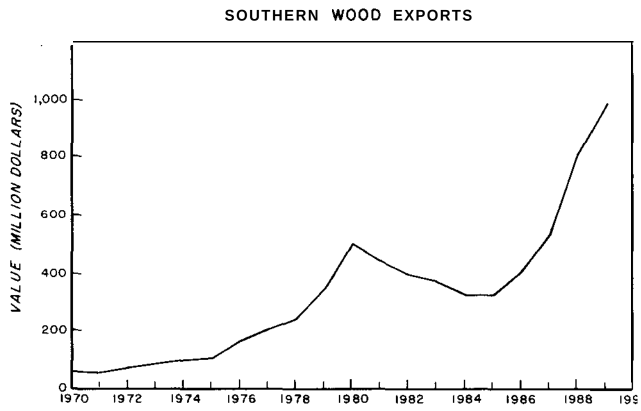


**Figure** ***12.-Changes in value of southern wood exports from 1970 to 1989.***

**Major Publications or Progress Reports**

Granskog, J.E. 1985. Eastern softwood exports. Southern Lumberman. 246(3064): 32-33.

Granskog, J.E. 1986. International trade and southern forests. In: Proceedings of the 4th biennial southern silvicultural research conference; 1986 November 4-6; Atlanta, GA. Gen. Tech. Rep. SE-42. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 8-12.

Granskog, J.E. 1986. The South's timber export potential Forest Farmer. 45(9): 14-15.

Granskog, J.E. 1988. Northern exports of softwood products. Northern Journal of Applied Forestry. 5(3): 215-219.

Wisdom, H.W.; Granskog, J.E.; Blatner, K.A. 1986. Caribbean markets for U.S. wood products. Res. Pap. SO-225. New Orleans, LA.: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 13 p.

## EVALUATION OF LEGAL, TAX, AND ECONOMIC INFLUENCES ON FOREST RESOURCE MANAGEMENT

### A Continuing Analysis of Trends in Exports of Southern Forest Products from the Eastern United States (See summary, p. 137.1

Domestic markets for wood products in the United States have exhibited considerable instability over time. As a consequence, domestic wood producers, including those in the Eastern United States, have in recent years shown an increased interest in exporting. To guide them in identifying the overseas markets with the greatest potential for expansion, these producers needed historical data on past foreign trade patterns and the trends therein, but this information was largely lacking for the eastern region. This study was implemented in response to this informational need. The objectives of the study are: (1) to maintain the data base for southern wood exports that had been developed under previous studies dating back to 1967 at the USDA Forest Service's Southern Forest Experiment Station; (2) to establish and maintain a new data base for northern softwood exports, thereby obtaining complete coverage of all eastern softwood exports; and (3) to analyze export trends by product and country of destination.

Since the study was begun in 1984, statistics on both the volume and value of all eastern softwood exports (fig. 12) have been compiled by product category, region or country of destination, and region or customs district of origin. Also, trade patterns have been analyzed and appropriate implications for potential exporters drawn.

### A Continuing Analysis of Changes and Developments in the Federal Income Tax with Implications for the Private Landowner and Timber Operator (See summary, p. 138.)

The profitability of a private timber growing venture can be significantly affected by the Federal income tax. Although this tax has had, and continues to have, a number of provisions that private forest owners, operators, and investors could use to greatly reduce their Federal income tax burdens, many taxpayers fail to take advantage of them either because they are unaware of their provisions or because they don't understand how the provisions apply to their individual situations. The objectives of this study, which are aimed at overcoming this informational gap, are to describe and analyze, on a continuing basis, any changes in the Federal Income Tax Code that influence the treatment of timber-related receipts and expenditures.

Since the inception of this study in 1979, legislative, administrative, and judicial developments pertaining to the Federal income tax-and which have relevance to private forest owners, operators, and investors-have been documented and described. Analyses of these changes have been used to formulate tax guidelines that should make the impacted parties more aware of both their responsibilities and prerogatives under the law. In recent years, effects resulting from passage of the 1986 Tax Reform Act have been the center of attention.

### Major Publications or Progress Reports


Condrell, W.K.; Tierney, J.E.; Siegel, W.C. 1987. Timber and tax reform: an overview of recent changes. Taxes-The Tax Magazine. 65(7): 411-433.

Hoover, W.L.; Siegel, W.C.; Myles, G.A.; Haney, H.L., Jr. 1989. Forest owner's guide to timber investments, the Federal income tax, and tax record keeping. Agric. Handb. 681. Washington, DC: U.S. Department of Agriculture. 96 p.

Siegel, W.C. 1985. Tax tips for timberland owners. American Forests. 91(2): 20-21, 53, 55-56.

Siegel, W.C. 1988. Tax help for forest landowners. American Forests. 94(1&2): 32-35, 49.

Siegel, W.C. 1989. Tax tests for woodland owners. American Forests. 95(1&2): 34-35, 72-73.

Siegel, W.C.; Balbu, W., Jr. 1985. The primarily for sale provisions of sections 1221 and 1231 of the Internal Revenue Code as related to timber transactions. Arkansas Law Review. 39(1): 73-98.


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### A Continuing Analysis of Changes and Developments in Federal and State Death Taxes with Implications for the Private Landowner and Timber Operator (See summary, p. 139.)

Federal and State death taxes can have a negative effect on levels of forest management if they promote instability of tenure and/or the fragmentation of large forest ownerships. To a large degree, private forest owners, operators, and investors can avoid these problems through proper tax (i.e., estate) planning; but, before such planning can be done, these individuals need to become familiar with the provisions of the applicable laws. This study, which was designed to help meet this informational need, has the following objective: to describe and analyze, on a continuing basis, any developments in the Federal and State death tax areas that have relevance to forest holdings.

Since the study was begun in 1980, all legislative, administrative, and judicial developments pertaining to Federal or State death taxes-and which have implications for private forest owners, operators, and investors-have been documented and described. Analyses of these developments have been used to formulate decision guidelines and planning strategies for the impacted parties.

### Major Publications or Progress Reports


Siegel, W.C. 1981. The Federal estate tax and forest productivity. In: Proceedings of the national convention of the Society of American Foresters; 1981 September 28; Orlando, FL. Bethesda, MD: Society of American Foresters: 79-83.

Siegel, W.C. 1987. Forestry provisions of the Federal estate tax. In: Proceedings of the national conference on forest taxation-adapting in an era of change; 1987 May 20-22; Atlanta, GA. Madison, WI: Forest Products Research Society: 65-70.

Siegel, W.C.; Utz, K.A. 1983. Recent law improves estate tax rules. Forest Farmer. 43(2): 34-35.

Wallen, J.B.; Haney, H.L., Jr.; Siegel, W.C. 1987. The impact of recent changes in State and Federal death tax laws on private nonindustrial forest estates in the South. Southern Journal of Applied Forestry. 11(1): 17-23.

Wallen, J.B.; Haney, H.L., Jr.; Siegel, W.C. 1988. Federal estate death tax implications for private nonindustrial forest landowners in the Northeast. Northern Journal of Applied Forestry. 5(2): 135-141.


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### A Continuing Analysis of Changes and Developments in Forest Resource and Forest Product Law as These Impact on the Economics of Practicing Forestry in the Private Sector (See summary, p. 139.)

Many of the actions initiated by private forest owners, operators, and investors are impacted, directly or indirectly, by the provisions of various forest resource and forest products laws enacted at the State level of government. Examples would include statutes dealing with such matters as timber trespass, fire liability, landowner liability, timber sale contracts, and timber leasing. Because of the pervasiveness of such legislation, those engaged in timber-growing ventures should be knowledgeable about current and proposed policies and how they could be affected by them. To help meet this need, the following objectives were established for this study: to describe, compare, and analyze existing and new legislation and legal trends in the general areas of forest resource and forest products law.

Since the inception of this study in 1981, all major legislative developments in the areas of interest have been monitored. To date, however, most of the work done has been concentrated in two areas: (1) the landowner liability area-where the landowner liability laws of all the Southern States have been reviewed and their key provisions summarized; and (2) the timber leasing area-where the amount of forest land under lease in the South has been determined and guidelines for the preparation of viable lease agreements have been formulated.

**Major Publications or Progress Reports**


Meyer, R.D.; Klemperer, W.D. 1984. Current status of long-term leasing and cutting contracts in the South. In: Proceedings of the annual meeting of the Southern Forest Economics Workers (SOFEW); 1984 March 13-15; Memphis, TN. Raleigh, NC: North Carolina State University: 125-130.

Siegel, W.C. 1980. Landowner liability law-implications for public use of private forest land. In: Proceedings of the 29th annual Louisiana State University forestry symposium-integrating timber and wildlife management in southern forests; [Dates unknown]; Baton Rouge, LA. Baton Rouge, LA: Louisiana State University Press: 17-24.

Siegel, W.C. 1981. The landowner liability puzzle. Forests & People. 31(3): 9-12, 38-41.

Siegel, W.C. 1985. Have you considered timber leasing? Forest Farmer. 44(5): 58-60.


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**A Continuing Analysis of Legislative and Economic Trends Associated with the Forest Property Tax and Related Taxes in the United States** **(See summary, p. 140.)**

State property and related forest taxes can significantly affect the profitability of a timber-growing venture. Accordingly, private forest owners, operators, and investors need to be knowledgeable about current and proposed policies and how these might impact them. To help meet this need, the following objectives were established for this study: (1) to identify emerging legislative, administrative, and judicial trends in the forest property and related tax areas; and (2) to evaluate the potential implications of these trends for the impacted parties.

Since the study was begun in 1979, legislative, administrative, and judicial developments in the forest property and related tax areas have been monitored for all 50 States. In addition, the key provisions of all existing forest property and related tax policies have been summarized. These data show that modified assessment laws, specifically those authorizing current-use valuation, are presently the most pervasive type of alternative forest tax. The provisions of these laws, however, as well as those of other special forest taxes, differ greatly in terms of such things as: (1) scope—i.e., mandatory or optional; (2) conditions of eligibility; (3) application requirements; (4) prescribed valuation procedures for land and timber; (5) penalties imposed upon declassification or program withdrawal; and (6) constraints placed on revenue usage.

**Major Publications or Progress Reports**


Hickman, C.A. 1982. Emerging patterns of forest property and yield taxes. In: Proceedings of the forest taxation symposium II; 1982 February 10-11; Williamsburg, VA. Blacksburg, VA: Virginia Polytechnic Institute, School of Forestry and Wildlife: 52-69.

Hickman, C.A. 1983. Use valuation of forest lands in the United States. International Real Estate Journal 4(1): 62-70.

Hickman, C.A. 1987. Current status of modified rate and nonproductivity-based modified assessment laws. In: Proceedings of the national conference on forest taxation: adapting in an era of change; 1987 May 20-22; Atlanta, GA. Madison, WI: Forest Products Research Society: 15-20.

Hickman, C.A. 1989. Timber severance taxes: current status and changing role. Forest Products Journal 39(10): 31-34.

Kronrad, G.D.; Hickman, C.A.; Siegel, W.C. 1986. Optional forest yield taxes in the United States. Res. Pap. SO-227. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 14 p.

Siegel, W.C.; Kerr, E. 1982. Update on property tax laws. American Forests. 88(7): 36-38, 62-63.


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**Continuing Analysis of Legislative, Administrative, and Judicial Developments in Forest Practice and Environmental Law** **(See summary, p. 141)**

Experience has shown that private forest lands will not always be voluntarily managed in a manner deemed to be consistent with the broad public interest-both in terms of the emphasis placed on the production of nonmarket goods and services and the attention given to the protection of environmental values. Because of this situation, government at all levels-Federal, State, and local-has enacted a variety of forest practice and environmental laws. For these laws to be effective, however, private forest owners, operators, and investors must be familiar with their provisions. To help meet this need, the following objectives were established for this study: (1) to monitor current and future legislative, administrative, and judicial developments in the forest practice and environmental law areas; and (2) to describe and analyze these developments as they relate to the impacted parties.

Since the inception of this study in 1984, all major legislative, administrative, and judicial developments in the areas of interest-and which have relevance to forest owners, operators, and investors-have been monitored. To date, however, most of the work done has been concentrated in three areas: (1) State and local forest practice laws; (2) State and local water quality laws; and (3) State and local wetlands protection laws. The key provisions of these types of laws have been summarized and their potential implications for forestry partially evaluated.

#### Major Publications or Progress Reports

Cubbage, F.W.; Siegel, W.C. 1985. The law regulating private forest practices. Journal of Forestry. 83(9): 538-545.

Cubbage, F.W.; Siegel, W.C. 1988. State and local regulation of private forestry in the East. Northern Journal of Applied Forestry. 5(2): 103-108.

Cubbage, F.W.; Siegel, W.C.; Lickwar, P.M. 1989. State water quality laws and programs to control nonpoint source pollution from forest lands in the South. In: Proceedings of the American Water Resource Association's (AWRA) national conference on water: laws and management; 1989 September 17-22; Tampa, FL. Bethesda, MD: American Water Resources Association: 8A–29 to 8A–37.

Haines, T.K.; Siegel, W.C.; Cubbage, F.W. 1988. Recent developments in State water quality laws affecting forestry in the East. In: Proceedings of the Technical Association of the Pulp and Paper Industry's (TAPPI) 1988 environmental conference; 1988 April 17-20; Atlanta, GA. New York, NY Technical Association of the Pulp and Paper Industry: 457-467.

Hickman, C.A. 1987. Preserving rural lands. Journal of Forestry. 85(3): 31-35.

Siegel, W.C. 1989. State water quality laws and programs to control nonpoint source pollution from forest land in the Eastern United States. In: Proceedings of the American Society of Agricultural Engineers's (ASAE) national symposium on nonpoint water quality concerns-legal and regulatory aspects; 1989 December 11-12; New Orleans, LA. St. Joseph, MI: American Society of Agricultural Engineers: 131-140.

## SILVICULTURE OF ARTIFICIALLY REGENERATED SOUTHERN PINES

### Row Versus Selective Thinning for Planted Loblolly and Slash Pines (See summary, p. 141.)

Forest stands can be thinned in numerous ways. In plantations, two major thinning methods can be easily defined: (1) row or corridor thinning, in which all trees in certain rows or swaths are removed (fig. 13); and (2) selective thinning, in which trees are chosen for felling according to certain criteria.

Many studies had been conducted and articles written concerning the economic and silvicultural advantages of each of these two broad thinning methods, but for loblolly (*Pinus taeda*) and slash (*P. elliottii*) pines, no studies had quantified, by certain useful aspects, the growth differences that can be expected after thinning by alternative methods. These aspects deal with equivalent basal-area levels in stands covering a range of site indices, initial planting densities, and different ages at thinning.

The objectives of this study were to compare the results of row thinning and selective thinning for slash and loblolly pine plantations from the perspectives of volume, basal area, and diameter growth and yield. Plantations were at different locations, were of various ages, had different site indices and initial planting densities, and had comparable stocking levels after thinning.

Data for the study were obtained from plots established in six plantations at five locations in central Louisiana. Basic prethinning data were as follows:

| Location | Pine species | Trees planted | Surviving trees at installation before thinning | Age at start of study |
|---|---|---|---|---|
| | | Number/acre | Number/acre | *Yr* |
| McNary | Slash | 908 | 646 | 15 |
| Meller | Loblolly | 1,210 | 944 | 15 |
| Pollock | Slash | 908 | 568 | 17 |
| Leesville | Loblolly | 807 | 707 | 20 |
| Hineston | Loblolly | 1,210 | 858 | 21 |
| Hineston | Slash | 1,210 | a22 | 22 |

Figure 13.-A *thinned 15-year-old slash pine plantation*

Estimated site index (base age 50) for the slash pine plantations averaged 97 ft and ranged from 86 to 104 ft on individual study plots. For the loblolly pine plantations, site index averaged 83 ft and ranged from 64 to 95 ft on individual plots.

Study plot area varied according to the planting spacing. Rectangular treatment plots contained a center measurement area that was 12 rows in width by 1 chain in length. Isolation strips surrounding the center plots were four rows in width on each side by 0.5 chain in length at each end; thus, each gross plot was 20 rows in width by 2 chains in length.

The following six thinning treatments and an unthinned control were included in each study plantation:

A. **Row-thinning methods:**
   1. 1 in 2: clearcut every other row with no other thinning.
   2. 1 in 3: clearcut every third row with no other thinning.
   3. 1 in 4: clearcut every fourth row initially and cut center row of remaining three rows 5 years later.

B. **Selective-thinning methods:**
   1. Residual basal area after thinning $+3\,ft^2$ of A-1(above); thin once.
   2. Residual basal area after thinning $+3\,ft^2$ of A-2; thin once.
   3. Residual basal area after thinning initially, and 5 years later, within $+3\,ft^2$ of each respective A-3 thinning; a total of two thinnings.

C. **Unthinned control**

Selective-thinning methods were carried out primarily from below. Dominant trees were cut only when rough, defective, forked, or diseased, or when removal would help adjacent dominants or codominants.

Overall, the study had a randomized block experimental design with each location considered to be a separate block. Within the block, treatments were randomly assigned to individual plots. The overall design was unbalanced because more than one treatment replication was not possible at some locations. The slash pine plantation at McNary had three replications of all treatments, the loblolly pine plantation at Hineston had two replications, and all others had only one replication.

Plot and tree measurements were made initially and in the 5th and 10th years following the first thinning to determine the changes in volume, diameter, and basal area and also the height, growth and yield, mortality, and diameter distributions of dominant-codominant trees.

The basal areas of plots were measured using all plot trees. Volumes were determined from a subset of those trees, which were chosen proportionately from each diameter class according to numbers within each class. The volumes of these selected trees were estimated by the height-accumulation method. Cubic-foot volumes of plots were estimated from volume-basal area ratios.

The study is closed, but most of the plots are still maintained and will be remeasured at 5-year intervals. All of the slash pine plots and three of the loblolly pine plots at the Hineston location were destroyed by a southern pine beetle infestation in 1987.

### Major Publications or Progress Reports

Baldwin, V.C., Jr.; Feduccia, D.P.; Haywood, J.D. 1989. Post-thinning growth and yield of row-thinned and selectively thinned loblolly and slash pine plantations. Canadian Journal of Forest Research. 19: 247-256.

Feduccia, D.P. 1976. Row vs. selective thinning for planted slash and loblolly pine. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Establishment report. 177 p.

Feduccia, D.P. 1982. Row vs. selective thinning for planted slash and loblolly pine. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 182 p.

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### Thinned Slash Pine Plantation Growth and Yield (See summary, p. 142.)

The three substudies discussed here were established in 1958, 1959, and 1964 in plantations established on cut-over lands in four locations in Louisiana. These plantations are outside of the natural range of slash pine (*Pinus elliottii*). The research objectives were to consider the effects of site, age, survival, timing of first thinning, subsequent repeated thinnings, and thinning intensity on the growth and yield of planted slash pine. Each substudy was established with somewhat different objectives, but the growth and yield modeling to date has combined the three data sets. Initial planting density did not vary within any of the three substudies, but there was some variation among them.

The oldest substudy was established during the winter of 1958-59 to measure the effects of the following on the growth, yield, and quality of planted slash pine on a good upland site: (1) five major stocking levels and variations of them; (2) D+ thinning of the USDA Soil Conservation Service (SCS); and (3) no thinning. This substudy is a cooperative effort with Bel Estate-Quatre Parish Company, Lake Charles, LA. The company furnishes the study area, protects the stand from fire, conducts preventative stump treatments against *Fomes annosus* root-rot infection, and administers timber sales. Furthermore, the SCS cooperates in marking the D+ plots, and soil scientists of the SCS have classified the soils of the study area. The thinning treatments for this substudy are as follows:

1. Thin to 70 $ft^2$/acre of basal area on a 5-year cutting cycle, beginning at age 17.
2. Thin to 85 $ft^2$/acre of basal area on a 5-year cutting cycle, beginning at age 17.
3. Thin to 100 $ft^2$/acre of basal area on a 5-year cutting cycle, beginning at age 17.
4. Thin to 95 $ft^2$/acre of basal area at age 17 and to 55 $ft^2$ at age 22 and every 5 years thereafter.
5. Thin to 95 $ft^2$/acre of basal area at age 17 and to 115 $ft^2$ at age 22 and every 5 years thereafter.
6. Thin to 85 $ft^2$/acre of basal area on a b-year cutting cycle, beginning at age 17.
7. Thin to progressively higher basal areas on a 5-year cutting cycle, starting with 85 $ft^2$/acre of basal area at age 17 and increasing the residual basal area to 90, 95, 100, 104, 108, 111, 114, 117, and 120 $ft^2$/acre at successive 5-year intervals.
8. Thin by the D+ method of SCS at age 17 and every 5 years thereafter.
9. Do not thin (check).

This substudy has a randomized block design with 4 replications; 36 plots were established. One plot was destroyed by an *Ips* pine beetle infestation following a lightning strike in the plot. Measurement plot size is 0.25 acre. Each measurement plot is surrounded by a 47.8-ft-wide isolation strip. The plantation was established by hand-planting during the winter of 1941-42 on cut-over longleaf pine (*Pinus palustris*) land at a spacing of about 6 by 7 ft.

The next oldest substudy was established in 1964 near Hineston, LA, to determine the effects of timing of first thinning, residual basal area, and age on the growth and yield of planted slash pine on a good cut-over site. Site index on this study area averaged 101 ft (base age 50). Eleven thinning treatments are included in this study. Periodic thinning was on a 3-year cutting cycle until age 19 and on a 5-year cycle thereafter. The treatments are as follows:

1. Thin to 70 $ft^2$/acre of basal area, starting at age 10.
2. Thin to 70 $ft^2$/acre of basal area; prune all leave-trees at age 10 to remove dead limbs below the live crown; extend pruned length to 17 ft at age 13.
3. Thin to 85 $ft^2$/acre of basal area, starting at age 10.
4. Thin to 100 $ft^2$/acre of basal area, starting at age 10.

5. Thin to 70 ft²/acre of basal area, starting at age 13.
6. Thin to 85 ft²/acre of basal area, starting at age 13.
7. Thin to 100 ft²/acre of basal area, starting at age 13.
8. Thin to 70 ft²/acre of basal area, starting at age 16.
9. Thin to 85 ft²/acre of basal area, starting at age 16.
10. Thin to 100 ft²/acre of basal area, starting at age 16.
11. Do not thin (check).

This substudy has a randomized block design with four replications. Plots were grouped into blocks by proximity; treatments were assigned within blocks at random. The 44 plots are 0.1 acre in size and are surrounded by a 0.5chain buffer strip. The plantation was established by hand-planting in December 1948 on former longleaf pine land at a spacing of approximately 6 by 7 ft. The plantation is owned by International Paper Company.

The third substudy was installed in 1964-65 in two plantations, 14 and 16 years old. The research objectives were to determine the effects of different thinning intensities on the growth, yield, and diameter distribution of slash pine planted on a cut-over area outside the natural range of this species that has a low to medium site index. The plantations are owned by Boise Cascade Company and are located in eastern Sabine Parish, about 2 miles from Peason, LA.

The two stands were established by machine-planting during the winters of 1948-49 and 1950-51 on cutover longleaf pine land at a spacing of approximately 6 by 8 ft. Eight treatments are being tested in this substudy. The treatments include thinning back to 40, 55, 70, 85, 100, 115, and 130 ft²/acre of basal area at 5-year intervals, beginning at ages 14 and 16, and an unthinned check. All plots assigned to the 40-, 55-, and 70-ft² stocking levels were thinned at the time of study installation. Basal area was too low for cutting on all plots of the 14-year-old stand that were to carry 85 ft²/acre or higher stocking levels. In the 16-year-old plantation, one of the three plots with a basal area of 85 ft²/acre, two of the plots with a basal area of 100 ft²/acre, and all plots assigned higher residual basal area levels were not thinned. After 5 years, all except four plots subjected to the thinning treatment to 130 ft²/acre of basal area had reached the assigned stocking level In 1974-75, three plots subjected to the treatment to 130 ft²/acre had barely reached the assigned level of density and were not thinned until 1979-80.

Site index averaged 80 and 72 ft for the younger and older stands, respectively. The substudy has a randomized block design. Two blocks are located in the younger plantation and three blocks, in the older plantation. Plots were grouped into blocks according to the indicated site index at the time of study installation, and treatments were randomly assigned within the blocks. The measurement plots are 0.15 acre in size and are surrounded by a 0.5-chain buffer strip. To date, all plots are still active, and the substudy continues (fig. 14).

**Major Publications or Progress Reports**


Dell, T.R.; Feduccia, D.P.; Campbell, C.E.; [and others]. 1979. Yields of unthinned slash pine plantations on cutover sites in the West Gulf region. Res. Pap. SO-147. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 84 p.

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Figure 14.-A *thinned slash pine stand: a, at age 19; and b, at* age 39.

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**Intensive Culture of Southern Pines (Includes studies SO-4101–1.150, 1.177 and 28; see summaries, p. 143-144.)**

Intensive cultural practices have been studied by researchers at the USDA Forest Service's Southern Forest Experiment Station at Alexandria, LA, since the mid-1950's by means of site-preparation treatments. Fertilization trials were established in the 1960's, and weed control experiments became important in the 1970's (fig. 15). Many of the first studies utilized small plots because the first objective was to determine the methodology of the practices, rather than the long-term effects on pine growth. As the practices became better understood, larger plots were established to follow pine growth to the first thinning or beyond.

The objective of the larger studies was to determine the effects of cultural practices on pine growth. Most studies have more than one practice because strong interactions were expected based on the results of earlier studies. Thus, two of the three studies mentioned here are factorial designs comparing different levels of fertilization and weed control

The plot size of these studies is relatively small because of the labor and materials required to establish and maintain the treatments. Thus, most of the stud-

Figure 15.—*The effect of weed control (left) vs. no weed control (right) in a 6-year-old slash pine stand.*

ies will not be measured past age 15. When possible, thinnings will be used for measurement of wood properties because of the dramatic changes in early growth of the trees.

### Major Publications or Progress Reports


Burton, J.D.; Shoulders, E.; Snow, G.A. 1985. Incidence and impact of fusiform rust vary with silviculture in slash pine plantations. Forest Science. 31: 671-680.

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### Site Preparation (Includes studies SO-4101-9.2, 9.4 through 9.7, 9.11, 9.23, 9.43, 9.57, and (1115)–3.5; See summaries, p. 144-150.)

Will pine seedlings on poorly drained soils develop more rapidly if planted in beds or discontinuous mounds? Is destruction of the herbaceous cover sufficient to boost seedling growth without raising the planting spot on these soils? Work done by scientists of the USDA Forest Service's Southern Forest Experiment Station on several sands in Florida determined that seedling development was dependent on soil drainage. But what would happen on finer textured, more fertile soils in other regions? Which species of southern pines will grow best on these poorly drained soils? Will any early gains in growth be maintained or lost as the pines reach sapling and pole size? These *were* among the practical questions researchers began seeking answers for in the West Gulf region during the early 1960's.

Pine plantations of the South's third forest were being established on many sites where a hardwood component was developing and aggressively competing for light, water, and nutrients with the planted pine trees. Previous research and practical experience had dealt mostly with the establishment and growth of pines on old fields and open range and the conversion of scrub hardwood stands to pine. Foresters knew that mechanical site preparation would control residual hardwoods on pine planting sites, but which method of site preparation was best? How much of a hardwood component would develop after each method of site preparation? How would the plantation pines develop? How would different soil types and fertilizers influence the choice of site-preparation method, and could the best choice be predicted on a case by case basis? These were among the practical questions researchers began seeking answers for in the West Gulf region during the early 1970's.

To answer the above two sets of questions, Southern Station scientists began establishing study sites in the West Gulf region. The studies dealt with loblolly (*Pinus taeda)* and slash *(P. elliottii)* pines, and often both species were planted on the same research site. Treatments of interest were studied using randomized complete block designs to ensure statistical validity. The length of these studies ranged from 6 to 20 years. Tree height, and, later, disease data were collected yearly at planting, but normally the interval between measurements increased to 2 or 5 years after age 5, and diameter data were sampled after the trees reached sapling size.

Several important findings have come from this research. Both loblolly and slash pine plantations are most productive if soil drainage averages about 1.5 acre-ft during winter. In the West Gulf region, flatwoods soils have an average winter drainage of about 0.6 acre-ft. Therefore, bedding is beneficial on the more poorly drained sites. However, single-pass bedding increases the volume on well-drained soil by only about 0.4 acre-ft, and maximum pine productivity would still not have been realized except for another, and unexpected, finding. The water table drops under bedded sites, and growth gains normally attributed to planting on beds actually result largely from this drop in the water table. Forest managers wishing to measure the winter water table do not need to monitor fluctuations in its depth. The best indicator of depth to winter water table is the depth to gray mottling in the soil, which can be determined at any time.

Many silt loam flatwoods in the West Gulf region have gently rolling topographies. It is generally believed that these slight topographic changes affect how planted pines respond to site amelioration, but little quantitative information was available. In recent years, Southern Station scientists have been able to recommend certain cultural practices based on topographic differences of flatwoods soils. One of these practices is to form distinct mounds for planting slash pine seedlings rather than bedding if beds will clearly disrupt surface drainage and impound water.

The method used to prepare better drained soils for planting is less important than accomplishing the four major objectives of site preparation: to destroy existing plant cover, reduce the chance of wildfires, provide access for planting, and improve soil aeration and water infiltration. Site preparation beyond ensuring stand establishment will not significantly increase long-term yields and will reduce the return on investment on better drained soils. If excessive soil displacement results from site preparation, yields may actually be reduced. Forest managers should forego extra practices in the hope of greatly increasing yields from pole stands of southern pines on better drained soils.

Phosphorus fertilization provides one exception to the above rule. Forest managers wishing to rapidly produce large individual pole-size loblolly pine trees should consider phosphorus fertilization with mechanical site preparation before planting on Udult (Ultisols) soils. If maximizing total stand volume is the primary objective, no simple fertilizer recommendations can be made because of the confounding effects of soil types and site-preparation methods on the survival and yield of stands. Fertilizer recommendations for maximizing total stand volume on better drained soils will have to be made on a case-by-case basis with risk of failure.

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**Long-Term Soil Productivity of Southern Pine Sites (Includes studies SO–4101–2.10, 2.14 and 15-7.11; see summaries, p. 151-152.)**

The effects of management practices on future rotations of southern pines have been examined by scientists of the USDA Forest Service's Southern Forest Experiment Station at Alexandria, LA, since about 1980. All studies have sound experimental designs so that negative results (assuming no differences between treatments) can be accepted with assurance by land managers. The studies were installed with the philosophy that using pines as a biological growth index is a better base on which to develop future policy than growth-predicting models that do not have an underlying data base.

Studies have been installed in new areas to determine the effects of logging practices on the growth of the next rotation and on old study sites to determine the effects of site preparation and fertilization on the growth of a succeeding rotation (fig. 16). The studies range in size from forty-eight 0.16-acre plots to fifty-two 0.55-acre plots. The time period during which measurements will be taken before ending the study or cutting and replanting varies with the plot size, with small plots being reestablished after 15 years.

Because this type of research was initiated since 1980, only three studies are included. However, because their usefulness is now apparent, more studies are being installed and will be added as stands reach age 10.

**Major Publications or Progress Reports**

Tiarks, Allan E. 1987. Effect of site preparation and fertilization on second rotation slash pine. In: Gresham, C.A., ed. Proceedings of the second rotation plantation establishment workshop; 1987 February 17-19; Baruch Forest Science Institute, Georgetown, SC. Clemson, SC: Clemson University: 56-62.

Tiarks, Allan E. 1989. Growth of slash pine planted in soil disturbed by wet-weather logging. Journal of Soil and Water Conservation. 45(3): 405-407.


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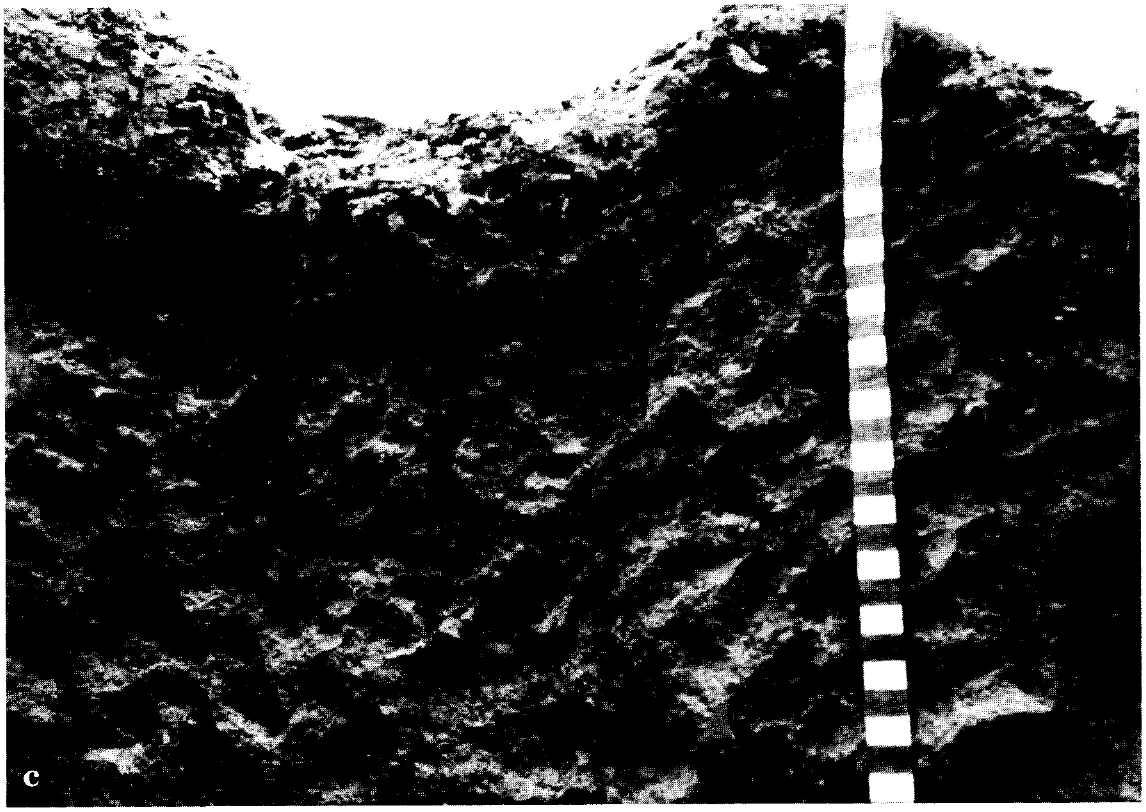


Figure 16.—*Effects of skidders: a, a site in southern Louisiana rutted by skidders operating on saturated soil; b, a skidder in operation in saturated soil in 40-year-old slash pine stand; and c, cross section of compacted soil beneath a skidder rut.*

## Effects of Initial Spacing and Precommercial Thinning in Forest Stands Established by Direct-Seeding (See summary, p. 152.)

An artificial regeneration alternative to planting seedlings is direct-seeding of an area. This method of forest establishment was especially appealing in the 20th century in the United States because vast cut-over areas needed to be reforested as quickly as possible. Direct-seeding could be most easily accomplished by broadcasting seeds over large areas by hand or by airplane. However, it was difficult to control seedling density by this method. Many of the seeds were consumed by birds or rodents before sprouting could occur. To counteract this loss, larger numbers of seeds were sowed than were actually needed, which most often produced very dense forest stands. Information was needed to determine the influence of various methods and intensities of early precommercial thinning in these dense young forest stands on survival, periodic growth and yield, wood characteristics, and financial returns.

Another method of controlling seeding density was to sow seeds in rows. Density could be controlled by varying the space between rows and the space between within-row seed spots. Information was also needed to determine the influence of various initial spacings in rows and between rows on tree survival, periodic growth and yield, wood characteristics, and financial returns.

To meet these objectives, studies utilizing direct-seeded loblolly (*Pinus taeda*), longleaf (*P. palustris*), and slash (*P. elliottii*) pines were established on low, medium, and high sites. The experimental designs were randomized complete block with three or four treatment replications. In the broadcast-seeded studies, 3- to 4-year-old stands were thinned selectively, in rows or swaths or a combination of these methods, to various residual stem densities. Unthinned control plots were also established. In the row-thinning studies, initial in-row spacings of 1 to 8 ft with rows 8 ft apart and an in-row spacing of 4 or 8 ft with rows 12 ft apart were established for comparison. The study plots have been periodically remeasured since establishment-every 1 to 3 years initially, every 3 years from age 5 through age 20, and every 5 years thereafter.

**Major Publications or Progress Reports**

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Lohrey, R.E. 1985. Aboveground biomass of planted and direct-seeded slash pine in the West Gulf region. In: Saucier, J.R., ed. Proceedings of the 1984 southern forest biomass workshop; 1984 June 5-7; Athens, GA. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 75-81.

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Lohrey, R.E. 1987. Site index curves for direct-seeded slash pines in Louisiana. Southern Journal of Applied Forestry. 11(1): 15-17.

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**Effects of Planting Spacing and Thinning Intensity on the Growth and Yield of Loblolly Pine** (See summary, p. 153.)

Two planting spacing studies established in the late 1940's and 1950's with loblolly pine (*Pinus taeda*) were converted to thinning density studies. The first (now closed) was located near Woodworth in central Louisiana, and the second is near Merryville in southwest Louisiana. The Woodworth study was on State-owned land and was maintained by the Louisiana Office of Forestry; the Merryville study is located on land owned and maintained by Rice Land Lumber Company. In both areas, the study objectives were to determine how initial planting density, site, age, survival, repeated thinnings, and thinning intensity affect the growth and yield of loblolly pine planted on sites similar to those studied. Both study sites were located on cutover land formerly occupied by longleaf pine (*P. palustris*). No mechanical or chemical site preparation was required.

In both study areas, the measurement plots were 0.1 acre in size, with about a 0.5-chain-wide buffer strip surrounding each plot. The Woodworth study contained 69 plots, 4 of which were unthinned control plots. Site index (base age 25) over the area ranged from 53 to 67 ft. The planting densities ranged from 400 to 2,700 stems per acre, and the residual basal area per-acre densities ranged from 70 to 100 $ft^2$. The first thinning occurred at planting age 20 in those plots that had sufficient basal area to be thinned to their target basal area. The Merryville study contains 73 thinned plots and 15 unthinned control plots. Site index ranges from 56 to 72 ft, planting densities range from 300 to 1,200 stems per acre, and after-thinning densities range from 60 to 120 $ft^2$/acre of basal area. This study was first thinned at planting age 17. In both studies, the thinning interval was 5 years, and thinning was generally from below, although nearly equal attention was given to maintaining rather uniform tree spacing in the stands.

The Woodworth study had to be closed in 1975 after a tornado destroyed numerous key plots. However, data are available through stand age 45. The Merryville study, with trees 41 years of age from planting at the time of this report (1995), continues.

**Major Publications or Progress Reports**

Baldwin, V.C., Jr. 1987. Green and dry-weight equations for above-ground components of planted loblolly pine trees in the West Gulf region. Southern Journal of Applied Forestry. 11(4): 212-218.

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Baldwin, V.C., Jr.; Feduccia, D.P. 1987. Loblolly pine growth and yield prediction for managed West Gulf plantations. Res. Pap. SO-236. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 27 p.

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## Development of a Loblolly Pine Plantation Thinned to Different Density Levels in Southern Arkansas (See summary, p. 154.)

The study discussed here was established in a 12-year-old loblolly pine (*Pinus taeda*) plantation located in southeast Arkansas. This study was designed to evaluate the effects of various thinning and crown-shortening treatments on volume growth. In 1970, personnel at the USDA Forest Service's Southern Forest Experiment Station established 40 experimental plots. These plots were maintained and inventoried by the USDA Forest Service until 1981. Since 1981, the study has been conducted by the Department of Forest Resources at the University of Arkansas at Monticello in cooperation with the USDA Forest Service and Georgia-Pacific Corporation. Continuity of methods and techniques (in particular, the use of the Zeiss teledendrometer for measuring upper stem diameters and heights) has been maintained to ensure the compatibility of results from all inventories. In 1987, the seventh remeasurement of the 30-year-old trees was completed.

The original study design includes four levels of thinning and three levels of crown shortening. Each combination has three replications within a randomized complete block design. Four additional plots were established to represent each of the four thinning treatments without crown shortening. Each plot is 132 by 132 ft in size and contains an inner 66- by 66-ft plot in which all trees are individually identified with numbers. Thus, the 0.1-acre measurement plot is surrounded by a similarly treated 0.3-acre buffer zone that is 0.5 chain in width.

Plots were initially thinned at 12 years of age to 40, 60, 80, and 100 $ft^2$/acre of basal area, and crowns were pruned to 25, 40, and 55 percent of the total tree height. After the second inventory at age 15, basal areas were reduced to 30, 50, 70, and 90 $ft^2$/acre, where they have since been maintained. A salvage cutting was made after a severe ice storm at age 16, and plots were thinned again at ages 24, 27, and 30. Trees were pruned only twice, at ages 12 and 15.

During the winter of 1974 and again in 1979, severe ice storms caused extensive damage to the plots. Trees on three plots were so heavily damaged that basal area was reduced and still remains below that intended for the treatments. Although data have been collected on individual trees, these plots have been eliminated from the analysis.

Five control plots (without thinning or pruning) were established on the adjacent untreated part of the plantation in 1984. The size and arrangement of each plot is the same as that of the 40 original plots. The natural hardwood competition was killed on the control plots by injections of Tordon 101-R. In 1986, the construction of a new road resulted in the elimination of a plot (after only one inventory period of measurement). The lost plot was replaced in 1986 with a plot that was measured for the first time in 1987.

When collecting inventory in the buffer strip, the d.b.h. of each tree was taken, basal area was calculated, and thinning was planned to maintain the same treatment level as the corresponding inner plots. On all inner plot trees, diameters were measured at 1, 3, and 4.5 ft (breast height) and at crown base. The crown radius was measured in the longest direction and 90 degrees to it. Heights were determined to the base of the live crown, to the top of the tree, and to the even diameters of the stem required to calculate volume by the Grosenbaugh (1954) height accumulation method. Measurements of height and upper stem diameters were done with a Zeiss teledendrometer, and lower diameters were measured with a diameter tape or caliper. When selecting trees to be thinned, foresters thinned the trees from below based on the following, somewhat overlapping, criteria (in order of decreasing importance): d.b.h., current increment, stem form, height, spatial distribution, and cone production.

### Major Publications or Progress Reports


Burton, James D. 1971. Loblolly pine crown size, stand density, production level, and wood quality. Crossett, AR: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Establishment report FS-SO-1115-4.2. 33 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

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### Choice of Species for Planting Sites
(See summary, p. 154.)

The purpose of this study was to determine which southern pine species to plant on a particular site. Which species should I grow here? This question is asked and answered annually for about a million acres of pine forest land in 12 Southern States that are planted or direct-seeded. In 1969, planners of the South's third forest predicted that it must be answered for more than 30 million acres in the South by 1985. To date, researchers have provided only fragmentary information to the forest manager on this subject. Clearly, then, the subject "choice of species" is as timely today as it was in the mid-1950's when researchers at the USDA Forest Service's Southern Forest Experiment Station, with the help of both public and private forestry organizations, established 113 trials with southern pine species on uniform sites in Louisiana and Mississippi.

The 113 outplantings were widely distributed in the two States south of a line formed by extending Louisiana's northern boundary across Mississippi. Collectively, these trials represented a wide range of site conditions. The installations were stratified into wet, intermediate, and dry sites from field estimates of internal drainage and horizon development of the soils. These determinations were made at the time or soon after sites were selected. Soils of the wet and intermediate sites correspond to Zahner's azonal and zonal soils, respectively. Dry-site soils have no real counterparts in Zahner's site-index work.

Wet-site soils lack prominent, abrupt changes in color or texture within 3 or 4 ft of the surface. These soils remain submerged or saturated with water during wet periods, especially in the winter, and are poorly to moderately drained.

The main distinguishing characteristic of intermediate sites is that the soils have well-defined horizons that differ from each other in both texture and color. These soils are moderately well to well drained.

The soils on dry sites have a thick surface layer of coarse sand to sandy loam that might or might not grade into somewhat heavier material below a depth of 3 ft. The soils are well to excessively drained and have a very limited capacity to store readily available moisture.

Three species of southern pines were planted on each site, loblolly (*Pinus taeda*), slash (*P. elliottii*), and longleaf (*P. palustris*). Shortleaf pine (*P. echinata*) was also planted on most of the sites. Three plots of each species were planted at each location in a randomized block design. The planting interval was 6 ft within and between the rows. In Mississippi and the Florida parishes of Louisiana, gross plots contained 12 rows of 12 trees each; west of the Mississippi River, plots contained 11 rows of 11 trees. First-year survival was computed from data for the gross plots. All other data were obtained from the center area of each of the 113 outplanting locations, 64 planting positions in plots east of the Mississippi River and 49 in plots west of the river.

Seedlings for the study were grown in State and Federal nurseries in Louisiana and Mississippi. Loblolly pine seedlings planted east of the Mississippi River were from seed lots collected in Mississippi, and those planted west of the river were from Louisiana seed lots. Slash pine seedlings for more than 80 percent of the plots were produced from seeds collected in south Mississippi or the Florida parishes of Louisiana. Seeds for the remaining stock were obtained from a Georgia dealer. No genetically improved seeds were used.

Seedlings were planted at 19 of the installations in January 1954, 42 in 1955, 38 in 1956, 12 in 1957, and 2 in 1958. Dead seedlings were replaced after 1 year, as follows. In Mississippi and the Florida parishes of Louisiana, survivors on individual inadequately stocked plots were destroyed, and the plots were completely replanted. More than once on a few plots, seedlings were destroyed, and the plots were replanted. In Louisiana, west of the river, individual dead or missing seedlings were replaced with 1-O nursery stock, or the entire outplantings were destroyed and replanted. Replacement trees became a part of the established stand if they survived but were not included in the computation of first-year survival

Survival was inventoried at the end of the first growing season. Subsequent inventories, when trees on the majority of plots in individual installations were 2, 3, 10, 15, 20, or 25 years old, provided information on stocking, growth and yield, and field infections of fusiform rust caused by the fungus *Cronartium quercuum* f. sp. *fusiforme*.

Soil in each block of each installation was sampled and analyzed at the time of planting for the following properties:

**Wet sites:** organic matter in A, horizon, texture of 6- to b-inch layer, and texture and 1/3 and 15 atmosphere percentages for moisture content of the B horizon.

**Intermediate sites:** organic matter in A, horizon, texture of A horizon, and texture and 1/3 and 15 atmosphere percentages for moisture content of the B horizon.

**Dry sites:** organic matter in A, horizon, texture of 6- to b-inch layer, and texture and 1/3 and 15 atmosphere percentages for the moisture contents of the 16- to 20-inch and 36- to 40-inch layers of soil

These properties had been identified in completed and ongoing research as the physical characteristics of soils most likely to be associated with tree growth.

During 1986-88, soils in 62 of the remaining 70 pine plantations (43 plantations did not survive until 1986) were sampled. A total of 3,029 core segments were collected, representing individual horizons from 581 research plots. Each horizon was described in the field, and enough soil was collected from each to analyze soil properties. Laboratory analyses of the physical properties of the soils were performed on all the Louisiana samples (1,393). The testing consisted of texture or particle size analysis (sand, silt, and clay) and soil moisture determinations giving the 1/3 and 15 atmosphere percentages.

Rainfall information was compiled from U.S. Weather Service records for weather stations nearest each installation. Fusiform rust infection of the main bole was recorded. Measurements of or determinations for the following criteria were made: d.b.h. to 0.1 inch and total heights to 1.0 ft of all trees at age 10; d.b.h. to 0.1 inch and total heights to 1.0 ft of all plot trees at ages 15 through 25; upper stem dimensions and crown classes of sample trees at ages 15 through 25; and height to base of the full live crown to 1.0 ft at age 25. Height of the dominant stand was determined, and mean annual increments were expressed in three ways-basal area, total cubic volume, and merchantable cubic volume. Also, relationships between the 15-year heights of loblolly and slash pines were compared.

## Major Publications or Progress Reports


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**Planting Site-Genotype Interactions in Loblolly and Slash Pines** **(See summary, p. 155.)**

Twenty families of trees from select parents, 10 each from loblolly (*Pinus taeda*) and slash (*P. elliottii*) pines, are being tested on 4 soil types that range from poorly drained to moderately well drained. The purpose of the study is to determine to what extent site characteristics influence the growth of select genotypes differently, to observe how families native to specific soil microenvironments perform over a range of site conditions, and to compare the survival and growth of the two species on the various sites. Results will be evaluated on the basis of survival, growth, and resistance to fusiform rust caused by the fungus *Cronartium quercuum* f. sp. *fusiforme*. Foresters who have obtained detailed information about particular soils can utilize the results of this study in making the best match of genotype and site to obtain maximum production.

These families of trees were outplanted at four locations within Louisiana (Oberlin, Pitkin, Jonesboro, and Haile) in the spring of 1977. At each location, the families were randomly organized into 3 blocks, replicated 3 times, and planted in 81-tree plots at a spacing of 8 by 8 ft. Each plot has 4 rows of isolation surrounding the measurement plot of 25 trees. The four soil types are Guyton silt loam and Caddo silt loam (Typic Glossoqualfs), Providence silt loam (Typic Fragiudalfs), and Malbis fine sandy loam (Plinthic Paleudults). The seedlings came from wind-pollinated seeds of 20 select seed orchard clones. A total of 972 trees per source, or a grand total of 19,440 trees, was planted in all 4 plantations.

The slash pine seeds were from selections in the Osceola and Apalachicola National Forests of Florida (extreme northern part of the State) and the DeSoto National Forest of Mississippi. Restricting the Florida slash collections to the northern part of the State avoided the possibility of natural hybridization with south Florida slash pine (*P. elliottii* var. *densa*), which is present in central and southern Florida.

The loblolly pine collections were from select clones from southeast Arkansas, northeast Louisiana, southeast Louisiana, southwest Mississippi, and coastal South Carolina. Loblolly pine sources from mountain areas and from the extreme northern portion of the range of the species were not used because seed source tests have indicated that trees from these sources do not perform well in the proposed planting areas. Seedlots used in the study are listed in table 1.

**Table 1.**— *Seedlots used in the planting site-genotype interactions in loblolly and slash pines study**

| Number | Seed parent | Origin | Source |
|---|---|---|---|
| 1 | SH-13 (Loblolly) | Union Parish, LA | Olinkraft |
| 2 | A-1-14 (Loblolly) | Washington Parish, LA | Crown Zellerbach |
| 3 | B-5-3 (Loblolly) | Livingston Parish, LA | Crown Zellerbach |
| 4 | CR-4 (Loblolly) | Ashley County, AR | USDA, Forest Service |
| 5 | SH-7 (Loblolly) | Union County, AR | Olinkraft |
| 6 | SC 2-131-4-1402 (Loblolly) | Berkeley County, SC | USDA, Forest Service |
| 7 | M-2-C (Loblolly) | Lawrence County, MS | Crown Zellerbach |
| 8 | SH-11 (Loblolly) | Union Parish, LA | Olinkraft |
| 9 | B-18 (Loblolly) | St. Helena Parish, LA | Crown Zellerbach |
| 10 | B-4-5 (Loblolly) | Livingston Parish, LA | Crown Zellerbach |
| 11 | Fla. 30 (Slash) | Wakulla County, FL | USDA, Forest Service |
| 12 | Fla. 27 (Slash) | Baker County, FL | USDA, Forest Service |
| 13 | Fla. 24 (Slash) | Leon County, FL | USDA, Forest Service |
| 14 | Fla. 32 (Slash) | Wakulla County, FL | USDA, Forest Service |
| 15 | MS 38 (Slash) | Wayne County, MS | USDA, Forest Service |
| 16 | MS 32 (Slash) | Wayne County, MS | USDA, Forest Service |
| 17 | Fla. 36 (Slash) | Wakulla County, FL | USDA, Forest Service |
| 18 | Fla. 38 (Slash) | Wakulla County, FL | USDA, Forest Service |
| 19 | MS 21 (Slash) | Wayne County, MS | USDA, Forest Service |
| 20 | Fla. 3 (Slash) | Wakulla County, FL | USDA, Forest Service |
| 21 | Continental Woodsrun (Loblolly) | | Continental Woodlands |
| 21 | SH-3 (Loblolly) | Union Parish, LA | Olinkraft |
| 22 | Continental Select (Loblolly) | | Continental Woodlands |
| 22 | B-5-7 (Loblolly) | Livingston Parish, LA | Crown Zellerbach |
| 23 | Fla. 41 (Slash) | Baker County, FL | USDA, Forest Service |

*No articles from this research have been published to date (1995).

## Growth and Yield of Loblolly and Slash Pines in Unthinned Plantations (See summary, p. 155.)

Growth and yield of loblolly (*Pinus taeda*), longleaf (*P. palustris*), and slash (***P.** elliottii*) pines have been studied by personnel at Research Work Unit 4101 of the USDA Forest Service's Southern Forest Experiment Station for about 40 years. Permanent plots measured at regular intervals over long periods of time have been used in the studies. The plots were used to determine the effects of initial planting spacing and thinning regimes on periodic growth and total production. Incidental to the primary objectives of these studies, a large body of information has been accumulated on yields from unthinned stands. In 1972 and 1973, supplementary plots were established in loblolly and slash pine plantations to broaden the array of sites, ages, planting densities, and survival percentages. The description of these additional studies and the accumulated data follow.

The objectives were to determine how site, age, initial planting spacing, and survival affect yields of unthinned loblolly and slash pine plantations on cutover sites. For loblolly pine, trees survived in 76 of 96 plots originally established in plantations ranging in age from 16 to 36 years on 18 study areas in Louisiana, Mississippi, and Texas. The "lost" plots were either accidentally cut by cooperators or were destroyed by insect, disease, wind, or ice damage. There were 47 slash pine plots ranging in age from 21 to 41 years in plantations located in 12 areas in 3 States. No effort was made to establish these plots in any particular statistical design for hypothesis testing because the main objective was to obtain growth and yield data for modeling purposes. The plots for each species were measured at establishment and remeasured every 5 years thereafter until studies were closed.

The study plots varied in size but were no smaller than 0.1 acre and contained at least 50 measurement trees at the time of establishment. A 0.5-chain buffer strip surrounded each measurement plot. The basal areas of the plots were measured using trees in all measurement plots. Volumes were determined from a subset of those trees, which were chosen proportionately from each diameter class according to numbers within each class. The volumes of these selected trees were estimated by the height-accumulation method. Cubic-foot volumes of plots were estimated from volume-basal area ratios.

The study is closed, and most of the plots that remained were either clearcut or thinned by the study cooperators.

## Major Publications or Progress Reports


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Feduccia, D.P. 1983. Effects of site, age, planting density, and survival on yield of slash pine on cutover sites. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Final report. 98 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

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Popham, T.W.; Feduccia, D.P.; Dell, T.R. [and others]. 1979. Site index for loblolly plantations on cutover sites in the West Gulf Coastal Plain. Res. Note SO-250. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 7 p.

Zarnoch, S.J; Feduccia, D.P. 1984. Slash pine plantation site index curves for the West Gulf. Southern Journal of Applied Forestry. 8(4): 223-225.

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Accelerated **Sawlog** Production (See summary, p. 156.)

Twelve 0.25-acre square plots, each with a 0.5-chain-wide isolation zone, were established in a g-year-old loblolly pine (*Pinus taeda*) plantation in Arkansas to determine and compare the effects of four intensive treatments on the cubic and board-foot yields and wood properties of selected trees. The plots were organized into three blocks according to basal area and suspected differences in site quality. In each plot, 100 crop trees per acre (25 per plot) that were well spaced, vigorous, and well formed were selected. Four treatments were assigned randomly within each block, making three replications of each plot. Two treatments were begun immediately, and two were started at age 12 when the average tree had attained merchantable pulpwood size-at least 4.6 inches in d.b.h. and containing at least two 63-inch bolts to a 3-inch (d.i.b.) top. The four treatments were as follows:

(1) Sawtimber only.-All but the crop trees were cut at age 9, which reduced basal area to 10 ft²/acre. Stands were thinned to 76 trees per acre at age 19, 64 trees at age 24, 48 trees at age 27, and 41 trees at age 30.

(2) Sawtimber-pulpwood.-At ages 9 and 12, noncrop trees having crowns that were within 5 ft of crop tree crowns were removed. The last noncrop trees were removed at age 15. Further thinnings left 80 trees per acre at age 19, 63 trees at age 27, and 52 trees at age 30.

(3) Delayed sawtimber.-All but the 100 crop trees per acre were removed at age 12. The 0.25-acre plots were thinned to 80 trees per acre at age 24, 53 trees at age 27, and 45 trees at age 30 (fig. 17).

(4) Control-Plots were thinned, mainly from below, to a basal area of 85 ft²/acre at age 12 and every 3 years afterward through age 30. The thinnings reduced stand density to 712 stems per acre at age 12, 468 stems at age 15, 333 stems at age 18, 251 stems at age 21, 193 stems at age 24, 148 stems at age 27, and 116 stems at age 30.

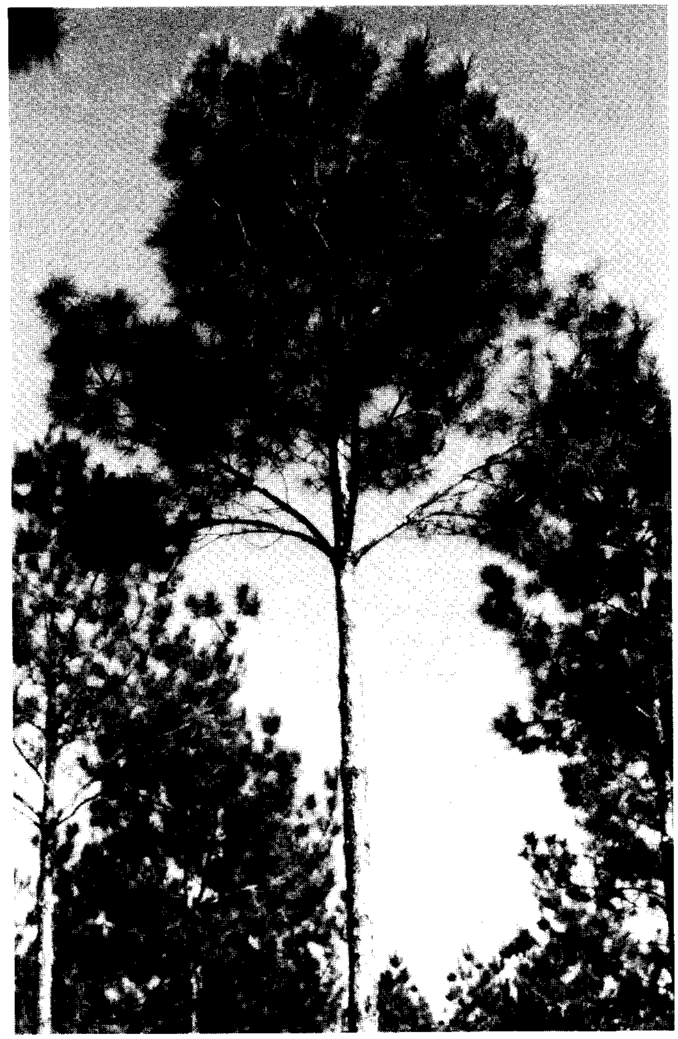

Figure 17.—*Loblolly pine trees pruned at age 16.*

Crop trees in the intensive treatments were pruned to about one-half of their total height after the first thinning in the treatment and every 3 years afterward through age 24 (fig. 18).

Beginning at age 19, the woody understory (hardwood sprouts, vines, and shrubs) in the intensive-culture plots was controlled by mowing at 2-year intervals. The purpose of heavy thinning and understory control was to reduce competition for soil moisture and thus to accelerate the growth of the crop trees.

## Major Publications or Progress Reports

Burton, J.D. 1981. Sawtimber by prescription-the sudden sawlog story through age 33. Res. Pap. SO-

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## RANGE MANAGEMENT FOR SOUTHERN PINE ECOSYSTEMS

### Interrelated Effects of Cattle Grazing and Reforestation in the Pine-Slender Bluestem Type (See summary, p. 157.)

The reforestation of cut-over lands in the Southeastern United States gained momentum during the 1950's and 1960's. Generally, reforested stands in the pine (*Pinus* spp.)-slender bluestem *(Andropogon* spp.) type were grazed by cattle, either continuously or after a period of exclusion following planting or seeding. Although timber production was considered the primary land use in the area, substantial numbers of range livestock grazed the reforested areas until the trees shaded out the forage resource. With the use of prescribed burning, the grazeable resource was maintained for longer periods beneath the young timber stand by removal of the litter.

The purpose of this study was to learn whether cut-over southern pine ranges could be successfully regenerated artificially with slash pine (*Pinus elliottii*) while being grazed yearlong by beef cattle. Specific objectives were: (1) to determine whether beef cattle production was compatible with the establishment and growth of artificially regenerated slash pine stands; (2) to measure the effects of various grazing intensities on the survival and growth of planted and direct-seeded slash pine regeneration; (3) to determine the effects of various grazing intensities on the production efficiency of beef breeding herds; and (4) to compare the economic returns from combined cattle grazing and pine production with those from timber alone.

The study, which was initiated in 1960, was located in three range units composed of about 1,600 acres on the Longleaf Tract in the Palustris Experimental Forest near McNary, LA. The three range units were stocked with native cows to produce light, medium, and heavy grazing intensities equal to 30-, 45-, and 60-percent utilization, respectively. About 17 percent of each range unit was planted to 1-0 slash pine seedlings, and about 8 percent of each unit was direct-seeded to slash pine during each of the first 4 years of the study. Seedlings were planted in May.

Site preparation by disking before seeding did not enhance the survival of a residual stand of pine. Without grazing, the number of pine seedlings decreased from an initial 15,000 to 6,000 per acre in May to less than 2,000 per acre by October of the second year. An initial 908 planted pine seedlings per acre decreased

Figure 18.-A *heavily thinned loblolly pine plantation.*

to an average of 731 trees by October of the second year on ungrazed areas. The greatest losses occurred by the first October following regeneration.

After 5 years, only heavy grazing intensities significantly reduced planted slash pine stands. These reductions mainly occurred before May following planting. None of the grazing intensities significantly reduced the number of seeded trees due to the high seedling survival. Tree heights after 5 years were about 6 and 10 ft for direct-seeded and planted pines, respectively. Only on the moderately grazed planted area were the grazed trees significantly shorter than protected trees.

Herbage production before forest regeneration averaged over 2,000 lb/acre initially, remained above 1,600 lb until tree age 9, and was about 1,300 lb at tree age 10. All range units produced less than 1,000 lb/acre by the 12th year and remained so until commercial pulpwood thinnings.

Heavy grazing reduced the density of planted seedlings during the first few months following regeneration. Although differences between heavily grazed and paired ungrazed plots persisted through the study, significant mortality occurred only during the first several months after planting. At tree age 18, tree density was less on heavily grazed plots, d.b.h. was more, and volume was the same compared to ungrazed plots.

These results illustrate that the greatest economic returns are obtained by a combination of livestock and timber. Equally important is that flexibility in land management aids in surviving poor markets.

### Major Publications or Progress Reports

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**Some Effects of Planted Pines on Range Forage Vegetation in Central Louisiana**
**(See summary, p. 157.)**

Long-term studies measuring overstory pine and understory herbage relationships were started on the Longleaf Tract in the Palustris Experimental Forest near McNary, LA, in 1960. The slash pine (*Pinus elliottii*) plantations were planted in 1955-56, and the longleaf pine (*P. palustris*) plantations were planted in 1951-52.

The purpose of this study was to determine the effects of canopy conditions in pine plantations on the quantity and chemical and botanical composition of understory herbage. The slash pine plantation was 4 years old, and the longleaf pine plantation was 8 years old when the study was initiated in 1960. Crown closure at that time had not occurred in either plantation; therefore, canopies did not have any important effects on forage composition. In 1969, additional plots of longleaf pine were added to the study to determine the effects of moderate grazing by cattle on the herbage vegetation.

Vegetation measurements included herbage yield, botanical composition and nutritive value, and basal area of trees; these measurements of the native range vegetation continued from 1960 through 1975. Chemical analyses of the herbage samples were conducted by personnel of the Feed and Fertilizer Laboratory at Louisiana State University.

During the first 10 years of investigation, herbage production decreased about 15 lb/acre for every square foot of increase in the basal area of longleaf or slash pine. Pinehill and slender bluestem *(Andropogon* spp.) produced about equal amounts of herbage on both the longleaf and slash pine ranges in 1960, yielding nearly 50 percent of the total; in 1969, pinehill bluestem produced about 50 percent of the total herbage, and slender bluestem generally produced less than 10 percent. The nutritive value of herbage was low but was enhanced through reforestation. (Herbages generally contain more protein and phosphorus on reforested pine range than on cut-over range.)

By 1975, pinehill and slender bluestem were still the principal herbaceous species on unforested treatment plots, and a mixture of forbs, pinehill bluestem, and other bluestem grasses were most abundant on forested treatment plots. A regression equation based on the basal area of pine and the precipitation for April through October explained 80 to 85 percent of the variation in herbage production.

Productive mixtures of herbaceous species can be maintained through periodic timber harvest and rotational burning, although 2 to 3 years of heavy use can be expected if clearcuts make up a minor percentage of a grazed range unit. Heavy use converts clearcuts predominantly to carpetgrass (*Axonopus* sp.) and forested range to a mixture of forbs.

The study was closed in 1981, and the plots were subsequently incorporated into a subterranean clover (*Trifolium subterranean)* study in cooperation with the School of Forestry and Wildlife at Louisiana State University.

**Major Publications or Progress Reports**

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Pearson, H.A. 1981. Some effects of planted pine on range forage vegetation in central Louisiana. Pineville, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Final report. 40 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

Wolters, G.L. 1973. Southern pine overstories influence herbage quality. Journal of Range Management. 26(6): 423-426.

Wolters, G.L. 1981. Timber thinning and prescribed burning as methods to increase herbage on grazed and protected longleaf pine ranges. Journal of Range Management. 34(6): 494-497.

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Wolters, Gale L. 1982. Longleaf and slash pine decreases herbage production and alters herbage composition. Journal of Range Management. 35(6): 762-763.

**Relationships of Stand Density to Herbage Yield in a Longleaf Pine Plantation (See summary, p. 158.)**

The relationships between overstory pines and understory forages have been studied for about 30 years. Studies of overstory-understory relationships in longleaf pine (*Pinus palustris*) plantations were initiated in 1964 on the Johnson Tract in the Palustris Experimental Forest near McNary, LA, in a cooperative effort between Research Work Units 4201 and 4101 of the USDA Forest Service's Southern Forest Experiment Station.

The study objective was to determine the relationships of herbage yield to basal area and other stand variables in a longleaf pine plantation that was prescribed burned and thinned at 5-year intervals.

The 40-acre study plantation, which was established on cut-over range in south-central Louisiana in 1935, contained four 6-acre blocks, each containing sixteen 0.62-acre plots. Trees were 30 years old at study initiation and were planted on four plots per block at each of four grid spacings of approximately 4, 5, 6, and 13 ft. Three of the four plots per block of each spacing (except 13 ft) were thinned initially at age 20 to basal areas of 60, 80, and 100 $ft^2$/acre and have been thinned every 5 years since then. The fourth plot of these spacings was thinned at age 16 to 100 trees per acre and pruned to a height of 17 ft. Other pruning treatments, including an unpruned check, were assigned to the 13-ft plots; only the unpruned 13-ft plots were used in this study. Timber Management Research personnel provided stand measurements for ages 30 and 35, including basal area, number of trees per acre, and height to live crown. Prescribed burning of the plots was during winter at 2- to 3-year intervals. Measurement plots were 0.1 acre in size with a 0.5-chain buffer between plots. Measurements included herbage production, precipitation, and basal area of trees. Plots were measured from tree age 30 through age 45.

Herbage production was measured annually in this ungrazed experimental longleaf pine plantation from age 30 to age 40 and again at age 45. Herbage yields at tree age 30 were 494, 486, and 332 lb/acre (ovendried) for basal areas of 60, 80, and 100 $ft^2$/acre, respectively; at tree age 35, yields were 1,093, 904, and 790 lb/acre; at tree age 40, yields were 1,322, 1,073, and 903 lb/acre; and at tree age 45, yields were 1,354, 1,340, and 1,084 lb/acre.

Timber measurements included basal area, number of trees per acre, and tree heights. Of all timber measurements, basal area was most significantly related to herbage yield, and the relationship was strengthened by the inclusion of rainfall amounts for May through September. Herbage measurements before tree age 35 were affected by prior heavy grazing in the plantation.

The study was closed in 1982, but plots and treatments remain intact at the present and are being maintained by Research Work Unit 4101.

**Major Publications or Progress Reports**

Grelen, H.E. 1982. Relationships of stand density to herbage yield in a longleaf pine plantation. Pineville, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Final report. 7 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Pineville, LA.

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Grelen, Harold E. 1967. Relationships of stand density to herbage yield in a longleaf pine plantation. Pineville, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Establishment and progress report. 30 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

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Grelen, Harold E.; Lohrey, Richard E. 1978. Herbage yield related to basal area and rainfall in a thinned longleaf plantation. Res. Note SO-232. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 4 p.

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**Understory Herbage Responses Following Timber Site Preparation (See summary, p. 158.)**

Thousands of acres of timber are harvested annually in the loblolly (*Pinus taeda*)-shortleaf (*P. echinata*) pine-hardwood forest type; however, reestablishment of a fully stocked stand of pines is extremely difficult due to aggressive hardwood competition. Industrial timber companies and government agencies have used various preplanting mechanical site-preparation treatments to improve establishment and growth of planted pines. Mechanical site preparation generally refers to treatment of a site before planting with equipment such as shearing blades, heavy disks, or rolling choppers to reduce or eliminate the competing hardwoods. Because of the specific intent of the treatment, mechanical site preparation is detrimental to understory vegetation.

The loblolly-shortleaf pine-hardwood forest type provides yearlong grazing for thousands of cattle, in addition to being prime deer habitat. The immediate and long-term impact of mechanical site preparation on understory vegetation needs to be known to determine the multiple-use potentials of this forest type following these treatments.

The objectives of this study were: (1) to determine the effects of various mechanical site-preparation treatments on the production and botanical composition of understory vegetation; (2) to determine the effects of soils on plant succession following site preparation; and (3) to determine the effects of fertilization on the understory vegetation.

Eight site-preparation treatments were applied to five soils during the fall of 1970 and 1971; years served as replications. Soil texture types included: (1) sand; (2) loam; (3) gravel; (4) clay (moderate permeability); and (5) clay (poor permeability).

Site preparation treatments included: (1) underplant-release; (2) chop-burn; (3) chop-burn-flat disk; (4) chop-delay-chop; (5) chop-burn-mound disk; (6) shear-burn; (7) shear-windrow-burn; and (8) shear-windrow-disk. The under-plant-release treatment served as the control for the seven mechanical treatments.

The study, located throughout central and northern Louisiana and southern Arkansas, consisted of 80 plots measuring 144 by 162 ft. After site-preparation treatments were completed, the 80 plots were split; approximately one-third of each plot was fertilized, and the remaining two-thirds served as the untreated control Plots were hand-planted to loblolly pine at 6- by 8-ft spacings during January.

Herbaceous vegetation was sampled on 20 systematically spaced quadrats (9.6 $ft^2$) on each plot. Percentages of basal cover, production, and composition were estimated for each species. The number, height, and crown diameter of all woody stems less than 1 inch in d.b.h. were determined for each species in four 0.01-acre circular quadrats on each plot. Woody stems 1 inch in d.b.h. and larger were measured on four 0.025acre circular quadrats on each plot. Pretreatment inventories were made on 80 plots, and post-treatment inventories were made on 160 split plots.

Initial posttreatment inventories were begun one complete growing season after site preparation and were repeated annually for 3 years and again at tree age 7. The responses of understory herbage to the treatments were compared. Because of the nature and extent of the problem, many industrial timber companies and government agencies pooled resources and facilities for the study. Installation began during June 1970. Study measurements are complete.

### Major Publications or Progress Reports


Haywood, J.D.; Thill, R.E.; Burton, James D. 1981. Intensive site preparation affects loblolly pine growth on upland sites. In: Forest regeneration: proceedings of symposium on engineering systems for forest regeneration; 1981 March 2-6; Raleigh, NC. St. Joseph, MI: American Society of Agricultural Engineers: 224-231.

Wolters, G.L. 1974. Understory herbage responses following timber site preparation. Pineville, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Establishment and progress report. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Pineville, LA.

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Wolters, Gale L.; Martin, Alton, Jr.; Clary, Warren P. 1977. Timber, browse, and herbage on selected loblolly-shortleaf pine-hardwood forest stands. Res. Note SO-223. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 9 p.


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### Assessment of Nonpoint Source Pollution from Intensive Silvicultural Practices and Livestock Grazing in Southeast Forests (Cooperative with Texas A&M University; see summary, p. 159.)

Concern over the impact of silvicultural practices and livestock grazing and an awareness of possible environmental effects of sediment-laden stream waters underscore the need for basic information on nonpoint source pollution from silvicultural practices and livestock grazing. Reliable data on water quality are also urgently needed by the State of Texas for it to comply with Federal regulations set forth in Section 208 of the 1972 Federal Water Pollution Control Act Amendments (PL 92–500). Such information is not available at present for Texas or the south-central region.

This cooperative study, which was initiated in 1980 near Broaddus, TX, provided data from five experimental watersheds on the quality and quantity of water during and after treatment. The objectives of the study were: (1) to develop baseline data on the quality and quantity of water for stabilized forest sites (those that have been relatively undisturbed for 15 to 20 years); (2) to assess the impact of clearcutting and mechanical site preparation on the quality and quantity of water during treatment and for 10 years following treatment; and (3) to assess the impact of two livestock grazing systems and no grazing on the quality and quantity of water for 10 years following treatment.

Three of the watersheds were treated by clearcutting and shearing all remaining vegetation (shrubs, culls, and unmerchantable timber) with a V-blade. Slash and debris were windrowed. The fourth watershed was clearcut and site prepared by roller chopping. Two of the clearcut watersheds were grazed by livestock, and the remaining three watersheds were not grazed; two of those were used to evaluate clearcutting and site preparation, and one (untreated) was the control Each watershed was characterized as to water yield; sedimentation; turbidity; nitrogen, phosphorus, potassium, and bacteria percentages; soil bulk density; and plant biomass.

This study also assessed the impact of livestock grazing systems on large grazing allotments located on the Angelina District of the Texas National Forest and the Vernon District of the Kisatchie National Forest in Louisiana; the effects of prescribed burning were also studied on the Palustris Experimental Forest near McNary, LA. Through use of a rainfall simulator, clearcut and timbered areas, grazed and ungrazed areas, and burned and unburned areas were characterized by infiltration, sediment production, amount of standing crop and ground cover, soil bulk density, organic matter concentration, coliform bacteria percentage, runoff, and nitrate nitrogen, total phosphate, and orthophosphate concentrations.

The study continued through 1990.

### Major Publications or Progress Reports


Blackburn, W.H. 1980. Assessment of nonpoint source pollution from livestock grazing on clearcuts in east Texas. College Station, TX: Texas A & M University. Study plan. 24 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

Blackburn, W.H. 1982. Status report of cooperative watershed research projects between Texas Agricultural Experiment Station, Southern Forest Experiment Station, and Angelina and Kisatchie National Forests. College Station, TX: Texas A & M University. Progress report. 5 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

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Blackburn, W.H. 1983. Resume of work accomplished. College Station, TX: Texas A & M University. Progress report. 30 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Pineville, LA.

Blackburn, W.H.; Wood, J.C.; Pearson, H.A. [and others]. 1986. Assessment of water yield and quality from intensive silvicultural practices and livestock grazing in southeast forests. College Station, TX: Texas Agricultural Experiment Station, Texas A & M University. Annual progress report. 223 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

Blackburn, W.H.; Wood, J.C.; Pearson, H.A.; Knight, R.W. 1987. Storm flow and sediment loss from intensively managed forest watersheds in east Texas. In: Pearson, Henry A.; Smeins, Fred E.; Thill, Ronald E., comps. Ecological, physical, and socioeconomic relationships within southern national forests: Proceedings of the southern evaluation workshop; 1987 May 26-27; Long Beach, MS. Gen. Tech. Rep. SO-68. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 233-243.

Blackburn, W.H.; Wood, J.C.; Weichert, A.T. [and others]. 1986. Assessment of water yield and quality from intensive silvicultural practices and livestock grazing in southeast forests. College Station, TX: Texas Agricultural Experiment Station, Texas A & M University. Annual progress report. 198 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

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DeHaven, M.; Blackburn, W.H. 1980. Assessment of nonpoint source pollution from intensive forest practices in east Texas. College Station, TX: Texas A & M University. Progress report. 37 p. On file with:

U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

Dobrowolski, J.P.; Blackburn, W.H.; Grelen, H.E. 1984. Infiltration rates and water quality of longleaf pine/bluestem range following 22 years of seasonal burning. [Abstract]. In: Abstract of papers of the 37th annual meeting of the Society for Range Management; 1984 February 12-17; Rapid City, SD. Denver, CO: Society for Range Management: 67.

Dobrowolski, J.P.; Blackburn, W.H.; Grelen, H.E. 1985. Effects of long term burning on the hydrological and chemical properties of southeast forest soils. College Station, TX: Texas A & M University. Final report. 370 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

Dobrowolski, J.P.; Blackburn, W.H.; Grelen, H.E. 1985. The influences of fire on nutrient movement in a longleaf pine/pinehill bluestem association. [Abstract]. In: Abstract of papers of the 38th annual meeting of the Society for Range Management; 1985 February 11-15; Salt Lake City, UT. Denver, CO: Society for Range Management: 56.

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Dobrowolski, James Phillip. 1985. Soil hydrologic changes and nutrient flux following long-term burning of a longleaf pine-bluestem association. College Station, TX: Texas A & M University. 367 p. M.S. thesis. Vol 1.

Fuchs, C.R.; Gray, L.D. 1982. Soil survey of a small forested watershed on nonpoint source loading in San Augustine County, Texas. USDA Soil Conservation Service. Soil survey report. 45 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

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Hunter, T.K.; Blackburn, W.H.; Knight, R.; Weichert, A.T. 1981. Assessment of nonpoint source pollution from livestock grazing on intensive managed forest in the Southeast. College Station, TX: Texas A & M University. Progress report. 57 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

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Hunter, T.K.; Blackburn, W.H.; Weichert, A.T.; Dobrowolski, J.P. 1983. Effect of forest site preparation and livestock grazing on stormflow and water quality in the Southeast. College Station, TX: Texas A & M University, Texas Water Resources Institute. Interim progress report. 100 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

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Knight, R.W.; Spillman, J.W.; Caffey, R.J. [and others]. 1990. Assessment of water yield and quality from intensive silvicultural practices and livestock grazing in southeast forests. College Station, TX: Texas Agricultural Experiment Station, Texas A & M University. Annual progress report. 208 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

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Beach, MS. Gen. Tech. Rep. SO-68. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 245-249.
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**Understory Herbage Response to Spacing of Loblolly Pine Following Site Preparation**
**(See summary, p. 160.)**

Mechanical site preparation and wide spacing in pine plantations were relatively new in the 1960's and 1970's; however, both are now standard practices in the South. The purpose of preparing sites is to provide a more favorable environment for growth of planted pine seedlings. Wide spacing reduces tree competition during early growth years and permits sunlight to reach the understory vegetation during the growth cycle of trees. The influence of site preparation and wide spacing on the value of range and wildlife habitat is not well documented.

The loblolly (*Pinus taeda*)-shortleaf (*P. echinata*) pine-hardwood forest type provides yearlong grazing for cattle and serves as prime white-tailed deer (*Odocoileus virginianus*) habitat. The immediate and long-term impacts of site preparation and wide spacing on understory vegetation need documenting to determine the future multiple-use potential of this forest type.

This study, which was initiated in 1970 in central Louisiana, was a cooperative effort among Research Work Unit 4101 of the USDA Forest Service's Southern Forest Experiment Station, the Kisatchie National Forest, and the Louisiana Forestry Commission. The objectives of the study were: (1) to determine the effects of different site-preparation treatments on pretreatment and posttreatment production and botanical composition of understory vegetation; (2) to determine the effects of soils on plant succession following site preparation; and (3) to determine the effects of pine spacing on development of understory vegetation.

Two site-preparation treatments (underplant and release, and shear-windrow-burn) were applied to two soils, Ruston (Typic Paleudults) and Sawyer (Aquic Paleudults), annually during 1970 and 1971; years served as replications. Following site preparation, plots were subdivided into five 144- by 162-ft plots and hand-planted to loblolly pine on spacings of 4 by 6, 6 by 8, 8 by 12, and 12 by 16 ft; an unplanted control plot was included.

Herbaceous vegetation was sampled on 20 systematically spaced quadrats (9.6 $ft^2$) on each plot. The percentages of basal cover, production, and composition were estimated by species. The number, height, and crown diameter of all woody stems less than 1 inch in d.b.h. were determined for each species in four 0.01-acre circular quadrats on each plot. Woody stems 1 inch in d.b.h. and larger were measured on four 0.025-acre circular quadrats on each plot.

Initial posttreatment inventories were begun the first growing season after site preparation and were repeated annually for 3 years and again at tree age 7. The responses of understory herbage to treatments were compared following each inventory by appropriate analysis of variance.

Pretreatment analysis of vegetation indicated that density and basal area of trees, density and crown cover of browse, and herbage production were greater on Sawyer soil than on Ruston. Approximately 50 percent of the total basal area was pine on Sawyer soil, and hardwoods furnished nearly 75 percent of the basal area on Ruston soil French mulberry (*Callicarpa americana*) was, by far, the most abundant browse species of Sawyer soil, but on Ruston, french mulberry and shining sumac (*Rhus copallinum*) shared importance. Longleaf and spike uniola (*Uniola* spp.) produced about 55 percent of the herbage on Sawyer soil but less than 5 percent on Ruston. Pinehill and broomsedge bluestem (*Andropogon* spp.) produced 40 percent of the herbage on Ruston soil but less than 5 percent on Sawyer.

The study measurements are complete.

**Major Publications or Progress Reports**

Wolters, G.L. 1971. Understory herbage response to spacing of loblolly pine following site preparation. Pineville, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 15 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.
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**Comparison of Burning Dates in a Young Natural Loblolly-Shortleaf Pine Stand**
**(See summary, p. 161.)**

The loblolly (*Pinus taeda*)-shortleaf (*P. echinata*) pine type in Louisiana typically consists of natural uneven-aged pine stands with a fairly dense midstory of hardwoods, an abundance of shrubs, and a paucity of herbaceous vegetation in the understory. The longleaf (*P. palustris*)-slash (*P. elliottii*) pine type usually lacks a hardwood midstory and has an abundance of herbaceous vegetation in the understory. Although the soils and topography of the two pine types differ, several million acres of longleaf pine in the Coastal Plain have been replaced by loblolly-shortleaf pine-hardwood forests because fire was excluded during stand development.

Current methods of harvesting loblolly-shortleaf pine timber include clearcutting small 40- to 50-acre compartments that are then site prepared and regenerated. These regenerated clearcuts ultimately lead to even-aged compartment management and provide managers an opportunity to restore fire to a more prominent role in the silviculture of loblolly-shortleaf pine stands. Early and frequent burning, if accompanied by periodic thinning, should maintain adequate herbaceous forage for livestock and wildlife.

The first burn should be made as early as possible after a stand of seedlings is established if maximum control of hardwoods is to be obtained and competition from younger unwanted pine regeneration eliminated. Some researchers recommend 10 years as the minimum age at which young pines, other than longleaf, can be safely burned, and others suggest that burns can be successful in 4- or 5-year-old plantations averaging 8 to 10 ft in height.

This study, which was initiated in 1982, was located on Saddle Bayou in the Catahoula Ranger District of the Kisatchie National Forest near Williana, LA. A 46-acre stand was clearcut and mechanically site prepared in 1976 and planted with loblolly pine seedlings in early 1977.

The original study objective was to determine the best dates for burning young natural stands of loblolly-shortleaf pine on regenerated clearcuts for: (1) improving the herbage resource (in conjunction with thinning); (2) controlling hardwood and unwanted pine regeneration; and (3) producing maximum herbaceous forage in the absence of pines and hardwoods (as a multiple-use alternative).

Researchers in the study compared March, May, and July burns in a young natural stand of loblolly and shortleaf pines to determine the burning season most effective for pine growth, herbage production, and hardwood control

Beginning in 1982, burning treatments were applied every other year to plots thinned to approximately 700 trees per acre. An unburned control plot was included. Pines were 5 years old at the beginning of the 1982 season. Treatments were also applied to plots from which pines and hardwoods had been completely removed. Treatments were applied in three randomized-block replications to 0.25-acre plots.

A 7-acre study area was fenced in within the 46-acre regenerated clearcut. Burning treatments were applied biennially to the smaller area in even-numbered years through 1992.

By the end of the 1983 growing season, some hardwood regrowth on burned plots was obviously too large to be controlled by the 1984 burning treatments. Thus, the study was revised to include top removal of hardwoods and shrubs not controlled by burning. Tops were severed during May of the odd-numbered years; burning treatments were applied in even-numbered years.

The revised objectives were as follows:

(1) to compare the survival and growth of pines and yield and botanical composition of herbage on unburned, unthinned, and otherwise undisturbed plots with those measurements on plots with pines thinned and hardwoods controlled by cutting and biennial burning in March, May, or July;
(2) to compare the yield and composition of herbage on plots with pines, hardwoods, and shrubs controlled by top removal alone with those measurements on plots with woody plants controlled by combinations of cutting and biennial burning in March, May, and July;
(3) to determine if the woody understory on loblolly-shortleaf pine sites could be controlled by biennial fires after several years of top removal by the combination of burning and cutting.

Treatment was applied through 1992 (see table 2 for treatments), and the study was completed in 1993.

Table 2.— *Treatments for the comparison of burning dates in a young natural loblolly-shortleaf pine stand study*

| Treatment | Timbered plots | Clearcut plots |
|---|---|---|
| Control | Unburned; pines unthinned; no woody plant control | Unburned; all woody plants above 3 ft tall cut back in odd-numbered years |
| Burn: | | |
| March 1 | Burned in even-numbered years; pines thinned; hardwoods cut back in odd-numbered years | Burned in even-numbered years; all woody plants cut back in odd-numbered years |
| May 1 | Same as for March burn | Same as for March burn |
| July 1 | Same as for March burn | Same as for March burn |

## Major Publications or Progress Reports


Grelen, Harold E. 1982. Comparison of burning dates in a young natural loblolly-shortleaf pine stand.

Pineville, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 9 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

Grelen, Harold E. 1984. Comparison of burning dates in a young natural loblolly-shortleaf pine stand. Pineville, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Establishment Report. 8 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

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**Grazing Systems for Forest Range**
**(See summary, p. 161.)**

Rotational burning studies for management of beef cattle on forest range can be successful. Moderate stocking on the range has been compatible for forage production, species composition, and livestock performance. With increased pressures for the forest range, new and innovative alternatives for grazing systems are needed by the land manager. Intensive livestock grazing systems have not been tested in the forest range of the Southeastern United States. An array of alternatives could be used that vary from an extensive, one-pasture, low-investment system (rotational burning) to an intensive, multiple-pasture, high-investment system (short-durational grazing).

Researchers in this study are testing three forest range grazing systems that may have applicability for the southeastern forest ranges. Specifically, these grazing systems are: (1) one-pasture rotational burning; (2) two-pasture switchback; and (3) multiple-pasture, short-durational grazing. The objectives of the study are: (1) to compare the economic and livestock production efficiencies of the three forest grazing systems and (2) to measure the effects of three grazing systems on the livestock, wildlife, watershed, and timber resources.

The study, which was initiated in 1984, is located on the Longleaf Tract of the Palustris Experimental Forest in central Louisiana. About 3,600 acres in six range units are being used in this replicated study of grazing systems. Breeding cattle consist of crossbred Brahman cows and English breed bulls. The data collected include calf crop percentages, calf weaning weights, and periodic cow weights; frequency, cover, and botanical composition of vegetation; and economic costs and returns. Timber management generally follows National Forest System guidelines; trees are thinned periodically to maintain relatively open stands, with tree basal areas ranging from 60 to 100 $ft^2$/acre. Supplemental studies, when overlaid on the three grazing systems, address watershed and wildlife implications.

The study is to be continued through 1996.

**Major Publications or Progress Reports**


Knight, Robert W. 1987. Assessment of infiltration and water quality from forest range grazing systems. Supplement A. College Station, TX: Texas Agricultural Experiment Station, Texas A & M University. Study plan. 8 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

Pearson, H.A. 1989. Forest-range management system effects on wildlife populations in the longleaf-slash pine type. Supplement B. Pineville, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study Plan. 10 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

Pearson, H.A.; Grelen, H.E.; Thill, R.E.; Rollins, D.A. 1984. Grazing systems for forest range. Pineville, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 15 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.

Pearson, Henry A.; Rollins, Douglas A.; Martin, Alton Jr.; Johnson, Charles Randal. 1990. Grazing systems for forest range. Pineville, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Establishment report. 13 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA.


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## TROPICAL AMERICAN FOREST MANAGEMENT

**Secondary Forest Inventory (See summary, p. 162.)**

An inventory was started in 1980, mainly in the subtropical moist and wet forests in the central mountains of Puerto Rico (fig. 19). The purposes of the inventory are to assess the timber potential of the secondary forest, to determine the growth and change in species composition, and to assess the forestry-related resources. Hopefully, the study will stimulate management of the secondary (new) forest.

Commercial and noncommercial lands were separated and the former were partitioned by life zone and

Figure 19.-A *secondary forest in the mountainous interior of Puerto Rico.*

soil type. A systematic 3-by 3-km grid with 437 ground locations within the commercial area was used. Standard inventory techniques used by the USDA Forest Service's Southern Forest Experiment Station were modified for local conditions. All species were identified, and diameter, height, and timber quality were recorded as well as several physical site characteristics.

### Major Publications or Progress Reports


Birdsey, R.A.; Weaver, P.L. 1982. The forest resources of Puerto Rico. Resour. Bull SO-85. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 59 p.

Birdsey, R.A.; Weaver, P.L. 1987. Forest area trends in Puerto Rico. Res. Note SO-331. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 5 p.

Birdsey, Richard A.; Weaver, Peter L. 1983. Puerto Rico's timberland. Journal of Forestry. 81(10): 671-672, 699.

Weaver, P.L.; Birdsey, R.A. 1986. Tree succession and management opportunities in coffee shade stands. Turrialba. 36(1): 47-58.

Weaver, P.L.; Birdsey, R.A.; Lugo, A.E. 1987. Soil organic matter in secondary forests of Puerto Rico. Biotropica. 19(1): 17-23.


### The Forest Resources of St. Vincent
(See summary, p. 163.)

The Island of St. Vincent, one of the Lesser Antilles located about 175 km west of Barbados, was inventoried, beginning in 1984. The program was undertaken to provide information on the resources of the island, to develop prescriptions for the management of the forest, and to train forestry personnel in inventory techniques (fig. 20). The study was funded by the United States Agency for International Development, with the cooperation of the St. Vincent Forestry Division, the Southern Forest Experiment Station, and the Institute of Tropical Forestry.

Results of the study include historical information, data on geology, physiography, climate, soils, agriculture, water resources, natural vegetation, forest legislation, and a plantation survey. Statistics were developed describing the composition of the timberland having some commercial potential Forest areas, species composition, and timber volume were determined from aerial photos and field work, using 88-grid intersections spaced at 2 by 2 km. Standard inventory techniques used by the Southern Station were modified for the tropical forest. All species were identified, and diameter, height, and timber quality were recorded, as well as several physical site characteristics. Detailed measurements were made on 57 plots at 19 locations.

Thirty-eight percent of St. Vincent's 345 $km^2$ is forested, and more than one-half of the forest is secondary; there are substantial areas of palm, dwarf, and dry scrub forest. Most of the primary forest is located at the highest elevations and far from roads. *Inga vera*, *Licania ternatensis*, *Dacryodes excelsa*, and *Cecropia peltata* are common tree species in the natural forest. *Hibiscus elatus*, *Pinus caribaea*, and *Swietenia macrophylla* are planted tree species. Of the planted species, *P. caribaea* has grown best (Birdsey and others 1986). Timber volume for all sound wood with an inside bark diameter of 10 cm and minimum length of 1 m averaged about 50 $m^3$/ha in young secondary forest, about 100 $m^3$/ha in advanced secondary forest, and about 250 $m^3$/ha in mature forest.

If population, tourism, and small industrial development continue to grow on St. Vincent, demands on the water supply will increase. A continuous supply of good-quality water depends on maintaining the forest on government-owned lands in the interior of the island.

Improvement of timber stocking in secondary stands with desirable saplings and poletimber is the best management plan for the area. Additional surveys of forest composition and the response of species to release may be carried out.

### Major Publications or Progress Reports

Birdsey, R.A.; Weaver, P.L.; Nichols, C.F. 1985. The forest resources of St. Vincent. In: Development, forestry, and environmental quality in the eastern Caribbean. Rio Piedras, PR: U.S. Department of Agriculture, Forest Service, Institute of Tropical Forestry: 35-102.

Birdsey, RA.; Weaver, P.L.; Nichols, C.F. 1986. The forest resources of St. Vincent, West Indies. Res. Pap. SO-229. New Orleans: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 25 p.

Weaver, P.L.; Birdsey, R.A.; Nichols, C.F. 1986. Los recursos forestales de San Vicente, Indias Occidentales. Res. Pap. SO-244. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 27 p.

Figure 20.—*Training of local assistants at the initiation of the St. Vincent forest inventory.*

**Pilot Management Study** **(See summary, p. 163.)**

Information on the growth rates of individual trees and forest stands is necessary to forest planning and management. In the moist tropical forests of the Western Hemisphere, such knowledge is needed for a variety of sites and conditions. A study was installed in the lower montane rain forest of the Luquillo Mountains of Puerto Rico in 1956 to determine the species composition of primary and secondary forests, to determine the growth rates of the trees, and to assess the effects of thinning on growth in the secondary forest. The plots were installed at Sabana 8 (80 ha) and Rio Grande (40 ha) in secondary forest and at Sabana 4 (129 ha) in primary forest. About one hundred 0.08-ha plots were placed systematically throughout each of the 3 study areas. On each plot, topography was classified as bottom, lower slope, upper slope, or ridge. All commercial species were identified, potential crop trees were selected, and height and d.b.h. were measured. One thinning was conducted at the beginning of the study in the two study areas in secondary forest. The plots were remeasured in 1975.

The measurement results indicate slow rates of diameter growth for trees in the moist tropical forest. Periodic annual diameter increments (PAI's) for species typically ranged from 0.30 to 0.60 cm/yr. The maximum PA1 for the sample population was only 1.83 cm/yr. Significant differences in growth rates existed among species and crown classes.

This study indicates that year-round growing conditions, warm temperatures, and abundant rainfall do not produce rapid rates of diameter growth in the rain forests of the Luquillo Mountains. The slowest growing species in the study were those of the genera *Cecropia* and *Didymopanax,* both considered to be rapidly growing pioneer tree types.

**Major Publications or Progress Reports**

Crow, T.R.; Weaver, P.L. 1977. Tree growth in a moist tropical forest of Puerto Rico. Res. Pap. ITF-22. Rio Piedras, PR: U.S. Department of Agriculture, Forest Service, Institute of Tropical Forestry. 17 p.

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**Long-Term Growth Rates in the Natural Forest of the Luquillo Mountains in Puerto Rico** **(See summary, p. 164.)**

During 1943–46, seven research plots were established in three of the five life zones of the Luquillo Mountains of Puerto Rico, in subtropical wet forest, rain forest, and lower montane wet forest. Plots in the subtropical wet forest included an undisturbed tabonuco (*Dacryodes excelsa*) stand on a slope, a thinned tabonuco stand, and a palm (*Prestoea montana*) stand on a slope. Later, a plot was established in this study in the lower montane rain forest, and the plot was studied for 4.5 years. The purpose of this study was to determine diameter growth rates in the natural forest and to determine changes in species composition over time. Most plots were 0.4 ha in size. Species were identified, diameters were measured, and ingrowth and mortality were tallied (fig. 21). On some plots, height was measured or estimated. The number of stems, basal area and volume per hectare, and changes in species composition were correlated with a past hurricane disturbance. Patterns of volume and basal area recovery over time were linear to convex in subtropical wet and rain forests but were linear to concave in lower montane wet forest. The patterns seem to be related to the differences in forest structure and to the nature of disturbance and recovery mechanisms (Weaver 1983).

Volume growth ranged from 0 to 5 $m^3$/ha/yr, basal area from 0 to 0.6 $m^2$/ha/yr, and diameter growth from 0.03 to 0.21 cm/yr. Diameter growth of species according to seral stage in thinned secondary subtropical wet forest was compared with diameter growth of species in undisturbed climax subtropical wet forest. The thinned climax species grew 100 percent faster than control species, the secondary species about 50 percent faster, and the pioneer species only 10 percent faster. There was no difference in diameter growth between the thinned climax lower montane wet forest and the climax lower montane wet forest, but basal area and volume growth, in contrast, were considerably higher on the thinned plot.

Thinning provides a way to enhance growth within the subtropical wet and lower montane wet forests. Slow growth on all undisturbed plots was attributed to high respirational demand of forests approaching steady state, as well as to the physiognomy of the forests, low solar insolation, and poorly drained soils (Weaver 1983).

The undisturbed long-term plots were composed of 33 to 48 species; Shannon-Weiner indices ranged from 2.60 to 4.48. During the years of the study, the number of species declined on the undisturbed plots but increased on the thinned plots. Pioneer species gradually disappeared over time on the undisturbed plots, causing the reduction in the number of species. Species richness was intermediate between continental tropical and continental temperate forests (Weaver 1983).

Despite the frequency of hurricanes in the region and numerous observations of damage to the vegetation, few studies of long-term changes in forests after

Figure 21.-Remeasurement of long-term Colorado plots in the Luquillo Mountains, Puerto Rico.

hurricanes have been carried out. The 35-year recovery in seven permanent plots in the Colorado forest covered the 14- through 49-year period after a major disturbance. Patterns of disturbance and recovery seem to vary along elevational and topographic gradients within the Luquillo Forest (Weaver 1986b).

The growth rates of magnolia *(Magnolia splendens)* were investigated to verify that the species is declining and to determine the reasons for the decline. *Magnolia splendens*, a valuable cabinet wood, is declining in abundance due to past logging and competition with other tree species in a forest recovering from hurricane disturbance. Poor seed germination, slow growth, and the need for canopy gaps are all factors contributing to magnolia's current decline (Weaver 1987).

The growth rates and probable ages of cyrilla *(Cyrilla racemiflora)* trees of different diameters were also investigated to provide plausible explanations for the large size of some cyrilla trees in the Colorado forest. The conclusion was that the large cyrillas in Puerto Rico are the result of growth and development on favorable, leeward sites at the lower limits of their range in elevation. The very large cyrillas are probably formed by the coalescence of proximate trees. If this is the case, the largest cyrillas are probably not much more than 1,000 years old. Apparently, cyrillas are finely attuned to life in a wet, montane habitat with recurrent storms (Weaver 1986a).

## Major Publications or Progress Reports


Crow, T.R. 1980. A rain forest chronicle: a thirty year record of change in structure and composition at El Verde, Puerto Rico. Biotropica. 12: 42-55.

Weaver, P.L. 1983. Tree growth and stand changes in the subtropical life zones of the Luquillo Mountains of Puerto Rico. Res. Pap. SO-190. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 24 p.

Weaver, Peter L. 1986a. Growth and age of *Cyrilla racemiflora* L. in montane forests of Puerto Rico. Interciencia. 11(5): 221-228.

Weaver, Peter L. 1986b. Hurricane damage and recovery in the montane forests of the Luquillo Mountains of Puerto Rico. Caribbean Journal of Science. 22(1–2): 53-70.

Weaver, Peter L. 1987. Ecological observations on *Magnolia splendens* Urban in the Luquillo Mountains of Puerto Rico. Caribbean Journal of Science. 23 (3–4): 340-351.

Weaver, Peter L. 1989. Forest changes after hurricanes in Puerto Rico's Luquillo Mountains. Interciencia. 14(4): 181-192.

Weaver, Peter L. 1989. Rare trees in the Colorado forest of Puerto Rico's Luquillo Mountains. Natural Areas Journal 9(3): 169-173.

Weaver, Peter L. 1990. Forest structure and productivity in Puerto Rico's Luquillo Mountains. Biotropica. 22(1): 69-82.

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**Population Dynamics of a Dry Forest Avian Community (See summary, p. 164.)**

The community structure of the birds of southwestern Puerto Rico is being assessed by determining the species diversity, demography, dispersal, longevity, and philopatry of migrant and permanent resident populations. The study was undertaken in 1972 to detect abrupt population fluctuations or directional trends over time by designating indicator species and summarizing data accumulated since the start of the study. Another objective is to determine the biological, ecological, and climatic factors affecting avian species that might result in sharp decreases or increases in population. Appropriate management prescriptions will be offered to mitigate the impact of factors affecting avian populations in Guanica, using information from similar vegetation associations throughout the Caribbean region. Variable-width transect census techniques are being employed in the study, and standard mist nets are being used.

**Major Publications or Progress Reports**

Faaborg, J.; Arendt, W.J. 1984. Population sizes and philopatry of winter resident warblers in Puerto Rico. Journal of Field Ornithology. 55: 376-378.

Faaborg, J.; Arendt, W.J.; Kaiser, M.S. 1984. Rainfall correlates of bird population fluctuations in a Puerto Rican dry forest: a nine-year study. Wilson Bulletin. 96: 575-593.

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**Reproductive Ecology of the Pearly-Eyed Thrasher (See summary, p. 165.)**

A study of the breeding biology, ecology, and demography of the pearly-eyed thrasher *(Margarops fuscatus)* was begun in 1979. One objective of the study is to obtain data on the ecological and biological requirements of the bird, a competitor and predator of the endangered Puerto Rican parrot (*Amazona vittata*). The results will be used to prescribe management procedures to mitigate the thrasher's impact on parrot reproduction. Populations of this bird in the Luquillo Forest will be compared with thrasher populations in areas where the parrot may be introduced, especially the Rio Abajo area. Density, distribution, predatory habits, prey species, diet, etc., will be compared. The suitability of the thrasher as a surrogate of the endangered parrot in experimental studies will be evaluated using the following criteria: parasite control measures; monitoring of growth, development, and mortality rates resulting from heavy ectoparasitism; physiological responses (production of antigens); and behavioral traits in combating heavy parasitism.

Each year, 30 to 50 artificial nesting boxes have been monitored. The entire study population has been banded with colored plastic and aluminum leg bands. Each bird wears a distinct color band combination for field identification without recapture. This study should result in indepth knowledge of the complete breeding biology, ecology, and demography of this predator of and competitor with the Puerto Rican parrot.

**Major Publications or Progress Reports**

Arendt, W.J. 1985. *Philornis* ectoparasitism of pearly-eyed thrashers. I. Impact on growth and development of nestlings. Auk. 102: 270-280.

Arendt, W.J. 1985. *Philornis* ectoparasitism of pearly-eyed thrashers. II. Effects on adults and reproduction. Auk. 102: 281-292.

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**Plantation Adaptability Trials (See summary, p. 165.)**

Beginning in the 1930's, many tree species were planted in Puerto Rico and the Virgin Islands. Over 50 species were planted using different methods and various plantation sizes and spacings in the range of soil types, topography, and climate of the study area. The objectives of the study are to identify plantation species that are adapted to local climates, to determine soil and site preferences of each species, and to document growth rates and make management recommendations. Periodic measurements will be made until each plantation reaches optimum size, and the site will be described. The growth of a species will be compared with the growth of that same species in other locations and with that of other locally adapted commercial species.

## Major Publications or Progress Reports

Figueroa, J.C.; Whitmore, J.L. 1980. Three species of eucalypts tested in Puerto Rico; five years after outplanting. Southern Journal of Applied Forestry. 4(4): 169-174.

Liegel, L.H.; Balmer, W.E.; Ryan, G.W. 1985. Honduras pine spacing trial results in Puerto Rico. Southern Journal of Applied Forestry. 992: 69-75.

Lugo, A.E.; Figueroa, J.C. 1985. Performance of *Anthocephalus chinensis* in Puerto Rico. Canadian Journal of Forest Research. 15: 577-585.

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## Tree **Growth in Several Tropical Forests of Puerto Rico** (See summary, p. 166.)

Between 1943 and 1951, the staff of the USDA Forest Service's Institute of Tropical Forestry established plots in several forests in Puerto Rico but discontinued them several years later. In the mid-1970's, the plots were remeasured to obtain data on long-term periodic annual d.b.h. increment (PAI), stand changes over time, and stand diversity in tropical forests (Weaver 1979).

Nine research plots were established in three life zones as follows: one in subtropical dry forest on azonal limestone at Guanica; six in subtropical moist forest, including two on azonal limestone at Cambalache, three in mangrove forest at Pifiones (fig. 22), and one on zonal soil at St. Just; and two in the lower montane wet Cobrado association, one at Toro Negro and one at Maricao. All trees on each plot were measured at breast height, crown classes were recorded, and, in some instances, thinnings or clearcuts were made. Periodically the plots were revisited, trees were measured, and mortality was recorded. During the last measurement, ingrowth was recorded as well. The Shannon-Wiener index was used to determine species diversity (Weaver 1979).

The PAI's for all stems greater than or equal to 4.1 cm in d.b.h. ranged from around 0.05 cm/yr in the dry limestone forest at Guanica in southwest Puerto Rico to about 0.45 cm/yr in the mangrove forest at Pifiones and early secondary rain forest at St,. Just in the subtropical moist life zone. The PAI's reported in this study are similar to those recorded in other studies in Puerto Rico and to those found in the Temperate Zone (Weaver 1979).

Although comparisons among stands are difficult because of confounding due to several factors, some trends seem apparent. The early secondary forests at St. Just and Pifiones are fast growing, but stems in the secondary forest that have been measured over a

Figure 22.-A *mangrove forest in a coastal area of Puerto Rico.*

long period show a gradual decline in growth, perhaps due to closing of the stand or senescence. In the wet limestone forest, trees on exposed summits have lower PAI's than those on slopes, probably due to moisture stress; PAI's also decrease with elevation. Tree growth is slower in the dry limestone forest due to lack of moisture. The forests of Puerto Rico seem to be intermediate in diversity, between those in the continental tropical forests and those in the continental temperate forests (Weaver 1979).

### Major Publications or Progress Reports

Weaver, Peter L. 1979. Tree growth in several tropical forests of Puerto Rico. Res. Pap. SO-190. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15 p.

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### A Phytosociological Study of Cinnamon Bay Watershed, St. John, U.S. Virgin Islands
**(See summary, p. 166.)**

The original vegetation of St. John was modified to some extent by the original inhabitants and greatly modified by the colonists who settled the island after Danish occupation in 1717. Many of the estates, which grew sugarcane and cotton, were abandoned by the late 19th century, and a secondary forest grew up. The Cinnamon Bay watershed is now part of the Virgin Islands National Park, which is administered by the U.S. Department of the Interior, National Park Service. The National Park Service has carried out several studies to understand the relationship between the vegetation and the surrounding aquatic systems.

This study was undertaken to describe the structure and species composition of woody vegetation in the watershed and to understand the phytosociological relationships of the trees based on elevation and topography (fig. 23). Sixteen plots 50 by 10 m in size were established within the watershed. Groups of three plots were located on ridges and slopes and in valleys at elevations of about 60, 120, 180, 210, and 240 m. One plot was near the summit at about 275 m in elevation. The height and diameter of all trees greater than 4.1 cm in d.b.h. were measured. All trees were permanently tagged and identified as to species, and crown classes were recorded (Weaver and Chinea-Rivera 1987).

Reciprocal averaging ordinations detected elevational trends and topographic preferences for several species. Watershed values for several structural parameters were as follows: stem density, 3,372±336/ha; mean height of stems, 8.0±0.23 m; mean diameter of stems, 9.1±0.33 cm; basal area, 30.4±2.3 $m^2$/ha; number of tree species, 69; and Shannon-Weiner species diversity index, 4.76. The largest number of tree species occurred on ridges, and the smallest number occurred in valleys. Mean heights and diameters for all species varied only slightly on different topographies, but these measurements for dominant and codominant trees were largest in valleys and smallest on ridges. Stem density was highest on the peaks and lowest in the valleys. Basal area was also highest on the peaks and lowest on the ridges (Weaver and Chinea-Rivera 1987).

Figure 23.-Low *forest characterizes the slopes and uplands on St. John, U.S. Virgin Islands.*

The species found in the Cinnamon Bay watershed also occur at other locations in the Caribbean. Many of the islands of the Lesser Antilles having the same type of vegetation as St. John are densely populated, and the vegetation is very disturbed. It seems unlikely that agricultural activities will be abandoned in the near future on these islands (Weaver and Chinea-Rivera 1987).

### Major Publications or Progress Reports


Weaver, Peter L. 1990. Tree diameter growth rates in Cinnamon Bay watershed, St. John, Virgin Islands. Caribbean Journal of Science. 26(1-2): 1-6.

Weaver, Peter L.; Chinea-Rivera, J.D. 1987. A phytosociological study of Cinnamon Bay watershed, St. John, U.S. Virgin Islands. Caribbean Journal of Science. 23(2): 318-336.


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## TECHNOLOGY OF EASTERN FOREST TREE SEEDS

### Long-Term Storage of Seeds of Major "Orthodox" Species (See summary, p. 167.)

Storage of seeds of "orthodox" species over periods of 5 years or less is not difficult, but there are some unanswered questions about such seed storage that deserve study. It is not known whether seeds of a species that are given the same treatment always react in the same way. If reliable models of storage behavior were available, storage practices could be tailored to meet specific needs, resulting in cost savings. This information would also be useful in planning for long-term conservation of genetic material

A long-term, 15-year study (test 1) was established in 1982 to provide data on seed storage of four major species: sweetgum *(Liquidambar styraciflua)*, sycamore (*Platanus occidentalis*), loblolly pine (*Pinus taeda*), and slash pine (P. *elliottii*). In addition, a short-term study (test 2) was initiated to provide data for development of survival curves, or models of storage behavior for these species. In test 1, three storage temperatures: -18, 2, and 10 °C, and three moisture levels: 6, 10, and 14 percent were used; there are three replications of all temperature-moisture combinations. In test 2, four storage temperatures: 15, 25, 35, and 45 °C, and four moisture levels: 8, 12, 14, and 18 percent were used. Samples are tested for survival at annual intervals in the long-term test and were tested at daily to bimonthly intervals in the shorter test (Bonner 1981).

### Major Publications or Progress Reports


Bonner, F.T. 1981. Long-term storage of seeds of major "orthodox" species. Starkville, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 5 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.


### Chromosome Effects During Storage of Sycamore, Sweetgum, Loblolly Pine, and Slash Pine Seeds (See summary, p. 167.)

Significant genetic change can occur in seeds during prolonged storage. Sweetgum *(Liquidambar styraciflua)*, sycamore (*Platanus occidentalis*), loblolly pine (*Pinus taeda*), and slash pine (*P. elliottii*) are collected and stored in relatively large amounts for long periods, and this storage may promote associated complications such as chromosome aberrations (fig. 24). A study was established in 1982 to determine if noticeable chromosome changes, ascertained by examination of root tips, occur in the seeds of these four species during prolonged storage under acceptable storage conditions (Vozzo 1982).

Locally collected seeds were stored at -18, 2, and 10 °C, with initial seed moisture levels of 6, 10, and 14 percent; all combinations were replicated three times. Seeds are germinated at bimonthly intervals, and primary roots are collected, measured, and fixed in 1:3 acetic acid/ethanol solution. The roots are then stained in acetocarmine solution and fixed as squash preparations. Results are expressed as mititic index

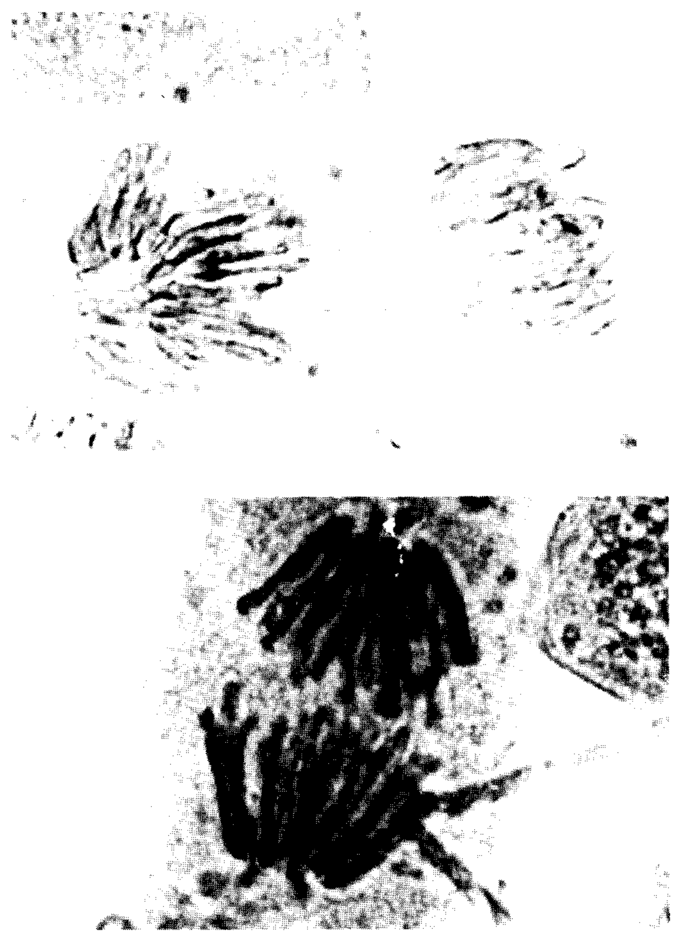

Figure 24.— *Upper and lower photos show chromosome fragmentation in germinating 50-year-old slash pine seeds.*

(MI) calculations. Data are collected to relate root length to MI, percentage of germination to MI, and percentage of germination to aberrant anaphase during mitosis. The preparations are also examined for other commonly reported aberrations (Vozzo 1982).

### Major Publications or Progress Reports

Vozzo, J.A. 1982. Chromosome effects during storage of sycamore, sweetgum, loblolly, and slash pine seed. Starkville, MS: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 5 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

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## GROWTH AND YIELD OF NATURAL EVEN-AGED LONGLEAF PINES

### Regional Longleaf Growth Study
**(See summary, p. 168.)**

This study of longleaf pine (*Pinus palustris*) was initiated by the USDA Forest Service's Southern Forest Experiment Station in 1964 and has been maintained for 30 years with cooperation from industrial and nonindustrial private forest owners, Region 8 of the USDA Forest Service and other public owners, and universities in the Midsouth. In 1990, this ongoing study was composed of 274 permanent plots installed on cooperator lands in a broad array of stand ages, site indices, and residual densities maintained by periodic low thinning (fig. 25). The study is inventoried on a 5-year cycle, and the plots are rethinned at each inventory, as needed, to maintain the assigned density level. Approximately one-third of the plots are inventoried each year during the dormant season for 3 consecutive years during an inventory period. The fifth 5-year inventory was started in the fall of 1989 and was scheduled to end before the spring of 1992.

The objective of the study is to monitor the development of thinned even-aged stands of naturally regenerated longleaf pine over time so the output in product volumes can be predicted at various ages for virtually any stand on a given site and maintained under a certain density regime. This is the only way such information can be obtained-it cannot be "simulated." The best such information ultimately comes from young stands that are managed to rotation age. However, rather than researchers having to wait through a rotation to obtain the estimates, plots were selected to fit into the array of cells formed by all possible combi-

Figure 25.-One *of the permanent plots of the regional longleaf pine growth study, installed in 1965, in the 20-year class, with site index of 80 ft at 50 years and residual basal area of 90 $ft^2$/acre.*

nations of four 20-year age classes, five 10-ft site index classes, and five 30-ft$^2$ basal area classes, with a target of three replications of each combination. This design allows responses to be quickly estimated after a few years and leads to a study structure that will afford better and better estimates as time passes. Stands having the desired age and site conditions were purposely selected for plot installation, and residual densities were assigned to plots within such stands as randomly as possible.

In the array of plot cells, the age classes initially ranged from 20 to 80 years, site indices ranged from 50 to 90 ft at age 50, and residual basal areas ranged from 30 to 150 ft$^2$/acre. Approximately 80 percent of the cells were filled with one or more plots. Because of increasing interest in the performance of stands older than those in what would be considered a normal rotation, the oldest plots are being maintained to an age of 120 years. In addition to the initial set of 20-year-old plots installed in the mid-1960's, a second set of 20-year-old plots was installed in the mid-1970's and a third set, in the mid-1980's, each with a similar complement of site and density combinations. Plans are to carry each set to a rotation age of 120 years. Besides affording the best information on stand and product development over time, these sets of plots will allow detection of any changes in growth rate that may occur with time.

On the net plots, all longleaf pines more than 0.5 inch in d.b.h. are positively and uniquely identified and referenced to plot center by azimuth and distance. All trees are included in basal area measurement, and the utility pole class and height of all qualifying trees are assessed. A subset of about one-fifth of the trees in each 1-inch d.b.h. class is systematically selected as a sample of trees for estimating plot age, site index, and volume. Age and site index are estimated from the age and total height of the dominant and codominant sample trees. Regressions of total height and height to base of crown of sample trees on the d.b.h. of sample trees are fitted to permit estimates of these two heights for each tree on the plot. Volumes for various products and merchantability specifications are estimated for each plot tree via stem-profile (taper) functions employing the d.b.h., total height, and crown ratio of the tree as input variables. Volume estimates for trees are summed to obtain estimates of plot volume. The 0.5-chain-wide isolation strip surrounding each net plot is maintained at the same density level as the net plot.

The study is a continuing one with overall maintenance, inventory, and analysis responsibilities shared by the USDA Forest Service, Southern Region, Auburn University, Mississippi State University, and the Southern Forest Experiment Station. However, the study could not exist without the land, timber, plot treatment, and plot-protection support provided by the several excellent cooperating landowners on whose property the plots are installed.

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## FOREST INVENTORY AND ANALYSIS FOR MIDSOUTH STATES

### Forest Inventory and Analysis (See summary, p. 168.)

The USDA Forest Service began conducting surveys of United States forests in 1933. The nationwide forest survey is a continuing effort to determine the extent, condition, and growth of the Nation's forests. The Forest Inventory and Analysis Unit of the USDA Forest Service's Southern Forest Experiment Station conducts the surveys in seven States in the Midsouth (Alabama, Arkansas, Louisiana, Mississippi, Oklahoma, Tennessee, and Texas) and Puerto Rico. The 100 million acres of forested land in the region are assessed by measuring more than 17,000 permanently established sample plots systematically located across the region. The forests are measured on a State-by-State basis until inventories in all States are complete, and then the cycle begins again. A complete cycle takes 8 to 10 years to complete, depending on the number of workers in the field crew. At present (1994), the field crew consists of 24 professional foresters who work in pairs (fig. 26) with each other or with assistants provided by outside agencies or private industry (May 1989).

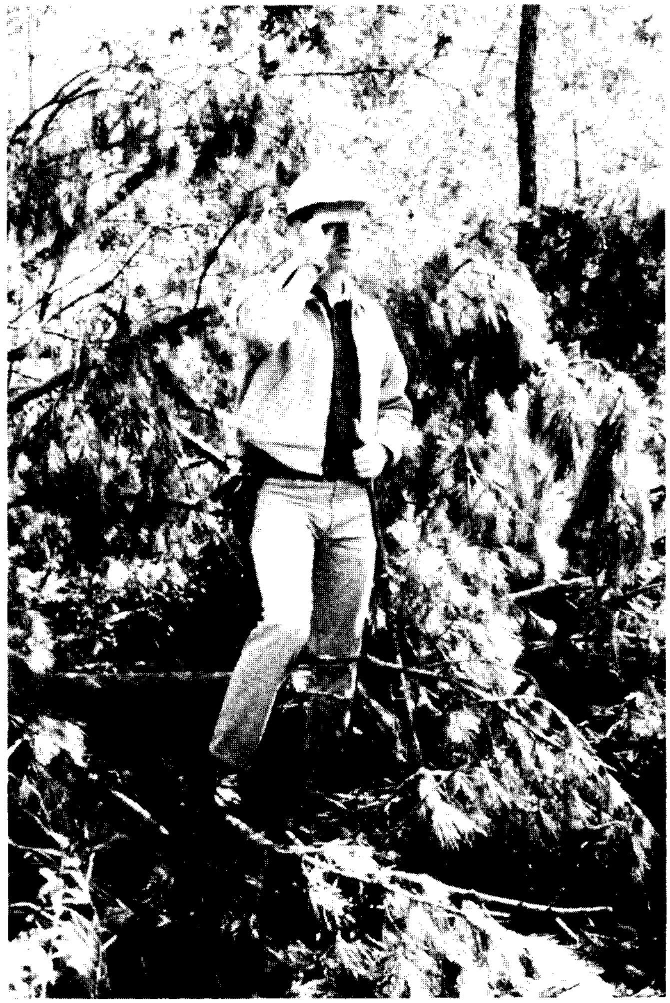

Figure 26.-A *member of the Southern Forest Experiment Station's Forest Inventory and Analysis field crew. The field crew is made up of 24 professional foresters.*

Sample plots are spaced on a 3- by 3-mi grid and represent approximately 5,760 acres of land. A forest/nonforest classification of 25 photo points around each sample plot is used to estimate forest area; then each plot is visited, and the forest resources are measured (fig. 27). The plots are measured using a cluster of ten 37.5prism points covering approximately 1 acre. Trees at least 5 inches in d.b.h. are measured; smaller trees are sampled on three 0.0036-acre fixed plots at the first three prism points. Field data are entered into portable data recorders and at 3- to 5-day intervals are transmitted via telephone to a survey computer in Starkville, MS. There, the data undergoes extensive editing and processing, and any errors are sent to the field crew for correction. Finalized data are tabulated for easy interpretation and are published as resource bulletins (May 1989).

When an entire State has been surveyed and the results verified, data are also entered into the Southern Forest Inventory and Analysis (SOFIA) data base to facilitate the retrieval and dissemination of survey results. The data base contains almost two complete

**Figure 27.**—*Data are collected by the Southern Forest Experiment Station's Inventory and Analysis field crew on more than 17,000 sample plots in 7 southern States, Puerto Rico, and the U.S. Virgin Islands.*

cycles of data. The survey data in the data base are managed by two systems that allow for differing degrees of user sophistication and data detail. The first, a relational data base management system called INGRES, retrieves data in answer to specific queries written in flexible and user-friendly languages, QUEL or SQL. The data are stored in tables organized at three levels, tree, plot, and county or parish, with differing degrees of detail in the data and different levels of user sophistication required. The tree-level tables contain the most detailed data but require a high degree of user sophistication. The second system is a menu-driven program called EZTAB that summarizes data into 50 standard tables for user-defined resource areas. The user answers a series of screen prompts to select the resource area, ownership group, and standard table desired. Training workshops lasting 2 days are held periodically to provide users with the knowledge necessary to interactively access the data base over the telephone. The data base currently accommodates more than 50 interactive users (May 1989).

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## REGENERATION AND MANAGEMENT OF SOUTHERN HARDWOODS

### Effects of Spacing on Species Yields in Minor Bottoms (See summary, p. 171.)

Growth and development of bottom land hardwood plantations have been studied by Research Work Unit 4104 of the USDA Forest Service's Southern Forest Experiment Station for about 20 years. These studies have utilized permanent plots measured at regular intervals over long periods of time. Plots have been used to study the effects of initial planting spacing, site-species relationships, and various levels of cultural intensities on nutrient and soil water availability. Bodies of knowledge have been gathered on thinned and unthinned plantations (fig. 28).

This study was initiated in 1976 on an area 55 to 60 acres in size near Monticello, AR; the cooperator is Georgia-Pacific. A wider range data base is needed for varying timing of thinning and harvesting in close-spaced hardwoods, peak biomass production, and site effects of intensively managed bottom land hardwoods. Data have been collected annually on total height, diameter 6 inches above ground line, d.b.h., survival, leaf weight, branch weight, bole weight, wood-bark ratio, specific gravity, moisture content, wood and bark volumes, and soil and tissue nutrient levels. Two trees from each of three plots in each species-by-spacing treatment have been destructively sampled each year. Trees in 2- by 8-, 3- by 8-, and 4- by 8-ft spacings of green ash (*Fraxinus pennsylvanica*), sycamore (*Platanus occidentalis*), and sweetgum (*Liquidambar styraciflua*) were clearcut after 7 years when mean annual increment peaked. Trees in 8- by 8- and 12- by 12-ft spacings were thinned by taking out every second diagonal row. The same data as those on the large trees have been collected on coppice in the close spacings. Trees in three close spacings of four oaks (*Quercus* spp.) were clearcut after 11 years.

The study is continuing.

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*Figure 28.-Thirteen-year-old oaks at 12- by 12-ft spacing in a hardwood plantation near Monticello, AR.*

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## Seed Tree versus Selection in Bottomland Hardwoods (See summary, p. 172.)

Growth and yield of sweetgum *(Liquidambar styraciflua)*-red oak *(Quercus* spp.) stands have been studied for more than 30 years by Research Work Unit 4104 of the USDA Forest Service's Southern Forest Experiment Station. Researchers in this study have utilized permanent plots measured at regular intervals over a long period of time (fig. 29). The objectives of the study are to compare stand establishment and stand growth and development under two silvicultural systems on two sites.

Each site, Saline River bottom and Chemin-a-haut Creek bottom, had three 10-acre treatment areas. Each of two treatments was assigned at random to the three treatment areas in each bottom. The treatments were selection and seed-tree cutting. Within each 10-acre area, 10 permanent 0.2-acre rectangular plots were established in a row, leaving 2 chains of isolation strip between plot strip and treatment boundary. Centered within each 0.2-acre plot were one 0.03-acre plot and four 1-milacre plots. Trees larger than 5.0 inches in d.b.h. were tallied on the 0.2-acre plots, trees from 1.0 to 5.0 inches in d.b.h. were tallied on the 0.03-acre plot, and those smaller than 1.0 inch in d.b.h. were tallied on each 1-milacre plot.

Data from selection systems are not very useable. The study variables were species, number of trees per acre, diameter, height, basal area and volume, and species composition. Most work has been done on re-

Figure 29.—*Twenty-nine-year-old hardwood regeneration in a seed-tree cut.*

generation development in the seed-tree area, species composition over the measurement periods, and stand volume by species.

Some plots were thinned at age 29. The study was remeasured at age 35 and continues.

### Major Publications or Progress Reports

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## Crown Length and Tree Growth of Open-Grown Cottonwood (See summary, p. 172.)

Growth and yield of cottonwood (*Populus deltoides*) plantations have been studied by Research Work Unit 4104 of the USDA Forest Service's Southern Forest Experiment Station for more than 20 years. Scientists working on these studies have utilized permanent plots measured at regular intervals over long periods of time. The plots have been used to determine the effects of various spacing, thinning, and pruning regimes on growth and total production. Incidental to the primary objectives of these studies are large bodies of data that have accumulated on yields from unthinned stands.

The main study objective was to determine maximum growth of wide-spaced cottonwoods subjected to four pruning treatments. Another objective was to see if cottonwood trees spaced wide enough to have maximum growing space would follow growth patterns similar to those grown at closer spacings. Differences in d.b.h. growth among pruning treatments began to occur in the second year with the first pruning, continued through the sixth year, and occurred again during the eighth year. The smallest diameter was in trees pruned by one-half of total height, followed by those pruned by one-third of total height, trees pruned to 17 ft, and trees in the control plots having the largest diameter. There was a trend toward height reduction in the trees pruned to one-half of their total height, but this reduction was only observable for 7 years after pruning. The 40- by 40-ft spacing (fig. 30) resulted in four to six times more volume per tree by pruning treatment after 10 years than the 10- by 10-ft spacing but in only three- to four-tenths times as much total volume per acre.

### Major Publications or Progress Reports

Krinard, R.M. 1979. Five years growth of pruned and unpruned cottonwood planted at 40-by-40 ft spacing. Res. Note SO-252. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 5 p.

Krinard, R.M. 1985. Ten years growth of pruned and unpruned cottonwood planted at 40-by-40-spacing. Res. Note 316. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 5 p.

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## Direct-Seeding Nuttall Oak in Relation to Environment, Sowing Depth, and Stratification Treatment (Study SO-4104-06; See summary, p. 173.)

### [Treatments to favor oak in mixed stands of hardwood regeneration (Study SO-4104-38; superimposed on SO-4104-06).]

Direct-seeding of bottomland oak and stand development following release have been studied for more than 20 years by Research Work Unit 4104 of the USDA Forest Service's Southern Forest Experiment Station (fig. 31). Researchers in the studies have utilized permanent plots measured at regular intervals over long periods of time. In one study (SO-4104-06), the plots were used to study the effects of various environments, sowing depths, and stratification treatments on the germination and survival of acorns. In another study (SO-4104-381, various mechanical and chemical release treatments are being studied in sapling-sized, direct-seeded stands.

In the acorn study, Nuttall oak (*Quercus nuttallii*) acorns were either machine or manually sown at 2-, 4-, or 6-inch depths in openings of 20 by 90 ft and 40 by 90 ft and in clearings 2.5 acres in size. Acorns were sown at a rate of two or three per spot in rows 10 ft apart and with spots 3 to 5 ft apart in rows. Field germination averaged 36 percent of all acorns sown, with 80 to 90 percent of seed spots having one or more trees. There were no significant differences in germination

*Figure 30.-Cottonwood trees planted at 40- by 40-ft spacing.*

among seeding methods or sowing depths. After 11 years, two-thirds of the Nuttall oaks, or 551 per acre in the 2.5acre clearings, were free to grow, averaging 2.1 inches in d.b.h. and 16.7 ft in height.

In the release study, seven release treatments were tested as follows: control; cut all nonoaks 15, 20, or 25 ft tall; and deaden all nonoaks 15, 20, or 25 ft tall There were no significant differences among release treatments. Researchers felt confident that the more intensive release treatments improved stocking of free-to-grow oaks but were not sure the additional trees and thus, the treatments, were necessary. Without release, many of the oaks would apparently be destined to become part of the predominant overstory upon reaching sawtimber size. Stands with a lower stocking of sapling oaks would possibly get different results.

The study will be remeasured after 17 years, and a decision made as to whether to continue on with the study.

### Major Publications or Progress Reports


Johnson, Robert L. 1983. Nuttall oak direct seedings still successful after 11 years. Res. Note SO-301. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 5 p.

Johnson, Robert L.; Krinard, Roger M. 1988. Development of Nuttall oak following release in a sapling-sized stand. Southern Journal of Applied Forestry. 12(1): 46-49.


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## Delta Experimental Forest Cypress Planting (See summary, p. 173.)

The growth and yield of baldcypress *(Taxodium distichum)* was studied on permanent plots in a small cypress plantation for more than 30 years by Research Work Unit 4104 of the USDA Forest Service's Southern Forest Experiment Station (fig. 32). The plots were used to determine the effects of regular and deep planting on the survival and growth of cypress seedlings with and without top clipping on five microsites. Seedlings were top-clipped to see if it would reduce transpiration during droughts.

After three growing seasons, average survival ranged from 60 to 68 percent and average heights, from 3.9 to 4.1 ft, but differences between planting methods were not significant. Survival at age 21 was 41 percent, and average diameter was 6.1 inches. Some cypress were suppressed by other hardwoods such as green ash *(Fraxinus pennsylvanica)* and boxelder *(Acer negundo)*. Diameters of the best 10 percent of the cypress trees averaged 11.1 inches at age 21. Mean annual increment on these trees was 0.53 inch per year, considerably more than the 0.32 inch per year estimated for dominant trees in natural stands during the prime development period. Survival of baldcypress planted on clay soil at a 6- by 10-ft spacing decreased from 41 percent at age 21 to 26 percent at age 31. In the b-year period, average diameter increased from 6.1 to 8.6 inches, basal area from 72 to 90 $ft^2$/acre, and total volume outside bark for trees greater than or equal to 3.0 inches in d.b.h. from 1,288 to 2,333 $ft^3$/acre. The 30 largest trees per acre averaged 14.2 inches in d.b.h. and 72 ft in height at age 31.

### Major Publications or Progress Reports


Johnson, R.L. 1958. Clip or deep-plant cypress. Southern Forestry Notes 116. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 1 p.

Krinard, R.M. 1959. No advantages to clipping baldcypress planting stock. Tree Planters' Notes. 36: 14.

Krinard, R.M.; Johnson, R.L. 1976. 21-year growth and development of baldcypress planted on a flood-prone site. Res. Note SO-217. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 4 p.

Krinard, Roger M.; Johnson, Robert L. 1987. Growth of 31-year-old baldcypress plantation. Res. Note SO-339. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 4 p.


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## SEWANEE RESEARCH CENTER

### Comparative Performance of Several Species in Plantations (See summary, p. 174)

In the 1950's, very little research had been done on the performance of species grown in forest plantations on the Cumberland Plateau. Although most existing plantations had been planted on open land, most future planting would have to take place in poorly stocked, low-grade, hardwood forests. Consequently, there was no basis for comparison of the growth and quality of tree species underplanted in the area.

In 1959, a study was established to compare the performance of eight tree species under a narrow range of site conditions in one locality having relatively uniform slope and soil The species tested were eastern white pine (***Pinus strobus***), loblolly pine (***P. taeda***), shortleaf pine (*P. echinata*), Virginia pine (*P. uirginiana*), Scotch pine (***P. sylvestris***), Austrian pine

**Figure 31.**-*Eighteen-year-old direct-seeded Nuttall oaks*

(*P. nigra*), Norway spruce (*Picea abies*), and yellow-poplar (*Liriodendron tulipifera*). Hardwood sawtimber on the area was cut, and other trees were deadened. There were three blocks each composed of eight plots, and one species was assigned at random to each plot. Plots were 0.25 acre in size (104.3 ft per side), with 221 seedlings per plot spaced 6 ft apart in north-south rows 8 ft apart. The 25 trees in the center of each plot were measured, and an individual record was kept for each tree. Height and survival were measured monthly for the first two growing seasons and at 5-year intervals after the fifth-year measurements (fig. 33). Diameter was measured after the 5th, 10th, and 15th growing seasons, and diameter and volume were measured at the end of the 20th growing season.

After 15 growing seasons, average survival for all species was 72 percent or higher. Loblolly, eastern white, Virginia, and shortleaf pines had grown best with average heights of from 33.1 to 38.2 ft and average d.b.h.'s of 4.9 to 5.7 inches.

## Major Publications or Progress Reports


Burton, James D. 1959. Comparative performance of several species in plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan and establishment record. 26 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Burton, James D. 1961. Comparative performance of several species in plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Second year progress report. 26 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Burton, James D. 1965. Comparative performance of several species in plantations. Sewanee, TN: U.S.

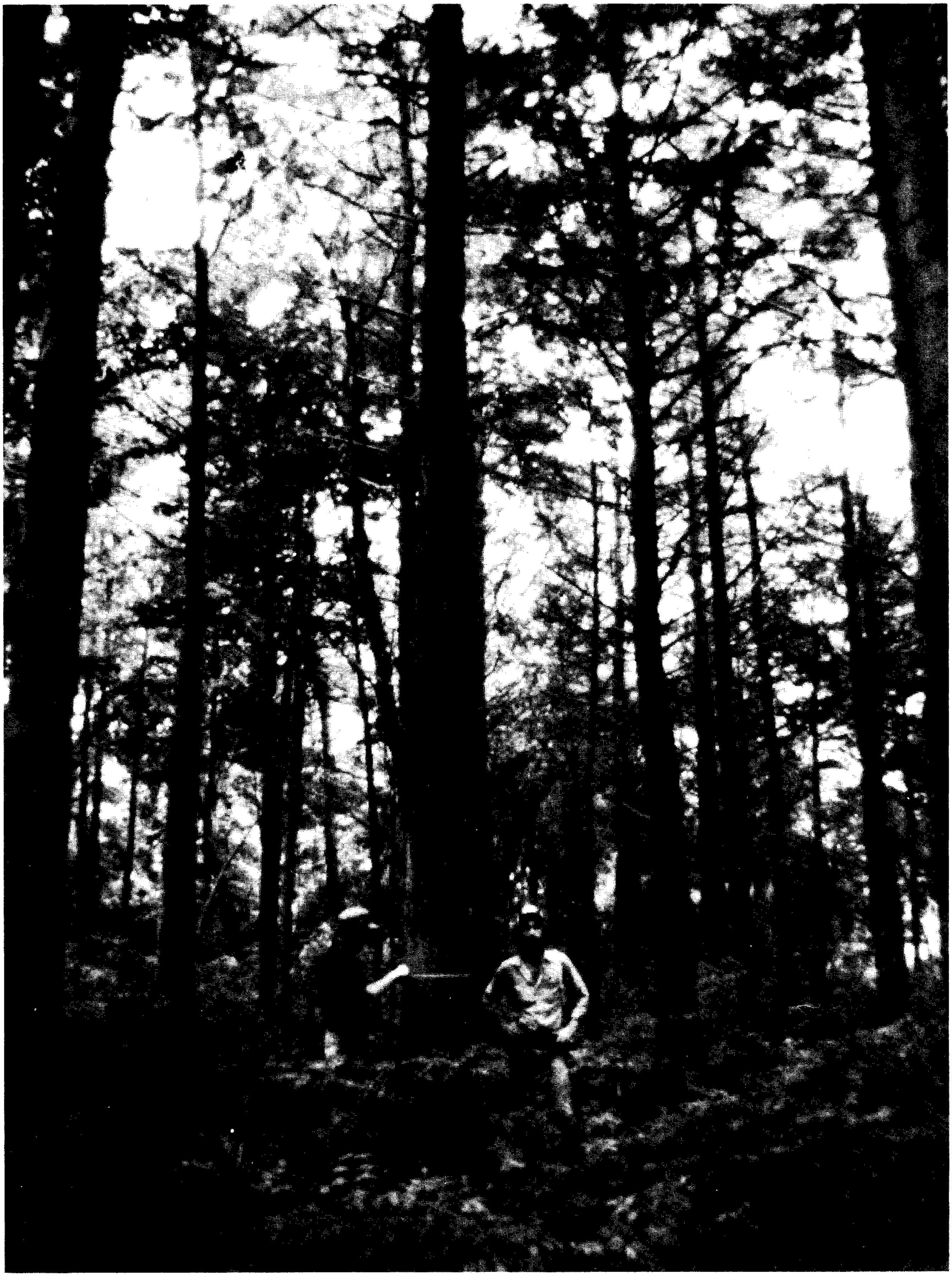

Figure 32.-A *30-year-old baldcypress plantation.*

Figure 33.-White *pine: a, 5 years after planting; b, at age 5, an average tree (left) and some exceptional trees (right).*

Department of Agriculture, Forest Service, Southern Forest Experiment Station. Fifth year progress report. 55 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Loftus, Nelson S. 1969. Comparative performance of several species in plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Tenth year progress report. 9 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Loftus, Nelson S. 1974. Comparative performance of several species in plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Fifteenth year progress report. 10 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

**Direct Seeding of Eastern White Pine on the Cumberland Plateau (See summary, p. 174.)**

A study was carried out on direct-seeding of eastern white pine (*Pinus strobus*) to determine if this would be a satisfactory method of seeding in converting low-grade highland hardwood stands to this pine species. The study area was located on the domain of the University of the South at Sewanee, TN, on typical cutover plateau land. Four randomly selected 0.1-acre plots were sown with seeds treated with repellent, and four were sown with untreated seeds. Field germination, survival, and stocking were checked on ten 1-milacre blocks per plot.

Significantly more treated seeds germinated and survived the first growing season than did untreated seeds. After four growing seasons, 2,050 seedlings per acre survived on plots planted with treated seeds, and 1,250 survived on plots planted with untreated seeds. Fourth-year height of the tallest trees was 1.3 ft.

This study indicates that direct-seeding of eastern white pine is appropriate for the Cumberland Plateau. Although planting of either treated or untreated seeds results in satisfactory stands, seed protection provides better stocking.

### Major Publications or Progress Reports


Harrington, T.A. 1959. Direct seeding of eastern white pine on the Cumberland Plateau. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan and establishment report. 14 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Harrington, Thaddeus A. 1960. Direct seeding of eastern white pine on the Cumberland Plateau. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 14 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Russell, Thomas E. 1961. Direct seeding of eastern white pine on the Cumberland Plateau. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 3 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Russell, Thomas E. 1963. Direct seeding of eastern white pine on the Cumberland Plateau. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Final office report. 20 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.


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## Optimum Spacing of Planted Loblolly Pines on the Cumberland Plateau (See summary, p. 175.)

Because of a good market for pine pulpwood, extensive areas of the Cumberland Plateau of Tennessee were planted to pine in the 1950's. Much of the Plateau had never been cleared, so many of the pines were planted on hardwood sites after the hardwoods were killed. Various spacings were used under these adverse conditions.

A study was established to evaluate the influence of spacing on the volume production of unthinned loblolly pine (*Pinus taeda*) over a 30-year rotation. Four study plots were located on the domain of the University of the South at Sewanee, TN, two on poor hardwood sites, and two on old fields. Spacings of 6 by 6, 9 by 9, and 12 by 12 ft were each randomly assigned to three of nine 0.25-acre plots in a block. Height measurements were taken the first few years, and diameter measurements were taken after the 3d, 5th, 7th, and 10th growing seasons and continued every 5 years through age 25 on all sites and through age 30 on two sites.

After 5 years, spacing had no influence on survival or height growth and little influence on diameter growth. Only one of the sites is still intact and has future value.

### Major Publications or Progress Reports


Harrington, T.A. 1957. Optimum spacing of planted loblolly pines on the Cumberland Plateau. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Work plan and establishment report. 16 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Harrington, Thaddeus A. 1958. Optimum spacing of planted loblolly pines on the Cumberland Plateau. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Supplement No. 1 to work plan and establishment report. 6 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Russell, Thomas E. 1961. Optimum spacing of planted loblolly pines on the Cumberland Plateau. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 32 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Russell, Thomas E. 1964. Optimum spacing of planted loblolly pines on the Cumberland Plateau. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 18 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.


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## Vegetation Responses Following Canopy Removal by Shearing and Chipping on the Cumberland Plateau (See summary, p. 175.)

Large areas of the South, such as the Cumberland and Piedmont Plateaus, are forested with low-quality hardwood stands that probably will not produce high-quality timber if left alone. Often, small landowners do not have much money to spend on improving their stands. Shearing and whole-tree chipping might provide an inexpensive and effective way to improve timber production. Chipping the low-grade hardwoods would provide the owner with some financial return and reduce site-preparation costs, but it was not certain what effect the operation would have on the various forests and different sites in the area. Costs could be reduced further by regenerating a pine-hardwood mixture (Sims and others 1981).

## Cumberland Plateau

A site typical of the Cumberland Plateau forest land, which has been logged and burned from time to time, was selected on land belonging to the University of the South at Sewanee, TN, to demonstrate and evaluate low-cost options for forest regeneration following shearing and whole-tree chipping. The land was forested with about 135 stems per acre of mostly intermediate-sized scarlet oak (*Quercus coccinea*) and white oak (*Q. alba*). Most overstory trees were relics and culls. Stems greater than 4 inches in d.b.h. were sheared with a feller-buncher, and the trees were skidded to a central site and fed into a chipper. The few sawtimber trees present were felled by conventional methods. Twenty-four 1-acre plots were established away from the central compacted area. Six plots were selected at random for each of four regeneration treatments: planting loblolly pine (*Pinus taeda*), planting eastern white pine (*P. strobus*), planting yellow-poplar *(Liriodendron tulipifera)*, and natural regeneration. In three randomly selected plots in each category, all remaining trees more than 4.5 ft tall were injected with herbicide (McGee 1986).

After five growing seasons, more than 90 percent of the planted loblolly pine, eastern white pine, and yellow-poplar had survived. And, 80 percent of the naturally regenerated plots contained one or more white oak, scarlet oak, black oak (*Q. velutina*), yellow-poplar, hickory (*Carya* spp.), black cherry (*Prunus serotina)* or other desirable species. Loblolly pines were taller than the other species. (Even on the injected plots, the stand will eventually become a pine-hardwood mixture.) There was not much variation in height growth between injected plots and those that were not injected, but there were more free-to-grow seedlings on the injected plots, especially loblolly pines (McGee 1986).

## Western Highland Rim of the Cumberland Plateau

This part of the study was similar to that on the Cumberland Plateau. The study site is located in Humphrey County on Koppers Company land near Buffalo, TN. The site index for oak at 50 years ranged from 57 to 74 ft. The study site is characterized by narrow ridges forested with a moderate overstory, many intermediate stems, and an abundant understory (McGee 1986).

Trees 1 inch in d.b.h. and larger were sheared, skidded, and chipped. Few stems remained after the cutting. Thirty-two plots were established and grouped into 4 blocks containing 2 plots each of planted loblolly pine, planted yellow-poplar, planted shortleaf pine (*P. echinata*), or naturally regenerated trees. One of each pair of plots received competition control

Almost all the shortleaf pine seedlings died, and these plots were replanted the following year. After 3 years, survival of the planted and naturally regenerated trees was acceptable to excellent. Drought, tip moths (*Rhyacionia* spp.), and sawflies (Tenthredinidae) were expected to cause future losses of loblolly pines. Nearly one-third of the yellow-poplars suffered top dieback and may not survive (McGee 1986).

Height growth of naturally regenerated trees, loblolly pine, and yellow-poplar was acceptable after the second growing season but was disappointing following the third growing season which was hot and dry. Shortleaf pine did not grow much at all and seemed unlikely to compete with naturally regenerated trees without release (McGee 1986).

This study demonstrates that intensive harvesting can provide several inexpensive options for improving forests on the Cumberland Plateau, including the Western Highland Rim. Because most of the old stand has been utilized, site-preparation costs can be kept to a mininum. Loblolly pine is already extensively planted in the plateau region. Yellow-poplar, now planted on the better plateau sites, has survived well but has poor height growth on these mediocre sites. It is uncertain what the final outcome will be for this species. Eastern white pine provides another option for landowners, provided release from overtopping vegetation is planned. Natural regeneration is apparently far more promising than the low-quality stand it replaced. It will be valuable for wildlife because oaks are plentiful Untreated stems will become more competitive in time, so release on an as-needed basis is advised for all treatments. It is important to note that the results obtained on these mediocre sites for hardwood probably would not be reproduced on better sites where more hardwood competition would be expected (McGee 1986).

Intensive utilization is recommended for landowners who cannot afford expensive site preparation or for those who do not necessarily want maximum production and will accept reduced survival and growth. Because there is a vast acreage of low-quality stands and a large market for chips, more private nonindustrial landowners will be inclined to improve their stands if made aware that site preparation and release can be inexpensive.

### Major Publications or Progress Reports


McGee, C.E. 1976. Vegetative response following canopy removal by shearing and chipping on the Cumberland Plateau. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 10 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

McGee, C.E. 1977. Vegetative response following canopy removal by shearing and chipping on the Cumberland Plateau. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Establishment report. 6 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

McGee, C.E. 1979. Vegetative response following canopy removal by shearing and chipping. I. Expanding options for reforestation of the Cumberland Plateau. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 16 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

McGee, C.E. 1979. Vegetative response following canopy removal by shearing and chipping on the Cumberland Plateau. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan amendment 1.3 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

McGee, C.E. 1980. Expanding options for reforestation of the Cumberland Plateau. Southern Journal of Applied Forestry. 4(4): 158-162.

McGee, C.E. 1983. Vegetative response following canopy removal by shearing and chipping. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan amendment and establishment report. 5 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

McGee, C.E. 1986. Regeneration after shear felling and chipping of upland hardwoods. Res. Pap. SO-224. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 13 p.

Pierce, Kenneth. 1981. Vegetative response following canopy removal by shearing and chipping. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 14 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Pierce, Kenneth. 1982. Vegetative response following canopy removal by shearing and chipping on the Western Highland Rim. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 10 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Sims, D.H.; McGee, C.E.; Galloway, J.; Rickman, B. 1981. Mixed pine-hardwood stands-a low-cost option for reforestation. Forest Farmer. 40(10): 10-11, 16-17.


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## White Oak Release in Relation to Stem Characteristics (See summary, p. 176.)

The presence of millions of overtopped white oaks (*Quercus alba*) on the Cumberland Plateau presents difficult choices to forest managers. Opinions vary on the value of intermediate white oaks, and there is little factual evidence to support either those who would cut most overtopped stems or those who would save certain individuals for future crop trees. What information does one need to determine if individual trees should be cut or left to grow? A study was planned to determine how white oaks that have been overtopped by other trees respond to release. Objectives of the study are to relate stem characteristics such as age, size, and quality to response after release; to compare released with unreleased tree response; and to compare the response of stems that are released and cut at ground level with stems that are uncut and unreleased, uncut and released, or cut and unreleased (McGee and Bivens 1984).

Three experiments were carried out, two on the domain of the University of the South in Franklin County, TN, and one on Franklin-Marion State Forest in Marion County, TN. Over 300 trees, ranging in age from 20 to 100 years and in d.b.h. from 1 to 12 inches were selected for study. The trees were measured using a dendrometer and ranked for quality according to form, epicormic sprouting, and apparent vigor. Remeasurements were made every 2 years.

### Experiment 1

High-, medium-, and low-quality trees were released from competition. A regression analysis was used to evaluate relationships of diameter, age, and quality class to growth. High-quality trees grew more vigorously than medium- and low-quality trees and were less variable. Larger trees increased more in volume after release than smaller trees. Surprisingly, a number of trees decreased in height after release because of tops that died or drooped. The number of epicormic sprouts on butt logs doubled after release (McGee and Bivens 1984).

### Experiment 2

The growth response after release of 40 high-quality white oaks was compared with the growth of a similar number of unreleased trees. The study and analysis were similar to Experiment 1. After 4 years, the released trees increased in volume twice as much as the unreleased trees. However, unreleased trees grew taller than released trees and had half as many epicormic sprouts (McGee and Bivens 1984).

### Experiment 3

There were four treatments, as follows: (1) removal of overtopping trees; (2) removal of overtopping trees and cutting of sample tree; (3) no release but cutting of sample tree; and (4) no release and no cutting of sample tree. (In treatments **1** and 2, directly overtopping trees were removed, but there was only partial release comparable to that following selection cutting, improvement cutting, or heavy thinning.) Measurements were carried out as above. The partially released trees had increased 30 percent more in volume than the unreleased trees but had not grown as well as the completely released trees in the first experiment. Partially released trees had more epicormic sprouts than unreleased trees but fewer than completely released trees. Smaller released and unreleased stumps sprouted vigorously, but trees more than 8 inches in d.b.h. had few or no sprouts. Sprouts on released stumps grew taller than those on shaded ones (McGee and Bivens 1984).

This study is ongoing, but results so far indicate that many overtopped white oaks will not make good crop trees. Although volume growth increases in released trees, height growth is poor, and epicormic sprouting doubles. Managers may wish to leave overtopped white oaks as crop trees when there are a number of good quality trees, thus decreasing site-preparation costs.

### Major Publications or Progress Reports


Bivens, D.L. 1981. White oak response to release in relation to stem characteristics. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 19 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Bivens, D.L. 1984. White oak response to release in relation to stem characteristics. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 21 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

McGee, Charles E. 1976. White oak release in relation to stem characteristics. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 17 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

McGee, Charles E. 1979. White oak response to release in relation to stem characteristics. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 23 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA70113.

McGee, Charles E. 1981. Response of overtopped white oak to release. Res. Note SO-273. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 4 p.

McGee, Charles E.; Bivens, Donald L. 1977. White oak release in relation to stem characteristics. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Establishment report. 16 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA70113.

McGee, Charles E.; Bivens, Donald L. 1984. A billion overtopped white oak-assets or liabilities? Southern Journal of Applied Forestry. S(4): 216-220.


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### Species, Site, and Plantation Yield (See summary, p. 177.)

During the 1960's, there was growing enthusiasm among timberland owners of the Great Valley, Cumberland Plateau, and Highland Rim of Alabama and Tennessee for improved management of hardwood species because of an increased market for pulpwood. Although loblolly (*Pinus taeda*), Virginia (*P. virginiana*), shortleaf (*P. echinata*), and eastern white (*P. strobus*) pines were the species most commonly planted, the pulp and paper mills accepted nearly all commercial forest tree species common to the study area. Because almost no research had been done on the response and yield of sites artificially established with pure hardwood stands, a study was established to give forest managers information on the best species or selection to plant on a particular site. The growth and yield and adaptability of two geographic sources of seeds of loblolly pine, yellow-poplar (*Liriodendron tulipifera*), black cherry (*Prunus serotina*), and black oak (*Quercus velutina*) were compared on four different sites in the uplands of central Tennessee. The sites included hollows and low relief ridges on the Cumberland Plateau and V-shaped hollows bounded by narrow ridges and gently undulating topography of the Eastern Highland Rim. The soils of each site were mapped, described, sampled, and analyzed.

After 5 years, loblolly pine grew consistently well on all sites, and yellow-poplar did well on the Western Highland Rim and on most plots on the Cumberland Plateau. All hardwoods did poorly on sites on the Eastern Highland Rim, where soils usually contained fragipans. Yellow-poplar and black cherry survived well (98 and 95 percent respectively), and loblolly pine averaged 90-percent survival overall, but only 76 percent on the Western Highland Rim, where natural hardwoods had invaded. Because black oak grew poorly at all sites and was unable to compete with weeds, it is not recommended as a commercial species on these sites.

A regression analysis relating topographic and soil features to 5-year height of yellow-poplar, black cherry, and loblolly pine explained 85 percent of the variation in height for yellow-poplar, 92 percent for black cherry, and 50 percent for loblolly pine. Increased slope seemed to be associated with increased 5-year height of all three species. Yellow-poplar and black cherry grew taller when available nitrogen was increased, and loblolly pine grew taller with an increase in total nitrogen. An increase in exchangeable magnesium in the A1 horizon of the soil helped yellow-poplar, and increased calcium in the B2 horizon was beneficial to black cherry. Growth of loblolly pine was best when the bulk density at 20 inches and the moisture-holding capacity in the A1 horizon were low. Some relationships indicated by the analysis may have been fortuitous and not biological because they were not easily explainable.

### Major Publications or Progress Reports


Burton, James D. 1965. Species, site, and plantation yield. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 31 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Francis, J.K.; Loftus, N.S. 1977. Chemical and physical properties of Cumberland Plateau and Highland Rim forest soils. Res. Pap. SO-138. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 44 p.

Francis, John K. 1977. Species, site, and plantation yield; phase I: survival, height growth and soils data. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Fifth year progress report. 16 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Francis, John K. 1977. Species, site, and plantation yield.; phase II: soil properties - height growth studies. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Fifth year progress report. 16 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Loftus, Nelson S., Jr. 1971. Species, site, and plantation yield, installations 1-5. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Establishment report. 15 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Loftus, Nelson S., Jr. 1972. Species, site, and plantation yield; installation 1, Sewanee, Tennessee; installation 2, Centerville, Tennessee. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Fifth year progress report. 16 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Loftus, Nelson S., Jr. 1972. Species, site, and plantation yield, installations 6-8. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Establishment report. 15 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Russell, T.E. 1977. Planting yellow-poplar-where we stand today Gen. Tech. Rep. SO-17. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 17 p.

Russell, Thomas E. 1978. How to grow yellow-poplars. Alabama Forests. April 28-29.

Russell, T.E.; Loftus, N.S.; Mignery, A.L.; Smalley, G.W. 1970. Planting yellow-poplar in central Tennessee

and northern Alabama. Res. Pap. SO-63. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 17 p.
Russell, T.E.; Poore, Steve. 1977. Yellow-poplar can be planted successfully in the Southern Highlands. Southern Lumberman. December 15: [Not paged].
Russell, T.E. 1978. How to plant yellow-poplar on the Cumberland Plateau and Highland Rim. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. [Not paged].
Russell, Thomas E. 1979. How to grow yellow-poplars. Tennessee Forestry Association Annual Meeting Magazine and Membership Directory. May: 14-15.

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## Mortality Patterns in Old Growth Upland Hardwood Forests (See summary, p. 178.)

Many acres of upland hardwood forests have been set aside as natural areas, parks, or wildernesses, but little is known about the mortality patterns that might occur in these areas. An opportunity to study mortality in an undisturbed old growth forest existed in Dick Cove on the domain of the University of the South in Tennessee. To determine the extent and patterns of mortality, surveys and cruises were made on living trees, and age, species, cause of death, tree size, and approximate date of death were determined for dead trees on a 100-acre study area.

During an 8-year period, 26 percent of the hickories (*Carya* spp.) and 18 percent of the white oak (*Quercus alba*) and northern red oak (*Q. rubra*) more than 17 inches in d.b.h. died in the cove. The dead trees ranged in age from 90 to 375 years. Northern red oak averaged 135 years, and white oak, chestnut oak (*Q. prinus*), and hickories averaged about 210 years. The cause of the accelerated mortality observed in the study area was apparently a combination of senescence, drought, insect attack, and blowdown.

Species composition is changing as a result of the mortality. Sugar maple (*Acer saccharum*) and yellow-poplar (*Liriodendron tulipifera*) are increasing in the overstory, and oaks, especially northern red oak, are decreasing. Hickories are decreasing in number but will still be represented in the overstory. It is interesting that the two species that are increasing in importance are ecologically very different. Sugar maple is slow growing and shade tolerant, and yellow-poplar is fast growing and shade intolerant. Perhaps the two species regenerated under different conditions, although they are growing in the same area (McGee 1984).

### Major Publications or Progress Reports

McGee, Charles E. 1982. Mortality patterns in an old growth mixed mesophytic forest. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 22 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.
McGee, Charles E. 1982. Mortality patterns in old growth upland hardwood forests. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 6 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.
McGee, Charles E. 1984. Heavy mortality and succession in a virgin mixed mesophytic forest. Res. Pap. SO-209. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 9 p.

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## Species-Site Relations in Forest Plantations (See summary, p. 178.)

Which are the best species for forest plantations in central Tennessee and northern Alabama? What yields and what losses can be expected in large plantations in the different physiographic regions and soil associations? How do old-field plantations differ from underplanted stands with respect to these topics? A study was begun in 1960 to provide partial answers to these questions. The demand for merchantable forest products had been increasing rapidly, and large areas of marginal farm lands and depleted forests were being planted, mostly with loblolly (*Pinus taeda*) or shortleaf (*P. echinata*) pine (Burton 1960).

Five species-loblolly, shortleaf, Virginia (*P. virginiana*), and eastern white pines (*P. strobus*) and yellow-poplar (*Liriodendron tulipifera*-were planted in seven widely separated localities having a wide range of site conditions. In each area, the study site was located on the soil series and land type most likely to be used for industrial pulpwood plantations, some on old fields and some on low-quality natural stands. The study was intended to continue for 30 years. The study design was a randomized block, with three blocks of five plots, each with a different species. Each plot was 104.3 ft on a side and contained 221 seedlings spaced 6 ft apart in rows 8 ft apart. Data were collected from 35 trees in the center of the plot (Burton 1960).

Measurements 10 years after planting showed that loblolly pine averaged 26.2 ft in height and 4.4 inches in diameter and that Virginia and shortleaf pines averaged 22.2 and 19.0 ft in height and 3.9 and 3.4 inches in diameter, respectively. Eastern white pine grew slowly at first but improved after the first 5 years. Yellow-poplar grew poorly where soil moisture was low and depth of roots was restricted. Survival of all species was 67 percent or higher except for one plantation of Virginia pine, which was damaged by voles (*Microtus* spp.) (Loftus 1974).

The 10-year results of the study suggest that loblolly and Virginia pines are the best species to plant on narrow ridgetops with droughty soil, on degraded sites, or on shallow soils. Virginia pine can be substituted for loblolly pine on the drier ridges of the Cumberland Plateau. Shortleaf pine grows more slowly than the species mentioned above but performs reasonably well when competition is controlled. Eastern white pine increases in growth after an initial establishment period and is a satisfactory species for the Cumberland Plateau and Highland Rim. Yellow-poplar can be expected to grow well only when sites are carefully selected and competition is controlled. These results indicate that loblolly, Virginia, shortleaf, and eastern white pines and yellow-poplar can be grown successfully on sites having soil limitations on the Cumberland Plateau and Highland Rim, barring unusual weather conditions and serious injury by pests or diseases (Loftus 1974).

### Major Publications or Progress Reports


Burton, James D. 1960. Species-site relations in forest plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 35 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Burton, James D. 1962. Species-site relations in forest plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Establishment report, installations 1 and 2. 24 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Burton, James D. 1962. Species-site relations in forest plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experi-. ment Station. Establishment report, installations 3 and 4. 12 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Burton, James D. 1963. Species-site relations in forest plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Establishment report, installations 5 and 6. 62 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Burton, James D. 1966. Species-site relations in forest plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Establishment report, installation 7. 49 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Burton, James D. 1966. Species-site relations in forest plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Fifth year progress report, installations 1 and 2. 28 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Burton, James D. 1967. Species-site relations in forest plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Fifth year progress report, installation 3 and fourth year progress and reestablishment report, installation 4. 25 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Francis, J.K.; Loftus, Nelson S. 1977. Chemical and physical properties of Cumberland Plateau and Highland Rim forest soils. Res. Pap. SO-138. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 44 p.

Loftus, Nelson. 1969. Species-site relations in forest plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Fifth year progress report, installations 5 and 6.6 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Loftus, Nelson. 1971. Species-site relations in forest plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Fifth year progress report, installation 4.7 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Loftus, Nelson 1971. Species-site relations in forest plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Tenth year progress report, installations 1 and 2. 16 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola **Avenue,** New Orleans, LA 70113.

Loftus, Nelson. 1972. Species-site relations in forest plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Tenth year progress report, installation 3. 11 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Loftus, Nelson. 1973. Species-site relations in forest plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Tenth year progress report, installations 5 and 6. 15 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Loftus, Nelson S. 1974. Performance of pine and yellow-poplar planted on low-quality sites in central Tennessee. Res. Note SO-176. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 5 p.

Russell, T.E. 1977. Planting yellow-poplar-where we stand today. Gen. Tech. Rep. SO-17. New Orleans: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 17 p.

Russell, T.E. 1978. How to plant yellow-poplar on the Cumberland Plateau and Highland Rim. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. [Not paged].

Russell, T.E.; Loftus, N.S.; Mignery, A.L.; Smalley, G.W. 1970. Planting yellow-poplar in central Tennessee and northern Alabama. Res. Pap. SO-63. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 17 p.

Russell, T.E.; Poore, Steve. 1977. Yellow-poplar can be planted successfully in the Southern Highlands. Southern Lumberman. December 15: [Not paged].

Russell, Thomas E. 1978. How to grow yellow-poplars. Alabama Forests. April 28-29.

Russell, Thomas E. 1979. How to grow yellow-poplars. Tennessee Forestry Association Annual Meeting Magazine and Membership Directory. May: 14-15.

Smalley, G.W. 1967. Species-site relations in forest plantations. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Final report, installation 7. 1 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

### Volume, Yield, and Soil-Site Relations of Young Loblolly and Shortleaf Pine Plantations in the Tennessee River Drainage (See summary, p. 179.)

Ever since the Tennessee Valley Authority came into existence, hundreds of thousands of acres have been reforested in the Tennessee Valley. Much of the land planted was eroded farm land. Loblolly (*Pinus taeda*) and shortleaf (*P. echinata*) pines were the most extensively planted species, and expansion of the pulping process in Tennessee provided a market for the pine plantations. There was a great need for information on the volume and yield of young plantations of these species and for a method of predicting the potential of idle lands for forest production. Data on comparative growth for assessing the need for changing from species comprising the existing forest cover on certain soils to better adapted species was also lacking (Smalley and Burton 1964).

A study was begun in 1964 to develop yield estimations for loblolly and shortleaf pine plantations up to 25 years of age based on stand parameters and/or soil properties, including soil taxonomic units; to develop site index estimators, base age 25, for these species based on the same parameters; and to develop tree volume estimators for young loblolly and shortleaf pine trees in plantations. The study area included plantations in Tennessee, Alabama, and Georgia, on the Cumberland Plateau, Highland Rim, and Ridge and Valley (Smalley and Bower 1971).

Data were collected during this comprehensive study of plantations in the region. Loblolly pine plantations 9 to 30 years of age were sampled on 302 temporary plots, which were 0.05 acre in size. The average height of dominant and codominant trees ranged from 22 to 72 ft, and site index (base age 25 from seed) ranged from 31 to 89. Of the 305 to 3,460 trees that were planted per acre, 202 to 2,240 per acre survived.

Detailed schedules of the number of trees per acre, basal area, mean tree height, and cubic-foot yields in eight volume categories by 1-inch diameter classes are presented for all combinations of four site indices, seven ages from seed, and nine planting densities in Smalley and Bailey (1974a).

Shortleaf pine plantations 10 to 34 years old were sampled on 116 temporary plots, which were mostly 0.05 acre in size. The average height of dominant and codominant trees ranged from 20 to 66 ft, and site index (base age 25 from seed) ranged from 26 to 58. Of the 400 to 4,500 trees that were planted per acre, 320 to 3,400 per acre survived.

Detailed schedules of the number of trees per acre, basal area, mean tree height, and cubic-foot yields in eight volume categories by 1-inch diameter classes are presented for all combinations of four site indices, seven ages from seed, and six planting densities in Smalley and Bailey (1974b).

Results of this study have been widely published and used by a number of people; however, the soil phase of the study was never begun.

### Major Publications or Progress Reports


Smalley, G.W. 1973. Weighting tree-volume equations for young loblolly and shortleaf pines. Res. Note SO-161. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 5 p.

Smalley, G.W. 1978. Growth and yield of shortleaf pine plantations. In: Proceedings of a symposium for the management of pines of the interior South; 1978 November 7-9; Knoxville, TN. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southeastern Area, State and Private Forestry: 28-47.

Smalley, G.W. 1986. Stand dynamics of unthinned and thinned shortleaf pine plantations. In: Proceedings of a symposium on the shortleaf pine ecosystem; 1986 March 31-April 2; Little Rock, AR. Monticello, AR: Arkansas Cooperative Extension Service: 114-134.

Smalley, G.W.; Bailey, R.L. 1974a. Yield tables and stand structure for loblolly pine plantations in Tennessee, Alabama, and Georgia highlands. Res. Pap. SO-96. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 81 p.

Smalley, G.W.; Bailey, R.L. 1974b. Yield tables and stand structure for shortleaf pine plantations in Tennessee, Alabama, and Georgia highlands. Res. Pap. SO-97. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 57 p.

Smalley, G.W.; Bower, D.H. 1968. Volume tables and point-sampling factors for loblolly pines in plantations on abandoned fields in Tennessee, Alabama, and Georgia highlands. Res. Pap. SO-32. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 13 p.

Smalley, G.W.; Bower, D.H. 1968. Volume tables and point-sampling factors for shortleaf pines in plantations on abandoned fields in Tennessee, Alabama, and Georgia highlands. Res. Pap. SO-39. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 13 p.

Smalley, G.W.; Bower, D.H. 1971. Site index curves for loblolly and shortleaf pine plantations on abandoned fields in Tennessee, Alabama, and Georgia highlands. Res. Note SO-126. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 6 p.

Smalley, G.W.; Burton, James D. 1964. Volume, yield and soil-site relations of young loblolly and shortleaf pine plantations in the Tennessee River drainage. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 34 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.


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### Effects of Intensity of Release on Survival and Growth of Underplanted Yellow-poplar

(See **summary, p. 179.**)

Yellow-poplar *(Liriodendron tulipifera)* has often been planted on cut-over areas of the southern Applachians, but the plantations often did poorly because of competition. Complete release solves this problem but is expensive. A study was installed to determine if partial control measures for competing vegetation would result in adequate growth of yellow-poplar.

Yellow-poplar seedlings from two seed sources were planted on better-than-average soil on the Cumberland Plateau near Sewanee, TN. There were three intensities of treatment: complete release, partial release (all stems greater than 2 inches in d.b.h. injected), and minimum release (all stems greater than 6 inches in d.b.h. injected).

After 15 years, saplings planted where all competing hardwoods had been injected with 2,4-D amine averaged 43 ft in height and 4.2 inches in d.b.h. Saplings planted where trees larger than 2 inches in d.b.h. had been injected averaged 35 ft in height and 3.7 inches in d.b.h., and those planted where stems larger than 6 inches in d.b.h. had been injected averaged only 18 ft in height and 1.4 inches in d.b.h.

This study demonstrates that the more effort put into control of competition, the greater the response of yellow-poplar. The results suggest that yellow-poplar is a viable alternative to pines on Hartsells fine sandy loam (Typic Hapludults) soil, which covers millions of acres on the Cumberland Plateau. However, better-than-average rainfall occurred during the duration of the study, and results may have been different with inadequate rainfall

### Major Publications or Progress Reports


McGee, Charles E. 1976. Effects of intensity of release on survival and growth of underplanted yellow-poplar. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station.

Progress report. 9 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

McGee, Charles E. 1977. Planted yellow-poplar grows well after essential site preparation. Tree Planters' Notes. 28: 5-7.

Mignery, Arnold L. 1967. Effects of intensity of release on survival and growth of underplanted yellow-poplar. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan and establishment record. 14 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

Pierce, Kenneth. 1982. Effects of intensity of release on survival and growth of underplanted yellow-poplar. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Progress report. 9 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.

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**Thirty-Year Yields, Height Growth, and Soil-Site Relations of Yellow-Poplar, Shortleaf Pine, and White Pine Plantations on the Norris Watershed (See summary, p. 180.)**

In the late 1930's, L.S. Minckler established eight plantations on abandoned fields near Norris Lake, TN, one of the most extensive planting experiments up to that time. The study included 117 blocks and 700 plots, a total of 167 acres. Most of the plantations were established on abandoned fields in various stages of soil exhaustion and erosion and included pure and mixed stands of 11 hardwoods and 3 conifers. A few plantings were established in understocked natural shortleaf pine (*Pinus echinata*) and sassafras (*Sassafras albidum*) stands. The initial emphasis was on plantation success as related to aspect and vegetative cover and to depth, type, and consistency of soils (Hohanshelt 1985).

In 1948-49, four experiments were measured by personnel of the USDA Forest Service's Southern Forest Experiment Station and the Tennessee Valley Authority, but the results were not published. By then, the other experiments had failed for various reasons. A 20-year inventory was made in 1957-58 by the same group, and the results were published by Burton (1964). In 1968, measurements were made in two of the four experiments on successful portions of 17 yellow-poplar (*Liriodendron tulipifera*), 27 shortleaf pine, and 22 eastern white pine (*P. strobus*) plots. The objectives of this study were to determine the potential yields of 30-year-old yellow-poplar, shortleaf pine, and eastern white pine plantations, to calculate the height on age curves for these species, and to correlate the physical and chemical properties of soils and site factors with several measures of site productivity for each species (Smalley 1968). However, the data were not analyzed or reported.

The Department of Forestry, Wildlife, and Fisheries of the University of Tennessee has accepted responsibility for future activity on Minckler's plots. Recent data have been turned over to the University of Tennessee, which is responsible for maintenance of the plots.

**Major Publications or Progress Reports**

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Fowler, John H. 1986. Use of merchantable height and correlated measurements in taper equations. Knoxville, TN: University of Tennessee. 79 p. M.S. thesis.

Hohanshelt, C.L. 1985. Site index curves and yield predictors for three species in the vicinity of Norris Lake. Knoxville, TN: University of Tennessee. 79 p. M.S. thesis.

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Minckler, L.S.; Chapman, A.G. 1948. Tree planting in the Central, Piedmont, and Southern Appalachian regions. U.S. Department of Agriculture Farmer's Bulletin. [Place of publication unknown]: [Publisher unknown]. 3 p.

Smalley, G.W.; Beck, D.E. 1971. Cubic-ft volume tables and point-sampling factors for white pine plantations in the southern Applachians. Res. Note SO-118. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 2 p.

Smalley, Glendon W. 1968. Thirty year yields, height growth, and soil-site relations of yellow-poplar, shortleaf pine, and white pine plantations on the Norris Watershed. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan. 28 p. On file with: U.S. Department of Agriculture, Forest Service,

Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.
Smalley, Glendon W. 1986. Stand dynamics of unthinned and thinned shortleaf pine plantations. In: Proceedings of a symposium on the shortleaf pine ecosystem; 1986 March 31–April 2; Little Rock, AR. Monticello, AR: Arkansas Cooperative Extension Service: 114-134.

### Effect of Spacing on Growth and Yield of Planted Virginia Pine (See summary, p. 180.)

Although spacing of pines in plantations has been widely researched, little information on spacing is available for Virginia pine (*Pinus virginiana*). Because this species is commercially important on the Cumberland Plateau, a study was established in 1961 near Sewanee, TN, to test the effects of spacing on the growth of unthinned Virginia pine. Another objective of the study was to determine if self-pruning, which is poor in Virginia pine, could be improved at high densities (Russell 1962).

Seedlings were planted at spacings of 4 by 4, 6 by 6, and 8 by 8 ft on 0.25-acre plots in a randomized block design with four replications. The measurement plot was approximately 0.1 acre in size. At age 20, survival was 38, 58, and 75 percent; d.b.h. averaged 5.1, 5.8, and 6.4 inches; and basal area averaged 141,123, and 114 $ft^2$, respectively, for the three spacings. Despite greater mortality, there were many more surviving pines in the 4- by 4-ft spacing than in the wider spacings. Self-pruning was not improved in the 4- by 4-ft spacing. There were more trees 4.6 inches in d.b.h. and larger in the 4- by 4-ft plots than in the other plots, but there were more trees 5.6 inches in d.b.h. and larger in the wider spaced plots. At age 20, there were no significant differences in stand volume among spacings.

Although the final decision on spacing of Virginia pine cannot be made from this study alone, the 20-year data show in detail the relative gains and losses associated with different spacings. These data provide information for planning establishment of Virginia pine plantations on similar sites. The study was intended to continue for 30 years, but the plantations were extensively damaged by an ice storm in February 1985, so the study was closed.

#### Major Publications or Progress Reports

Russell, T.E. 1979. Plantation spacing affects early growth of planted Virginia pine. Res. Note SO-248. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 5 p.
Russell, Thomas E. 1962. Effect of spacing on growth and yield of planted Virginia pine. Sewanee, TN: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Study plan and establishment report. 10 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, 701 Loyola Avenue, New Orleans, LA 70113.
Smalley, Glendon W. 1985. Growth of 20-year-old Virginia pine planted at three spacings in Tennessee. Southern Journal of Applied Forestry. 9(1): 32-37.

### Yellow-Poplar Geographic Seed Source Study (See summary, p. 181.)

Yellow-poplar *(Liriodendron tulipifera)* is one of the South's most widely planted hardwoods. Research in genetic improvement of the species was needed because the association of genetic variation with geographic source is important to both breeding and cultural efforts.

A geographic seed source study of yellow-poplar was undertaken in the mid-Cumberland Plateau and eastern Highland Rim regions of Tennessee in 1961. The objective of the study was to evaluate the extent of geographic variation among four southern seed sources: Sewanee, TN; Oxford, MS; Birmingham, AL; and Gloster, MS. The Sewanee installations were just one part of the study. At Sewanee, a randomized block design was used with four replications at each of two sites. One area was a good mixed-hardwood cove site, and the other was an oak-hickory site on the top of the Cumberland Plateau. Seedlings from the four sources were planted at the two sites, and other hardwoods were controlled (Russell and others 1970).

After 20 years, no significant differences were detected among the seed sources at the hardwood cove site for any characteristic, but significant variation among blocks of individual seed sources existed for many characteristics. At the oak-hickory site, height, diameter, basal area, and yield of plantations from the two Plateau seed sources (Sewanee and Oxford) were significantly greater than those from the Coastal Plain sources (Birmingham and Gloster) at ages 15 and 20. The diameter and height of yellow-poplars at the hardwood cove site were greater than those at the oak-hickory site (Smalley 1982).

It was concluded that seeds for planting yellow-poplar in the mid-Cumberland Plateau region can be obtained from several southern locations, and growth on less than optimal sites is more dependent on seed source. On sites such as the oak-hickory site, seeds from the Plateau region are probably best, and seeds from the Coastal Plain should be avoided. On better hardwood cove sites, trees from all four sources grew well. The study confirmed that the cool hardwood cove site was excellent for yellow-poplar and that the upland on top of the Plateau was average (Smalley 1982).

### Major Publications or Progress Reports


Russell, T.E. 1977. Planting yellow-poplar-where we stand today. Gen. Tech. Rep. SO-17. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 17 p.

Russell, T.E. 1978. How to plant yellow-poplar on the Cumberland Plateau and Highland Rim. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. Leaflet. [Not paged].

Russell, T.E.; Loftus, N.S.; Mignery, A.L.; Smalley, G.W. 1970. Planting yellow-poplar in central Tennessee and northern Alabama. Res. Pap. SO-63. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 17 p.

Russell, T.E.; Poore, Steve. 1977. Yellow-poplar can be planted successfully in the southern highlands. Southern Lumberman. December 15. [Not paged].

Russell, Thomas E. 1978. How to grow yellow-poplars. Alabama Forests. April: 28-29.

Russell, Thomas E. 1979. How to grow yellow-poplars. Tennessee Forestry Association Annual Meeting Magazine and Membership Directory. May: 14-15.

Smalley, G.W. 1982. Landtype and seed source affect 20-year growth of planted yellow-poplar on the Cumberland Plateau in Tennessee. In: Muller, R.N., ed. Proceedings of the 4th central hardwood forestry conference; 1982 November 8-10; Lexington, KY. Lexington, KY: University of Kentucky: 158-168.

Smalley, G.W.; Pierce, K. 1972. Yellow-poplar, loblolly pine, and Virginia pine compared in Cumberland Plateau plantations. Res. Note SO-141. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 6 p.

# STUDY SUMMARIES

**Study Title: Competition Impacts on Loblolly Pine: a Regional Assessment of the Competition Omission Monitoring Project (COMProject) (See description, p. 4.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest growth, forest management, growth competition, loblolly pine, *Pinus taeda,* silviculture, site preparation, stand establishment.

**Study Locations:** Fourteen locations in Louisiana, Arkansas, Mississippi, Tennessee, Alabama, Georgia, and Virginia.

**Objectives:** (1) To determine the growth response of loblolly pine established under four competition situations on major soil series across the region; (2) to compare the relative importance of herbaceous versus woody competition as they affect the early and long-term growth of loblolly pine on a wide range of sites; (3) to identify the major herbaceous and woody competitors and document early succession; and (4) to study the effects of the interaction between competition and pine growth on insect predation and disease infection.

**Design:** The four competition conditions under study represent the corner extremes of a pine-growth response surface where the independent variables are woody competition and herbaceous competition. Treatments during the first 4 years were control of: (1) all competition (total control); (2) woody competition; (3) herbaceous competition; and (4) no control Factorial randomized complete-block design using 4 blocks of 4 plots each established at 12 of the 14 locations. Five blocks established at one location and completely randomized design at another. All sites recently harvested and site-prepared by roller drum chopping; also, one site windrowed and another left to regenerate naturally. Treatment plots 0.25 acre in size, and measurement plots 0.09 acre in size. Pines double-planted at a 9- by 9-ft spacing and thinned to one per spot after 1 year (538 per acre).

**Year Installed:** 1984.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Annually on pines and competition.

**Data Machine Readable? Yes,** data sets of Statistical Analysis Systems.

**Variables:** Pine: stocking, cover, diameters (groundline diameter, D6, and d.b.h.), total height, height to crown, crown diameter, and incidence of tip moth *(Rhyocionia* spp.), fusiform rust *(Cronartium quercuum* f.sp. *fusiforme*), pitch canker fungus *(Fusarium lateritium* f. *pini*), and ice damage. Competition: cover (grasses and sedges, forbs, vines, semiwoody, and woody), principal herbaceous species, and rootstock counts by arborescent and nonarborescent species. Nutrition: soil sampling and macronutrient analyses by depth at establishment; pine foliar analysis of macronutrients at ages 2 and 6.

**Year(s) Of Establishment Record And Progress Reports:** 1987.

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**Study Title: The Impact of Mechanical Site Preparation on the Continued Forest Productivity of Piedmont Soils (See description, p. 4.)**

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**Keywords:** Forest growth, forest management, growth competition, loblolly pine, nutrition, *Pinus taeda,* silviculture, site preparation, soils, stand establishment.

**Study Locations:** Georgia and Alabama Piedmont.

**Objectives:** To monitor changes in the nutritional and physical properties of soils following mechanical site preparation that can influence the establishment and growth of loblolly pine.

**Design:**

***Study*** 1-Effects of rootraking on levels of available nutrients and organic constituents of soils have been under investigation at six locations on the Georgia and Alabama Piedmont-five operationally treated sites and one check. At each location, soil samples taken before treatment (July and August), immediately after shearing and rootraking (September), and for 3 consecutive years, and then in the fifth year. Sampling along permanent 100-ft sample lines. After treatment, sample lines reestablished between windrows and within a windrow on the ridge, upper slope, and lower slope positions. At 10-ft intervals along lines, samples taken from depths of 0 to 1, 1 to 2, 2 to 4, 4 to 6, 6 to 12, 12 to 18, and 18 to 24 inches and composited by depth.

***Study*** 2-Six levels of site preparation applied to replicated 2-acre plots at Hitchiti Demonstration and Research Forest. Treatments were as follows:

1. Check (no site preparation)-plots harvested only.
2. Hand-clear-all trees greater than 1 inch in d.b.h. were felled.
3. Shear and chop (single pass of a single drum chopper).
4. Shear, chop, and apply herbicide (hexazinone pellets).
5. Shear, chop, burn, and disk.
6. Shear, chop, burn, disk, fertilize, and apply herbicide-after mechanical site preparation, 100 lb/acre of soluble nitrogen added and sulfometuron applied for herbaceous weed control

Soils sampled at regular intervals along diagonal transects before treatment (after harvest) and at intervals for 7 years. Composited bulk samples from depths 0 to 6 and 6 to 24 inches analyzed for available nutrients, texture, pH, organic matter, and nitrogen. Six core samples (0 to 3 inches in depth) per plot used to determine changes in physical properties.

**Year Installed:** 1981.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Study 1: 1981-84 and 1986; study 2: 1982-83, 1985, and 1988.

**Data Machine Readable? Yes,** data sets of Statistical Analysis Systems.

**Variables:** Soils in both studies: available phosphorus, potassium, calcium, and magnesium; texture; pH; organic matter; and organic nitrogen; in study 1: bulk density, available moisture-holding capacity, and macropore space.

**Year(s) Of Establishment Record And Progress Reports:** Study 1: 1982 and 1984; Study 2: 1984.

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**Study Title: Understory Succession and Overstory Growth in Longleaf Pine Small Pole Stands Following Fire, Mechanical, and Chemical Treatments** **(See description, p. 5.)**

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**Keywords:** Fire, forest growth, forest management, longleaf pine, *Pinus palustris*, plant succession, silvicultural treatments, site preparation.

**Study Location:** Escambia Experimental Forest, AL.

**Objectives:** To determine the effects of fire, mechanical, and chemical treatments for understory hardwood control on understory succession and overstory growth.

**Design:** Twelve treatments, randomly assigned among twelve 0.4-acre plots in each of three blocks; included biennial burns in winter, spring, and summer and an unburned check, each combined with three supplemental treatments, namely: (1) initial herbicide treatment of all hardwood stems; (2) periodic hand-clearing of all woody vegetation over 4.5 ft tall; and (3) untreated check. Treatments established in 14-year-old longleaf pine stands thinned to 500 stems per acre.

**Year Installed:** 1973.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Pine: Ages 14, 21, 24, 27, and 30; hardwood: 1980, 1983, 1986, and 1989; understory biomass (woody plants, grasses, forbs, legumes, and organic litter) by species group: 1973, 1980, 1982; stem counts of trees, shrubs, and vines by species and size class: 1980, 1983, 1986, and 1989.

**Data Machine Readable? Yes,** all trees per net plot greater than 1.5 inches in d.b.h.

**Variables:** Pine: d.b.h. (0.1 inch), height (feet), and crown class; growth-d.b.h., height, basal area, and volume (total, merchantable); survival. Hardwood: d.b.h. (0.1 inch) by species, trees greater than 0.5 inch in d.b.h.; growth-d.b.h., volume, basal area, and number of stems per acre. Biomass: by species group, number of pounds per acre ovendried. Fire: wind (speed, direction), clouds, temperature, humidity, type of fire, flame length, fire width, rate of spread, and crown scorch (each net plot of pine).

**Year(s) Of Establishment Record and Progress Reports:** 1985, 1988, and 1990.

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**Study Title: Longleaf Pine Regeneration Trials (See description, p. 5.)**

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**Keywords:** Forest management, longleaf pine, pine regeneration, *Pinus palustris*, shelterwood system, stand establishment, survival

**Study Locations:** Alabama, Mississippi, Louisiana, Florida, Georgia, South Carolina, and North Carolina.

**Objectives:** Operational tests of the two-cut and three-cut shelterwood systems of natural regeneration of longleaf pine.

**Design:** None; regionwide tests and demonstrations.

**Years Installed:** 1966-70.

**Year Completed:** Continuing; observations completed on 10 of 20 cooperator tests.

**Ages or Intervals Data Collected:** Annually, all tests continuing, except where presence of the red-cockaded woodpecker *(Dendrocopus borealis)* has prevented completion of the regeneration trials.

**Data Machine Readable?** Yes.

**Variables:** Annual springtime counts of flowers, conelets, and cones on marked sample trees; 4-milacre, 1-milacre, and 0.25-milacre stocking of longleaf pine regeneration; height of tallest seedling per stocked 4-milacre and 1-milacre plots; seedling counts on selected plots.

**Year(s) Of Establishment Record And Progress Reports:** Annually 1967-89.

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**Study Title: Escambia "Farm Forty" (See description, p. 6.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest management, harvesting returns, longleaf pine, management costs, *Pinus palustris,* product yields, silviculture, stand growth.

**Study Location:** Escambia Experimental Forest, AL.

**Objectives:** Management demonstration on small farm woodlot to produce high-quality logs and poles using low-cost natural regeneration method.

**Design:** None.

**Year Installed:** 1947.

**Year Completed:** 1963 (study closed); observations continuing.

**Ages or Intervals Data Collected:** Complete inventory of all stems greater than 3.5 inches in d.b.h. on entire 40 acres, beginning in winter of 1947-48; annual harvests associated with farm forestry field days for first 15 years; product yields and management costs and returns through 19 years; annual leaflets on management results through 19 years.

**Data Machine Readable? No.**

**Variables:** Stand growth, product yields, management costs, and returns.

**Year(s) Of Establishment Record And Progress Reports:** Annually 1949–52, 1954, 1960, and 1963.

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**Study Title: Timing of Scrub Oak Control (See description, p. 6.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Competition control, forest management., longleaf pine, pine release, *Pinus palustris,* silviculture, stand establishment.

**Study Locations:** Escambia Experimental Forest and Conecuh National Forest, AL.

**Objectives:** To determine if seedling age at time of release from overtopping hardwoods is an important factor in development of longleaf pine regeneration.

**Design:** Six blocks of six plots each, two on average sites and two on poor sites in Escambia Experimental Forest and two on average sites in Conecuh National Forest. Six treatments: release from hardwood competition at seedling ages 1, 2, 3, 4, and 8, plus unreleased check. Six additional plots added to the four Escambia blocks in 1950 to test effects of hardwood removal 1 year before seedling establishment, at time of seedling establishment, and at seedling ages 1 and 2; plus two check plots, one with hardwoods and one in a natural opening without hardwoods.

**Year Installed:** 1949.

**Year Completed:** 1966 (final report); observations continued periodically through age 31.

**Ages or Intervals Data Collected:** 1947 seed crop seedlings: ages 1-4, 6, 8, 10, 24, and 31; 1951 seed crop seedlings: ages 1, 2, 4, and 6.

**Data Machine Readable? No.**

**Variables:** Pine diameter (root collar for seedlings) and height, brown spot *(Scirrhia acicola)* infection, quadrat stocking, number and diameter class of hardwoods, and percentage of herbaceous ground cover.

**Year(s) Of Establishment Record And Progress Reports:** 1950, 1954, and 1966.

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**Study Title: Aerial Application of Three New Silvicides to Longleaf Regeneration Areas (See description, p. 7.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest management, hardwood control, herbicides, longleaf pine, pine regeneration, *Pinus palustris,* silviculture, stand establishment.

**Study Location:** Escambia Experimental Forest, AL.

**Objectives:** To determine if two new formulations of 2,4,5-T are as effective as an older formulation for controlling hardwoods while causing less damage to longleaf pine seedlings.

**Design:** Butoxy ethanol ester, emulsifiable acid, and emulsifiable amine plus untreated check randomly assigned among four 1-acre plots in each of four 40-acre compartments.

**Year Installed:** 1959.

**Year Completed:** 1961 (final report).

**Ages or Intervals Data Collected:** 1 month and 1 year after treatment.

**Data Machine Readable? No.**

**Variables:** Mortality and damage to: 600 longleaf pine seedlings from 1958 seed crop (first growing season), 600 older longleaf pine seedlings, 750 scrub oaks less than 2 inches in d.b.h., and 750 scrub oaks 2 to 8 inches in d.b.h.

**Year(s) Of Establishment Record And Progress Reports:** 1960 and 1961.

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**Study Title: Longleaf Pine Seed Production (See description, p. 8.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Cone production, flowering date, forest management, longleaf pine, pine flowering, *Pinus palustris,* pollen production, seed production, silviculture.

**Study Location:** Escambia Experimental Forest, AL.

**Objectives:** (1) To explore factors affecting cone production by longleaf pine and the long-term variability in, and relationship between, pollen and cone production; and (2) to examine the weather factors affecting date of peak pine flowering and methods of predicting flowering date.

**Design: Two** blocks, each with five 2.5acre plots. In 1957, plots cut to assigned densities of 9, 18, 27, 36, and 45 $ft^2$/acre of basal area of dominant longleaf pines greater than 8.5 inches in d.b.h. All trees in central 0.9-acre net plots measured in 1964: height, diameter, and stem length to base of live crown. Pollen shed monitored by pollen traps maintained in standard weather instrument shelter.

**Year Installed:** 1964.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? Yes.**

**Variables:** Annual cone production by each pine in each net plot; dates and amounts (number of grains per square centimeter) of pollen shed annually.

**Year(s) Of Establishment Record And Progress Reports:** 1968-69.

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## GENETICS OF SOUTHERN PINES

**Study Title: A Seed Source Study and Progeny Test of Select East Coast Loblolly Pines (Study SO-1401-13.31; see description, p. 8.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Loblolly pine, *Pinus taeda,* progeny test, provenance test, seed source.

**Study Locations: Two** sites in Arkansas and one in north Mississippi.

**Objectives:** To study the geographic and tree-to-tree genetic effects of open-pollinated seed orchard families.

**Design:** Randomized block, 5 replications, 64 tree plots.

**Year Installed:** 1973.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Every 5 years.

**Data Machine Readable? No.**

**Variables:** Height, d.b.h., and fusiform rust (*Cronartium quercuum*).

**Year(s) Of Establishment Record And Progress Reports:** 1973, 1980, and 1987.

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**Study Title: Thirty-Six Seed Sources of Loblolly Pine Tested in Southern Arkansas (Study SO-1401-13.29; see description, p. 9.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Genetics, loblolly pine, *Pinus taeda*, provenance test, seed source.

**Study Location:** Southern Arkansas.

**Objectives:** To study geographic variation in loblolly pine.

**Design:** Thirty-six seed sources, 8 blocks (36 plots per block), 49 trees per square plot.

**Year Installed:** 1957.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** After 3, 5, 10, and 25 years; samples measured at age 16; yearly measurements for 576 trees.

**Data Machine Readable? Yes.**

**Variables:** Height, d.b.h., fusiform rust (*Cronartium quercuum*), and unexplained late mortality.

**Year(s) Of Establishment Record And Progress Reports:** 1957.

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**Study Title: The Effects of Intensive Culture and Wood Quality on Growth and Yield of Longleaf, Slash, and Loblolly Pines (Study SO-1401-1.52; see description, p. 9.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Genetics, growth and yield, intensive culture, loblolly pine, longleaf pine, *Pinus elliottii*, *P. palustris*, *P. taeda*, silviculture, slash pine, wood quality.

**Study Location:** Harrison County, MS.

**Objectives:** To compare the relative growth rates and yields of three species of pine subjected to intensive cultural treatments.

**Design:** Large split plots, randomized complete block, total of 60 acres, four replications.

**Year Installed:** 1959.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Annually 1 through 5 years; then after 9, 12, and 26 years.

**Data Machine Readable? No.**

**Variables:** Height, d.b.h., specific gravity

**Year(s) Of Establishment Record And Progress Reports:** Not available.

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**Study Title: Yield, Stability, and Fusiform Rust Comparisons for Single and Multifamily Blends of Loblolly Pine (Study 50-1401-4.1; see description, p. 10.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Cronartium quercuum*, deployment strategy, fusiform rust, genetics, loblolly pine, *Pinus taeda*, seed blends, yield.

**Study Locations:** Harrison Experimental Forest, MS, and near Bogalusa, LA.

**Objectives:** (1) To determine the yielding ability of representative families of loblolly pine in both pure and mixed family plots; (2) to develop a working model for predicting the yields of mixed plots based on a knowledge of the yields of each family in pure plots; (3) to compare the performance of row-plot mixtures with that of single random mixtures (blends) for mixtures of up to six families; (4) to develop, if possible, a working model to predict pure-plot and mixed-plot yields in large plots based on family performance in small row plots; and (5) to compare the yield stability of pure versus mixed plots.

**Design:** Four test plantations, each with 4 blocks, 30 test plots per block; 10 pure plots, 18 binary mixtures (9 mixtures, 2 proportions), 1 blend, 1 row mix.

**Year Installed:** 1984.

**Year Completed:** Continuing, expected completion date, 2004.

**Ages or Intervals Data Collected:** 1st–6th, 8th, 10th, and 12th growing seasons in the field.

**Data Machine Readable? No.**

**Variables:** Height, diameter, fusiform rust, and crown dimensions.

**Year(s) Of Establishment Record And Progress Reports: 1984.**

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**Study Title: Yield, Stability, and Fusiform Rust Comparisons for Single and Multifamily Blends of Slash Pine (Study 50-1401-4.2; see description, p. 10.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Cronartium quercuum* f. sp. *fusiforme*, deployment strategy, fusiform rust, genetics, *Pinus elliottii*, seed blends, slash pine, yield.

**Study Location:** Harrison Experimental Forest, MS.

**Objectives: (1)** To determine the yielding ability of representative families of slash pine in both pure and mixed family plots; (2) to develop a working model for predicting the yields of mixed plots based on a knowledge of the yields of each family in pure plots; (3) to compare the performance of row-plot mixtures with that of single random mixtures (blends) for mixtures of up to six families; (4) to develop, if possible, a working model to predict pure-plot and mixed-plot yields in large plots based on family performance in small row plots; and (5) to compare the yield stability of pure versus mixed plots.

**Design:** Ten pure main-test family plots of the 10 main-test families, 1 pure check plot, 10 binary family mixtures of main-test families (5 mixtures, in 2 proportions), 10 check-family mixtures (25:75 ratio), 2 common binary family mixtures in each of the 2 proportions, 1 blend of all main-test families, and 1 row mix of all main-test families; test 1: 2- by 2-m spacing, 3 replications; test 2: 2- by 1m spacing, 4 replications.

**Year Installed:** 1984.

**Year Completed:** Continuing, expected completion date 2004.

**Ages or Intervals Data Collected:** 1st–6th, 8th, 10th, and 12th growing seasons in the field.

**Data Machine Readable?** Partly.

**Variables:** Height, diameter, fusiform rust, and crown dimensions.

**Year(s) Of Establishment Record And Progress Reports:** 1984.

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**Study Title: Mixing Eastern and Western Seed Sources of Loblolly Pine in Oklahoma Plantings (Study 50-1401-4.3; see description, p. 10.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Cronartium quercuum* f. sp. *fusiforme*, fusiform rust, genetics, loblolly pine, *Pinus taeda*, seed blends, yield.

**Study Location:** Oklahoma.

**Objectives:** (1) To develop a strategy for deployment of seed source material; and (2) to reduce potential risks of using loblolly pine seeds from North Carolina in Arkansas.

**Design:** Five treatments: pure North Carolina seeds (NC), 3 mixes of Arkansas seeds (AR) and NC in ratios of 25:75, 50:50, and 75:25, and pure AR, 100 trees per plot, 8- by 8-ft spacing.

**Year Installed:** 1984.

**Year Completed:** Continuing; expected completion date, 2004.

**Ages or Intervals Data Collected:** 1st–6th, 8th, 10th, and 12th growing seasons in the field.

**Data Machine Readable? No.**

**Variables:** Height, diameter, fusiform rust, and crown dimensions.

**Year(s) Of Establishment Record And Progress Reports:** 1984.

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**Study Title: Southwide Pine Seed Source Study-Slash Pine (see description, p. 11.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Genetics, geographic variation, *Pinus elliottii*, provenance test, seed source, slash pine.

**Study Location:** Southeastern United States.

**Objectives:** To determine to what extent inherent geographic variation in the species is associated with geographic variation in climate and physiography.

**Design:** Randomized complete block, four replications in each 2.4-acre plantation; one series of seed sources in each plantation. Six seed sources representing the northeastern and western extremities of the range and a more southerly portion of the range than was included in any earlier study. Nine plantings established, with at least one plantation in vicinity of each of six seed sources and three plantations outside the range of slash pine. Each plantation was intended to be an installation of an entire series, but many were incomplete. A plot contained 121 trees of a given seed source planted at a spacing of 6 by 6 ft. Measurement plot consisted of the central 49 trees.

**Years Installed:** 1952-53.

**Year Completed:** 1983.

**Ages or Intervals Data Collected:** 1, 3, 5, 10, 15, 20, and 25 years after planting.

**Data Machine Readable? Yes.**

**Variables:** Height, d.b.h., and fusiform rust (*Cronartium quercuum* f. sp. *fusiforme*).

**Year(s) Of Establishment Record And Progress Reports:** Not available.

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**Study Title: Southwide Pine Seed Source Study-Longleaf Pine Study (See description, p. 11.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Genetics, geographic variation, longleaf pine, *Pinus palustris*, provenance test, seed source.

**Study Location:** Southeastern United States.

**Objectives:** To determine to what extent inherent geographic variation in the species is associated with geographic variation in climate and physiography.

**Design:** Randomized complete block, 4 replications in each 2.4-acre plantation; 15 seed sources over greater part of the range, with noticeable gap between south Florida and central Georgia. There were 37 plantings from southeastern Virginia to eastern Texas, as far north as northeastern Alabama and as far south as the central gulf coast. Seed sources and plantings grouped into six series for testing. In two of the plantations, seed sources from the east-west extremes of the range were evaluated; in two, sources from the north-south extremes were evaluated; and in two, differences in soil properties were evaluated. There were 15 seed sources and 18 plantings, with at least 1 plantation in the vicinity of each of 6 seed sources. Each plantation was intended to be an installation of an entire series, but many were incomplete. A plot contained 121 trees of a given seed source planted at a spacing of 6 by 6 ft. The measurement plot consisted of the central 49 trees.

**Years Installed:** 1952-53 and 1956-57.

**Year Completed:** 1983.

**Ages or Intervals Data Collected:** 1, 3, 5, 10, 15, 20, and 25 years after planting.

**Data Machine Readable? Yes.**

**Variables:** Height and d.b.h.

**Year(s) Of Establishment Record And Progress Reports:** Not available.

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**Study Title: Southwide Pine Seed Source Study-Loblolly Pine (See description, p. 11.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Genetics, geographic variation, loblolly pine, *Pinus taeda*, provenance test, seed source.

**Study Location:** Southeastern United States.

**Objectives:** To determine to what extent inherent geographic variation in the species is associated with geographic variation in climate and physiography.

**Design:** Randomized complete block, four replications in each 2.4-acre plantation; two series of seed sources, one representing a major portion of the range and the other restricted to a mostly continental east-west transect. There were 15 seed sources and 18 plantings from eastern Maryland to east Texas and from central Arkansas and Tennessee to south Georgia, with at least 1 plantation being in the vicinity of each of 6 seed sources. A plantation was intended to be an installation of an entire series, but many were incomplete. A plot contained 121 trees of a given seed source planted at a spacing of 6 by 6 ft. Measurement plot consisted of the central 49 trees.

**Years Installed:** 1952-53.

**Year Completed:** 1983.

**Ages or Intervals Data Collected:** 1, 3, 5, 10, 15, 20, and 25 years after planting.

**Data Machine Readable? Yes.**

**Variables:** Height, d.b.h., and fusiform rust (*Cronartium quercuum* f. sp. *fusiforme*).

**Year(s) Of Establishment Record And Progress Reports:** Not available.

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**Study Title: Southwide Pine Seed Source Study-Shortleaf Pine Study (See description, p. 11.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Genetics, geographic variation, *Pinus echinata,* provenance test, seed source, shortleaf pine.

**Study Location:** Southeastern United States.

**Objectives:** To determine to what extent inherent geographic variation in the species is associated with geographic variation in climate and physiography.

**Design:** Randomized complete block, four replications in each 2.4-acre plantation. There were six series of seed sources and plantations; each of four series included sources from different parts of latitudinal range, and two series included sources from along an east-west transect. There were 23 rangewide seed sources and 40 plantations, which extended from southeastern Virginia to eastern Texas and as far south as the Mississippi gulf coast and as far north as central New Jersey. A plot contained 121 trees of a given seed source planted at a spacing of 6 by 6 ft. Measurement plot consisted of the central 49 trees.

**Years Installed:** 1952–53 and 1956–57.

**Year Completed:** 1983.

**Ages or Intervals Data Collected:** 1, 3, 5, 10, 15, 25, and 30 years after planting.

**Data Machine Readable? Yes.**

**Variables:** Height and d.b.h.

**Year(s) Of Establishment Record And Progress Reports:** Not available.

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**Study Title: Control Pollinating to Determine Efficient Methods of Breeding Longleaf Pine for Brown Spot Resistance (Study SO-3.45; see description, p. 14.)**

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**Keywords:** Brown spot needle blight, brown spot resistance, genetics, longleaf pine, *Pinus palustris*, pollination, progeny test, *Scirrhia acicola*.

**Study Locations:** Harrison Experimental Forest near Gulfport, MS, and Alexandria, LA.

**Objectives:** (1) To determine, where brown spot is chronic, whether more gain can be realized by breeding trees for specific geographic areas than by breeding trees for general adaptiveness; (2) to determine, where brown spot is chronic in one area but not in another, whether more relative gain can be realized by breeding trees for specific geographic areas than by breeding trees for general adaptiveness; and (3) to determine whether gains made by crossing a set of elite parents are equal to gains obtained by crossing the best individuals in the best families.

**Design:** For objective 1-partial diallel of 9 parents whose progeny have displayed the particular treatment tendency desired; 4 diallels with 18 crosses planted as single-tree plots, with 24 replications, at two sites, Harrison Experimental Forest and Alexandria. For objective 2-two 18-family diallels planted in single-tree plots, with 24 replications at 2 sites, Harrison Experimental Forest. For objective 3-split plot, having an 18-family diallel of parent trees and an N-family diallel of progeny of these parents paired and planted in single-tree plots, with 24 replications, Harrison Experimental Forest.

**Years Installed:** 1982-83.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Annually, years 1-5.

**Data Machine Readable? Yes;** Microvac at Gulfport; Larry Lott files ST345A1.MTW, ST345A2.MTW, ST4586B3.MTW, and STC345.MTW.

**Variables:** Survival, brown spot needle blight, height, and groundline diameter.

**Year(s) Of Establishment Record And Progress Reports:** 1984-85.

## WOOD PRODUCTS INSECT RESEARCH

**Study Title: Evaluation of Chemicals Used as Soil Treatments for Control of Subterranean Termites, Gulfport, MS (Study SO-4.102; see description, p. 15.)**

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**Keywords:** *Reticulitermes* spp., subterranean termites, termite control

**Study Location:** Gulfport, MS.

**Objectives:** To determine the effectiveness of formulations of various insecticides for use as soil treatments to control subterranean termites.

**Design:** Various chemicals tested, mixed with fuel oil or water, at several dosages per cubic foot of soil Chemicals sprinkled on surface of a 17-inch$^2$ area that had been cleared of leaves and debris. After the chemicals had soaked into the soil, a 1- by 6- by 6-inch sap pine board was laid on surface of treated area and weighted with a brick. Treatments distributed in a randomized block design with 10 replications. Boards that had decayed replaced with new ones. Stakes also used in testing chemical treatments in a randomized block design with 10 replications. Three methods using stakes designed to simulate treatment around the foundation of buildings were used. In first method, a hole 15 by 19 inches in size and 12 inches deep was dug, and as the soil was being returned to the hole, it was treated with the chemical; after the soil was replaced, the stake was set. In second method, after a hole 15 by 10 inches in size and 12 inches deep was dug, half the chemical was poured into the hole, the soil was replaced, the stake was set 12 inches deep, and the remaining chemical was applied at soil surface. In third method, four holes 12 inches deep were made with a crowbar, equidistant from a stake, in a 2-ft$^2$ sample area. The chemical was divided equally among, and applied to, the four holes.

**Years Installed:** 1946-52.

**Year Completed:** 1987.

**Ages or Intervals Data Collected:** Not available.

**Data Machine Readable? No.**

**Variables:** Percentage of boards and stakes attacked by termites. When five boards or stakes became damaged by termites, treatment was considered a failure and closed.

**Year(s) Of Establishment Record And Progress Reports:** Not available.

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**Study Title: Control of the Formosan Termite (*Coptotermes formosanus* Shiraki) (Study SO-4.104; see description, p. 15.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** ***Coptotermes formosanus,*** Formosan termite, subterranean termites, termite control

**Study Location:** Lake Charles, LA.

**Objectives:** To determine if soils treated with chlordane and dieldrin could control the Formosan subterranean termite.

**Design:** Standard ground-board method (see study SO-4.102) and a modified stake method were used. Because termite colonies live in cypress stumps, a circular trench was dug around selected stumps, the trench was divided into 12 equal sectors in which the soil was treated, and stakes were placed 12 inches deep.

**Year Installed:** 1966.

**Year Completed:** 1979.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? No.**

**Variables:** Penetration of treated soil by termites.

**Year(s) Of Establishment Record And Progress Reports:** 1966 and 1967–79.

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**Study Title: Soil Treatment Test at Beltsville, Maryland, 1943-49 (Study SO-4.105; see description, p. 15.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** ***Reticulitermes*** spp., subterranean termites, termite control

**Study Location:** Beltsville, MD.

**Objectives:** To evaluate various chemicals as soil treatments for subterranean termite control

**Design:** There were 74 treatments, representing 27 chemicals and chemical mixtures. A hole 15 by 19 inches in size and 12 inches deep was dug, and chemical was applied to the soil as it was being returned to the hole. A sap pine stake 2 by 4 by 18 inches in size was set vertically in center of hole and buried to depth of 12 inches.

**Years Installed:** 1943-49.

**Year Completed:** 1987.

**Ages or Intervals Data Collected:** Annually, in the fall

**Data Machine Readable? No.**

**Variables:** Termite attack on pine stakes in treated soil

**Year(s) Of Establishment Record And Progress Reports:** 1943, 1968, 1970, 1973, 1976, 1979, 1983, 1986, and 1987.

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**Study Title: Evaluation of Chemicals Used as Soil Treatments for Control of Subterranean Termites, Gulfport, MS, 1956 (Study SO-4.151; see description, p. 15.)**

**Principal Investigator(s) Or Contact And Address(es):**


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**Keywords:** *Reticulitermes* spp., subterranean termites, terniite control

**Study Location:** Gulfport, MS.

**Objectives:** To determine the relative effectiveness of various formulations of certain soil poisons for control of subterranean termites.

**Design:** Tests include both ground-board and stake methods; very high and very low concentrations of chemicals are used.

**Year Installed:** 1956.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Every 2 years.

**Data Machine Readable? No.**

**Variables:** Termite penetration of treated soil

**Year(s) Of Establishment Record And Progress Reports:** Twenty-six progress reports through 1988.

**Study Title: Evaluation of Chemicals Used as Soil Treatments, Gulfport, MS, 1958 (Study SO-4.152; see description, p. 15.)**

**Principal Investigator(s) Or Contact And Address(es):**


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**Keywords:** *Reticulitermes* spp., subterranean termites, termite control

**Study Location:** Gulfport, MS.

**Objectives:** To determine the effectiveness of different concentrations, formulations, and dosages of aldrin, benzene hexachloride, chlordane, chlordane-heptachlor mixture, dieldrin, and thiodan as soil treatment termiticides.

**Design:** Standard ground-board and stake methods (see study SO-4.102) were used. Randomized block design with 10 replications used for distributing treatments over test area.

**Year Installed:** 1958.

**Year Completed:** 1987.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? No.**

**Variables:** Termite penetration of treated soil

**Year(s) Of Establishment Record And Progress Reports:** Annually 1958-87.

**Study Title: Evaluation of Chemicals Used as Soil Treatments, Gulfport, MS, 1959 (Study SO-4.153; see description, p. 15.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Reticulitermes* spp., subterranean termites, termite control

**Study Location:** Gulfport, MS.

**Objectives:** To determine the effectiveness of certain new insecticides for use as soil treatments to control subterranean termites; including Kepone, Dichlordane, and SD-4402.

**Design:** Standard ground-board and stake methods (see study SO-4.102) used. Randomized block design with 10 replications used for distributing treatments over test area. Various concentrations of chemical formulations applied in fuel oil solutions or water emulsions at the rate of 1 $pt/ft^2$ using ground-board method and in fuel oil or water emulsions at the rate of 3.2 $pt/ft^3$ using the stake method.

**Year Installed:** 1959.

**Year Completed:** 1979.

**Ages or Intervals Data Collected:** Ground boards-semiannually for 5 years, then annually thereafter; stakes-annually.

**Data Machine Readable? No.**

**Variables:** Termite penetration of treated soil

**Year(s) Of Establishment Record And Progress Reports:** Not available.

**Study Title: Evaluation of Carbamates, Phosphates, and Terpenes Against the Subterranean Termites in Ground-Board Tests and Under Concrete Slabs, Gulfport, MS, 1965 (Study SO-4.154; see description, p. 15.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Reticulitermes* spp., subterranean termites, termite control

**Study Location:** Gulfport, MS.

**Objectives:** (1) To evaluate newer insecticides in an attempt to find one that is less toxic than chlorinated hydrocarbons and that would still give satisfactory control of subterranean termites; and (2) to determine the duration of effectiveness of the chlorinated hydrocarbon insecticides chlordane and dieldrin when applied under a concrete slab for prevention and control of subterranean termites.

**Design:** Standard ground-board method and concrete-slab method; each treatment has 10 replications distributed over experimental area in randomized block design.

**Year Installed:** 1965.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? No.**

**Variables:** Termite penetration of treated soil

**Year(s) Of Establishment Record And Progress Reports:** Twenty-one progress reports through 1990.

**Study Title: Evaluation of Soil Insecticides for Control of Various Species of Subterranean Termites in Various Soil Types and Climatic Conditions (Study SO-4.155 and supplement 3; see description, p. 15.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Reticulitermes* spp., subterranean termites, termite control

**Study Locations:** Pima County, AZ; Calhoun County, FL; Prince Georges County, MD; Union County, SC; and Dent County, MO.

**Objectives:** To determine the efficacy of applying aldrin, chlordane, dieldrin, and heptachlor to the soil to prevent and/or control various species of subterranean termites in different soil types and climatic conditions.

**Design:** Standard ground-board method of installation.

**Year Installed:** 1964.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable?** ***No.***

**Variables:** Termite penetration of treated soil

**Year(s) Of Establishment Record And Progress Reports:** Twenty-five progress reports through 1990.

**Study Title: Field Evaluation of Laboratory-Screened Chemicals as Subterranean Termite Controls, Harrison Experimental Forest, 1972 (Study SO-4.158 and supplement 1; see description, p. 15.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Reticulitermes* spp., subterranean termites, termite control

**Study Location:** Harrison Experimental Forest, Saucier, MS.

**Objectives:** To evaluate the promising insecticides HCS-3260 and Bromodan, selected from laboratory bioassays, for control of subterranean termites in the field.

**Design:** HCS-3260 installed using both the ground-board and concrete-slab methods, with 10 replications; Bromodan installed using concrete-slab method only.

**Year Installed:** 1972.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable?** ***No.***

**Variables:** Termite penetration of treated soil

**Year(s) Of Establishment Record And Progress Reports:** Annually 1972-77 and 1979-90.

**Study Title: Field Evaluation of Laboratory-Screened Chemicals as Subterranean Termite Controls, Harrison Experimental Forest, Mississippi, Santa Rita Experimental Forest, Arizona, and Chipola Experimental Forest, Florida, 1974 (Study SO-4.161; see description, p. 15.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Reticulitermes* spp., subterranean termites, termite control

**Study Locations:** Harrison Experimental Forest, MS; Santa Rita Experimental Forest, AZ; and Chipola Experimental Forest, FL.

**Objectives:** To determine the efficacy of laboratory-screened insecticides applied to the soil to control various species of subterranean termites in different soil types and climatic conditions.

**Design:** Insecticides applied at the rate of 1 pt/ft$^2$ of soil surface area using concrete-slab installation method, with 10 replications per treatment.

**Year Installed:** 1974.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? No.**

**Variables:** Termite penetration of treated soil

**Year(s) Of Establishment Record And Progress Reports:** 1975, 1977, and annually 1979-90.

**Study Title: Field Evaluation of Laboratory-Screened Chemicals as Subterranean Termite Controls at Five Locations: Mississippi, Florida, Arizona, South Carolina, and Maryland, 1975 (Study SO-4.163; see description, p. 15.)**

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**Keywords:** *Amitermes* spp., *Gnathamitermes perplexus, Heterotermes aureus, Reticulitermes flavipes, R. hageni, R. tibialis, R. virginicus,* subterranean termites.

**Study Locations:** Harrison County, MS; Calhoun County, FL; Pima County, AZ; Union County, SC; and Prince Georges County, MD.

**Objectives:** To determine the efficacy of Bromodan, N-2596, and Tiovel when applied to the soil to prevent subterranean termites from penetrating through the soil and attacking the wood above the treated area.

**Design:** Three insecticides (Bromodan, N-2596, and Tiovel) installed in five concentrations (0.125, 0.25, 0.50, 1.0, and 2.0 percent) per location at the rate of 1 pt/ft$^2$ of soil surface area by concrete-slab method. Each treatment had 10 replications distributed over study area in randomized fashion. Insecticides installed in two concentrations (0.125 and 1.0 percent) per location at the rate of 1 pt/ft$^2$ of soil surface area by standard ground-board method.

**Year Installed:** 1975.

**Year Completed:** 1990.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? No.**

**Variables:** Termite penetration of treated soil

**Year(s) Of Establishment Record And Progress Reports:** 1975-88, 1990.

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**Study Title: Field Evaluation of Laboratory-Screened Chemicals as Subterranean Termite Controls at Four Locations: Mississippi, Florida, Arizona, and South Carolina, 1958 (Study SO-4.168; see description, p. 15.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Reticulitermes* spp., subterranean termites, termite control

**Study Locations:** Mississippi, Florida, Arizona, and South Carolina.

**Objectives:** To determine the efficacy of Pounce and Pydrin when applied to the soil to prevent subterranean termites from penetrating through the soil and attacking the wood above the treated area.

**Design:** **Two** insecticides installed in five concentrations (0.062, 0.125, 0.25, 0.50, and 1.0 percent) per location at the rate of 1 pt/ft$^2$ of soil surface area by standard concrete-slab method.

**Year Installed:** 1958.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? No.**

**Variables:** Termite penetration of treated soil

**Year(s) Of Establishment Record And Progress Reports:** 1978, 1979, 1981, and annually 1983-88.

**Study Title: Evaluation of Laboratory-Screened Insecticides in the Field as Subterranean Termite Controls: Arizona, Florida, Mississippi, and South Carolina, 1980 (Study SO-4.173; see description, p. 15.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Reticulitermes* spp., subterranean termites, termite control

**Study Locations:** Arizona, Florida, Mississippi, and South Carolina.

**Objectives:** To determine whether various formulations of insecticides, when applied to the soil, will effectively prevent penetration of the soil by subterranean termites.

**Design:** Ectiban installed in six concentrations (0.05, 0.062, 0.125, 0.25, 0.50 and 1.0 percent) at the rate of 1 pt/ft$^2$ of soil surface area using concrete-slab and ground-board methods; Amaize installed in three concentrations (0.50, 1.0, and 2.0 percent) at the rate of 1 pt/ft$^2$ of soil surface area using only ground-board method. Chlordane served as a standard. Experiment was a randomized complete block with 10 replications.

**Year Installed:** 1980.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? No.**

**Variables:** Termite penetration of treated soil

**Year(s) Of Establishment Record And Progress Reports:** Annually 1980-81 and 1983-88.

**Study Title: Evaluation of Laboratory-Screened Insecticides in the Field as Subterranean Termite Controls, 1982 (Study SO-4.176; see description, p. 15.)**

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**Keywords:** *Reticulitermes* spp., subterranean termites, termite control

**Study Locations:** Arizona, Florida, Mississippi, and South Carolina in the United States, and Panama.

**Objectives:** To determine whether various concentrations of Sumithrin and Actellic, when applied to the soil, would effectively prevent penetration of the soil by subterranean termites.

**Design:** Sumithrin installed in four concentrations at the rate of 1 pt/ft$^2$ of soil surface area using concrete-slab method. Leaves and debris removed to expose soil in 24-in$^2$ area. A 21-in$^2$ wood frame was placed in cleared area, and a trench (2 inches deep and 2 inches wide) was dug inside and adjacent to the frame. Insecticides applied over a 17-in$^2$ area in middle of surrounding trench. Vapor barrier placed over treated area, and concrete poured over it to depth of 1 inch and into trench to form simulated house slab, with a 4-inch-diameter plastic tube placed in the center of treated area. Vapor barrier later removed, and a sap pine block was placed in the tube, which was covered. Ground-board method also used (see study SO-4.102). Experiment installed as a randomized block design, and each treatment replicated 10 times. Actellic soil treatments installed only in four States.

**Years Installed: 1982** and 1984.

**Year Completed:** 1987.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? No.**

**Variables:** Termite penetration of treated soil

**Year(s) Of Establishment Record And Progress Reports:** Annually 1982-87.

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**Study Title: Evaluation of Ro 13-5223 for Termite Control When Applied in a Bait to Infested Buildings at Fort Sill, Oklahoma (Study SO-4.177; see description, p. 15.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Reticulitermes* spp., subterranean termites, termite control

**Study Location:** Fort Sill, OK.

**Objectives:** To determine the effectiveness of Ro 13-5223 applied in bait blocks to infested areas in and around buildings for termite control

**Design:** Four concentrations of Ro 13-5223 applied to blocks of sweetgum *(Liquidambar* spp.) that had decayed to a 15-percent loss in weight due to brownrot fungus. Five buildings of slab-type construction and five of pier-type construction were treated with each concentration of Ro 13-5223. Five bait blocks buried 1 to 2 in in soil at each point of termite entry, and five bait blocks placed within infested wood at each site.

**Year Installed:** 1983

**Year Completed:** 1989.

**Ages or Intervals Data Collected:** Every 6 months.

**Data Machine Readable? No.**

**Variables:** Termite attacks on bait blocks, extent of termite activity, and morphological changes in termites.

**Year(s) Of Establishment Record And Progress Reports:** Annually 1983-89.

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**Study Title: Screening Candidate Termiticides in the Laboratory (Study SO-4.603; see description, p. 15.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Coptotermes formosanus, Reticulitermes uirginicus,* subterranean termites, termite control

**Study Location:** Gulfport, MS.

**Objectives:** To evaluate candidate termiticides in the laboratory as soil toxicants or repellents to control subterranean termites; or to prevent termites from attacking wood in buildings or in storage.

**Design:** Potential termiticides tested for toxicity on soil and for repellency; 3 replications of 10 termites each exposed to 10 concentrations of the chemical

**Year Installed:** 1976.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Not applicable.

**Data Machine Readable? No.**

**Variables:** Condition of exposed termites.

**Year(s) Of Establishment Record And Progress Reports:** 1976, 1978, 1980, 1982, 1984, 1988, and 1989.

**Study Title: Evaluation of Selected Insecticides as Soil Treatments for Control of *Coptotermes formosanus* Shiraki, the Formosan Subterranean Termite, on Midway Island (Study SO-4.175; see description, p. 19.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Coptotermes formosanus,* Formosan termite, subterranean termites, termite control

**Study Location:** Sand Island on Midway Atoll, near the western end of the leeward Hawaiian Islands.

**Objectives:** To determine the effectiveness of various insecticide formulations applied to soil to prevent penetration of the soil by Formosan subterranean termites.

**Design:** Chlordane, chlordane-heptachlor combination, Dursban, Ectibane, heptachlor, N-2596, Oftanol, Pounce, and Tiovel applied to soil in concentrations varying from 62 to 1,000 ppm. Modified stake test method used (see U.S. termiticide studies at beginning of this section), with 10 replications per treatment randomly distributed over experimental area. When termites have penetrated treated soil in 50 percent of a particular treatment, the treatment is considered a failure.

**Year Installed:** 1981.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? No.**

**Variables:** Termite penetration of treated soil

**Year(s) Of Establishment Record And Progress Reports:** 1981 and 1989.

**Study Title: Testing of Insecticides for Use as Soil Treatments for the Control of Subterranean Termites-Republic of Panama (Study SO-4.172; see description, p. 20.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Coptotermes* spp., *Heterotermes* spp., subterranean termites, termite control

**Study Location:** Chiva Chiva, Panama.

**Objectives:** To compare the effectiveness of two formulations of Dursban (M-4504 and M-4548), six concentrations of Pydrin and Ectiban, five concentrations of Oftanol, and three concentrations of Termide when applied to the soil to prevent subterranean termites from penetrating through the soils in tropical areas.

**Design:** Oftanol tested by standard concrete-slab method and Termide by standard ground-board method (see U.S. termiticide studies at beginning of this section). Dursban M-4504, Dursban M-4548, Pydrin, and Ectiban tested by concrete-slab and ground-board methods. Ten replications of each treatment distributed over study area in a randomized fashion. Inspections made annually. When treated soil in 5 of the 10 replications is penetrated by termites, treatment is considered a failure.

**Years Installed:** 1980-82.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? No.**

**Variables:** Termite penetration of treated soil

**Year(s) Of Establishment Record And Progress Reports:** Annually 1980-87 and 1989-90.

**Study Title: Isolation, Characterization, and Identification of Biologically Active Components from Termite-Resistant Woods, 1978 (Study SO-9.541; see description, p. 21.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Subterranean termites, termite control

**Study Location:** Gulfport, MS.

**Objectives:** To obtain information concerning the feasibility of preventing termite damage by choosing naturally resistant woods or using extractive constituents of the woods as wood preservatives. The specific objectives are to fractionate, isolate, characterize, and identify extraneous components of the wood extracts that are detrimental to the termites.

**Design:** A 1-mL aliquot of test solution (extract, fraction, or isolate) applied to absorbent paper, and paper is put into a container with 25 termites. Condition of termites checked at 24 and 72 hours and biweekly for 4 weeks.

**Year Installed:** 1978.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Not applicable.

**Data Machine Readable? No.**

**Variables:** Survival of termites, duration of survival of termites that die during the 4-week period.

**Year(s) Of Establishment Record And Progress Reports:** Annually 1978-88.

**Study Title: Evaluation of Chemicals used as Soil Treatments for Control of Subterranean Termites-Panama Canal Zone (Study SO-4.103; see description, p. 22.)**

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**Keywords:** Subterranean termites, termite control

**Study Location:** Panama.

**Objectives:** To determine the effectiveness of various chemical formulations applied as emulsions and/or oil solutions for use as soil treatment for control of subterranean termites in tropical areas.

**Design:** Standard ground-board method (see study SO-4.102) and standard stake method used. Treatments distributed over experimental plots in a randomized block; each treatment had 10 replications.

**Years Installed:** 1943, 1952–53, and 1963.

**Year Completed:** 1979.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? No.**

**Variables:** Termite damage to treated boards and stakes.

**Year(s) Of Establishment Record And Progress Reports:** 1952, 1966, 1975, 1977, and 1979.

## DISEASES OF SOUTHERN PINES

**Study Title: Lab and Field Testing for Growth and Brown Spot Resistance of Longleaf Pine Progeny (Study SO-2208-10.20; see description, p. 23.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Brown spot needle blight, brown spot resistance, diseases, genetics, longleaf pine, *Pinus palustris*.

**Study Location:** Harrison Experimental Forest, Saucier, MS.

**Objectives:** (1) To compare laboratory and field techniques for detecting resistance to brown spot needle blight in longleaf pine; and (2) to evaluate the growth of and resistance to this disease in promising longleaf parents and their progeny for use in future breeding programs.

**Design:** Split plot with five completely randomized blocks; total number of trees, 3,000.

**Year Installed:** 1976.

**Year Completed:** 1982.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? No,** data sheets only.

**Variables:** Height growth, percentage of infection, survival, and diameter growth.

**Year(s) Of Establishment Record And Progress Reports:** 1977 and 1982.

**Study Title: Control of Brown Spot Needle Blight on Outplanted Longleaf Pine Seedlings by Stimulation of Rapid Height Growth (Study 50-2208-10.26; see description, p. 23.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Brown spot needle blight, diseases, genetics, longleaf pine, *Pinus palustris, Scirrhia acicola*.

**Study Location:** Harrison Experimental Forest, Saucier, MS.

**Objectives:** To study the effects of seedling quality, weed control, nutrition, and brown spot needle blight, and the interaction among these factors on the growth of longleaf pine.

**Design:** Two experiments, each established as a $2^4$ factorial with a randomized complete block design with 5 blocks; 25 trees per block, or a total of 4,000 trees.

**Year Installed:** 1974.

**Year Completed:** 1984.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? Yes,** in Larry Lott Microvac file at Gulfport; ST1026182.Dat and ST102628d.Dat.

**Variables:** Survival, percentage of infection, diameter growth, and height growth.

**Year(s) Of Establishment Record And Progress Reports:** 1979 and 1984.

**Study Title: The Effect of a *Pisolithus* Ectomycorrhizal Root-Dip Treatment on the Survival and Growth of Brown Spot Infection in Select Longleaf Pine Families (See description, p. 24.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Brown spot needle blight, ectomycorrhizal root dip, genetics, longleaf pine, *Pinus palustris, Pisolithus tinctorius, Scirrhia acicola*.

**Study Location:** Mississippi.

**Objectives:** (1) To evaluate different longleaf pine families for susceptibility to infection by ectomycorrhizae of *P. tinctorius* (*Pt*); (2) to evaluate the effects of *Pt* ectomycorrhizae on the survival and growth of, and infection by, brown-spot needle blight in the different longleaf pine families; (3) to evaluate a *Pt* dipping method for the inoculation of longleaf pine with ectomycorrhizae; and (4) to determine the persistence of *Pt* ectomycorrhizae on longleaf pine seedlings.

**Design: Two** field tests involving 15 longleaf pine families evaluated. Both tests designed as split plots; test 1, with bare-root seedlings, had 4 blocks; test 2, with seedlings grown in tubes, had 20 blocks. Paired seedlings dip-treated with either a *Pt* ectomycorrhizae slurry or plain water before being set out.

**Year Installed:** 1982.

**Year Completed:** 1986.

**Ages or Intervals Data Collected:** At 1, 2, and 3 years after planting.

**Data Machine Readable?** **Yes,** Gulfport Microvax, Larry Lott file 10.32 TF85 data.

**Variables:** Survival, height growth, percentage of infection by brown spot needle blight, and presence and percentage of *Pt* ectomycorrhizal roots.

**Year(s) Of Establishment Record And Progress Reports:** 1982.

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**Study Title: Forest Site Evaluation of Fusiform Rust in Mississippi (Study SO-20.30; See description, p. 25.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Cronartium quercuum* f. sp. *fusiforme*, fusiform rust, genetics, *Pinus elliottii*, slash pine.

**Study Locations:** Hancock, Harrison, and Jackson Counties in coastal Mississippi.

**Objectives:** (1) To document factors affecting the incidence of fusiform rust in plantations representing a wide range of potential site hazards conducive to the development and spread of the disease; (2) to study the effects of fusiform rust on the height and diameter growth of planted slash pine; and (3) to determine the effects of fusiform rust on the probabilities of tree death.

**Design:** There were originally 10 study areas, but 2 have been lost-1 to fire and 1 to land sale. Seedlings hand-planted in 25 rows, with 30 trees per row. Seedlings from one of three seed sources planted in each row, with seven replications of each seed source.

**Year Installed:** 1974.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable?** **Yes,** in Froelich files on Gulfport Microvax.

**Variables:** Climate; seed source; soil properties; pine growth; fungus and host phenology, including year of origin of gall, year of discovery of gall, height of gall above ground, distance of branch galls from stem, fate (year of gall death, tree death, and year branch galls spread into main stem), abundance of aeciospore-producing galls and telia, number of basidiospores trapped; and spatial relationships of oaks to the plantations.

**Year(s) Of Establishment Record And Progress Reports:** Dates not reported.

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**Study Title: Reaction of Loblolly Pine Diallel Families to Cultures of Fusiform Rust (Study SO-2208-20.44; see description, p. 26.)**

**Principal Investigator(s) And Address(es):**

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**Keywords:** *Cronartium quercuum* f. sp. *fusiforme*, fusiform rust, genetics, loblolly pine, *Pinus taeda*.

**Study Location:** Hancock County, MS, on Interpine lands.

**Objectives:** To evaluate the interaction of pine families with fusiform rust inocula.

**Design:** Breeding: 1/2 diallel with 10 parents; greenhouse: randomized block with two replications; field:

randomized block, with 6 replications, 10 tree row plots.

**Year Installed:** 1979.

**Year Completed:** 1988.

**Ages or Intervals Data Collected:** Field plantings: each year through year 5.

**Data Machine Readable? Yes,** Dana Nelson has greenhouse data on Gulfport Vax Computer; height and rust infection recorded; data in Larry Etheridge file 20.44 MTW:18.

**Variables:** Percentage of trees galled, gall form (length and diameter), number of galls per tree, and tree height.

**Year(s) Of Establishment Record And Progress Report:** 1982.

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**Study Title: Mapping Virulence of *Cronartium quercuum* f. sp. *fusiforme* on Loblolly Plantations in and near Madison County, Florida (Study 50-2208-20.54; see description, p. 27.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Cronartium quercuum* f. sp. *fusiforme*, fusiform rust, genetics, loblolly pine, *Pinus elliottii*, *P. taeda*, slash pine.

**Study Locations:** Madison County, FL, and adjacent counties in Georgia.

**Objectives:** To determine if fusiform rust in Madison County, GA, differs in virulence from that at other locations in Georgia and Florida.

**Design:** Not applicable.

**Year Installed:** 1986.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** 1, *2*, *3*, and 4 years after planting.

**Data Machine Readable? Yes,** Container Corporation of America has first 3 years of data; year 4 is on Gulfport computer: Larry Lott files FLA 50, 51, 55, 66, MTW; FLA 50, 64, MTW:4; and FLA 50, 97, MTW:1.

**Variables:** **Tree** height and number of galls per tree each year after outplanting.

**Year(s) Of Establishment Record And Progress Reports:** 1986.

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**Study Title: Screening of Rust-Free Slash Pine Trees in Intensively Cultured Plantations for Resistance to Fusiform Rust (Study SO-4503-20.60; see description, p. 27.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Cronartium quercuum* f. sp. *fusiforme*, fusiform rust, genetics, *Pinus elliottii*, slash pine.

**Study Locations:** Palustris Experimental Forest in Louisiana and Harrison Experimental Forest in Mississippi.

**Objectives:** To determine the relative resistance of selected individuals from the study to fusiform rust; and to preserve germplasm of at least 20 individuals of good form and growth rate that show a high degree of resistance to fusiform rust.

**Design:** Eighteen plots of 324 trees, with a spacing of 6 by 8 ft; 20 rust-free trees were chosen for cloning.

**Year Installed:** 1988.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Information not available.

**Data Machine Readable? No.**

**Variables:** Presence of rust.

**Year(s) Of Establishment Record And Progress Reports:** 1988.

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**Study Title: The Effects of Benomyl on Genetically Improved Longleaf Pine (Study SO-2208-10.28; see description, p. 27.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Benomyl, brown spot needle blight, genetics, longleaf pine, *Pinus palustris, Scirrhia acicola*.

**Study Location:** Harrison Experimental Forest, Saucier, MS

**Objectives:** To determine if a benomyl root-dip treatment is required for selections of longleaf pine that are resistant to brown spot needle blight.

**Design:** Test A consisted of seedlings of 40 wind-pollinated families, and test B consisted of seedlings of 24 cross-pollinated and 5 wind-pollinated families. Roots of each test group (A and B) were moistened in water and shaken in a plastic bag containing dry kaolinite clay or mixture of dry clay and benomyl (10 percent a.i. by volume). Seedlings in each test planted in 5 blocks in a paired design with 40 or 29 families, 2 treatments per family, and 8 seedlings in each row plot, the experimental unit.

**Year Installed:** 1982.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** After 1, 2, and 3 years in the field.

**Data Machine Readable? Yes,** files ST10.28, 87, MTW: 19.

**Variables:** Height growth, survival, and infection.

**Year(s) Of Establishment Record And Progress Reports:** 1982 and 1984.

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**Study Title: Control of Brown Spot Needle Blight on Longleaf Pine Seedlings by Benlate Fungicide-Dip Treatment (Study SO-220% 10.22; see description, p. 28.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Brown spot needle blight, fungicide, genetics, longleaf pine, *Pinus palustris, Scirrhia acicola*.

**Study Locations:** Louisiana, Mississippi, Georgia, Alabama, and Florida.

**Objectives:** (1) To test the effectiveness of Benlate root-dip fungicidal treatment for the control of brown spot needle blight over a wide geographic area in five Southern States; (2) to determine the optimal dosage rate of the fungicide; and (3) to determine the duration of effective control

**Design:** There were 9 treatments, randomized within each of 6 blocks, 1 row for each treatment and 25 trees per row. Seedlings were planted 3 ft apart in rows 10 ft apart, with blocks separated by 20-ft buffer zones.

**Year Installed:** 1978.

**Year Completed:** 1985.

**Ages or Intervals Data Collected:** Annually.

**Data Machine Readable? Yes,** Larry Lott Microvax file at Gulfport, files 5 ST102284.Dat and ST10222S.MTW; 3.

**Variables:** Height growth, survival, and percentage of infection.

**Year(s) Of Establishment Record And Progress Reports:** 1978 and 1985.

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**Study Title: Major Factors of the Successful Growth of Longleaf Pines in the South (Study SO-10.33; see description, p. 29.)**

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**Keywords:** Genetics, longleaf pine, *Pinus palustris*.

**Study Locations:** Louisiana, Mississippi, Alabama, Florida. and South Carolina

**Objectives:** (1) To measure and demonstrate the effects of *Pisolithus tinctorius* ectomycorrhizae, weed control, and fertilizer on the growth and survival of longleaf pine in plantations with high and low rates of infection by brown spot needle blight (*Scirrhia acicola*); and (2) to quantify the effectiveness of a chemical fungicide in controlling brown spot needle blight in longleaf pine plantations provided with different cultural treatments.

**Design:** At each of 5 sites, 18 plots consisting of 6 different treatments in each of 3 complete blocks; each plot measured 90 by 54 ft (0.1116 acre) in size and contained 81 trees in 9 rows of 9 trees; rows were 10 ft apart, and trees, 6 ft apart within rows. Each measurement plot 70 by 42 feet (0.0674 acres) in size contained 49 trees in 7 rows of 7 trees each.

**Year Installed:** 1984.

**Year Completed:** 1986.

**Ages Data Collected:** Periodically. Exact ages not reported.

**Data Machine Readable? Yes,** on file at Gulfport Computer Center Microvax: Larry Lott file 10.33-85 data.

**Variables:** Mycorrhizae, weed control, fertilizer, survival, pine height and diameter.

**Year(s) Of Establishment Record And Progress Reports:** Dates not reported.

**Study Title: Impact of Fusiform Rust in Southern Pine Plantations (Study SO-2208-20.38, see description, p. 29.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Cronartium quercuum* f. sp. *fusiforme*, fusiform rust, genetics, loblolly pine, *Pinus elliottii*, *P. taeda*, slash pine.

**Study Location:** Coastal Mississippi.

**Objectives:** To experimentally determine the effects of fusiform rust on the yields of planted slash and loblolly pines.

**Design:** Study replicated 5 consecutive years and involves approximately 300 plots with 80 trees per plot. Yields of rust-resistant slash and loblolly pines compared with those of trees more susceptible to the disease.

**Years Installed:** 1978-83.

**Year Completed:** 1993.

**Ages Data Collected:** Annually since planting.

**Data Machine Readable? Yes,** in Froelich files on Gulfport Microvax.

**Variables:** Height, diameter, and rust infection.

**Year(s) Of Establishment Record And Progress Reports:** 1984.

**Study Title: Use of Top-Cross Testers to Evaluate Loblolly Pines for Resistance to *Cronartium quercuum* f. sp. *fusiforme* (Study 50-2208-20.53; see description, p. 30.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Cronartium quercuum* f. sp. *fusiforme*, fusiform rust, genetics, loblolly pine, *Pinus taeda*.

**Study Location:** Eight miles west of Bogalusa, LA, off Highway 60 on Franklinton Road; plot is on land owned by Cavenaugh, Inc.

**Objectives:** (1) To screen several loblolly pines for use as top-cross testers for fusiform rust resistance; and (2) to assess the potential value of these testers to evaluate parent trees for rust resistance.

**Design:** Planting utilized single-tree plots; there are 60 rows; each row has 64 families; i.e., 1 tree from each of 64 families. There were 10 candidate trees, with progeny exposed to 5 sources of inoculum in 2 field tests and 2 greenhouse tests.

**Year Installed:** 1986.

**Year Completed:** Continuing.

Ages **or Intervals Data Collected:** Yearly through fourth year.

**Data Machine Readable? Yes,** Larry Lott file BOG 90:MPW;12.

**Variables:** Number of galls per tree, gall form (length and diameter), and tree height.

**Year(s) Of Establishment Record And Progress Reports:** 1986.

**Study Title: An Evaluation of Loblolly Pine from East Texas for Resistance to Fusiform Rust (Study SO-2208-20.55; see description, p. 30.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** *Cronartium quercuum* f. sp. *echinata*, *C. quercuum* f. sp. *fusiforme*, fusiform rust, genetics, loblolly pine, *Pinus taeda*.

**Study Locations:** Phase 1-Alexandria, LA; phase 2-Harrison Experimental Forest, Saucier, MS, and Savannah River Project, SC.

**Objectives:** (1) To rank 21 full-sib pine families for susceptibility to *Cronartium quercuum* f. sp. *fusiforme* and C. *quercuum* f. sp. *echinata;* and (2) to plant rust-free survivors for future sources of resistant stock.

**Design:** Randomized block.

**Years Installed:** 1985 and 1989.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Yearly.

**Data Machine Readable? Yes,** Larry Lott file 20.55 ALEX data.

**Variables: Tree** height, number of galls per tree, gall length, and gall diameter.

**Year(s) Of Establishment Record And Progress Reports:** 1985.

**Study Title: Relation of Mycorrhizae on Longleaf Pine to Brown Spot Needle Blight (Study 50-2208-10.21; see description, p. 31.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Brown spot needle blight, genetics, longleaf pine, mycorrhizae, *Pinus palustris, Scirrhia acicola*,

**Study Location:** Harrison Experimental Forest on H 2 Road, near Saucier, MS; part of Longleaf Technical Transfer Tour.

**Objectives:** To determine the effects of *Pisolithus tinctoris* and benomyl on outplanted longleaf pine seedlings.

**Design: Two** sites, randomized block, with 8 replications and 8 treatments; 24 plants per treatment row.

**Year Installed:** 1976.

**Year Completed:** 1982.

**Ages or Intervals Data Collected:** Years 1-5, year 10, and periodically for growth and diameter.

**Data Machine Readable?** Year 10 only, rest on data sheets; Larry Lott Microvac file at Gulfport, 10.21 87.MTW;50.

**Variables:** Mycorrhizae, needle blight.

**Year(s) Of Establishment Record And Progress Reports:** Final report, 1982.

## MULTIRESOURCE MANAGEMENT OF NATURALLY REGENERATED UPLAND FORESTS IN THE MIDSOUTH

**Study Title: Growth and Development of Well-Stocked, Natural Even-Aged Stands of Loblolly-Shortleaf Pine Under Different Thinning Methods** **(See description, p. 31.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest growth, forest management, forest yield, harvesting income, loblolly pine, management costs, *Pinus echinata, P. taeda,* shortleaf pine, silviculture.

**Study Locations:** Ashley County, AR, and Morehouse Parish, LA.

**Objectives:** To determine growth and stand development of natural, even-aged stands of loblolly-shortleaf pine as affected by different thinning regimes.

**Design:** The 1949 installation consisted of 9 thinning treatments replicated 3 times each on a good site (site index 85 to 90 ft, loblolly pine, base age 50) and a medium site (site index 75 to 80 feet, loblolly pine, base age 50) in 20-year-old stands for a total of 54 plots. The 1954 installation consisted of 3 supplemental treatments replicated 3 times and installed in 25-year-old stands on good sites for a total of 63 plots. No specific study design was followed. The plots were circular, 0.1 acre in size, and surrounded by a 33-ft isolation strip. The plots have been remeasured every 5 years and thinned if needed. Hardwoods have been periodically controlled by herbicides or mowing.

**Years Installed:** 1949 and 1954.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** 1959, 1964, 1969, 1974, 1979, 1984, and 1989.

**Data Machine Readable? Yes.**

**Variables:** Until 1959, detailed measurements were taken on selected crop trees on each plot. The measurements included d.b.h. to the nearest 0.1 inch, total height, length of clear bole, crown diameter, Girard form class, log grade, merchantable height (3-inch top, inside bark), sawlog height (8-inch top, inside bark), pole class, and crown class. Other trees were tallied by 1-inch d.b.h. classes and 4-ft height classes. In 1959, all trees were given numbers, and more complete measurements were taken. Since 1979, the same variables have been measured on all trees.

**Year(s) Of Establishment Record And Progress Reports:** 1954, 1959, 1964, 1969, 1974, 1979, 1984, and 1989.

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**Study Title: Crossett "Farm Forestry Forties"** **(See description, p. 32.)**

**Principal Investigator(s) Or Contact And Address(es):**

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Phone: (501) 367-3463

**Keywords:** Forest yield, loblolly pine, *Pinus echinata, P. taeda,* selection management, shortleaf pine, silviculture.

**Study Location:** Crossett Experimental Forest, Crossett, AR.

**Objectives:** To determine if selection management can be used to rehabilitate cut-over stands while providing good income to the owner.

**Design:** Unreplicated case study consisting of two 40-acre tracts, one reasonably well stocked and the other, poorly stocked. Stocking was gradually increased by cutting only a portion of growth. Annual cuts were made until stocking and diameter distributions were acceptable; then harvests were conducted every 5 years.

**Year Installed:** 1937.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Approximately every 5 years,

**Data Machine Readable? Yes,** most of the data.

**Variables:** Complete inventories of trees 3.6 inches in d.b.h. and larger by 1-inch diameter classes; cut trees also tallied by 1-inch classes.

**Year(s) Of Establishment Record And Progress Reports:** Not applicable.

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**Study Title: Reproduction Cutting Methods for Establishing and Maintaining Well-Stocked Pine Stands (See description, p. 32.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest growth, forest yield, harvesting methods, loblolly pine, *Pinus echinata, P. taeda*, shortleaf pine, silvicultural systems, stand regeneration.

**Study Location:** Crossett Experimental Forest, Crossett, AR.

**Objectives:** To compare the regeneration and growth and yield of stands composed mostly of loblolly and shortleaf pines subjected to four reproduction cutting methods.

**Design:** Four cutting methods-clearcut, heavy-seed-tree, selection, and diameter-limit-were imposed on twelve 4.4-acre plots in a 3-replicate, completely randomized design. Measurements were taken on an interior 2.5-acre measurement plot.

**Years Installed:** 1942-43.

**Year Completed:** 1979; continuing as a demonstration area, and periodic harvesting is still being done.

**Ages or Intervals Data Collected:** Information not available.

**Data Machine Readable?** Partially.

**Variables:** Overstory measurements consisting of tallies by 1-inch diameter classes.

**Year(s) Of Establishment Record And Progress Reports:** Dates not reported.

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**Study Title: Recovery and Development of Understocked Loblolly-Shortleaf Pine Stands and Suppressed Trees (See description, p. 32.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest growth, forest management, forest yield, loblolly pine, *Pinus echinata, P. taeda*, shortleaf pine, silviculture, stand density, stocking control

**Study Location:** South Arkansas.

**Objectives:** To determine the recovery period needed for understocked, cut-over stands of loblolly-shortleaf pine of different stocking levels to regain acceptable stocking levels.

**Design:** Three replications of five 1-acre treatment plots installed on a good site and a medium site; measurement plots were 0.5 acre in size.

**Year Installed:** 1979.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Information not available.

**Data Machine Readable? No.**

**Variables:** Complete tallies of merchantable trees by 1-inch diameter classes and detailed measurements on selected suppressed trees.

**Year(s) Of Establishment Record And Progress Reports:** 1980, 1982, and 1985.

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**Study Title: Suitability of Pine-Hardwood Mixtures for Stand Growth and Wildlife Habitat** **(See description, p. 33.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest management, loblolly pine, pine-hardwood stands, *Pinus echinata, P. taeda,* shortleaf pine, uneven-aged management, wildlife habitat.

**Study Location:** Crossett Experimental Forest, Crossett, AR.

**Objectives:** To investigate the suitability of uneven-aged pine-hardwood stands composed of different percentages of loblolly-shortleaf pine and hardwood for stand growth and wildlife habitat.

**Design:** Three replications of five treatments in a partially randomized design; plots 0.62 acre in size, with interior measurement plots approximately 0.22 acre in size.

**Year Installed:** 1983.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Information not available.

**Data Machine Readable? Yes.**

**Variables:** Plots were cut back to 65 $ft^2$/acre of basal area and to the following percentages of pine to total basal area-50, 70, 80, 90, and 100. Individual overstory tree tallies were by diameters to the nearest 0.1 inch, and species and tree locations were determined by azimuth and distance from center of plot. Percentage of cover of ground level vegetation was measured annually on twelve 1-$m^2$ subplots in each 0.22-acre plot, and current year's growth was clipped, ovendried, and weighed. Five years after establishment, percentages of cover of ground level, shrub, and midstory vegetation were measured at 30 sample points within each plot.

**Year(s) Of Establishment Record And Progress Reports:** 1983 and 1988.

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**Study Title: Precommercial Thinning and Management of Natural Loblolly-Shortleaf Pine Stands for Rapid Sawlog Production** **(See description, p. 33.)**

**Principal Investigator(s) Or Contact And Address(es):**

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Phone: (501) 364-8730

**Keywords:** Forest management, loblolly pine, *Pinus echinata, P. taeda,* precommercial thinning, sawlog production, shortleaf pine, stand density control

**Study Location:** Crossett Experimental Forest, Crossett, AR.

**Objectives:** (1) To demonstrate a proven and recommended precommercial thinning technique in dense, natural, even-aged loblolly-shortleaf pine stands; and (2) to investigate the production of sawlog-sized pines in an abbreviated time period by use of commercial thinning techniques.

**Design:** In part 1 of the study, there are 15 completely randomized 0.4-acre treatment plots with 0.2-acre measurement plots. In 1986, 200 crop trees per acre were chosen for detailed measurement. In part 2 of the study, the treatments are: control—thinning natural mortality; conventional thinning from below to 85 $ft^2$/acre every 3 to 5 years; and 200 crop trees—selecting 200 crop trees and thinning to 75 $ft^2$/acre every 3 to 5 years while favoring crop trees. Part 2 was installed after 1990 growing season.

**Year Installed:** 1979.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Two-year intervals.

**Data Machine Readable? No.**

**Variables:** Stem counts of pines and hardwoods on 1-milacre, 0.00125-acre, and 0.002-acre subplots; height and d.b.h. on all pines within each subplot; total height (nearest 0.1 ft), height to live crown (nearest 0.1 ft), and d.b.h. (nearest 0.1 inch) of 200 crop trees.

**Year(s) Of Establishment Record And Progress Reports:** 1980, 1982, 1984, 1986, 1988, and 1990.

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**Study Title: Objective Regulation of Uneven-Aged Loblolly-Shortleaf Pine Stands in Arkansas (See description, p. 34.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest growth, forest yield, loblolly pine, *Pinus echinata, P. taeda*, shortleaf pine, stand density control, uneven-aged management.

**Study Location:** South Arkansas.

**Objectives:** To investigate the efficacy of the basal area-maximum diameter-q method for regulating uneven-aged loblolly-shortleaf pine stands (q is the ratio of the number of trees in successive diameter classes).

**Design:** No statistical design; consists of 16 stands ranging from 4.32 to 10.12 acres in size that were cut to varying basal areas, maximum diameters, and q's.

**Years Installed:** 1980-81.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Information not available.

**Data Machine Readable? Yes.**

**Variables:** Stand tables by 1-inch diameter classes for loblolly and shortleaf pines.

**Year(s) Of Establishment Record And Progress Reports:** 1985 and 1989.

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**Study Title: Inventories of Unmanaged Cutover Pine Stands (See description, p. 34.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest growth, forest yield, loblolly pine, *Pinus echinata, P. taeda*, plant succession, shortleaf pine, stand dynamics.

**Study Location:** Crossett Experimental Forest, Crossett, AR.

**Objectives:** To document long-term stand dynamics and succession in unmanaged cut-over loblolly-shortleaf pine stands.

**Design:** No statistical design; study consists of two 40-acre compartments originally cut in 1915.

**Year Installed:** 1937.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Information not available.

**Data Machine Readable? No.**

**Variables:** Periodic two-percent tallies of trees by 1-inch diameter classes and broad species groups.

**Year(s) Of Establishment Record And Progress Reports:** Not applicable.

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**Study Title: Effects of Cutting-Cycle Length on the Production and Development of Uneven-Aged Pine Stands (See description, p. 34.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Cutting cycles, forest growth, forest yield, loblolly pine, *Pinus echinata*, *P. taeda*, shortleaf pine, stand development, uneven-aged management.

**Study Location:** Crossett Experimental Forest, Crossett, AR.

**Objectives:** To investigate the effects of cutting-cycle length on the production and development of uneven-aged loblolly-shortleaf pine stands.

**Design: No** statistical design; study consisted of twenty-four 40-acre compartments of which 8 were assigned to each cutting cycle of 3, 6, and 9 years.

**Year Installed:** 1937.

**Year Completed:** 1968.

**Ages or Intervals Data Collected:** Information not available.

**Data Machine Readable? Yes.**

**Variables:** Complete before-cut and harvest inventories of loblolly and shortleaf pines by 1-inch diameter classes for each cutting cycle.

**Year(s) Of Establishment Record And Progress Reports:** Not applicable.

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**Study Title: Effects of Fertilization and Release on the Diameter Growth of Overstocked Poletimber Oak Stands (See description, p. 35.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Fertilization, forest growth, forest yield, poletimber stands, *Quercus* spp., stand density control, stocking, thinning, upland oaks.

**Study Location:** North Arkansas.

**Objectives:** To determine the effects of thinning and fertilization on the diameter growth of red and white oak trees.

**Design:** Split-plot, with thinning as major plot treatment and fertilization as subplot treatment.

**Year Installed:** 1975.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Information not available.

**Data Machine Readable? No.**

**Variables:** **Tree** diameters to the nearest 0.1 inch.

**Year(s) Of Establishment Record And Progress Reports:** Dates not reported.

**Study Title: Effects of Intermediate Cutting and Fertilization on Understory Development in Poletimber Oak Stands of the Ozark Highland and Boston Mountains (See description, p. 35.1**

**Principal Investigator(s) Or Contact And Address(es):**

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Phone: (501) 5215695

**Keywords:** Fertilization, forest growth, forest yield, poletimber stands, *Quercus* spp., stand density control, stocking, thinning, upland oaks.

**Study Location:** North Arkansas.

**Objectives:** To observe the response of oak, ash, and cherry reproduction to fertilization and overstory release in poletimber stands.

**Design:** Fourteen to sixteen 2-milacre circular subplots on each of sixty-four 0.4- to 0.5-acre overstory plots. The overstory plots are surrounded by a 33-ft buffer strip.

**Years Installed:** 1975-78.

**Year Completed:** Continuing.

Ages **or Intervals Data Collected:** Information not available.

**Data Machine Readable? Yes.**

**Variables:** All regeneration on each 2-milacre plot was tallied by species, origin, and total height.

**Year(s) Of Establishment Or Progress Reports:** Dates not reported.

## EVALUATION OF LEGAL, TAX, AND ECONOMIC INFLUENCES ON FOREST RESOURCE MANAGEMENT

**Study Title: A Continuing Analysis of Trends in Exports of Southern Forest Products from the Eastern United States (Study SO-4802-5.2; see description, p. 36.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Exports, forest products, wood products.

**Study Location:** **New** Orleans, LA.

**Objectives:** (1) To maintain the data base for southern wood exports that has been developed under previous Southern Station studies dating back to 1967; (2) to establish and maintain a new data base for northern softwood exports, thereby obtaining complete coverage of all eastern softwood exports; and (3) to analyze export trends by product and country of destination.

**Design:** A formal experimental design or sampling scheme was not deemed to be necessary. All the trade figures used in the study originated from the foreign trade statistical records maintained by the U.S. Bureau of the Census. Each year the Bureau publishes Report EA622, which shows exports from the United States by product, customs district of exportation, country of destination, and method of transportation. These data are available on either magnetic tape or microfiche, and, once secured, are combined or disaggregated as needed for purposes of this undertaking.

**Year Installed:** 1984.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Annually, since inception of the study.

**Data Machine Readable?** The raw data compiled by the U.S. Bureau of the Census are available on computer tape; however, the data, as compiled for purposes of this study, are not available on computer tape.

**Variables:** The statistics that have been prepared in connection with this study show, for the entire period of the study, both the volume and value of annual eastern softwood exports. This information is available for: (1) different categories of products; (2) various regions or countries of destination; and (3) various regions or customs districts of origin.

The product categories that have been recognized in the analysis include the following: (1) roundwood—logs, posts, poles and pulpwood, and wood chips; (2) lumber-rough, dressed, and other; (3) wood-based panels-veneer, plywood, and particleboard; and (4) miscellaneous manufactured products-builders' woodwork, picket fences, prefabricated wood structures, and other products. Within some of these product classes, species distinctions have also been noted; i.e., southern pine, eastern white and red pines, spruce-fir, and other softwoods.

The various regions or countries of destination that have been recognized in the analysis include the following: Canada, Caribbean, South America, European Economic Community, Other Europe, Near East Asia, Other Asia, Japan, Oceania, and Africa.

Finally, the various regions or customs districts of origin that have been recognized in the analysis are as follows: (1) in the north-Pembina, ND; Duluth, MN; Milwaukee, WI; Chicago, IL; Detroit, MI; Cleveland, OH; Ogdensburg, NY; Buffalo, NY; St. Albans, VT; Portland, ME; Boston, MA; Providence, RI; Bridgeport, CT, New York, NY; Philadelphia, PA; and Baltimore, MD; and (2) in the South-Norfolk, VA; Wilmington, NC; Charleston, SC; Savannah, GA; Miami, FL; Tampa, FL; Mobile, AL; New Orleans, LA; Port Arthur, TX; Houston, TX; and Laredo, TX.

**Year(s) Of Establishment Record And Progress Reports:** Progress reports have been prepared annually since the study was begun.

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**Study Title: A Continuing Analysis of Changes and Developments in the Federal Income Tax with Implications for the Private Landowner and Timber Operator (Study SO-4802-1.4; see description, p. 36.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Federal income tax, private forest owner, private timber operator.

**Study Location:** New Orleans, LA.

**Objectives:** To describe and analyze, on a continuing basis, changes in the Federal income tax that apply to forest owners, operators, and investors. Of necessity, this involves considering new legislative developments in the income tax area, new administrative rulings and regulations of the Internal Revenue Service, and new court decisions on relevant cases.

**Design:** A formal experimental design or sampling scheme was not deemed to be necessary. Relevant legislative, administrative, and judicial developments are identified by monitoring various tax reporting services such as Commerce Clearing House's "Federal Tax Reporter" and the Research Institute of America's "Federal Tax Coordinator." Detailed information on new pieces of legislation is compiled by reviewing both the new laws and the various congressional committee reports that were prepared pursuant to passage of the new laws. Similarly, detailed information on new judicial developments is obtained by reviewing the relevant case transcripts. The latter are retrievable by computer using either the VERLEX or LEXIS data base.

**Year Installed:** 1979.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Annually, since inception of the study.

**Data Machine Readable? No.**

**Variables:** All legislative, administrative, and judicial developments pertaining to the Federal income tax-and which have relevance to forest owners, operators, and investors-have, for the period of the study, been documented and described. Analyses of these developments have been used to formulate tax guidelines that should make the affected parties more aware of both their responsibilities and perogatives under the law.

**Year(s) Of Establishment Record And Progress Reports:** Periodic progress reports have been prepared since the study was begun.

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**Study Title: A Continuing Analysis of Changes and Developments in Federal and State Death Taxes with Implications for the Private Landowner and Timber Operator (Study SO-4802-1.7; see description, p. 37.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Federal death taxes, private forest owner, private timber operator, State death taxes.

**Study Location:** New Orleans, LA.

**Objectives:** To describe and analyze, on a continuing basis, changes and developments in State and Federal death taxes as they apply to private forest owners, operators, and investors. Of necessity, this involves considering new tax legislation and regulations, new administrative decisions and revenue rulings, and new court decisions.

**Design:** A formal experimental design or sampling scheme was not deemed to be necessary. Relevant legislative, administrative, and judicial developments are identified by monitoring such tax reporting services as Commerce Clearing House's "State Tax Review" and "Federal Estate and Gift Tax Reporter." More detailed information concerning the situation in particular States is compiled on an "as needed" basis by using reference materials available in the Louisiana Law Library. Similarly, detailed information on important judicial developments is obtained by using the VERLEX and LEXIS computer data bases to retrieve copies of the desired case transcripts.

**Year Installed:** 1980.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Annually, since the inception of the study.

**Data Machine Readable? No.**

**Variables:** All legislative, administrative, and judicial developments pertaining to both State and Federal death taxes-and which have relevance to forest owners, operators, and investors-have, for the period of the study, been documented and described. Analyses of these developments have been used to formulate decision guidelines that should make the affected parties more aware of both their responsibilities and perogatives under the law.

**Year(s) Of Establishment Record And Progress Reports:** Periodic progress reports have been prepared since the study was begun.

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**Study Title: A Continuing Analysis of Changes and Developments in Forest Resource and Forest Product Law as these Impact on the Economics of Practicing Forestry in the Private Sector (Study SO-4802-2.3; see description, p. 37.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest product law, forest resource law, private forest owner, private timber operator.

**Study Location: New** Orleans, LA.

**Objectives:** To describe, compare, and analyze new and existing legislation and legal trends in the general areas of forest resource and forest products law. Within these general areas, the specific topics that have been addressed include: (1) timber trespass law; (2) measurement, marketing, and harvesting law; (3)

labor law in relation to forest workers; (4) landowner liability law; and (5) the legal framework for the extension of forest credit.

**Design:** A formal experimental design or sampling scheme was not deemed to be necessary. Relevant developments in the various areas of interest are initially identified by monitoring appropriate professional journals and, as they become available, legislative reports from the different States. More detailed information is then obtained on an "as needed" basis by consulting such sources as the annotated statute books of each State, reported court decisions, law review articles, and knowledgeable State and local officials.

**Year Installed:** 1981.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Annually, since inception of the study.

**Data Machine Readable? No.**

**Variables:** Although major legislative developments in all the areas of interest have been monitored, to date, most of the work done in connection with this study has focused on the landowner liability issue. The landowner liability laws of all the Southern States have been reviewed, and their key provisions, summarized. Also, various proposals for a model State law have been critically evaluated. In a somewhat different vein, some attention has been given to the timber-leasing question, Data have been gathered as to the amount of forest land that is under lease in the South. In addition, guidelines for the preparation of viable lease agreements have been formulated.

**Year(s) Of Establishment Record And Progress Reports:** Periodic progress reports have been prepared since the study was begun.

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**Study Title: A Continuing Analysis of Legislative and Economic Trends Associated with the Forest Property Tax and Related Taxes in the United States (Study SO-4802-1.3; see description, p. 38.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest property tax, private forest owner, private timber operator.

**Study Location: New** Orleans, LA.

**Objectives:** (1) To identify emerging legislative, judicial, administrative, and economic trends that pertain to the forest property tax and related forest taxes in the United States and (2) to analyze these trends in terms of their potential implications for private woodland owners, operators, and investors.

**Design:** A formal experimental design or sampling scheme was not deemed to be necessary. Relevant legislative, judicial, and administrative developments are identified by monitoring various tax reporting services such as Commerce Clearing House's "State Tax Review." More detailed information concerning the situation in particular States is compiled on an "as needed" basis by using reference materials available at the Louisiana Law Library and contacting knowledgeable tax and forestry officials in the States of interest.

**Year Installed:** 1979.

**Year Completed:** Continuing.

**Ages or Intervals Data Collected:** Annually, since inception of the study,

**Data Machine Readable? No.**

**Variables:** The forest property and related tax policies of all 50 States have been identified and the key provisions thereof summarized. The tax policies have been categorized as follows: (1) traditional ad valorem property tax laws; (2) exemption and rebate laws; (3) modified assessment laws; (4) modified rate laws; (5) yield tax laws; and (6) severance tax laws. For each type of law and State, information has been compiled as appropriate on each of the following variables: (1) dates of enactment and subsequent amendments; (2) scope; i.e., mandatory or optional; (3) conditions of eligibility; (4) application requirements; (5) valuation procedures prescribed for forest land and timber; (6) specified tax rates; (7) penalties imposed upon declassification or program withdrawal; and (8) any constraints that limit revenue usage.

**Year(s) Of Establishment Record And Progress Reports:** With a few exceptions, progress reports have been prepared annually since the study was begun.

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**Study Title: Continuing Analysis of Legislative, Administrative, and Judicial Developments in Forest Practice and Environmental Law (Study SO-4802-2.9; see description, p. 38.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Environmental law, forest practice law, private forest owner, private timber operator.

**Study Location:** New Orleans, LA.

**Objectives:** (1) To monitor current and future legislative, administrative, and judicial developments in the forest practice and environmental law areas; and (2) to describe and analyze these developments as they relate to forest landowners, operators, and investors.

**Design:** A formal experimental design or sampling scheme was not deemed to be necessary. Relevant legislative, administrative, and judicial developments are identified by screening various professional journals; by tracking appropriate resource and environmental newsletters; e.g., "Land Letter," "Resource Hotline," "Natural Resources Law Newsletter," "National Wetlands Newsletter," etc.; and by reviewing the Environmental Law Institute's "Environmental Law Reporter." More detailed information concerning a specific issue is obtained on an "as needed" basis by using reference materials available at the Louisiana Law Library and by contacting knowledgeable State and Federal officials.

**Year Installed:** 1984.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Annually, since inception of the study.

**Data Machine Readable? No.**

**Variables:** All major legislative, administrative, and judicial developments in the areas of interest-and which have relevance to forest owners, operators, and investors-have been monitored during the duration of this project. To date, however, the bulk of the work done in this study has been concentrated in three areas: (1) State and local forest practice laws; (2) State and local water quality laws; and (3) State and local wetlands protection laws. These types of laws have been described in terms of their key provisions. Furthermore, the potential implications of these types of laws for forest owners, operators, and investors have been partially evaluated.

**Year(s) Of Establishment Record And Progress Reports:** Progress reports have been prepared annually since the study was begun.

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## SILVICULTURE OF ARTIFICIALLY REGENERATED SOUTHERN PINES

**Study Title: Row Versus Selective Thinning for Planted Loblolly and Slash Pines (Study SO-4101-3.33; see description, p. 39.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest management, loblolly pine, pine plantation, *Pinus elliottii, P. taeda,* silviculture, slash pine, thinning.

**Study Location:** Louisiana.

**Objectives:** (1) To determine how row thinning compares with selective thinning in cubic volume, basal area, and diameter growth for slash and loblolly pine plantations of various ages, on different sites, and having various initial planting densities when stocking levels after thinning are comparable; and (2) to determine how diameter distributions are affected by the two thinning methods.

**Design:** Randomized block design; each study location was considered a block, but the design was unbalanced because each treatment was not replicated at each location. A total of 63 total plots were established-35 were slash pine and 28 loblolly pine—within 6 plantations. At establishment, the plots ranged in age from 15 to 22 years, in site index (base age 50) from 64 to 104 ft, and in initial planting density from 800 to 1,200 trees per acre. Plot size varied according to treatment but was 12 rows in width and 1 chain in length, with a buffer of 4 rows on 2 sides and 0.5 chain on each of the other 2 sides. The thinning treatments were: (1) remove every other row selectively thinning to the same basal area; (2) remove every third row selectively thinning to the same basal area; (3) remove every fourth row initially selectively thinning to the same basal area, and then cut the middle of the remaining three rows 5 years later selectively thinning to the same basal area; (4) no thinning.

**Year Installed:** 1976; remeasured in 1981 and 1986.

**Year Completed: 1990.**

**Ages Or Intervals Data Collected:** 1976, 1981, and 1986.

**Data Machine Readable? Yes,** in ASCII format.

**Variables:** D.b.h. to 0.1 inch on all plot trees; total height and height to base of full live crown to 1.0 ft, and crown class on sample trees; upper-stem diameters of outside bark on sample trees; and estimates of cubic-foot volume of plots.

**Year(s) Of Establishment Record And Progress Reports:** 1976, 1982, and 1986.

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**Study Title: Growth and Yield of Thinned Slash Pine Plantations (Studies 50-4101-3.5, 3.6, 3.14; see description, p. 41.)**

**Principal Investigator(s) Or Contact And Address(es):**

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Phone: (318) 473-7227

**Keywords:** Forest growth, forest management, forest yield, pine plantations, *Pinus elliottii,* silviculture, slash pine, thinning.

**Study Location:** Pineville, LA.

**Objectives:** To determine how site, age, survival, timing of first thinning, subsequent repeated thinnings, and thinning intensity affect the growth and yield of slash pine plantations on cut-over sites.

**Design:** Randomized block design for each of three substudies. In some cases there are unequal numbers of replications within the blocks. Altogether, there are 113 plots at 4 locations. Target planting density per acre for 2 locations was 1,037 trees and for the other 2 locations was 908 trees. At establishment, the plots ranged in age from 10 to 17 years and in site index (base age 50), from 80 to 111 ft. The various thinning treatments are as follows: thin to residual basal area (BA) of 40, 55, 70, 85, 100,115, or 130 ft$^2$/acre at study installation and every 5 years thereafter; thin to BA 95 and then to BA 55 or BA 115 ft$^2$/acre 5 years later and to BA55 or BA 115 ft$^2$/acre every 5 years thereafter; initially thin to BA 90 ft$^2$/acre at installation and then up to BA 120 ft$^2$/acre in 3- to 5-ft$^2$/acre increments over eight 5-year periods; thin every 5 years according to the D+ thinning rule; thin to BA 70, 85, or 100 ft$^2$/acre at age 10 and repeatedly thin to the same respective BA; thin to BA 70, 85, or 100 ft$^2$/acre at age 13 and repeatedly thin to the same respective BA; or thin to BA 70, 85, or 100 ft$^2$/acre at age 16 and repeatedly thin to the same respective BA. Measurement plots are at least 0.1 acre in size with a 0.5-chain buffer strip surrounding them.

**Years Installed:** 1958, 1959, 1964, and 1965.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Ages 10, 14, 16, and 17.

**Data Machine Readable? Yes,** in ASCII format.

**Variables:** D.b.h. to 0.1 inch on all plot trees; total height and height to base of full live crown to 1.0 ft, and crown class on sample trees (and recently on all trees); upper-stem diameters of outside bark on sample trees; and estimates of cubic-foot volume of plots.

**Year(s) Of Establishment Record And Progress Reports:** 1958, 1959, 1964, and approximately every 5 years thereafter.

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**Study Title: Growth Response of Planted Loblolly Pine to Brush Control, Herbaceous Plant Control, and Fertilization (Study SO-4101-1.150; see description, p. 44.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Competition control, fertilization, forest growth, forest management, forest yield, fungicidal control, fusiform rust, loblolly pine, pine plantations, *Pinus taeda,* silviculture, site preparation.

**Study Location:** Pineville, LA.

**Objectives:** (1) To evaluate the growth response of loblolly pine undergoing the following treatments: fertilization (yes or no), woody competition control (yes or no), and herbaceous weed control (yes or no); and (2) to determine the optimum combination of these cultural treatments for improving survival, wood production, and wood quality.

**Design:** Treatments were applied in a 2 by 2 by 2 factorial replicated four times in a randomized complete block design; rotary mowing was appended to the factorial

**Year Installed:** 1977.

**Year Completed:** Continuing until 1995.

**Ages Or Intervals Data Collected:** Yearly through age 11, then approximately every 5 years until close.

**Data Machine Readable? Yes,** in ASCII format.

**Variables:** Pine d.b.h. and total height were measured, and occurrence of stem fusiform rust (*Cronartium quercuum* f. sp. *fusiforme)* was noted.

**Year(s) Of Establishment Record And Progress Reports:** 1977, 1982.

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**Study Title: Response of Planted Pine Seedlings to Herbaceous Weed Control on a Grass-Bound Site (Study SO-4101-1.177; see description, p. 44.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Competition control, fertilization, forest growth, forest management, forest yield, fungicidal control, fusiform rust, loblolly pine, pine plantations, *Pinus taeda,* silviculture, site preparation.

**Study Location:** Pineville, LA.

**Objectives:** (1) To determine the growth response of loblolly pine to the following weed control treatments: check, harrowing before planting only, harrowing before and after planting, glyphosphate before planting only, and glyphosphate after planting; and (2) to determine the optimum combination of these cultural treatments for use before and after planting.

**Design:** Treatments were appled in a completely randomized block design with three replications.

**Years Installed:** 1981-82.

**Year Completed:** 1993

**Ages Or Intervals Data Collected:** Annually through age 5; then at ages 7 and 10.

**Variables:** Pine d.b.h. and total height were measured, and occurrence of stem fusiform rust (*Cronartium quercumm* f. sp. *fusiforme)* was noted.

**Year(s) Of Establishment Record And Progress Reports:** 1982, 1987, 1993.

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**Study Title: Fungicidal Control of Fusiform Rust in Intensively Cultured Slash Pine Plantations (Study SO-4101-28; see description, p. 44.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Competition control, fertilization, forest growth, forest management, forest yield, fungicidal control, fusiform rust, pine plantations, *Pinus elliottii,* silviculture, site preparation, slash pine.

**Study Location:** Pineville, LA.

**Objectives:** (1) To measure the successive contributions of weed control and fertilizer to increased stemwood yield of slash pine in plantations having high and low rates of rust infection; and (2) to quantify the effectiveness of a chemical fungicide in controlling fusiform rust in slash pine plantations given different degrees of cultural treatment.

**Design:** Two weeding treatments (yes and no), three fertilizer treatments (fertilized at planting, fertilized 5 years after planting, and no fertilizer), and two fungicidal treatments (yes and no) were applied in the following selected combinations: (1) check; (2) check with fungicide; (3) weeded; (4) weeded with fungicide; (5) weeded with delayed fertilizer; (6) weeded, delayed fertilizer with fungicide; (7) weeded with fertilizer at planting; and (8) weeded, fertilized at planting with fungicide. Each treatment is replicated three times in a complete block random design.

**Year Installed:** 1979.

**Year Completed:** Continuing until 1999.

**Ages Or Intervals Data Collected:** Annually, ages 2 through 10, and then at age 14.

**Data Machine Readable? Yes,** in ASCII format.

**Variables:** Pine d.b.h. and total height were measured, and occurrence of stem fusiform rust ***(Cronartium quercuum*** f. sp. ***fusiforme)*** was noted.

**Year(s) Of Establishment Record And Progress Reports:** 1979.

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**Study Title: Effects of Furrowing and Disking on the Growth of Planted Loblolly and Slash Pine (Study 50-4101-9.2; see description, p. 45.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Bedding, fertilization, forest growth, forest soils, forest yield, loblolly pine, pine plantations, *Pinus elliottii, P. taeda,* site preparation, slash pine, soil drainage.

**Study Location:** Pineville, LA.

**Objectives:** (1) To determine if pine seedlings develop more rapidly on silty soils when planted on beds; (2) to determine if destruction of the herbaceous cover is sufficient to boost seedling growth without raising the planting spot; (3) to determine which species, loblolly or slash pine, grows best on these soils; and (4) to determine if early gains in growth are maintained or lost as the pines reach sapling and pole size.

**Design:** Treatments and species were in a randomized complete block factorial design with three blocks. Site treatments were: (1) check-seedlings planted in a heavy grass rough; (2) disked—2.1-m-wide strips double flat-disked with a heavy-duty offset plowing harrow that cuts about 10 cm deep; (3) bedded—2.1-m-wide strips double flat-disked, then continuous beds made with a terracing harrow; and (4) furrowed-furrows 8 to 10 cm deep and about 1.2 m wide and cut with a fire plow. Treatments installed in 1963. Beds about 30 cm high before settling. Freshly lifted, graded, 1-O loblolly and slash pine seedlings planted by hand at a 2.4- by 1.8-m spacing on 0.17-ha plots during February 1964.

**Years Installed:** 1963-64.

**Year Completed:** 1978.

**Ages Or Intervals Data Collected:** Ages 1 through 5, 10, and 15.

**Data Machine Readable?** **No,** on field data sheets, but plans are to transcribe the 5th-, 10th-, and 15th-year data into ASCII format.

**Variables:** Pine d.b.h. and total height were measured, and occurrence of stem fusiform rust *(Cronartium quercuum* f. sp. *fusiforme)* was noted for all pine trees.

**Year(s) Of Establishment Record And Progress Reports:** 1964, 1969, 1974, 1979.

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**Study Title: Modification of a Wet Site to Promote Pine Growth (Study SO-4101-9.4; see description, p. 45.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Bedding, fertilization, forest growth, forest soils, forest yield, loblolly pine, pine plantations, *Pinus elliottii, P. taeda,* site preparation, slash pine, soil drainage.

**Study Location:** Pineville, LA.

**Objectives:** (1) To determine if pine seedlings develop more rapidly on silty soils when planted on beds; (2) to determine if destruction of the herbaceous cover is sufficient to boost seedling growth without raising the planting spot; (3) to determine which species, loblolly or slash pine, grows best on these soils; and (4) to determine if early gains in growth are maintained or lost as the pines reach sapling and pole size.

**Design:** Treatments and species were in a randomized complete block factorial design with four blocks. Site treatments were: (1) check-plots burned before planting to reduce the heavy grass rough; (2) disked—after burning, plots double flat-disked with a heavy-duty offset plowing harrow that cuts about 10 cm deep; and (3) bedded-after burning, plots double flat-disked, and then continuous beds made with a harrow not equipped with a shaping roller. Treatments installed in 1960. Beds about 45 cm from furrow to crest before settling and spaced 2.4 m apart. Freshly lifted, graded, 1-O loblolly and slash pine seedlings planted by hand at a 2.4- by 1.8-m spacing on 0.15-ha plots during March 1961.

**Years Installed:** 1960-61.

**Year Completed:** 1970.

**Ages Or Intervals Data Collected:** Ages 1 through 5 and 10.

**Data Machine Readable?** **No,** on field data sheets.

**Variables:** Pine d.b.h. and total height were measured for all pine trees.

**Year(s) Of Establishment Record And Progress Reports:** Final report, 1970.

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**Study Title: Test of Site Modification to Promote Pine Growth on Beauregard-Caddo Soils (Study SO-4101-9.5; see description, p. 45.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Bedding, fertilization, forest growth, forest soils, forest yield, loblolly pine, pine plantations, *Pinus elliottii, P. taeda,* site preparation, slash pine, soil drainage.

**Study Location:** Pineville, LA.

**Objectives:** (1) To determine if pine seedlings develop more rapidly on these soils when planted on beds to determine if destruction of the herbaceous cover is sufficient to boost seedling growth without raising the planting spot; (2) to determine which species, loblolly or slash pine, grows best on these soils; and (3) to determine if early gains in growth are maintained or lost as the pines reach sapling and pole size.

**Design:** Treatments and species were in a randomized complete block factorial design with four blocks. Site treatments were: (1) check-plots burned before planting to reduce the heavy grass rough; (2) disked-after burning, plots double flat-disked with a heavy-duty offset plowing harrow that cuts about 10 cm deep; and (3) bedded-after burning, plots double flat-disked and then continuous beds made with a harrow. Treatments installed in 1960-61. Beds about 50 cm from furrow to crest before settling and spaced 2.4 m apart. At age 15, beds were 25 cm high. Freshly lifted, graded, 1-O loblolly and slash pine seedlings planted by hand at a 2.4- by 1.8-m spacing on 0.15-ha plots during February 1962.

**Years Installed:** 1960-62.

**Year Completed:** 1979

**Ages Or Intervals Data Collected:** Ages 1 through 10, 13, 15, and 20.

**Data Machine Readable? No,** on field data sheets, but plans are to transcribe 5th-, 10th-, 13th-, 15th-, and 20th-year data into ASCII format.

**Variables:** Pine d.b.h. and heights were measured, and occurrence of stem fusiform rust *(Cronartium quercuum* f. sp. *fusiforme)* was noted for all pine trees.

**Year(s) Of Establishment Record And Progress Reports:** 1960, 1965, 1970, 1975, 1980.

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**Study Title: Effect of Site Modification on Growth of Loblolly and Slash Pines on a Poorly Drained Site in Central Louisiana (Study 50-4101-9.6; see description, p. 45.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Bedding, fertilization, forest growth, forest soils, forest yield, loblolly pine, pine plantations, *Pinus elliottii, P. taeda,* site preparation, slash pine, soil drainage.

**Study Location:** Pineville, LA.

**Objectives:** (1) To determine if pine seedlings develop more rapidly on poorly drained soils when planted on beds; (2) to determine if destruction of the herbaceous cover is sufficient to boost seedling growth without raising the planting spot; (3) to determine which species, loblolly or slash pine, grows best on this soil; and (4) to determine if early gains in growth are maintained or lost as the pines reach sapling and pole size.

**Design:** Treatments and species were in a randomized complete block factorial design with four blocks. Site treatments were: (1) check-plots burned before planting to reduce the heavy grass rough; (2) disked-after burning, plots double flat-disked with a heavy-duty offset plowing harrow that cuts about 10 cm deep; (3) bedded-after burning, plots double flat-disked, then continuous beds made with a bedding harrow not equipped with a shaping roller; and (4) drained (check) after burning, dikes formed around each plot so water within dikes could be pumped out as needed and water outside dikes would not enter. (However, the treatment failed and the dikes were opened.) Treatments installed in 1963. Beds about 38 cm high furrow to crest before settling. Freshly lifted, graded, 1-O loblolly and slash pine seedlings planted by hand at a 2.4- by 1.8-m spacing on 0.14-ha plots during February 1965. (First-year planting failed on bedded plots.)

**Years Installed:** 1963-65.

**Year Completed:** 1984.

**Ages Or Intervals Data Collected:** Ages 5, 10, and 20. (Most of the plots were commercially thinned once or twice before age 20.)

**Data Machine Readable? No,** on field data sheets.

**Variables:** Pine d.b.h. and total height were measured, and occurrence of stem fusiform rust (*Cronartium quercuum* f. sp. *fusiforme)* was noted for all pine trees.

**Year(s) Of Establishment Record And Progress Reports:** 1963, 1968, 1973, 1984.

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**Study Title: Site Treatments to Increase Growth of Loblolly and Slash Pines on a Caddo Silt Loam Soil (Study SO-4101-9.7; see description, p. 45.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Bedding, fertilization, forest growth, forest soils, forest yield, loblolly pine, pine plantations, *Pinus elliottii, P. taeda,* site preparation, slash pine, soil drainage.

**Study Location:** Pineville, LA.

**Objectives:** (1) To determine if pine seedlings develop more rapidly on this soil when planted on beds; (2) to determine if destruction of the herbaceous cover is sufficient to boost seedling growth without raising the planting spot; (3) to determine which species, loblolly or slash pine, grows best on this soil; and (4) to determine if early gains in growth are maintained or lost as the pines reach sapling and pole sizes.

**Design:** Treatments and species were in a randomized complete block factorial design with four blocks. Site treatments were: (1) check-plots burned before planting to reduce the heavy grass rough; (2) disked—after burning, plots double flat-disked with a heavy-duty offset plowing harrow that cuts about 10 cm deep; and (3) bedded-after burning, plots double flat-disked, and then continuous beds made with a harrow equipped with a shaping roller. Treatments installed in 1970. Beds about 36 cm from furrow to crest before settling and spaced 2.4 m apart. Freshly lifted, graded, 1-0 loblolly and slash pine seedlings planted by hand at a 2.4- by 2.4-m spacing on 0.15-ha plots during February 1971.

**Years Installed:** 1970-71.

**Year Completed:** 1985.

Ages **Or Intervals Data Collected:** Ages 1 through 5, 10, and 15.

**Data Machine Readable? No,** on field data sheets, but plans are to transcribe 5th-, 10th-, and 15th-year data into ASCII format.

**Variables:** Pine d.b.h. and total height were measured, and occurrence of stem fusiform rust *(Cronartium quercuum* f. sp. *fusiforme)* and tip moth *(Rhyacionia* spp.) was noted for all pine trees.

**Year(s) Of Establishment Record And Progress Reports:** 1970, 1975, 1980, 1985.

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**Study Title: Cooperative Study on Mechanical Site Preparation for Planting on Hardwood-Dominated Upland Sites (Study SO-4101-9.11; see description, p. 45.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Bedding, fertilization, forest growth, forest soils, forest yield, loblolly pine, pine plantations, *Pinus taeda,* site preparation, soil drainage.

**Study Locations:** Arkansas and Louisiana.

**Objectives:** (1) To determine which site-preparation method is best on upland better drained soils in the west gulf region; (2) to determine how much of a hardwood component develops after each method of site preparation; (3) to determine how the plantation pines develop; (4) to determine how the different soil types and fertilizer treatments influence the choice of site-preparation method; and (5) to determine if the best choice for a site-preparation method can be predicted on a case-by-case basis.

**Design:** Treatments, subsoil textures, and fertilizer were blocked on year of planting (1971 or 1972) in a randomized complete block, split-plot design. The site-preparation treatments and subsoil textures were the major factors, and the phosphorus fertilizer treatment was the split-plot factor. Site-preparation treatments were underplant-inject, chop-burn, chop-burn-disk, double chop, shear-burn, shear-windrow, and shear-windrow-disk. Subsoil textures were loam, gravelly clay, silt, silty clay, and clay. The two fertilizer levels were none and 168 kg/ha $P_2O_5$ (as triple superphosphate) broadcast before planting. Treatments installed in 1970 and 1971. Freshly lifted, graded, 1-0 loblolly pine seedlings planted by hand at a 2.4- by 1.8-m spacing on 0.22-ha' plots during the winter before hardwood injection on underplanted plots or after mechanical site preparation.

**Years Installed:** 1970-72.

**Year Completed:** 1983.

Ages **Or Intervals Data Collected:** Ages 1 through 5, 7, and 12.

**Data Machine Readable? Yes,** 7th- and 12th-year data in ASCII format.

**Variables:** Pine d.b.h. and total height were measured, and occurrence of stem fusiform rust (*Cronartium quercuum* f. sp. *fusiforme)* was noted for all pine trees.

**Year(s) Of Establishment Record And Progress Reports:** 1971, 1976, 1983.

**Study Title: Site Treatment and Fertilization to Stimulate Growth of Slash Pine on a Poorly Drained Wrightsville Silt Loam Soil (Study SO-4101-9.23; see description, p. 45.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Bedding, fertilization, forest growth, forest soils, forest yield, pine plantations, *Pinus elliottii,* site preparation, slash pine, soil drainage.

**Study Location:** Pineville, LA.

**Objectives:** (1) To determine if pine seedlings develop more rapidly on this soil when planted on beds; (2) to determine if destruction of the herbaceous cover is sufficient to boost seedling growth without raising the planting spot; (3) to determine if fertilizer boosts the development of pine seedlings; and (4) to determine if early gains in growth are maintained or lost as the pines reach sapling and pole sizes.

**Design:** Site-preparation and fertilizer treatments were in a randomized complete block factorial design with four blocks. Site treatments were: (1) check—plots burned before planting to reduce the heavy grass rough; (2) disked-after burning, plots double flat-disked with a heavy-duty offset plowing harrow that cuts about 10 cm deep; and (3) bedded-after burning, plots double flat-disked, and then continuous beds made with a harrow not equipped with a shaping roller. Treatments installed in 1972. Beds were about 25 cm from furrow to crest after settling and spaced 2.4 m apart. Two fertilizer levels were used, none and 560 kg/ha of triple superphosphate broadcast before mechanical site preparation. Freshly lifted, graded, 1-0 slash pine seedlings planted by hand at a 2.4- by 2.4-m spacing on 0.16-ha plots during February 1973.

**Years Installed:** 1972-73.

**Year Completed:** 1981.

**Ages Or Intervals Data Collected:** Ages 1 through 6 and 9.

**Data Machine Readable? Yes,** the 5th-, 6th-, and 9th-year data are in ASCII format.

**Variables:** Pine d.b.h. and total height were measured, and occurrence of stem fusiform rust (*Cronartium quercuum* f. sp. *fusiforme)* was noted for all pine trees.

**Year(s) Of Establishment Record And Progress Reports:** 1972, 1978, 1982.

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**Study Title: Discontinuous Mounds for Planting Slash Pine Seedlings on Poorly Drained Sites (Study SO-4101-9.43; see description, p. 45.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Bedding, fertilization, forest growth, forest soils, forest yield, pine plantations, *Pinus elliottii,* site preparation, slash pine, soil drainage.

**Study Location:** Pineville, LA.

**Objectives:** (1) To determine if pine seedlings develop more rapidly on these soils when planted on discontinuous mounds; and (2) to determine if early gains in growth are maintained or lost as the pines reach sapling and pole sizes.

**Design:** Treatments were in a randomized complete block design, with two blocks on two soils. The soils (both Typic Glossaqualfs) were a somewhat poorly drained Caddo silt loam and a poorly drained Wrightsville silt loam. The site-preparation treatments were: (1) check-before planting, plots burned to reduce the grass rough; (2) low mounds-38-cm-high mounds formed with a John Deere T350 crawler tractor pushing piles of topsoil with a straight 1.8-m dozer blade; and (3) high mounds—75-cm high mounds formed as before. Treatments installed in 1975. Rows of mounds spaced 3 m apart, center to center; adjacent rows offset in a staggered pattern. This arrangement allowed for 537 mounds per hectare. After settling, three uniformly graded O- 1 slash pine seedlings planted on each mound at 60-cm intervals in February 1976. Untreated checks planted at same rate and spacing. If all seedlings survived, one per mound was rogued based on presence of fusiform rust galls, spacing on mound, and vigor.

**Years Installed:** 1975-76.

**Year Completed:** 1981. (Study was destroyed by an ice storm.)

**Ages Or Intervals Data Collected:** Ages 1 through 6.

**Data Machine Readable? No,** on field data sheets.

**Variables:** Pine d.b.h. and total height were measured, and occurrence of stem fusiform rust *(Cronartium quercuum* f. sp. *fusiforme)* was noted for all pine trees.

**Year(s) Of Establishment Record And Progress Reports:** 1975, 1981.

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**Study Title: Mounding and Bedding Poorly Drained Sites to Boost Growth of Slash Pine (Study SO-4101-9.57; see description, p. 45.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Bedding, fertilization, forest growth, forest soils, forest yield, pine plantations, *Pinus elliottii,* site preparation, slash pine, soil drainage.

**Study Location:** Pineville, LA.

**Objectives:** (1) To determine if pine seedlings develop more rapidly on these soils when planted on discontinuous mounds; and (2) to determine if early gains in growth are maintained or lost as the pines reach sapling and pole sizes.

**Design:** Treatments were in a randomized complete block design with four blocks. The soils (both Typic Glossaqualfs) were a somewhat poorly drained Caddo silt loam and a poorly drained Wrightsville silt loam. The site-preparation treatments were: (1) check-before planting, plots burned to reduce the grass rough; (2) low mounds—38-cm high mounds formed with a John Deere T350 crawler tractor pushing piles of topsoil with a straight 1.8-m dozer blade; (3) high mounds-70-cm high mounds formed as before; (4) bedded-beds formed 3 m apart with a bedding disk equipped with a shaping roller, and beds 23 cm high furrow to crest after settling; and (5) intermittent beds-beds formed as before but disk was lifted periodically so continuous beds were not formed. Rows of mounds spaced 2 m apart, center to center; adjacent rows offset in a staggered pattern, which allowed for 537 mounds per hectare. Treatments installed in 1975 and 1976. After settling, uniformly graded O-1 slash pine seedlings planted in February 1977.

**Years Installed:** 1975-76.

**Year Completed:** **1983.** (Study was destroyed by a wildfire.)

**Ages Or Intervals Data Collected:** Ages 1, 3, and 6.

**Data Machine Readable?** **No,** on field data sheets.

**Variables:** Pine d.b.h. and total height were measured, and occurrence of stem fusiform rust *(Cronartium quercuum* f. sp. *fusiforme)* was noted for all pine trees.

**Year(s) Of Establishment Record And Progress Reports:** 1975, 1983.

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**Study Title: Effect of Site Preparation and Fertilization on Growth of Slash Pine (Study SO-4101-(1115)-3.5; see description, p. 45.)**

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**Keywords:** Bedding, fertilization, forest growth, forest soils, forest yield, pine plantations, *Pinus elliottii*, site preparation, slash pine, soil drainage.

**Study Location:** Pineville, LA.

**Objectives:** (1) To determine if pine seedlings develop more rapidly when planted on beds; (2) to determine if destruction of the herbaceous cover is sufficient to boost seedling growth without raising the planting spot; (3) to determine the influence of fertilizer on the development of pine seedlings; and (4) to determine if early gains in growth are maintained or lost as the pines reach sapling and pole sizes.

**Design:** Site-preparation and fertilizer treatments were in a randomized complete block, split-plot design with four blocks. The site-preparation treatments were the major factors, and the fertilizer treatments were the split-plot factors. Site-preparation treatments were: (1) check-plots burned before planting to reduce the heavy grass rough; (2) disked-plots double flat-disked with an offset harrow; and (3) bedded—plots bedded with a bedding harrow, forming the beds 30 cm high from furrow to crest. Four fertilizer treatments broadcast to subplots: (1) no fertilizer; (2) lime—1,120 kg/ha; (3) phosphorus-99 kg/ha as triple superphosphate; and (4) lime plus phosphorus. Treatments installed in 1967. Graded, 1-O slash pine seedlings planted by hand on 0.16-ha plots at a 2.4- by 1.8-m spacing in February 1969.

**Year Installed:** 1967.

**Year Completed:** 1981.

**Ages Or Intervals Data Collected:** Ages 1 through 5, 7, 10, and 13.

**Data Machine Readable?** **No,** data on field sheets.

**Variables:** Pine d.b.h. and total height were measured, and occurrence of stem fusiform rust *(Cronartium quercuum* f. sp. *fusiforme)* was noted for all pine trees.

**Year(s) Of Establishment Record And Progress Reports:** 1967, 1972, 1977, 1981.

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**Study Title: Growth of Slash Pine Seedlings on Sites Subjected to Wet- and Dry-Weather Logging and to Different Repair Practices (Study SO-4101-2.10; see description, p. 47.)**

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**Keywords:** Forest growth, forest management, forest soils, nutrient depletion, pine plantations, *Pinus elliottii*, silviculture, site amelioration, slash pine, soil compaction.

**Study Location:** Louisiana (Boise Cascade-West Bay, Allen Parish; section 13, T4S R5W).

**Objectives:** (1) To determine if compaction of the soil and surface disturbance caused by wet-weather logging reduces the growth of the next pine rotation; (2) to determine if shearing following wet-weather logging improves pine growth more than shearing on soils logged when dry; (3) to determine the growth response of seedlings to phosphorus fertilization; and (4) to determine if early differences in growth change as the pines reach sapling and pole sizes.

**Design:** Treatments replicated four times in a randomized complete block design. Site treatments were: (1) logged when dry with no site preparation; (2) logged when dry followed by shearing and piling; (3) logged when wet with no site preparation; (4) logged when wet followed by shearing; (5) logged when wet followed by shearing and then root raking; and (6) logged when wet followed by shearing, root raking, and disking. Plots split, and 50 lb/acre of phosphorus applied to one of the splits. Treatments installed in 1979. Freshly lifted, graded 1-0 slash pine seedlings planted by hand at a 6- by 10-ft spacing on 200- by 400-ft plots during February 1980.

**Years Installed:** 1979-80.

**Year Completed:** Full rotation, perhaps 30 years, will be required to verify the early results.

**Ages Or Intervals Data Collected:** Ages 1, 3, 5, and 9.

**Data Machine Readable? Yes,** presently on obsolete machine, but plans are to transcribe into ASCII format.

**Variables:** Pine d.b.h. and total height were measured, and occurrence of stem fusiform rust (*Cronartium quercuum* f. sp. *fusiforme*) was noted.

**Year(s) Of Establishment Record And Progress Reports:** 1979, 1984, 1988.

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**Study Title: Effects of Site Amelioration on Next-Rotation Slash and Loblolly Pines (Study SO-4101-2.14; see description, p. 47.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest growth, forest management, forest soils, loblolly pine, nutrient depletion, pine plantations, *Pinus elliottii, P. taeda,* silviculture, site amelioration, slash pine, soil compaction.

**Study Location:** Louisiana.

**Objectives:** (1) To determine if pines can be replanted directly on beds formed before the prior rotation; (2) to determine if disking or bedding before the prior rotation has any effect on the growth and production of pines during the next rotation; and (3) to determine if any unknown factors may limit the growth and production of pines.

**Design:** Check, harrow, and bed treatments installed in a completely randomized block design with four replications. Seedlings planted between stumps of a previous study (SO-1102-9.5) that had received the site-preparation treatments. No further site preparation done before planting seedlings in second study.

**Years Installed:** 1983-84.

**Year Completed:** The present rotation will be harvested in 2003.

**Ages Or Intervals Data Collected:** Ages 1 through 5.

**Data Machine Readable? Yes,** in ASCII format.

**Variables:** Pine d.b.h. and total height were measured, and occurrence of stem fusiform rust (*Cronartium quercuum* f. sp. *fusiforme)* was noted for all pine trees.

**Year(s) Of Establishment Record And Progress Reports:** 1983, 1988.

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**Study Title: Effects of Site Preparation and Fertilization on Second-Rotation Slash Pine (Study SO-4101-15-7.11; see description, p. 47.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest growth, forest management, forest soils, nutrient depletion, pine plantations, *Pinus elliottii*, silviculture, site amelioration, slash pine, soil compaction.

**Study Location:** Louisiana.

**Objectives:** (1) To determine if pines can be replanted directly on beds formed before the prior rotation; (2) to determine if disking, bedding, or application of lime or phosphorus (P) fertilizer before the prior rotation has any effect on the growth and production of pines during the next rotation; and (3) to determine if any unknown factors triggered by these cultural treatments may limit the growth and production of pines.

**Design:** Check, harrow, and bed treatments installed in a completely randomized block design with four replications. Seedlings planted between stumps of a previous study (SO-1102-3.5) that had received the site-preparation treatments. No further site preparation done before planting seedlings in second study. Plots in previous study had been split, with subplots receiving P or no P and lime or no lime. The P treatments were repeated, but application of nitrogen at age 7 was substituted for the lime.

**Years Installed:** 1983-84.

**Year Completed:** The present rotation will be harvested in 1999.

**Ages Or Intervals Data Collected:** Ages 1 through 5, and every 5 years thereafter.

**Data Machine Readable? No.**

**Variables:** Pine d.b.h. and total height were measured, and occurrence of stem fusiform rust *(Cronartium quercuum* f. sp. *fusiforme)* was noted for all pine trees.

**Year(s) Of Establishment Record And Progress Reports:** 1983, 1988.

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**Study Title: Effects of Initial Spacing and Precommerical Thinning in Forest Stands Established by Direct Seeding (See description, p. 49.)**

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**Keywords:** Direct seeding, forest management, loblolly pine, longleaf pine, *Pinus elliottii, P. palustris, P. taeda*, precommercial thinning, silviculture, slash pine.

**Study Location:** Louisiana.

**Objectives:** To determine the influence of initial spacing in rows and between rows on survival; periodic growth in diameter, height, and volume; total yield; wood characteristics; and financial returns in forest stands established by direct seeding in rows.

**Design:** Initial in-row spacings of 1 to 8 ft with rows 8 ft apart, and an in-row spacing of 4 or 8 ft, with rows 12 ft apart, were established in eight stands, including slash and loblolly pines on low, medium, and high sites and longleaf pine on low and medium sites. Within each stand is a randomized complete block test with either three or four replications.

**Years Installed:** 1964-71.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Every 1 to 3 years initially, then ages 5, 8, 11, 14, 17, 20, and every 5 years thereafter.

**Data Machine Readable? Yes,** in ASCII format; OS or SAS data sets on g-track tape.

**Variables:** D.b.h. to 0.1 inch on all trees, total height to 1.0 ft and crown class on sample trees, upper-stem diameters outside bark on sample trees at some ages.

**Year(s) Of Establishment Record And Progress Reports:** **An** establishment report was produced for each individual study, and progress reports were written periodically, usually every 5 years.

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**Study Title: Effects of Planting Spacing and Thinning Intensity on the Growth and Yield of Loblolly Pine (See description, p. 50.)**

**Principal Investigator(s) Or Contact And Address(es):**


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**Keywords:** Forest growth, forest management, forest yield, loblolly pine, pine plantations, *Pinus taeda*, silviculture, stand density, thinning.

**Study Locations:** Oldest study was near Woodworth, LA; other study is near Merryville, LA.

**Objectives:** To determine how initial planting density, site, age, survival, repeated thinnings, and thinning intensity affect the growth and yield of loblolly pine planted on cut-over sites in the West Gulf Coastal Plain.

**Design:** Randomized block design for each study. In both studies, measurement plots were 0.1 acre in size, with about a 0.5-chain-wide buffer strip surrounding each plot. Woodworth study contained 69 plots, 4 of which were unthinned control plots. Site index (base age 25) ranged from 53 to 67 ft, the planting densities ranged from 400 to 2,700 stems per acre, and residual basal area per-acre densities ranged from 70 to 100 $ft^2$. First thinning was done at planting age 20. Merryville study contains 88 plots of which 15 are unthinned controls. Site index ranges from 56 to 72 ft, planting densities range from 300 to 1,200 stems per acre, and after-thinning densities range from 60 to 120 $ft^2$/acre of basal area. Plots in this study were first thinned at planting age 17. In both studies, the thinning interval was 5 years, and thinning generally was from below, although nearly equal attention was given to maintaining rather uniform tree spacing in the stands.

**Years Installed:** Woodworth, 1948; Merryville, 1969.

**Year Completed:** Woodworth study was closed in 1975 due to tornado damage; Merryville study continues.

**Ages Or Intervals Data Collected:** Woodworth: ages 20, 25, 30, 35, 40, and 45; Merryville: ages 17, 22, 27, 32, 37, and 42.

**Data Machine Readable? Yes,** in ASCII format.

**Variables:** D.b.h. to 0.1 inch on all trees; total height and height to base of full live crown to 1.0 ft, and crown class on sample trees (and recently on all trees); upper-stem diameters outside bark on sample trees at some ages; estimates of plot cubic-foot volume.

**Year(s) Of Establishment Records And Progress Reports:** **An** establishment report was produced for each individual study after installation, and progress reports were written every 5 years thereafter. Reports are available for the Woodworth study for 1948-73 and for the Merryville study for 1969-87.

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**Study Title: Development of a Loblolly Pine Plantation Thinned to Different Density Levels in Southern Arkansas (See description, p. 51.)**

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**Keywords:** Forest growth, forest management, forest yield, loblolly pine, pine plantations, *Pinus taeda*, silviculture, stand density, thinning.

**Study Location:** Southern Arkansas

**Objectives:** To evaluate the effects of various thinning and crown-shortening treatments on volume growth.

**Design:** Four levels of thinning and three levels of crown shortening. Each combination has three replications within a randomized complete block design. Four additional plots established to represent each of the four thinning treatments without crown shortening. Each plot is 132 by 132 ft in size and contains an inner plot that is 66 by 66 ft in size (0.1 acre) in which all trees are individually identified with numbers. Thus, the O.l-acre measurement plot is surrounded by a similarly treated 0.3-acre buffer zone that is 0.5 chain in width.

**Year Installed:** 1970.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Ages 12, 15, 16, 19, 24, 27, and 30.

**Data Machine Readable? Yes.**

**Variables:** Diameters at 1 ft, 3 ft, and 4.5 ft (breast height) and at crown base; crown radius measured in the longest direction and 90 degrees to it; heights to base of live crown, to top of tree, and to even diameters of stem required to calculate volume by the Grosenbaugh height accumulation method.

**Year(s) Of Establishment Record And Progress Reports:** 1970, 1974, 1977, 1982, 1987, 1990.

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**Study Title: Choice of Southern Pine Species for Planting Sites (See description, p. 52.)**

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**Keywords:** Forest growth, forest management, forest yield, loblolly pine, longleaf pine, pine plantations, *Pinus elliottii*, *P. echinata*, *P. palustris*, *P. taeda*, shortleaf pine, silviculture, site quality, slash pine.

**Study Locations:** Louisiana and Mississippi.

**Objectives:** To determine which of the four major southern pine species to grow on a particular site as based on best overall performance relative to the site.

**Design:** Randomized block design. Initially, 113 outplantings established. Three plots of each species planted at each location. Planting interval 6 ft within and between rows. In Mississippi and the Florida parishes of Louisiana, gross plots contained 12 rows of 12 trees each; west of the Mississippi River, plots contained 11 rows of 11 trees.

**Years Installed:** Mid-1950's.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Ages 1, 2, 3, 10, 15, 20, and 25.

**Data Machine Readable? Yes,** in ASCII format.

**Variables:** Fusiform rust infection of main bole; d.b.h. to 0.1 inch and total height to 1.0 ft of all trees at age 10; d.b.h. to 0.1 inch and total height to 1.0 ft on all plot trees at ages 15 through 25; upper-stem dimension and crown class on sample trees at ages 15 through 25; height to base of full live crown to 1.0 ft at age 25; height of dominant stand determined and mean annual increment expressed in three ways—basal area, total cubic volume, and merchantable cubic volume.

**Year(s) Of Establishment Record And Progress Reports:** At installation and every 5 years thereafter.

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**Study Title: Planting Site-Genotype Interactions in Loblolly and Slash Pines (See description, p. 54.)**

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**Keywords:** Forest growth, forest soils, fusiform rust resistance, loblolly pine, *Pinus elliottii*, *P. taeda*, site quality, slash pine, survival

**Study Location:** Louisiana.

**Objectives:** (1) To determine to what extent site characteristics, especially the physical properties of soils, influence the growth of select genotypes differently; (2) to observe how families native to specific soil microenvironments perform over a range of site conditions represented by the outplantings and thus gain information that will contribute to the successful selection of genotypes best able to utilize particular sites; (3) and to compare the survival and growth of the two pine species on the various sites.

**Design:** Randomized block design; each of 4 study locations contains 3 blocks of seedlings grown from seed lots of known origin from 20 different families.

**Year Installed:** 1977.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Ages 1, *3*, *7*, and 10.

**Data Machine Readable? No.**

**Variables:** Survival of all plot trees; heights through age 3 to the nearest 0.1 ft and to the nearest 0.5 ft for ages 7 and 10; diameters to the nearest 0.1 inch at age 10; trees having fusiform rust infection identified as having branch, stem, or branch and stem infections.

**Year(s) Of Establishment Record And Progress Reports:** 1979.

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**Study Title: Growth and Yield of Loblolly and Slash Pine in Unthinned Plantations (See description, p. 55.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest growth, forest management, forest yield, loblolly pine, *Pinus elliottii*, *P. taeda*, silviculture, slash pine, stand density.

**Study Locations:** Louisiana, Mississippi, and Texas.

**Objectives:** To determine how site, age, initial planting density, and survival affect yields of unthinned loblolly and slash pine plantations on cut-over sites. Plots were installed to supplement existing data available from other ongoing studies. The goal was to broaden the array of sites, ages, planting densities, and survival in those active studies.

**Design:**

***Loblolly* Pine**-There were 76 plots on 15 study areas in the 3 States; at establishment, they ranged in age from 16 to 36 years, in site index (base age 50), from 35 to 113 ft, and in planting density, from 109 to 1,390 stems per acre. Plots varied in size, but were no smaller than 0.1 acre and contained at least 50 measurement trees at the time of establishment. A 0.5-chain buffer strip was left around each plot.

***Slash Pine--The 47*** plots at 12 locations in 3 States ranged in age at establishment from 21 to 41 years, in site index, from 33 to 116 ft, and initial planting density, from 302 to 1,253 stems per acre. Specific plot characteristics were the same as those mentioned above for loblolly pine. There was no effort made to set up any particular statistical design for hypothesis testing. Study objectives were to obtain data for development of growth and yield prediction models. The plots were measured at establishment and remeasured twice at 5-year intervals.

**Years Installed:** Slash pine, 1972; loblolly pine, 1973; remeasured 1977, 1978.

**Year Completed:** Slash pine, 1987; loblolly pine, 1988.

**Ages Or Intervals Data Collected:** At establishment and every 5 years thereafter until studies were closed.

**Data Machine Readable? Yes,** in ASCII format.

**Variables:** D.b.h. to O.1inch on all plot trees; total height and height to the base of the full live crown to 1.0 ft, and crown class, on sample trees; upper-stem diameters outside bark on sample trees; estimates of plot cubic-foot volume.

**Year(s) Of Establishment Record And Progress Reports:** 1972, 1973, 1977, 1978, 1982, 1983, 1987, 1988.

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**Study Title: Accelerated Sawlog Production in a Loblolly Pine Plantation** **(See description, p. 56.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest growth, forest management, forest yield, loblolly pine, pine plantations, *Pinus taeda*, pruning, silviculture, stand density, thinning.

**Study Location:** Arkansas.

**Objectives:** (1) To determine whether large-size, good-quality loblolly pine sawtimber could be grown in a rotation much shorter than the 60- to 80-year period commonly planned in 1953; and (2) to compare cubic yields, board-foot yields, and wood properties resulting from application of four intensive treatments having the same attributes as those used under conventional industrial silviculture.

**Design:** Randomized block design; three blocks with four levels of thinning at different ages established in a g-year-old loblolly plantation.

**Year Installed:** 1954.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Age 9 and at 3-year intervals through age 33. The study was remeasured again at ages 39 and 45.

**Data Machine Readable? Yes**

**Variables:** D.b.h. to 0.1 inch on all plot trees; total and merchantable heights to 0.5 ft on sample trees; upper-stem diameters outside bark on sample trees; estimates of cubic-foot volume on each sample tree; crown class and crown width to 1.0 ft on sample trees; also, two measurements of stem form calculated: Girard form class and absolute form quotient.

**Year(s) Of Establishment Record And Progress Reports:** 1954 and every 3 years until 1978.

## RANGE MANAGEMENT FOR SOUTHERN PINE ECOSYSTEMS

**Study Title: Interrelated Effects of Cattle Grazing and Reforestation in the Pine-Slender Bluestem Type (Study 1701-3.3; see description, p. 57.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Agroforestry, artificial regeneration, cattle grazing, herbage production, pine survival, *Pinus elliottii*, range management, slash pine.

**Study Location:** Central Louisiana.

**Objectives:** (1) To determine whether beef cattle production is compatible with the establishment and growth of planted slash pine stands; (2) to measure the effects of various grazing intensities on the survival and growth of planted and direct-seeded slash pine regeneration; (3) to determine the effects of various grazing intensities on the production efficiency of beef breeding herds; and (4) to compare the economic returns from combined cattle grazing and pine production with those from timber alone.

**Design:** The study was located in three range units composed of about 1,600 acres on the Longleaf Tract, Palustris Experimental Forest, McNary, LA. All units were stocked with native cows to produce light, medium, and heavy grazing intensities equal to 30-, 45-, and 60-percent utilization, respectively. About 17 percent of each range unit was planted to 1-0 slash pine seedlings, and about 8 percent of each unit was direct seeded to slash pine during each of the first 4 years of the study.

**Year Installed:** 1960.

**Year Completed:** 1984.

**Ages Or Intervals Data Collected:** Information not available.

**Data Machine Readable? Yes.**

**Variables:** Calf crop percentages, calf weaning weights, and periodic cow weights; frequency, cover, and botanical composition of vegetation; and economic costs and returns.

**Year(s) Of Establishment Record And Progress Reports:** Establishment report 1960; progress reports 1970, 1972, 1984.

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**Study Title: Some Effects of Planted Pines on Range Forage Vegetation in Central Louisiana (Study 1701-2.1; see description, p. 59.)**

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**Keywords:** Agroforestry, artificial regeneration, cattle grazing, herbage production, longleaf pine, pine survival, *Pinus elliottii, P. palustris*, range management, slash pine.

**Study Location:** Central Louisiana.

**Objectives:** (1) To determine the effects of canopy conditions in longleaf and slash pine plantations on the quantity and chemical and botanical composition of understory herbage; and (2) to determine the effects of moderate grazing by cattle on the herbage vegetation.

**Design:** The slash pine plantation was 4 years old, and the longleaf pine plantation was 8 years old when the study was initiated in 1960. Crown closure at that time had not occurred in either plantation; therefore, canopies did not have any important effects on forage composition.

**Year Installed:** 1960.

**Year Completed:** 1981.

**Ages Or Intervals Data Collected:** Information not available.

**Data Machine Readable? Yes.**

**Variables:** Herbage yield, botanical composition and nutritive value. and basal area of trees.

**Year(s) Of Establishment Record And Progress Reports:** Study plan, 1960; progress reports, 1971, 1981.

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**Study Title: Relationships of Stand Density to Herbage Yield in a Longleaf Pine Plantation (Study 1701-2.2; see description, p. 60.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Agroforestry, forage production, longleaf pine, pine plantations, *Pinus palustris,* thinning.

**Study Location:** Central Louisiana.

**Objectives:** To determine the relationships of herbage yield to basal area and other stand variables in a longleaf pine plantation that was prescribe-burned and thinned at 5-year intervals.

**Design:** The 40-acre study plantation contained four 6-acre blocks each containing sixteen 0.62-acre plots with 0.1-acre measurement plots and a 0.5-chain buffer between plots. Trees were 30 years old at study initiation in 1964 and were planted on four plots per block at each of four grid spacings of about 4, 5, 6, and 13 ft. Three of the four plots per block of each spacing (except 13 ft) were thinned initially at age 20 to basal areas of 60, 80, and 100 ft²/acre and have been thinned every 5 years since then. The fourth plot of these spacings was thinned at age 16 to 100 trees per acre and pruned to a height of 17 ft. Other pruning treatments, including an unpruned check, were assigned to the 13-ft plots, but only the unpruned 13-ft plots were used in this study. Plots were prescribe-burned during the winter at 2- to S-year intervals.

**Year Installed:** 1964.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Information not available.

**Data Machine Readable? Yes.**

**Variables:** D.b.h. to 0.1 inch on all plot trees; total height and height to base of full live crown to 1.0 ft, and crown class on sample trees; upper-stem diameters outside bark on sample trees; basal area per unit area; and estimates of plot cubic-foot volume. Herbage production measured in dry weight per unit area.

**Year(s) Of Establishment Record And Progress Reports:** 1964, 1967, 1971, 1982.

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**Study Title: Understory Herbage Response to Spacing of Loblolly Pine Following Site Preparation (Study 1701-1.1; see description, p. 60.)**

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**Keywords:** Forage production, forest management, forest soils, loblolly pine, pine survival, *Pinus taeda*, site preparation.

**Study Locations:** Central and north Louisiana and southern Arkansas.

**Objectives:** (1) To determine the effects of various mechanical site-preparation treatments on the production and botanical composition of understory vegetation; (2) to determine effects of soils on plant succession following site preparation; and (3) to determine effects of fertilization on the understory vegetation.

**Design:** Eight site-preparation treatments were applied to five soils during the fall of 1970 and 1971; years served as replications. Soil textural types included: (1) sandy; (2) loam; (3) gravelly; (4) clayey (moderate permeability); and (5) clayey (poor permeability). Site-preparation treatments were: (1) underplant-release; (2) chop-burn; (3) chop-burn-flat disk; (4) chop-delay-chop; (5) chop-burn-mound-disk; (6) shear-burn; (7) shear-windrow-burn; and (8) shear-windrow-disk. The underplant-release treatment served as the control for the seven mechanical treatments. Following site preparation, 80 plots measuring 144 by 162 ft were split; approximately one-third of each plot was fertilized and the remaining two-thirds served as the untreated control. Plots were planted on 6- by 8-ft spacings. Herbaceous vegetation was sampled on 20 systematically spaced quadrats (9.6 $ft^2$) on each plot. Estimates for woody species with stem diameters less than 1 inch in d.b.h. were made from four 0.01-acre circular quadrats on each plot. Woody stems 1 inch in d.b.h. and larger were measured on four 0.25-acre circular quadrats on each plot.

**Years Installed:** 1970 and 1971.

**Year Completed:** 1992.

**Ages or Intervals Data Collected:** Measured at ages 1, 2, 3, and 7.

**Data Machine Readable? Yes.**

**Variables:** Number, total height, and d.b.h. of woody stems greater than or equal to 1 inch in d.b.h.; number, total height, and crown diameter of woody stems less than 1 inch in d.b.h.; and percentage of basal cover, production, and composition of the herbaceous vegetation by species.

**Year(s) Of Establishment Record And Progress Reports:** 1970, 1974, 1994.

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**Study Title: Assessment of Nonpoint Source Pollution from Intensive Silvicultural Practices and Livestock Grazing in Southeast Forests (Study 1701-1.121; see description, p. 61.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest management, livestock grazing, loblolly pine, *Pinus taeda*, silviculture, site preparation, water pollution.

**Study Locations:** East Texas and Louisiana.

**Objectives:** (1) To develop baseline data on the quality and quantity of water for stabilized forest sites (those that have been relatively undisturbed for 15 to 20 years); (2) to assess the impact of clearcutting and mechanical site preparation on the quality and quantity of water during treatment and for 10 years following treatment; and (3) to assess the impact of two livestock grazing systems and no grazing on the quality and quantity of water for 10 years following treatment.

**Design:** Five 12-acre forested watersheds were instrumented to determine the effects of forest harvesting, mechanical site preparation, and livestock grazing on storm flow, peak discharge rate, and sediment loss. After 3 years of pretreatment calibration, four of the watersheds were treated as follows: (1) clearcutting followed by roller chopping; (2) clearcutting followed by shearing and windrowing; (3) clearcutting followed by shearing, windrowing, and rotational grazing; and (4) clearcutting followed by shearing, windrowing, and continuous grazing. The remaining watershed was the control.

**Year Installed:** 1980.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Information not available.

**Data Machine Readable? Yes.**

**Variables:** Storm flow rate, peak discharge rate, sediment production, standing crop, ground cover, soil bulk density, organic matter, coliform bacteria, runoff, nitrate nitrogen, total amount of phosphates and orthophosphate, turbidity, potassium, and plant biomass.

**Year(s) Of Establishment Record And Progress Reports:** Annually, 1980-86 and 1988-90.

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**Study Title: Understory Herbage Response to Spacing of Loblolly Pine Following Site Preparation (Study 1701-1.2; see description, p. 64.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forage production, forest management, forest soils, loblolly pine, pine survival, *Pinus taeda*, site preparation.

**Study Location:** Central Louisiana.

**Objectives:** (1) To determine the effects of different site-preparation treatments on pretreatment and posttreatment production and botanical composition of understory vegetation; (2) to determine the effects of soils on plant succession following site preparation; and (3) to determine the effects of pine spacing on the development of understory vegetation.

**Design: Two** site-preparation treatments (underplant-release and shear-windrow-burn) were applied to two soils (Ruston and Sawyer) annually during 1970 and 1971; years served as replications. Following site preparation, plots were subdivided into five 144- by 162-ft plots and hand-planted to loblolly pine spacings of 4 by 6, 6 by 8, 8 by 12, and 12 by 16 ft; and an unplanted control plot was included. Herbaceous vegetation was sampled on 20 systematically spaced quadrats (9.6 $ft^2$) on each plot. Information on woody species with stem diameters less than 1 inch in d.b.h. was estimated from four 0.01-acre circular quadrats on each plot. Woody stems 1 inch in d.b.h. and larger were measured on four 0.025-acre circular quadrats on each plot.

**Year Installed:** 1970.

**Year Completed:** 1992.

**Ages Or Intervals Data Collected:** Measured at ages 1, 2, 3, and 6.

**Data Machine Readable? Yes.**

**Variables:** Number, total height, and d.b.h. of all woody stems greater than or equal to 1 inch in d.b.h.; number, total height, and crown diameter of woody stems less than 1 inch d.b.h.; and percentage basal cover, production, and composition of the herbaceous vegetation by species.

**Year(s) Of Establishment Record And Progress Reports:** 1970, 1971, 1974, 1994.

**Study Title: Comparison of Burning Dates in a Young Natural Loblolly-Shortleaf Pine Stand (Study 1701-3.26; see description, p. 64.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Controlled burning, forage production, forest management, hardwood control, loblolly pine, *Pinus echinata, P. taeda*, shortleaf pine, silviculture.

**Study Location:** Central Louisiana.

**Objectives:** To determine the best dates for burning young natural stands of loblolly-shortleaf pine on regenerated clearcuts by: (1) comparing survival and growth of pines and yield and botanical composition of herbage on unburned, unthinned, and otherwise undisturbed plots with those measurements on plots of pines thinned and hardwoods controlled by cutting and biennial fires in March, May, or July; (2) comparing yield and composition of herbage on plots with pines, hardwoods, and shrubs controlled by top removal alone with those measurements on plots with woody plants controlled by combinations of cutting and biennial fires in March, May, and July; and (3) determining if the woody understory on loblolly-shortleaf pine sites could be controlled by biennial fires after several years of top removal by the combination of burning and cutting.

**Design:** The 46-acre study area was clearcut in 1976. Beginning in 1982, burning treatments were applied every other year to plots thinned to about 700 trees per acre. An unburned control plot was included. Pines were 5 years old at the beginning of the 1982 season. Treatments were also applied to plots from which pines and hardwoods had been completely removed. Treatments were applied in three randomized-block replications to 0.25-acre plots. A 7-acre study area was fenced in within the 46-acre regenerated clearcut. Burning treatments were applied biennially to the smaller area in even-numbered years.

**Year Installed:** 1982.

**Year Completed:** 1994.

**Ages Or Intervals Data Collected:** Information not available.

**Data Machine Readable? Yes.**

**Variables:** Survival, growth, and yield of pines; and yield and botanical composition of competing hardwoods and herbage.

**Year(s) Of Establishment Record And Progress Reports:** 1982, 1984, 1995.

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**Study Title: Grazing Systems for Forest Range (Study 1701-3.27; see description, p. 66.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Cattle grazing, forage production, livestock production, longleaf pine, *Pinus elliottii, P. palustris*, slash pine.

**Study Location:** Central Louisiana.

**Objectives:** (1) To compare the economic and livestock production efficiencies of three forest grazing systems: one-pasture rotational burning, two-pasture switchback, and multiple-pasture, short-durational grazing; and (2) to measure the effects of grazing systems on the livestock, wildlife, watershed, and timber resources.

**Design:** About 3,600 acres in six range units are utilized in the replicated grazing systems. These six units range in size from about 550 to 700 acres. Breeding cattle consist of crossbred Brahman cows and English breed bulls. Timber management generally follows National Forest System guidelines; trees are thinned periodically to maintain relatively open stands, with tree basal areas ranging from 60 to 100 $ft^2$/acre. Supplemental studies, when overlaid on the three grazing systems, address watershed and wildlife implications.

**Year Installed:** 1984.

**Year Completed:** Continuing through at least 1996.

**Ages Or Intervals Data Collected:** Information not available.

**Data Machine Readable? Yes.**

**Variables:** Calf crop percentages, calf weaning weights, and periodic cow weights; frequency, cover, and botanical composition of vegetation; and economic costs and returns.

**Year(s) Of Establishment Record And Progress Reports:** 1984, 1990.

## TROPICAL AMERICAN FOREST MANAGEMENT

**Study Title: Inventory of the Secondary Forest of Puerto Rico (See description, p. 66.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Inventory, Puerto Rico, secondary forest, tropical forest.

**Study Location:** Puerto Rico.

**Objectives:** (1) To assess the timber potential of secondary forests in Puerto Rico; (2) to determine growth and change in species composition in established permanent plots; (3) to utilize the basic data for the development of studies to stimulate secondary forest management; and (4) to assess forestry-related resources on the island.

**Design:** Systematic 3- by 3-km grid with 437 ground locations within the commercial area.

**Year Installed:** 1980.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** All ages, every 5 or 10 years.

**Data Machine Readable? No.**

**Variables:** Species, diameter, height, timber quality, and several site characteristics.

**Year(s) Of Establishment Record And Progress Reports:** Establishment report, 1984; no information available on progress reports.

**Study Title: The Forest Resources of St. Vincent Island, West Indies** (See description, p. 67.)

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest inventory, St. Vincent, tropical forest.

**Study Location:** The island of St. Vincent, West Indies.

**Objectives:** (1) To estimate the area of various forest classes; (2) to develop statistics describing the composition of the timber land having commercial potential; and (3) to provide information on the resources of the island.

**Design:** Eighty-eight grid intersections spaced at 2 by 2 km; standard Southern Forest Experiment Station inventory techniques modified for local conditions.

**Year Installed:** 1984.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** All ages; data collection cycle not determined.

**Data Machine Readable? No.**

**Variables:** Species, diameter, height, timber quality, and several physical site characteristics.

**Year(s) Of Establishment Record And Progress Reports:** Establishment report, 1984; no information available on progress reports.

**Study Title: Pilot Management Study In The Luquillo Mountains of Puerto Rico** (See description, p. 69.)

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Primary forest, Puerto Rico, secondary forest, tree growth rates, tropical forest.

**Study Location:** Luquillo Mountains of Puerto Rico in the subtropical wet forest; Sabana 8 (80 ha), Rio Grande (40 ha), and Sabana 4 (129 ha).

**Objectives:** (1) To determine species composition of primary and secondary forests; (2) to determine the growth rates of the species present; and (3) to assess the effects of thinning on growth in secondary forests.

**Design:** One hundred plots 0.08 ha in size placed systematically throughout each of three study areas; topography classified (bottom, lower slope, upper slope of ridge); commercial species identified, potential crop trees selected; measurements taken; and one thinning done in secondary areas.

**Year Installed:** 1956.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** 1962, 1975, and in the 1980's.

**Data Machine Readable? No.**

**Variables:** Diameter, height, topography, and species.

**Year(s) Of Establishment Record And Progress Reports:** Establishment report, 1956; no information available on progress reports.

**Study Title: Long-Term Growth Rates in the Natural Forest of the Luquillo Mountains in Puerto Rico** (See description, p. 69.)

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Puerto Rico, tree growth rates, tropical forest.

**Study Location:** Luquillo Mountains of Puerto Rico, mainly subtropical wet forest, rain forest, and lower montane wet forest.

**Objectives:** (1) To determine diameter growth rates in the natural forest; and (2) to determine changes in species composition over time.

**Design:** Eight plots, most are 0.4 ha in size; includes thinned and undisturbed forests in four life zones.

**Years Installed:** 1943-47.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** All ages, depending on plot: 1943, 1946, 1948, 1951, 1956, 1976, and 1981.

**Data Machine Readable? No.**

**Variables:** Species, diameter, ingrowth, and mortality; height measured or estimated on some plots.

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

**Study Title: Population Dynamics of a Dry Forest Avian Community in Puerto Rico** (See description, p. 71.)

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Avian population dynamics, Puerto Rico, tropical forest.

**Study Location:** Southwestern Puerto Rico.

**Objectives:** (1) To determine and assess avian community structure; (2) to detect abrupt population fluctuations or directional trends over time in both migrant and native bird populations by designating indicator species using cumulative data summarized since the start of the study; (3) to determine biological, ecological, and climatic factors affecting avian species that might result in sharp population increases or decreases; and (4) to offer appropriate management prescriptions in Guanica.

**Design:** Variable-width transect census; use of standard mist nets.

**Year Installed:** 1972.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Information not available.

**Data Machine Readable? No.**

**Variables:** Species, demography, dispersal, turnover rate, longevity, and philopatry.

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

**Study Title: Reproductive Ecology of the Pearly-Eyed Thrasher in Puerto Rico**
(See description, p. 71.)

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Pearly-eyed thrasher, Puerto Rico, reproductive ecology, tropical forest.

**Study Location:** Luquillo Experimental Forest in Puerto Rico.

**Objectives:** (1) To obtain data on the ecological and biological requirements of the pearly-eyed thrasher in an effort to mitigate its deleterious effects on the endangered Puerto Rican parrot; (2) to compare populations of this bird in the Luquillo Forest with those in potential parrot reintroduction areas; and (3) to evaluate the suitability of this species as a surrogate for the parrot in experimental studies.

**Design:** Entire study population banded, 30 to 50 artificial nesting boxes monitored yearly, individual nesters followed yearly.

**Year Installed:** 1979.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Information not available.

**Data Machine Readable? No.**

**Variables:** Information not reported.

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

**Study Title: Plantation Adaptability Trials in Puerto Rico and the Virgin Islands**
(See description, p. 71.)

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** growth rates, Puerto Rico, site preference, soil preference, tropical forest.

**Study Locations:** Puerto Rico and the Virgin Islands.

**Objectives:** (1) To identify plantation species that are adapted to local climates; (2) to determine soil and site preferences of each species; and (3) to document growth rates and make management recommendations.

**Design:** Various.

**Years Installed:** Beginning in 1930's.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Various.

**Data Machine Readable? No.**

**Variables:** Diameter and height.

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

**Study Title: Tree Growth in Several Tropical Forests of Puerto Rico** **(See description, p. 72.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Puerto Rico, stand diversity, tree growth rates, tropical forest.

**Study Location:** Puerto Rico.

**Objectives:** (1) To determine periodic annual d.b.h. increment (PAI); and (2) to evaluate the potential of different species and forest types for timber production.

**Design:** Nine research plots in three life zones; d.b.h. of stems greater than or equal to 4.1 cm was recorded.

**Years Installed:** 1943-51.

**Year Completed:** Maricao and Toro Negro are still ongoing; other plots are closed.

Ages **Or Intervals Data Collected:** Information not available.

**Data Machine Readable? No.**

**Variables:** D.b.h., crown class, mortality, and ingrowth.

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

**Study Title: A Phytosociological Study of Cinnamon Bay Watershed, St. John, U.S. Virgin Islands** **(See description, p. 73.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** St. John, secondary forest, species composition, tropical forest, Virgin Islands.

**Study Location:** St. John, U.S. Virgin Islands.

**Objectives:** (1) To describe the structure and species composition of arborescent vegetation of the watershed; and (2) to explore phytosociological relationships of trees according to elevation and topography within the watershed.

**Design:** Sixteen plots located on ridges and slopes and in valleys at elevations of about 60, 120, 180, 210, and 240 m; one plot, about 275 m.

**Year Installed:** 1983.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** All ages, approximately every 5 years.

**Data Machine Readable? No.**

**Variables:** Height, d.b.h., and crown class.

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

## TECHNOLOGY OF EASTERN FOREST TREE SEEDS

**Study Title: Long-Term Storage of Seeds of Major "Orthodox" Species (Study 4103-3.2; see description, p. 74.)**

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**Keywords:** *Liquidambar styraciflua*, loblolly pine, orthodox species, *Pinus elliottii, P. taeda, Platanus occidentalis,* seed storage, slash pine, sweetgum, sycamore.

**Study Location:** Starkville, MS.

**Objectives:** To study 15-year storage of seeds of four major tree species.

**Design:** Test 1: three storage temperatures: -18, 2, and 10 °C; three moisture levels: 6, 10, and 14 percent; and three replications of all temperature- moisture combinations. Test 2: four storage temperatures: 15, 25, 35, and 45 °C; and four moisture levels: 8, 12, 14, and 18 percent.

**Year Installed:** 1982.

**Year Completed:** Test 1 still ongoing; test 2 complete.

**Ages Or Intervals Data Collected:** Test 1: annually; test 2: daily to bimonthly.

**Data Machine Readable? No.**

**Variables:** Seed viability.

**Year(s) Of Establishment Record And Progress Reports:** 1981; progress report information not reported.

**Study Title: Chromosome Effects during Storage of Sycamore, Sweetgum, and Loblolly and Slash Pine Seeds (Study 50-4103-3.3; see description, p. 74.)**

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**Keywords:** Chromosome changes, *Liquidambar styraciflua*, loblolly pine, *Pinus elliottii, P. taeda, Platanus occidentalis,* seed storage, slash pine, sweetgum, sycamore.

**Study Location:** Starkville, MS.

**Objectives:** To determine if noticeable chromosome changes in seeds occur during prolonged storage under acceptable storage conditions.

**Design:** Seeds stored at -18, 2, and 10 °C, with initial seed moisture levels of 6, 10, and 14 percent; all combinations replicated three times.

**Year Installed:** 1982.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Biennially.

**Data Machine Readable? No.**

**Variables:** Number of cells in prophase, anaphase, and telophase, and total number of cells in squash preparations; root length, percentage of germination, percentage of germination with aberrant anaphase during mitosis, and other common aberrations.

**Year(s) Of Establishment Record And Progress Reports:** 1982; progress report information not reported.

## GROWTH AND YIELD OF NATURAL EVEN-AGED LONGLEAF PINES

**Study Title: Regional Longleaf Pine Growth Study** **(See description, p. 75.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** even-aged stands, growth and yield, longleaf pine, natural regeneration, *Pinus palustris*.

**Study Location:** Alabama, Florida, Georgia, and Mississippi.

**Objectives:** To determine how stand age, site index, and residual density left after thinning influence the development of individual trees and stands of naturally regenerated even-aged longleaf pines.

**Design:** In 1990, 274 permanent plots had survived out of 296 installed on cooperator lands in a rectangular distribution of cells formed by all combinations of a set of age, site-index, and density classes. Initially, age classes were 20, 40, 60, and 80 years; site-index classes were 50, 60, 70, 80, and 90 ft at age 50; and residual basal area classes were 30, 60, 90, 120, and 150 ft$^2$/acre. Age classes were extended to include 100 and 120 years. Net plots are circular and are surrounded by a 0.5-chain-wide isolation strip (receiving the same density treatment as the net plot) plus an additional 0.5-chain-wide untreated protective buffer. Virtually all net plots (282) were 0.2 acre in size; only 14 were 0.1 acre in size. Remeasurements are made at 5-year intervals. Residual densities were established by improvement cutting and/or low thinning and have been maintained by low thinning, as needed, at each remeasurement. Three-time replications of the youngest age class (20 years) have been established at 5-year intervals. Intent is to maintain the study until all three-time replications reach a rotation of 120 years.

**Years Installed:** 1964-67.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** 1969-72, 1974–77, 1979–82, 1984–87, and 1989-92.

**Data Machine Readable? Yes.**

**Variables:** For all plot trees larger than 0.5 inch in d.b.h.: d.b.h. to nearest 0.1 inch, crown class, magnetic azimuth from plot center to nearest degree, distance from plot center to nearest 0.1 ft, and utility pole class and length. For a systematic sample of about 20 percent of trees in each 1-inch d.b.h. class: total height to nearest foot, height to crown base to nearest foot, age to nearest year (if dominant or codominant).

**Year(s) Of Establishment Record And Progress Reports:** 1963 and 1967; subsequently, publications have served in lieu of progress reports.

## FOREST INVENTORY AND ANALYSIS FOR MIDSOUTH STATES

**Study Title: Forest Inventory and Analysis** **(See description, p. 77.)**

**Principal Investigator(s) Or Contact And Address(es):**

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**Keywords:** Forest inventory, forest survey, Midsouth States.

**Study Location:** Midsouth.

**Objectives:** To determine the forest resources of the Midsouth.

**Design:** More than 17,000 permanently established sample plots are systematically located across the region. Plots are spaced on a 3- by 3-mi grid and include approximately 5,760 acres of land. A forest/nonforest classification of 25 photo points around each sample plot is used to estimate forest area; then each plot is visited, and the forest resources are measured. The plots are measured using a cluster of ten 37.5-prism points covering approximately 1 acre. Trees at least 5 inches in d.b.h. are measured; smaller trees are sampled on three 0.0036-acre fixed plots at the first three prism points.

**Year Installed:** 1933.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Not applicable.

**Data Machine Readable? Yes.**

**Variables:**

| No. | Acronym | Description |
|---|---|---|
| 1 | fia | Forest inventory and analysis code |
| 2 | st | State code |
| 3 | un | Unit number |
| 4 | co | County number |
| 5 | lo | Plot location number |
| 6 | sdate | Date of the survey |
| 7 | match | State+ unit+ county+ location combination (specific location) |
| 8 | cdate | Current date - year, month, day |
| 9 | pdate | Past date - year, month, day |
| 10 | samp | Sample kind |
| 11 | guse | Current ground use |
| 12 | pguse | Past ground use |
| 13 | own | Currrent ownership code, major categories |
| 14 | org | Stand origin |
| 15 | sitec | Site class |
| 16 | phyc | Physiographic class |
| 17 | age | Stand age, midpoint |
| 18 | ncru | Number of points cruised |
| 19 | svc | Stand volume class |
| 20 | sizec | Stand class size |
| 21 | ftype | Forest type |
| 22 | topo | Topography |
| 23 | slope | Slope (percent) |
| 24 | aspect | Aspect |
| 25 | rdis | Distance to nearest all-weather road |
| 26 | farea | Size of forest |
| 27 | exp | Current expansion factor |
| 28 | rexp | Resurveyed expansion factor |
| 29 | ask | Acceptable stocking (percent/acre) |
| 30 | rrsk | Rough and rotten stocking (percent/acre) |
| 31 | lsk | All live tree stocking (percent/acre) |
| 32 | invsk | Inhibiting vegetation stocking (percent/acre) |
| 33 | nosk | Nonstocked (percent/acre) |
| 34 | noskov | Nonstocked and overtopped (percent/acre) |
| 35 | unsk | Nonstockable (percent/acre) |
| 36 | pnsk | Pine live trees stocking (percent/acre); species codes 100 through 150 |
| 37 | hwsk | Hardwood live trees stocking (percent/acre) |
| 38 | cfgssw | Net cubic-foot volume/acre, growing stock trees, softwoods |
| 39 | cfgshw | Net cubic-foot volume/acre, growing stock, hardwoods |
| 40 | cfgs | Net cubic-foot volume/acre, growing stock |
| 41 | cflvsw | Net cubic-foot volume/acre, all live trees, softwoods |
| 42 | cflvhw | Net cubic-foot volume/acre, all live trees, hardwoods |
| 43 | cflv | Net cubic-foot volume/acre, all live trees |
| 44 | cfrrsw | Net cubic-foot volume/acre, rough and rotten, softwoods |
| 45 | cfrrhw | Net cubic-foot volume/acre, rough and rotten, hardwoods |
| 46 | cfrr | Net cubic-foot volume/acre, rough and rotten |
| 47 | cfctsw* | Annual cubic-foot volume/acre, cut and removal trees, softwoods |
| 48 | cfcthw* | Annual cubic-foot volume/acre, cut and removal trees, hardwoods |
| 49 | cfct* | Annual cubic-foot volume/acre, cut and removal trees |
| 50 | cfmtsw* | Annual cubic-foot volume/acre, mortality trees, softwoods |
| 51 | cfmthw* | Annual cubic-foot volume/acre, mortality trees, hardwoods |
| 52 | cfmt* | Annual cubic-foot volume/acre, mortality trees |
| 53 | gcflvsw* | Gross cubic-foot volume/acre, all live trees, softwoods |
| 54 | gcflvhw | Gross cubic-foot volume/acre, all live trees; hardwoods |
| 55 | gcflv | Gross cubic-foot volume/acre, all live trees |
| 56 | slgssw | Net cubic-foot volume/acre in sawlog, growing stock, softwoods |
| 57 | slgshw | Net cubic-foot volume/acre in sawlog, growing stock, hardwoods |
| 58 | slgs | Net cubic-foot volume/acre in sawlog, growing stock |
| 59 | slctsw* | Annual cubic-foot volume/acre in sawlog, cut and removal trees, softwoods |
| 60 | slcthw* | Annual cubic-foot volume/acre in sawlog, cut and removal trees, hardwoods |
| 61 | slct* | Annual cubic-foot volume/acre in sawlog, cut and removal trees |
| 62 | slmtsw* | Annual cubic-foot volume/acre in sawlog, mortality trees, softwoods |
| 63 | slmthw* | Annual cubic-foot volume/acre in sawlog, mortality trees, hardwoods |
| 64 | slmt* | Annual cubic-foot volume/acre in sawlog, mortality trees |
| 65 | gslgssw | Gross cubic-foot volume/acre in sawlog, growing stock, softwoods |
| 66 | gslgshw | Gross cubic-foot volume/acre in sawlog, growing stock, hardwoods |
| 67 | gslgs | Gross cubic-foot volume/acre in sawlog, growing stock |
| 68 | bfgssw | Net board-foot volume/acre in sawlog, growing stock, softwoods |
| 69 | bfgshw | Net board-foot volume/acre in sawlog, growing stock, hardwoods |
| 70 | bfgs | Net board-foot volume/acre in sawlog, growing stock |
| 71 | bfctsw* | Annual board-foot volume/acre in sawlog, cut and removal trees, softwoods |
| 72 | bfcthw* | Annual board-foot volume/acre in sawlog, cut and removal trees, hardwoods |

| | | |
|---|---|---|
| 73 | bfct* | Annual board-foot volume/acre in sawlog, cut and removal trees |
| 74 | bfmtsw* | Annual board-foot volume/acre in sawlog, mortality trees, softwoods |
| 75 | bfmthw* | Annual board-foot volume/acre in sawlog, mortality trees, hardwoods |
| 76 | bfmt* | Annual board-foot volume/acre in sawlog, mortality trees |
| 77 | lvacsw | Number of live trees per acre, softwoods |
| 78 | lvachw | Number of live trees per acre, hardwoods |
| 79 | lvac | Number of live trees per acre |
| 80 | grgssw* | Cubic-foot volume/acre/year (periodic growth per year), growing stock, softwoods |
| 81 | grgshw* | Cubic-foot volume/acre/year (periodic growth per year), growing stock, hardwoods |
| 82 | grgs* | Cubic-foot volume/acre/year (periodic growth per year), growing stock |
| 83 | bagssw | Basal area, growing stock, softwoods |
| 84 | bagshw | Basal area, growing stock, hardwoods |
| 85 | bags | Basal area, growing stock |
| 86 | barrsw | Basal area, rough and rotten, softwoods |
| 87 | barrhw | Basal area, rough and rotten, hardwoods |
| 88 | barr | Basal area, rough and rotten |
| 89 | balvsw | Basal area, all live trees, softwoods |
| 90 | balvhw | Basal area, all live trees, hardwoods |
| 91 | balv | Basal area, all live trees |
| 92 | top1 | Treatment opportunities |

* These variables are calculated using the past number of trees per acre with the exception of a condition in the growth calculations. (See next section.) Use caution in the use of these variables. Several of the States have zero values for them. Also, depending upon the State, the derivation of these values is distinctive.

## Data Base Management System Directory--Tree Level

| Variable No. | Acronym | Description |
|---|---|---|
| 1 | st | State code |
| 2 | un | Unit number |
| 3 | co | County number |
| 4 | lo | Plot location number |
| 5 | sdate | Date of the survey |
| 6 | match | State+unit+county+location combination (specific location) |
| 7 | pt | Point number |
| 8 | tr | Tree number |
| 9 | sp | Species |
| 10 | thist | Tree history |
| 11 | d.b.h. | Current diameter at breast height (inches, tenths of an inch) |
| 12 | pdbh | Past diameter at breast height (inches, tenths of an inch) |
| 13 | az | Azimuth to the tree (degrees) |
| 14 | tdis | Distance to the tree (feet, tenths of an inch) |
| 15 | bole | Current bole length (feet) |
| 16 | pbole | Past bole length (feet) |
| 17 | cfcull | Cubic-foot cull (current) |
| 18 | bfcull | Board-foot cull (current) |
| 19 | saw | Sawlog length (feet) |
| 20 | th | Total height (feet) |
| 21 | htc | Height to base of live crown (feet) |
| 22 | tcl | Current tree class or cover code |
| 23 | ptcl | Past tree class or cover code |
| 24 | damg | Damage code |
| 25 | ddbk | Double bark thickness at breast height (inches, hundredths of an inch) |
| 26 | stdia | Stump diameter (inches, tenths of an inch) |
| 27 | stht | Stump height (feet, tenths of an inch) |
| 28 | lg | Current log grade |
| 29 | crown | Crown class |
| 30 | swhw | Softwood-hardwood code |
| 31 | two | Current 2-inch diameter size (midpoint inch) |
| 32 | tsz | Current tree size |
| 33 | psz | Past tree size |
| 34 | exp | Current expansion factor (acres/plot, tenths of an inch) |
| 35 | rexp | Resurveyed expansion factor (acres/plot, tenths of an inch) |
| 36 | time | Period elapsed time (years, tenths of a year) |
| 37 | rtime | Removal or mortality elapsed time (years, tenths of a year) |
| 38 | ryr | Number of years since tree died or was removed |
| 39 | stock | Stocking percentage of the tree |
| 40 | tpa | Number of trees per acre |
| 41 | ptpa | Past number of trees per acre |
| 42 | cf | Current net cubic-foot volume |
| 43 | pcf | Past net cubic-foot volume |
| 44 | cfsl | Current net cubic-foot volume in sawlog |
| 45 | pcfsl | Past net cubic-foot volume in sawlog (calculated) |
| 46 | cfgr | Annual change in net cubic-foot volume (growth per year) |
| 47 | cfslgr | Annual change in net cubic-foot volume in sawlog (growth per year) |
| 48 | cbf | Current net board-foot volume |
| 49 | pbf | Past net board-foot volume |
| 50 | bfgr | Annual change in net board-foot volume (growth per year) |
| 51 | baf | Basal area factor per acre |
| 52 | edbh | Estimated d.b.h. (if used equation or estimated from annual change in diameter, inches, tenths of an inch) |
| 53 | ibk | Inside bark surface area (square inches, tenths of a square inch) |
| 54 | veq | Volume equation species code |
| 55 | | |
| 56 | | |
| 57 | lg1 | Log grade 1 (board feet/acre) |
| 58 | lg2 | Log grade 2 (board feet/acre) |
| 59 | lg3 | Log grade 3 (board feet/acre), hardwoods only |
| 60 | lg4 | Log grade 4 (board feet/acre), hardwoods only |

### Biomass Weights (lb)

| | | |
|---|---|---|
| 61 | bioflv | Total green weight (bole, limbs, top, etc., all live trees, tree history code <20) |
| 62 | biofgs | Growing stock, merchantable portion (bole to 4-inch top, green weight) |

| | | |
|---|---|---|
| 63 | biofsap | Sapling size tree, green weight |
| 64 | biofrg | Rough tree (tree class = 30), total green weight |
| 65 | biofro | Rotten sound portion, green weight |
| 66 | biofres | Total residual, green weight (nonmerchantable weight) |
| 67 | biodlv | Total dry weight (bole, limbs, top, etc., all live trees, tree history code <20) |
| 68 | biodgs | Growing stock, merchantable portion (bole to 4-inch top), dry weight |
| 69 | biodsap | Sapling size tree, dry weight |
| 70 | biodrg | Rough tree (tree class = 30), total dry weight |
| 71 | biodro | Rotten sound portion, dry weight |
| 72 | biodres | Total residual, dry weight (nonmerchantable weights) |
| 73 | guse | Current ground use |
| 74 | own | Current ownership code, major categories |
| 75 | ownz | Current ownership, detail-sensitive |
| 76 | samp | Sample kind |
| 77 | ftype | Forest type |
| 78 | biofcwn | Biomass of crown, green weight |
| 79 | biodcwn | Biomass of crown, dry weight |
| 80 | biofmrt | Biomass of mortality trees, green weight |
| 81 | biodmrt | Biomass of mortality trees, dry weight |

*The first four variables are the key for matching with the plot and other data lists; variable 6 is the combination of the first four variables.

**Year(s) Of Establishment Record And Progress Reports:** Not applicable.

## REGENERATION AND MANAGEMENT OF SOUTHERN HARDWOODS

**Study Title: Effects of Spacing on the Yields of Hardwood Species in Minor Bottoms (See description, p. 81.)**

**Principal Investigator(s) Or Contact And Address(es):**

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RWU-4104
Southern Forest Experiment Station
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Stoneville, MS 38776
Phone: (601) 686-7218

**Keywords:** Cherrybark oak, forest growth, forest management, forest yield, *Fraxinus pennsylvanica*, green ash, hardwood plantations, *Liquidambar styraciflua*, Nuttall oak, *Platanus occidentalis*, *Quercus falcata* var. *pagodifolia*, *Q. michauxii*, *Q. nigra*, *Q. nuttallii*, silviculture, swamp chestnut oak, sweetgum, sycamore, thinning, water oak.

**Study Location:** Southeastern Arkansas; minor stream bottoms.

**Objectives:** (1) To determine the effects of species and spacing on the weight yield of hardwoods planted in minor stream bottoms; (2) to compare coppice versus pulpwood management of each species; (3) to determine the combination of spacing and rotation length that will maximize fiber yield for each species; and (4) to determine the effects of species, spacing, and rotation length on nutrient and soil water availability.

**Design:** There are 140 plots, each planted on a 13- by 13-row rectangular grid, or 169 trees per plot. Spacings are 2 by 8, 3 by 8, 4 by 8, 8 by 8, and 12 by 12 ft. There are four replications of each spacing-by-species combination. The interior 5 by 5 rows are maintained as permanent measurement plots. The outside four rows are buffer rows, and destructive sampling is done on the two interior buffer rows. Statistical design is a randomized complete block.

**Year Installed:** 1976.

**Year Completed:** Continuing.

Ages **Or Intervals Data Collected:** Annually from ages 1 through 13.

**Data Machine Readable? Yes,** through age 10.

**Variables:** Biomass production, coppice rotations versus pulpwood management, maximization of fiber yield, possible site deterioration, and nutrient cycling in eight bottomland hardwoods planted at five spacings. Cottonwood was dropped from the study at age 5 because of mortality caused by being off-site.

**Year(s) Of Establishment Record And Progress Reports:** 1983.

**Study Title: Seed-Tree versus Selection Cutting in Bottomland Hardwoods** **(See description, p. 82.)**

**Principal Investigator(s) Or Contact And Address(es):**

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Phone: (601) 686-7218

**Keywords:** Cherrybark oak, forest growth, forest yield, hardwood management, *Liquidambar styraciflua*, *Quercus falcata* var. *pagodifolia*, *Q. nigra*, *Q. phellos*, seed tree method, selection method, silvicultural systems, sweetgum, water oak, willow oak.

**Study Location:** Southeastern Arkansas; stream bottoms in Coastal Plain.

**Objectives:** To compare stand establishment and stand growth and development under two silvicultural systems on two sites.

**Design:** Sixty acres in the Saline River bottom and Chemin-a-haut Creek bottom were divided into six 10-acre treatment areas. Each of 2 treatments, selection and seed-tree cutting, were assigned at random to the 3 treatment areas in each bottom, and 10 permanent 0.2-acre rectangular plots were established in a row, leaving 2-chain isolation strips between plot strip and treatment boundary. Within each 10.2-acre plot, at plot center, one 0.03-acre plot and four 1-milacre plots were established to measure small trees.

**Year Installed:** 1957.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** 1957, 1958, 1959, 1962, 19651979, and 1985.

**Data Machine Readable?** No.

**Variables:** Stand development (species, number of trees per acre, diameter, height, basal area, and volume) following seed-tree and selection cutting.

**Year(s) Of Establishment Record And Progress Reports:** 1958, 1959, 1960, 1964, 1966, 1975, 1982, and 1986.

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**Study Title: Crown Length and Tree Growth of Open-Grown Cottonwood** **(See description, p. 84.)**

**Principal Investigator(s) Or Contact And Address(es):**

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P.O. Box 227
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Phone: (601) 686-7218

**Keywords:** Cottonwood, establishment density, forest growth, forest yield, hardwood plantations, *Platanus occidentalis*, *Populus* spp., pruning, thinning.

**Study Location:** West-central Mississippi, Mississippi River batture.

**Objectives:** To compare growth of cottonwood trees planted at 40- by 40-ft spacing and subjected to four treatments controlling crown length from the second through eighth years.

**Design:** Randomized complete block with four blocks of four treatments.

**Year Installed:** 1974.

**Year Completed:** 1994.

**Ages Or Intervals Data Collected:** Annually from 1976 through 1988.

**Data Machine Readable? No.**

**Variables:** Pruning treatments were: (1) control; (2) prune one-third of total height yearly; (3) prune one-half of total height yearly; and (4) prune 17 ft when average d.b.h. exceeded 8.5 inches, which occurred in the fourth year.

**Year(s) Of Establishment Record And Progress Reports:** Annually from 1978 to 1988.

**Study Title: Direct Seeding of Nuttall Oak in Relation to Environment, Sowing Depth, and Stratification Treatment (Study SO-4104-06; see description, p. 84.) (Treatments to favor oak in mixed stands of hardwood regeneration, Study SO-4104-38, superimposed on SO-4104-06.)**

**Principal Investigator(s) Or Contact And Address(es):**

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Phone: (601) 686-7218

**Keywords:** Forest management, Nuttall oak, *Quercus nuttallii*, seed germination, seed stratification, silvicultural systems, silviculture, survival

**Study Location:** West-central Mississippi, Delta Experimental Forest.

**Objectives:**

***Study SO-4104-06***—(1) to solve problems associated with direct seeding of Nuttall oak; specifically, (2) to study the effects of various combinations of four field environments, three stratification treatments, and three sowing depths on the germination and survival of Nuttall oak acorns.

***Study SO-4104-38***—(3) to test and evaluate seven different stand treatments for favoring the development of 11-year-old, direct-seeded Nuttall oaks in competition with natural regeneration in the same area.

**Design:**

***Study*** SO-4104-06 split-plot design, with three replications of four treatments (environments).

***Study SO-4104-38***—randomized complete block with three replications of seven stand treatments.

**Years Installed: SO-4104-06: 1969; SO-4104-38: 1980.**

**Year Completed: SO-4104-06: 1979; SO-4104-38: Continuing.**

**Ages Or Intervals Data Collected: SO-4104-06: years 1, 2, 5, and 10; SO-4104-38: years 7 and 17.**

**Data Machine Readable? No.**

**Variables:**

***SO-4104-06***—germination, **growth, and survival of direct-seeded** Nuttall **oak acorns.**

***SO-4104-38***—development **of** Nuttall **oak following** release treatments after 11 growing seasons in a sapling-sized stand.

**Year(s) Of Establishment Record And Progress Reports: SO-4104-06: 1969 and 1980; SO-4104-38: 1980 and 1987.**

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**Study Title: Planting Cypress in the Delta Experimental Forest (See description, p. 86.)**

**Principal Investigator(s) Or Contact And Address(es):**

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Southern Hardwoods Laboratory
P.O. Box 227
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Phone: (601) 686-7218

**Keywords: Baldcypress, forest growth, forest** management, forest yield, silviculture, *Taxodium distichum*, tree survival

**Study Location: West-central Mississippi, Delta Experimental Forest.**

**Objectives:** To test regular and deep planting of cypress seedlings, with and without top clipping, on five microsites: ridge (0.27 acre); slope (0.23 acre); and three flats sloughs (0.23, 0.23, and 0.27 acre).

**Design: Probably randomized complete block.**

**Year Installed: 1955.**

**Year Completed: 1958, but trees were remeasured in 1976 and 1986.**

**Ages Or Intervals Data Collected: Ages 4, 21, and 31.**

**Data Machine Readable? No.**

**Variables:** Seedling survival, d.b.h., and height.

**Year(s) Of Establishment Record And Progress Reports:** 1956, 1957, 1958, and manuscripts in 1977 and 1987.

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### SEWANEE RESEARCH CENTER

**Study Title: Comparative Performance of Several Tree Species in Plantations**
**(See description, p. 86.)**

**Principal Investigator(s) Or Contact And Address(es):**

Southern Research Station
Office of Planning and Applications
200 Weaver Blvd., P.O. Box 2680
Asheville, NC 28802
Phone: (704) 257-4304

**Keywords:** Austrian pine, eastern white pine, forest growth, forest management, forest yield, *Liriodendron tulipifera*, loblolly pine, Norway spruce, *Picea abies*, *Pinus echinata*, *P. nigra*, *P. strobus*, *P. sylvestris*, *l? taeda*, *P. virginiana*, Scotch pine, shortleaf pine, silviculture, Virginia pine, yellow poplar.

**Study Location:** Domain of the University of the South, Sewanee, TN.

**Objectives:** To determine which of the eight species would produce the greatest volume of merchantable wood, the greatest monetary value of product, the greatest weight of dry fiber, and the greatest weight of cordwood.

**Design:** Three randomized blocks of eight plots, each 0.25 acre in size (104.3 ft per side), with 221 seedlings per plot spaced 6 ft apart in north-south rows 8 ft apart; the center 25 trees in each plot comprised the measurement plot.

**Year Installed:** 1959.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Survival and height monthly for first two growing seasons, then every 5 years after 5th-year measurements; diameter at end of 5th, 10th, and 15th growing seasons; and diameter and volume at end of 20th and 30th growing seasons.

**Data Machine Readable? No.**

**Variables:** Survival, height, d.b.h., and volume.

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

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**Study Title: Direct Seeding of Eastern White Pine on the Cumberland Plateau**
**(See description, p. 89.)**

**Principal Investigator(s) Or Contact And Address(es):**

Southern Research Station
Office of Planning and Applications
200 Weaver Blvd., P.O. Box 2680
Asheville, NC 28802
Phone: (704) 257-4304

**Keywords:** Direct seeding, eastern white pine, *Pinus strobus*, seed treatments, silviculture, site treatment.

**Study Location:** Domain of the University of the South, Sewanee, TN.

**Objectives:** To determine if the site and seed treatments that had proven satisfactory for direct seeding of southern pines would also be satisfactory for direct seeding of eastern white pine on the southern Cumberland Plateau.

**Design:** Repellent-treated seeds were sown on four of eight randomly selected rectangular O. l-acre plots, and untreated seeds were sown on the other four plots. On each plot, 20 treated and 20 untreated seeds were placed under wire cones to check germination. During the first year, the number of seedlings and monthly survival were recorded on 10 regularly spaced 1/7 milacre plots in each block; survival was recorded monthly during the second growing season and three times during the third and fourth growing seasons. Height of the three most vigorous seedlings on each plot was measured each year.

**Year Installed:** 1959.

**Year Completed:** 1963.

**Ages Or Intervals Data Collected:** First, second, third, and fourth growing seasons.

**Data Machine Readable? No.**

**Variables:** Total germination, survival, and height.

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

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**Study Title: Optimum Spacing of Planted Loblolly Pines on the Cumberland Plateau** **(See description, p. 90.)**

**Principal Investigator(s) Or Contact And Address(es):**

Southern Research Station
Office of Planning and Applications
200 Weaver Blvd., Box 2680
Asheville, NC 28802
Phone: (704) 257-4304

**Keywords:** Forest yield, loblolly pine, *Pinus taeda*, spacing.

**Study Location:** Domain of the University of the South, Sewanee, TN.

**Objectives:** Determine which of the three spacings of planted loblolly pines would yield the greatest cubic volume of wood during a 30-year pulpwood rotation.

**Design:** The study consisted of four 2.25-acre sites, two on old fields and two on poor hardwood sites. Each block contained nine square 0.25acre plots, with three spacings of planted pines: 6 by 6, 6 by 9, and 12 by 12 ft, each randomly assigned to three plots in a block. The central 0.1 acre was used for plot measurements. Height measurements were made at the end of each growing season until trees had reached 6 ft in height, after which only the 10 tallest trees on each plot were measured annually. Diameter measurements 6 inches above the ground were taken after the third, fifth, and seventh growing seasons. At the end of the 10th growing, season, d.b.h. was measured at 5-yr intervals through age 25 on all sites and through age 30 on two sites. Data from these measurements were used to compute basal area, diameter growth, and cubic volume growth; a local volume table will be prepared based on d.b.h. measurements.

**Years Installed:** 1957-58.

**Year Completed:** One site still intact.

**Ages Or Intervals Data Collected:** After 1st, 2d, 3d, 5th, 7th, and 10th growing seasons and then every 5 years through age 25 on all sites and through age 30 on two sites.

**Data Machine Readable? Yes,** on tape.

**Variables:** Height, diameter 6 inches above the ground, and d.b.h.

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

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**Study Title: Responses of Vegetation to Canopy Removal by Shearing and Chipping on the Cumberland Plateau** **(See description, p. 90.)**

**Principal Investigator(s) Or Contact And Address(es):**

Southern Research Station
Office of Planning and Applications
200 Weaver Blvd., P.O. Box 2680
Asheville, NC 28802
Phone: (704) 257-4304

**Keywords:** Canopy removal, eastern white pine, forest growth, forest regeneration, *Liriodendron tulipifera*, loblolly pine, *Pinus echinata, P. strobus, I? taeda*, shortleaf pine, yellow-poplar.

**Study Locations:** Domain of the University of the South, Sewanee, TN, and the Western Highland Rim of the Cumberland Plateau near Buffalo, TN.

**Objectives:** To demonstrate and evaluate low-cost options for forest regeneration following shearing and whole-tree chipping. Specific objectives were (1) to compare the growth and development of naturally regenerated trees with those measurements of planted eastern white pine, yellow-poplar, shortleaf pine, and loblolly pine on the sheared area; and (2) to determine what effect small stems missed by shearing may have on subsequent regeneration.

**Design:**

Sewanee-randomized complete block, three replications, twenty-four 1-acre plots on 37 acres; 0.25 acre measurement plot within each 1-acre plot. Before harvest, vegetation was sampled by species and size classes in a series of nested plots. Most of the woody vegetation was harvested by shearing at ground level and feeding the sheared material into the chipper. On one-half of the plots, small leftover stems were injected or sprayed. Four regeneration treatments included naturally regenerated trees, planted loblolly pine, planted yellow-poplar, and planted eastern white pine, each randomly assigned to three 1-acre plots with stem control and three without stem control Seedlings were planted at an 8- by 10-ft spacing. Cleaning was carried out around eastern white pine after 6 years in each of the six plots.

*Western Highland* Rim-randomized complete block with four blocks and eight treatments in each block, thirty-two 1-acre plots, with a central 0.25acre measurement plot. Plots were grouped into the four blocks based on soil series, topographic position, and aspect. Four plots in each block received no competition control after harvest, and four plots received hand-administered brush control treatments 1 or 2 years after harvest. Vegetation was sampled before harvest as at the Sewanee site, and 32 well-distributed trees were measured for age and height. After harvesting of all standing trees, the 1-acre plots were planted with loblolly pine, shortleaf pine, and yellow-poplar or allowed to regenerate naturally Spacing was 10 by 10 ft.

**Years Installed:** *Sewanee:* 1976; *Western Highland Rim:* 1980.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected: 2, 5,** and 10 years after planting.

**Data Machine Readable?** Information not reported.

**Variables:** Height, diameter, and volume of natural stems and planted seedlings; number of free-to-grow stems on plot and number of residual stems over 4.5 ft tall

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

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**Study Title: White Oak Release in Relation to Stem Characteristics (See description, p. 92.)**

**Principal Investigator(s) Or Contact And Address(es):**

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200 Weaver Blvd., P.O. Box 2680
Asheville, NC 28802
Phone: (704) 257-4304

**Keywords:** Forest management, *Quercus alba*, release, white oak.

**Study Locations:** Experiments 1 and 2 on the domain of the University of the South, Sewanee, TN; experiment 3 on Franklin-Marion State Forest in Marion County, TN.

**Objectives:** The broad objective is to determine how white oaks that have been overtopped by other trees respond to release. Specific objectives are (1) to determine which stem characteristics are related to response after release; (2) to compare the performance of released and unreleased stems; and (3) to compare the response of stems that are released and cut at stump level, released and not cut, not released and cut, and not released and not cut.

**Design:**

*Experiment 1a* total of 104 sample trees 2 to 12 inches in d.b.h., 20 to 60 years old, and characterized as having low-, medium-, or high-quality stems were released. Age was determined from a core taken 1 ft above the ground, and a point 4.5 ft from the ground was marked on the sample trees for diameter measurement. Height, crown length and diameter, and bole length were measured with a Barr and Stroud dendrometer to determine main-stem volume. Sweep and crook were observed and measured, and epicormic sprouts on the first 16-ft log were counted and assigned to length categories. Trees overtopping the sample trees were either felled or poisoned. Remeasurement was carried out every 2 years after treatment.

***Experiment*** 2-forty high-quality sample trees were measured (same measurements as those taken in experiment 1) and released, and 40 were measured and not released.

***Experiment*** 3-same measurements as those taken in Experiment 1. Eighty trees were released from the overtopping trees; 40 were cut at ground level Eighty trees were not released; 40 were cut at ground level Number of sprouts per stump and height, quality, and condition of tallest sprout per stump were recorded.

**Year Installed:** 1976.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Every 2 years after treatment.

**Data Machine Readable:** Information not reported.

**Variables:** D.b.h.; age; quality class; volume growth; height; number and length category of epicormic sprouts; number of stump sprouts; and height, quality, and condition of tallest sprout.

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

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**Study Title: Species, Site, and Plantation Yield (See description, p. 93.)**

**Principal Investigator(s) Or Contact And Address(es):**

Southern Research Station
Office of Planning and Applications
200 Weaver Blvd., P.O. Box 2680
Asheville, NC 28802
Phone: (704) 257-4304

**Keywords:** Black cherry, black oak, forest management, forest yield, *Liriodendron tulipifera,* loblolly pine, *Pinus taeda, Prunus serotina, Quercus velutina,* yellow-poplar.

**Study Locations:** East-central Tennessee and northern Alabama; the hollows and uplands of the Cumberland Plateau and Highland Rim.

**Objectives:** (1) To determine which of four tree species is best adapted to the four most important upland hardwood sites in east-central Tennessee and northern Alabama when underplanted in pure stands; (2) to determine the expected average periodic yields for each species on each site; and (3) to obtain some measurement of the interaction between race and site. Two geographic selections of each species are included in each plantation.

**Design:** Randomized complete block; eight installations were established consisting of two replications of eight plots, one for each of two geographic sources of seeds of four species. Each measurement plot was a square 0.25acre in size, with a 7- by 7-ft spacing, surrounded by a 35-ft isolation zone having the same stock and spacing. All plots were underplanted in hardwood forests, and overstory and understory woody vegetation were controlled.

**Years Installed:** Installations 1 through 5, 1967; installations 6 through 8, 1972.

**Year Completed:** Continuing, but black oak was dropped from the study

**Ages Or Intervals Data Collected:** Height measured at end of 1st, 2d, 5th, 10th, 15th, and 20th growing seasons and at subsequent 5-year intervals. D.b.h. was measured along with height after d.b.h. approximated 1 inch.

**Data Machine Readable? No.**

**Variables:** Survival, height, basal area, and yield at various ages.

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

**Study Title: Mortality Patterns in an Old-Growth Upland Hardwood Forest**
(See **description, p. 95.)**

**Principal Investigator(s) Or Contact And Address(es):**

Southern Research Station
Office of Planning and Applications
200 Weaver Blvd., P.O. Box 2680
Asheville, NC 28802
Phone: (704) 257-4304

**Keywords:** *Acer saccharum*, American beech, black oak, *Carya* spp., chestnut oak, *Fagus grandifolia*, *Fraxinus americana*, hickory, *Liriodendron tulipifera*, mortality, northern red oak, old-growth forest, *Quercus alba*, *Q. prinus*, *Q. rubra*, *Q. velutina*, sugar maple, white ash, white oak, yellow-poplar.

**Study Location:** Dick Cove Natural Area, University of the South, Sewanee, TN.

**Objectives:** (1) To examine past, current, and future tree mortality in an old-growth forest; and (2) to determine if mortality patterns exist in relation to age, species, size, and stand position of the dead trees.

**Design:** Species and diameters of all live trees 5 inches in d.b.h. or larger were determined; trees over 9 inches in d.b.h. that apparently had been dead for 8 years or less were examined and data were collected. Ring counts were taken when possible, and time of mortality was estimated. Monitoring of mortality is continuing.

**Year Installed:** 1982.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** Annually

**Data Machine Readable? No.**

**Variables:** Species, d.b.h. of live trees 5 inches in d.b.h. or larger; species, d.b.h. of dead trees more than 9 inches in d.b.h., as well as estimated total height, number of years dead, cause of mortality (blowdown, insects, drought, or unknown), density of surrounding trees (prism count), age (ring counts on some trees), and condition of trees (standing, broken, wind-thrown, etc.)

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

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**Study Title: Species-Site Relations in Forest Plantations (See description, p. 95.)**

**Principal Investigator(s) Or Contact And Address(es):**

Southern Research Station
Office of Planning and Applications
200 Weaver Blvd., P.O. Box 2680
Asheville, NC 28802
Phone: (704) 257-4304

**Keywords:** Eastern white pine, forest management, forest yield, *Liriodendron tulipifera*, loblolly pine, *Pinus echinata*, *F! strobus*, *P. taeda*, *P. virginiana*, shortleaf pine, soil productivity, Virginia pine, yellow-poplar.

**Study Locations:** Central Tennessee and northern Alabama.

**Objectives:** (1) To determine which of five tree species are most suitable for planting on the major soil sites in central Tennessee and northern Alabama; (2) to compare the productivity of the major soils of the various physiographic provinces of the area; and (3) to determine the soil factors that are correlated with volume growth for each species.

**Design:** Randomized block, with three blocks of five plots each, one species per plot. The five species were to be compared for height growth and pulpwood volume increment for up to 30 years. The study was replicated in seven different localities within the area.

**Years Installed:** Installations 1 and 2: 1960; installations 3 and 4: 1962; installations 5 and 6: 1963; and installation 7: 1964.

**Year Completed:** Installations 1 through 5 continuing; installation 7 closed in 1967.

**Ages Or Intervals Data Collected:** At close of 1st, 2d, 3rd, 5th, 10th, 15th, 20th, and 30th growing seasons.

**Data Machine Readable? No.**

**Variables:** Survival, height, volume and quality of merchantable dry fiber production over a 30-yr period, d.b.h., specific gravity, and soil type.

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

---

**Study Title: Volume, Yield, and Soil-Site Relations of Young Loblolly and Shortleaf Pine Plantations in the Tennessee River Drainage** **(See description, p. 97.)**

**Principal Investigator(s) Or Contact And Address(es):**

Gregory Reams or Project Leader, RWU-4107
Southern Forest Experiment Station
701 Loyola Avenue, Rm. T-10210
New Orleans, LA 70113
Phone: (504) 589-4544

**Keywords:** Forest yield, loblolly pine, *Pinus echinata*, *P. taeda*, shortleaf pine.

**Study Locations:** Tennessee, Alabama, and Georgia; Cumberland Plateau, Highland Rim, and Ridge and Valley.

**Objectives:** (1) To develop formulas for estimating site index at 25 years and yields of loblolly and shortleaf pine plantations up to 25 years of age based on stand parameters and/or soil properties, including soil taxonomic units; and (2) to construct volume tables for young loblolly and shortleaf pines growing in plantations.

**Design:** There were 200 plantations of each species, and trees were measured on 0.05-acre rectangular plots.

**Year Installed:** 1964.

**Year Completed:** 1979.

**Ages Or Intervals Data Collected:** Ages 9 to 30 for loblolly; ages 10 to 34 for shortleaf.

**Data Machine Readable? Yes.**

**Variables:** D.b.h. of all trees, height and crown classification of sample trees, measurements of four felled trees per plot in plantations at least 25 years old, and soil properties.

**Year(s) Of Establishment Record And Progress Reports:** 1964, 1967, 1968, 1970, 1973, and 1979.

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**Study Title: Effects of Intensity of Release on the Survival and Growth of Under-planted Yellow-Poplar** **(See description, p. 98.)**

**Principal Investigator(s) Or Contact And Address(es):**

Southern Research Station
Office of Planning and Applications
200 Weaver Blvd., P.O Box 2680
Asheville, NC 28802
Phone: (704) 257-4304

**Keywords:** Forest management, *Liriodendron tulipifera*, release, yellow-poplar.

**Study Location:** Domain of the University of the South, Sewanee, TN.

**Objectives:** To determine the effects of complete release and two lesser intensities of release on the survival and early growth of yellow-poplar seedlings planted on a mediocre site.

**Design:** Randomized block, with three intensities of release and two seed sources, three replications, in eighteen 0.25-acre plots at a spacing of 7 by 7 ft.

**Year Installed:** 1966.

**Year Completed:** Continuing, but recommended for closure.

**Ages Or Intervals Data Collected:** Every month for first year, then yearly.

**Data Machine Readable? No.**

**Variables:** Survival and height.

**Year(s) Of Establishment Record And Progress Reports:** Dates not available.

**Study Title: Thirty-year Yields, Height Growth, and Soil-Site Relations of Yellow-Poplar, Shortleaf Pine, and White Pine Plantations on the Norris Watershed**
**(See description, p. 99.)**

**Principal Investigator(s) Or Contact And Address(es):**

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University of Tennessee
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P.O. Box 1071
Knoxville, TN 37901

Southern Research Station
Office of Planning and Applications
200 Weaver Blvd., P.O. Box 2680
Asheville, NC 28802
Phone: (704) 257-4304

**Keywords:** Eastern white pine, forest management, forest yield, *Liriodendron tulipifera, Pinus echinata, P. strobus*, shortleaf pine, yellow-poplar.

**Study Location:** Norris Lake watershed, Tennessee.

**Objectives:** (1) To determine the potential yields of yellow-poplar, shortleaf pine, and eastern white pine growing on three parent materials (limestone, dolomite, and shale) and two aspects (north and south); (2) to develop site index curves for each species; and (3) to correlate physical, chemical, and morphological soil properties with several measurements of site productivity.

**Design:** Various.

**Years Installed:** 1937-38.

**Year Completed:** Continuing.

**Ages Or Intervals Data Collected:** 1, 3, 5, 11, 20, *30,* and 46 years after planting.

**Data Machine Readable? No.**

**Variables:** Diameter, height, volume, and stem analysis measurements.

**Year(s) Of Establishment Record And Progress Reports:** 1968, 1970, 1983, 1984, and 1985.

---

**Study Title: Effects of Spacing on the Growth and Yield of Planted Virginia Pine**
**(See description, p. 100.)**

**Principal Investigator(s) Or Contact And Address(es):**

Southern Research Station
Office of Planning and Applications
200 Weaver Blvd., P.O. Box 2680
Asheville, NC 28802
Phone: (704) 267-4304

**Keywords:** Forest yield, *Pinus virginiana,* spacing, Virginia pine.

**Study Locations:** Middle Cumberland Plateau and the domain of the University of the South, Sewanee, TN.

**Objectives:** To evaluate the effects of spacing on the growth of unthinned Virginia pine and to determine if self-pruning could be improved at high densities.

**Design:** Randomized block with four replications; four blocks of three plots 0.25 acre in size, with spacings of 4 by 4, 6 by 6, and 8 by 8 ft. The measurement plot was the central 0.1 acre.

**Years Installed:** 1961-62.

**Year Completed:** 1986.

**Ages Or Intervals Data Collected:** 1 through 5, 10, 15, and 20 years after planting.

**Data Machine Readable? No.**

**Variables:** Survival, height, d.b.h., and volume.

**Year(s) Of Establishment Record And Progress Reports:** 1962, 1968, 1972, 1977, and 1983.

**Study Title: Geographic Seed Source Study of Yellow-Poplar (See description, p. 100.)**

(See description, p. 100.)

**Principal Investigator(s) Or Contact And Address(es):**

Southern Research Station
Office of Planning and Applications
200 Weaver Blvd., P.O. Box 2680
Asheville, NC 28802
Phone: (704) 257-4304

**Keywords:** Geographic variation, *Liriodendron tulipifera,* seed source, yellow-poplar.

**Study Locations:** Mid-Cumberland Plateau and Eastern Highland Rim, TN.

**Objectives:** To evaluate the extent of geographic variation among four southern seed sources of yellow-poplar.

**Design:** Randomized block design with four replications at each of two sites; seedlings from four seed sources were planted at each site.

**Years Installed:** 1961.

**Year Completed:** Information not reported.

**Ages Or Intervals Data Collected:** After *20* years.

**Data Machine Readable? No.**

**Variables:** Information not reported.

**Year(s) Of Establishment Record And Progress Reports:** 1961, 1964, 1972, 1977, and 1983.

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## Table of Equivalents

| Metric Units | Approximate English Units |
|---|---|
| 1 cubic meter | 35.3 cubic feet or 424 board feet |
| 1 square meter | 10.9 square feet |
| 1 meter or 100 centimeters | 39.4 inches or 3.3 feet |
| 1 centimeter or 25.4 millimeters | 2.54 inches |
| 1 hectare or 10,000 square meters | 2.45 acres or 106,722 square feet |
| 0.41 hectare | 1 acre or 43,560 square feet |
| Degrees Celsius (°C)<br>(degrees F-32) (5/9) | Degrees Fahrenheit (°F)<br>(degrees C)(5/9) + 32 |
| 1.6 kilometers | 1 mile or 5,280 feet |
| 1 kilogram | 2.2 pounds |

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife-if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

Devall, Margaret S.; Baldwin, Virgil C., comps. 1998. Long-term research does pay off; a summary of the Southern Station experience. Gen. Tech. Rep. SO-124. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 190 p.

Description and summaries of completed and ongoing long-term research studies (those in existence for 5 or more years) conducted by scientists of the USDA Forest Service's former Southern Forest Experiment Station (now part of the Southern Research Station) are presented in this report.

**Keywords:** Forestry, long-term studies, Midsouth, Southern Forest Experiment Station.