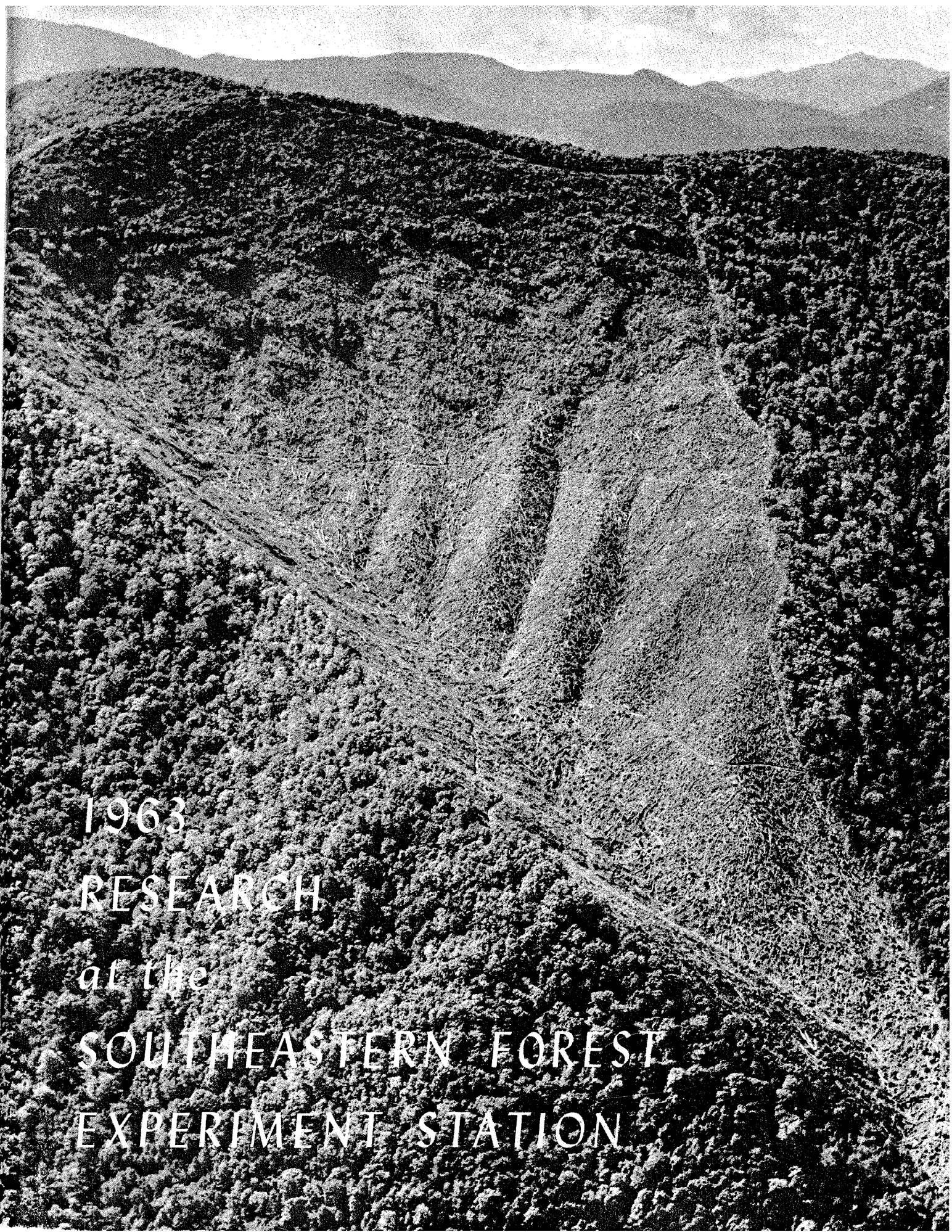

1963
RESEARCH
at the
SOUTHEASTERN FOREST
EXPERIMENT STATION

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Southeastern Forest Experiment Station
Asheville, **North** *Carolina*

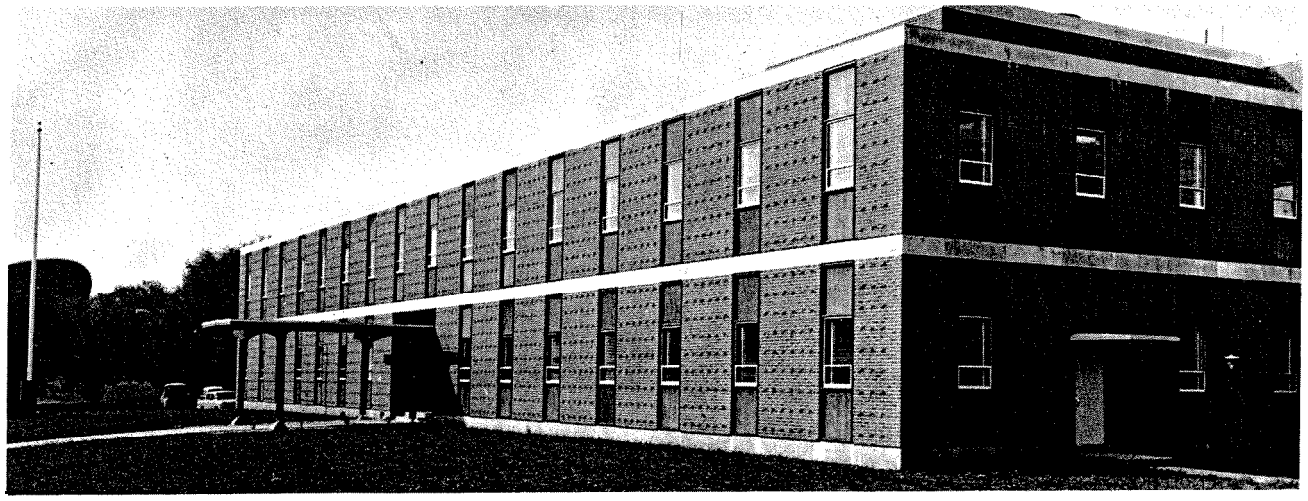
COVER PHOTO

One of two watersheds at Coweeta, clear cut as an APW project, will serve as an outdoor proving ground to make earlier findings more widely applicable on municipal watersheds and other large holdings. Seen here in an aerial view, the very steep 107-acre watershed was cleared by APW crews at the rate of 9 man-days per acre.

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New Forestry Sciences Laboratory on the campus of the University of Georgia, near the School of Forestry and Science Center. The 4-acre site was donated to the U. S. Forest Service by the University. The 2-story building contains 30 offices and 19 specialized laboratories. The lab is one of *the main research centers in the Southeast for utilization studies* of *wood quality, treating, laminating, and more* efficient *sawmilling methods. Basic investigations in insect and disease control, as well as hardwood planting are already* **producing useful results.**

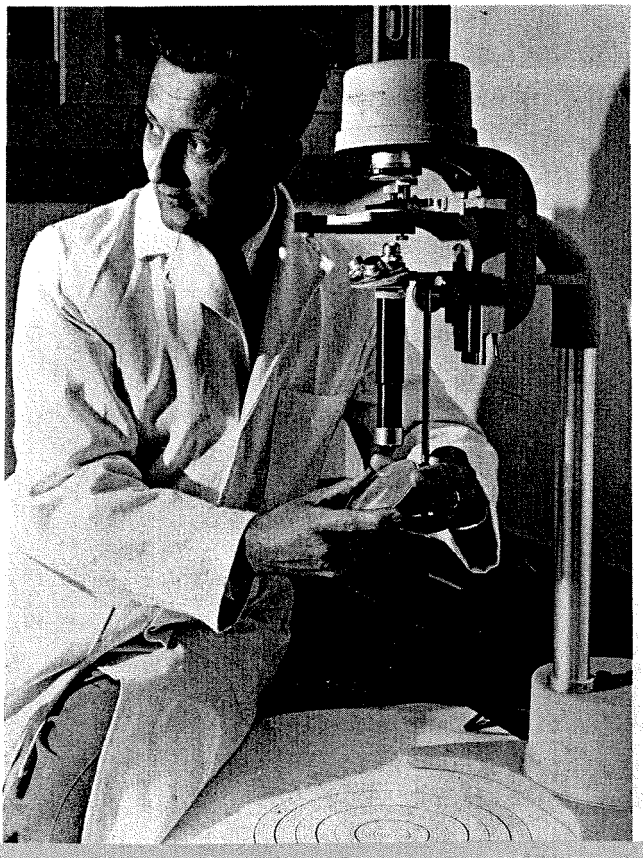
New Labs and Facilities

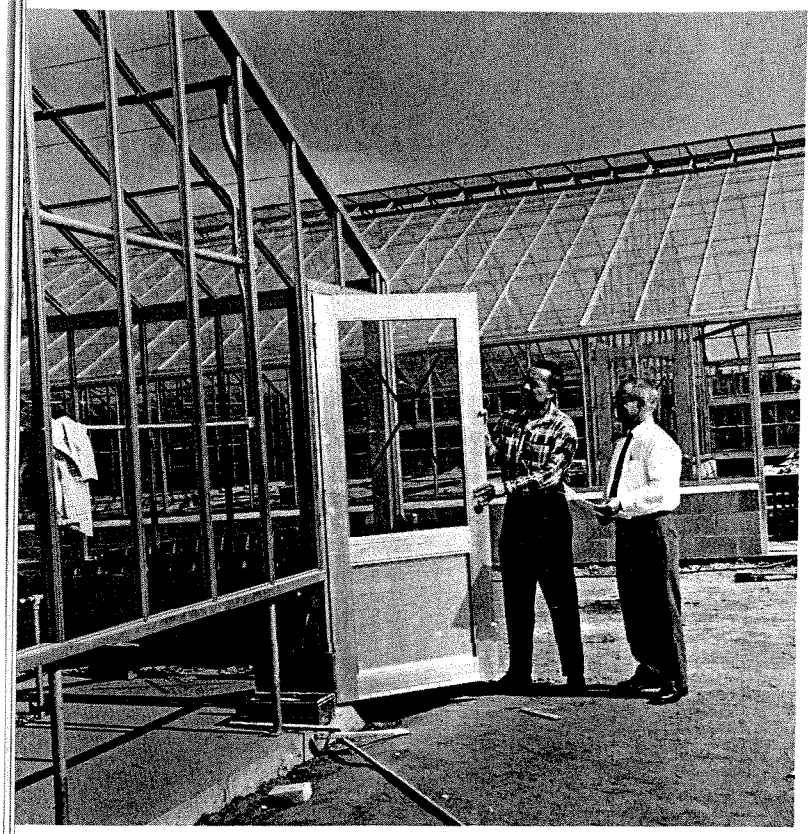
In 1963 the Station's new Forestry Sciences Laboratory at Athens, Georgia, was completed and we moved in. At the laboratory in North Carolina's Research Triangle a full program of work is in progress and the building of auxiliary greenhouses and insectaries practically finished. The Station now has four outstanding modern research facilities providing work space, offices, instruments, and equipment for 70 scientists.

Georgia Senator Richard B. Russell lays cornerstone **of** *Forestry Sciences Laboratory in Athens, Georgia.*

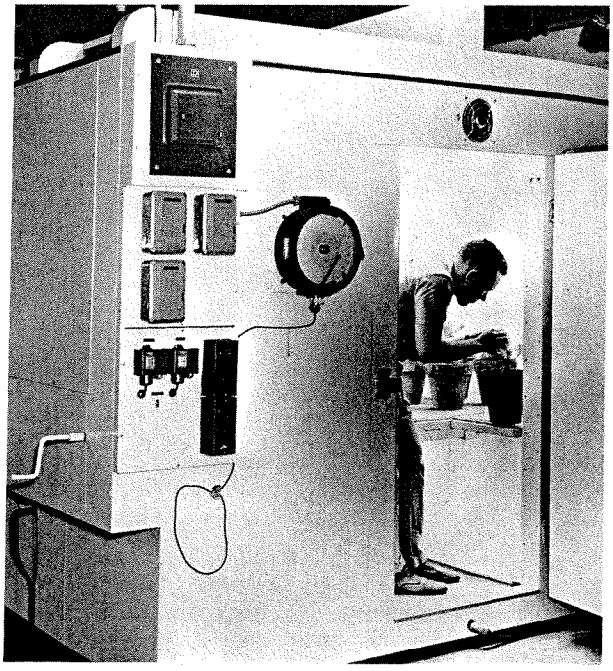


Microprojector being adjusted to project an enlarged image of wood fibers on a calibrated bull's-eye **for** *the* **purpose of** *determining fiber lengths.*



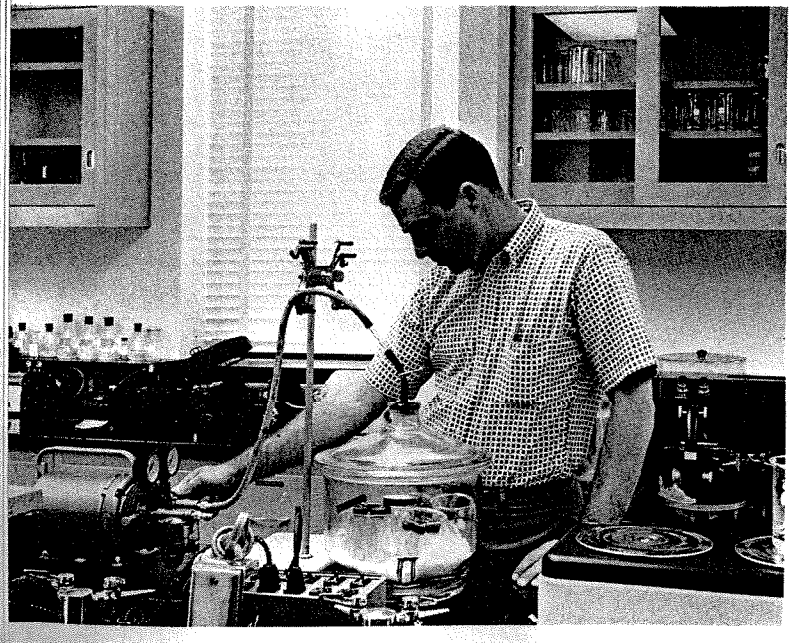


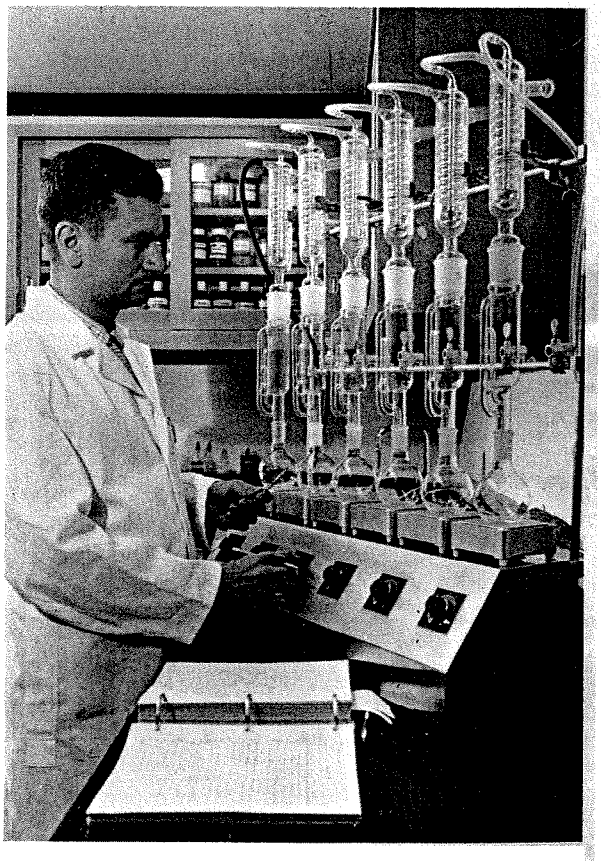
Two **large greenhouses** *have been constructed in cooperation with the University of Georgia. These greenhouses will be used in timber management, forest disease and insect studies involving* **plant** *nutrition,* **and** *the testing of plants resistant to disease and insect attack.*



Control environment chamber at Athens **for** *greenhouse studies of tree growth, insects, and diseases. Here* **nutrition,** *photosynthesis, and respiration can be charted under precise conditions* **of** *temperature,* **humidity,** *and day length.*

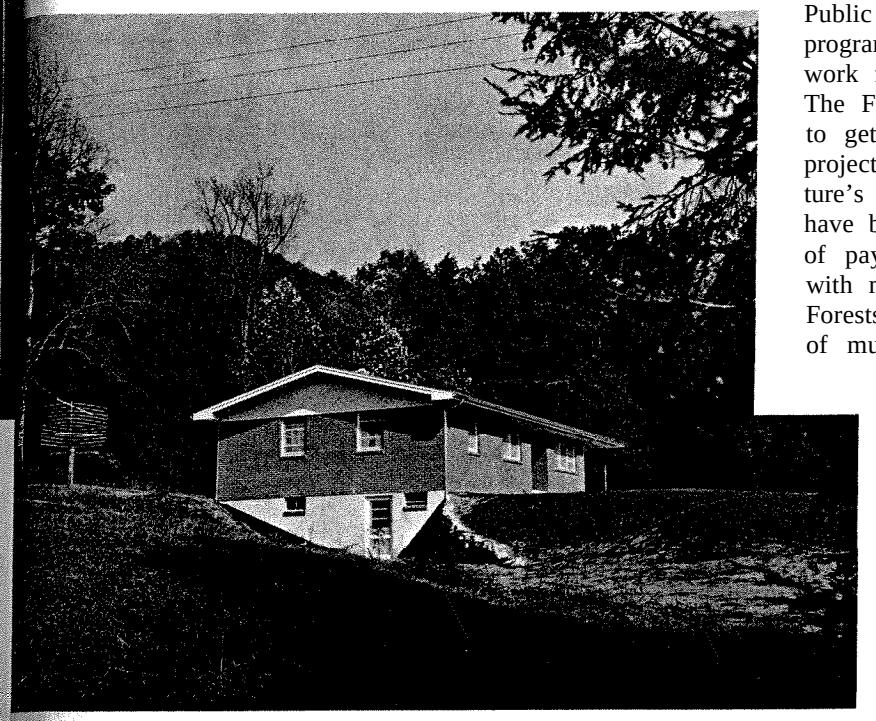
One far-reaching aim of the forest pathology team at Athens is effective, economical, field control of fusiform **rust, a primary** *problem in southern pines. The battle has been virtually won* **in nurseries, but** *field control is a long, complex road.*





Apparatus **used in** *the removal* **of gums, resins,** *and other extractives from wood for the purpose of preparing extractive-free wood, which in turn is used for specific gravity* **determinations.**

Another big accomplishment this year was the construction and improvement at Coweeta, at the Santee Experimental Forest in South Carolina, and at the Triangle, made possible by Accelerated Public Works. Congress authorized the APW program in order to provide immediate useful work for the unemployed in labor surplus areas. The Forest Service was the first Federal agency to get projects under way. Generally our APW projects tied in with the Department of Agriculture's Rural Areas Development campaign. There have been many benefits to workers in the form of pay-checks and useful jobs, to communities with more money in circulation, and to National Forests and Experimental Forests in the form of much-needed improvements.



A new 3-bedroom forest superintendent's dwelling was constructed at Coweeta to release the older dwelling for use as a bunkhouse and conference room.



AT COWEETA

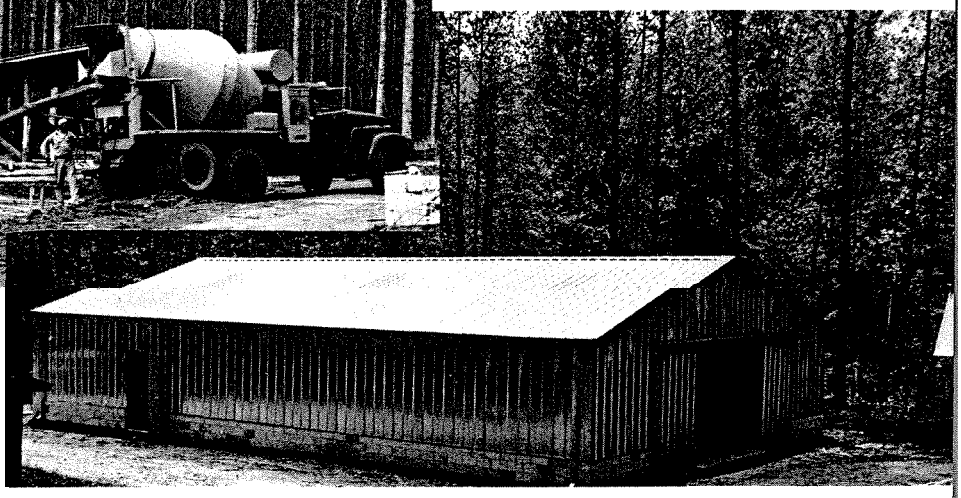
In the Accelerated Public Works (APW) program at Coweeta, 94 men were hired for a total of 310 man-months. In addition to the wages these jobs brought, about $80,000 went for local machine rentals, supplies, and materials. The work encompassed some 1.5 projects.

The original buildings, roads, and stream weirs at Coweeta were built under the Civilian Conservation Corps program some 30 years ago. Much of the old construction was in sad repair, some of it literally falling down because of termites, rot, and old age. Storage was severely limited, as were office space for researchers, and protection for research facilities. The area water system was limited to about 1,500 gallons of storage, and pressure was inadequate for fire protection. Plans call for reducing the number of sheds and buildings from 13 to 7. The APW program has provided a long-anticipated opportunity to upgrade Coweeta research facilities.



Crew laying culvert on contour road into multiple use study area. This is part of 180 acres clear cut to observe and measure expected increase in water yields. Sprout reproduction will provide wildlife forage and, in time, an improved stand of timber. Assisted by bulldozers and dynamite teams, about 20 men reconstructed 2.5 miles of roads and trails needed for access to experimental areas, They replaced dozens of timber bridges, installed culverts, improved grades and stabilized raw banks under grass.





The completed storage warehouse is 40x60. It doubles storage space and takes the place of a number of separate buildings and sheds. The old shop building has been retained for laboratory and **instrument room** *facilities.*

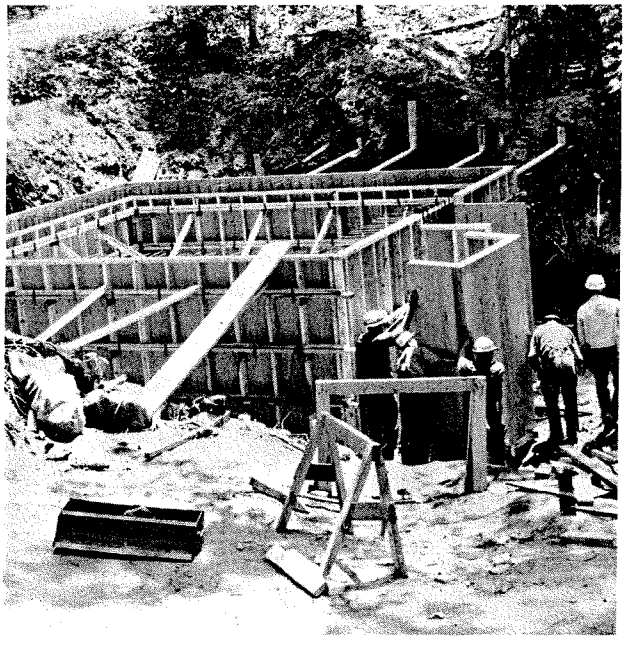


A new wing was added to the old administration building. For the first time the research staff **has individual office space.**

A n 18-inch pip lme delivers gravity water to a new hydrology workshop **known as** *the Wet Lab. This 40x100-ft. building* **is** *used for* **studies** *involving large tilting models, flowing water, sprinkliing systems, and movable soil tanks.*



APW crew **erecting forms** *for 20,000 gallon fresh water reservoir. A plastic pipe bring gravity water from a spring 3/4-mile away. The new gravity supply system will meet all estimated future needs.*





The watershed at the Santee Experimental Forest used for wetland research needed ditching to divert surface water.



Completed stream gaging station measures a flow that averages about 300,000 gallons a day.

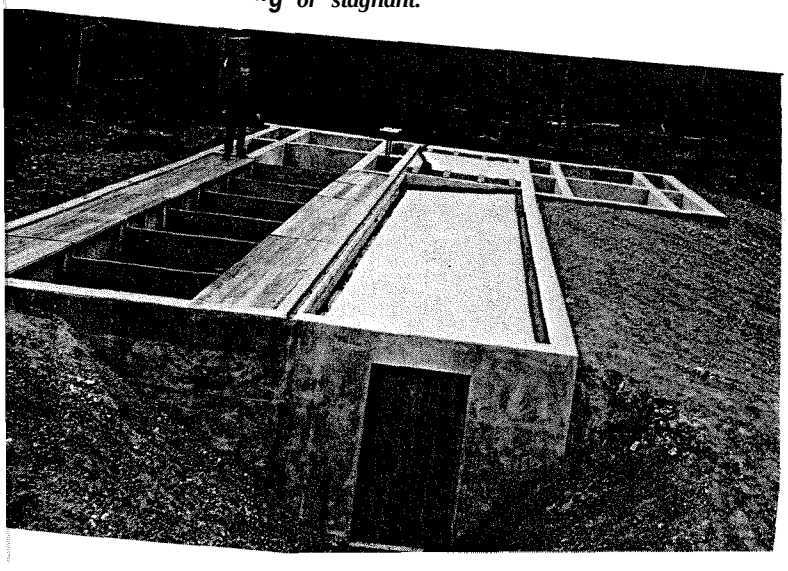


Piling being driven at stream gaging site on the Santee.

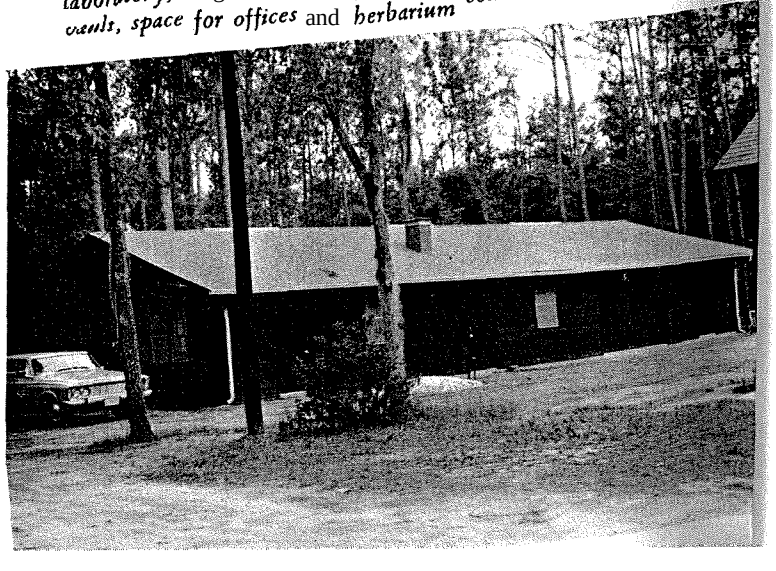
AT THE SANTEE

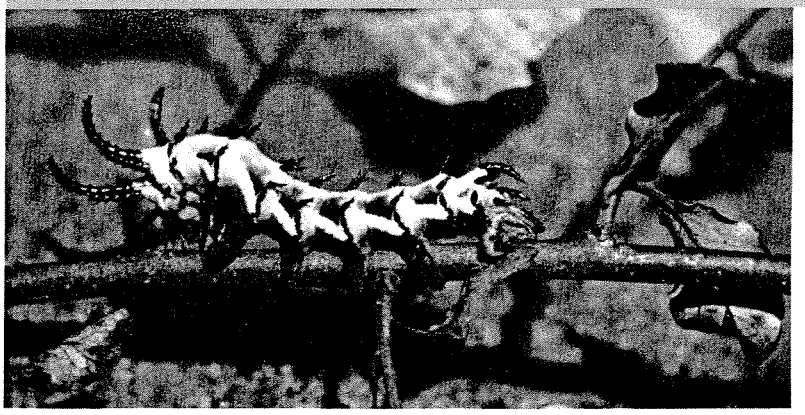
At the Santee Experimental Forest in the South Carolina coastal plain, accomplishments included a new office and work center, new lathhouse, soil tanks, water system, nursery beds, and permanent firelines; also repairs on several existing buildings and development of an isolated experimental watershed area including drainage ditches, gaging stations and water-course improvements.

New Soil tanks to [illegible] requirements of selected wetland timber species. The compartments will be filled with soil and planted or seeded to swamp and water tupelo. To simulate swamp conditions, ground water can be maintained at a given level or tanks can be flooded to varying depths, with water either moving or stagnant.



Building at [illegible] Recently completed Work Center at the Santee Experimental Forest provides a silvical laboratory, large work area, a fireproof records vault, space for offices and herbarium collections.





Forest Insects

REARING INSECTS – A MAJOR STEP TOWARD CONTROL

If we are to devise and improve methods of forecasting, preventing, and controlling insect outbreaks, we must learn how to rear large quantities of insects for experimental purposes. The planned rearing of insects is by no means a new idea. Most people are familiar with the rearing of silkworms for silk production, which had its origin centuries ago. The rearing of the fruit fly, Drosophila, employed in the study of genetics, is classic to students and scientists. In recent years, the mass rearing and large-scale release of irradiated, sterile male screw-worm flies has made it possible to virtually exterminate the pest and has gained worldwide attention. Less known, but equally important, are the techniques employed in studying beneficial and destructive insects that affect food crops and forests. Success in rearing most species has seldom been spectacular, and failures have been many, but modern instrumentation and knowledge provide assurance that highly effective methods can be developed wherever a need exists.

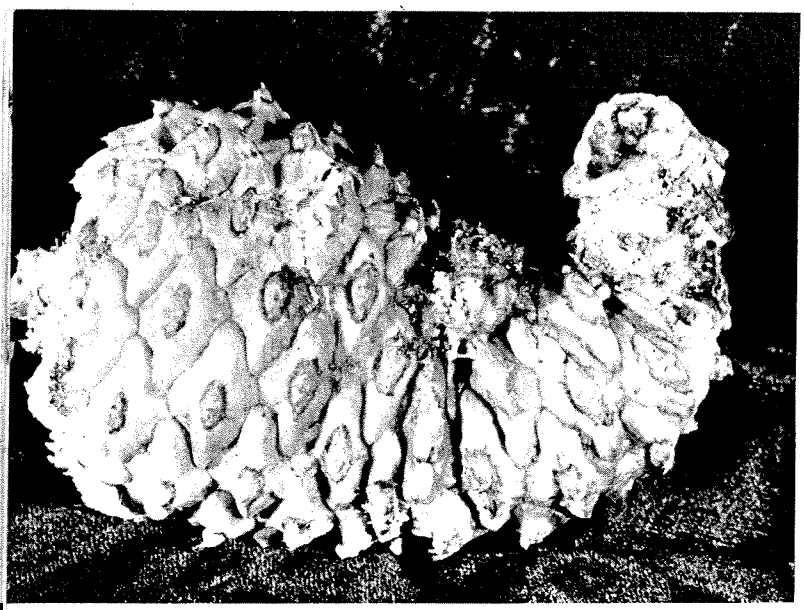
One might ask, "Why rear insects? It is obvious they are abundant. The woods are full of them!" Basically, the scientist needs a continuous supply of known insects so that he can learn about every possible detail of an insect's identification, life history, habits and behavior, its relationship to the environment, and its control. In the past this has been done largely through field or laboratory study of field-collected material. And it is still being done, for it is an essential part of insect research. In order to gain a deeper understanding of basic factors in the insect's life which will relate to its ultimate control, however, the scientist must virtually live with the insect year round. Just as the medical researcher must have a constant supply of monkeys, chickens, rats, and mice for laboratory study of cancer, polio, and other diseases, so the entomologist must have insects for biological study. He must have a large and continuous supply of greatest uniformity within and between generations, and they must be of known background raised under uniform nutritional and environmental conditions.

The environment insects are reared in is no longer simply a screened cage or shelter; specialized facilities can now control temperature, humidity, and light. In certain studies small control cabinets suffice; in others, "climate" rooms are needed where insects, host plants, and environmental conditions may be studied together. Isolation must be provided to protect insect cultures from various forms of adverse biological and chemical contamination.

In recent years emphasis on the fundamental study of forest insect biology has been increasing at this Station. Progress in research on insect rearing and in setting up rearing facilities during 1963 has been particularly noteworthy.

Insects Affecting Seed Production

A few years ago, virtually nothing was known about insects that injured the flowers, cones, and seeds of pine. Our early studies began at Lake City, Florida, with observation of trees and the various parts that might be expected to harbor insects affecting seed: flowers, buds, cones, seeds, twigs, and stems. Later, infested material was caged and studied in the field or collected, caged, and studied in the insectary. Insects were reared to the adult stage and identified, and the nature and extent of damage and host preferences were determined.



Distortion of maturing longleaf pine cone caused by coneworm larvae burrowing within the cone.



Rearing cone insects from field-infested material caged in the insectary.

The primary species discovered were: the coneworms, ***Dioryctria amatella, D. abietella,*** and ***D. clarioralis;*** the seedworms, ***Larpeyreria ingens*** and ***L. anaranjada;*** and the slash pine flower thrips, ***Gnophothrips piniphilus.*** Coneworms damaged first- and second-year cones, buds, shoots, and male and female flowers, and prevented seed development. The seedworms caused direct injury to seed. The flower thrips primarily damaged female flowers. These primary species were found responsible for an annual loss of 30 to 50 percent of the seed crop.

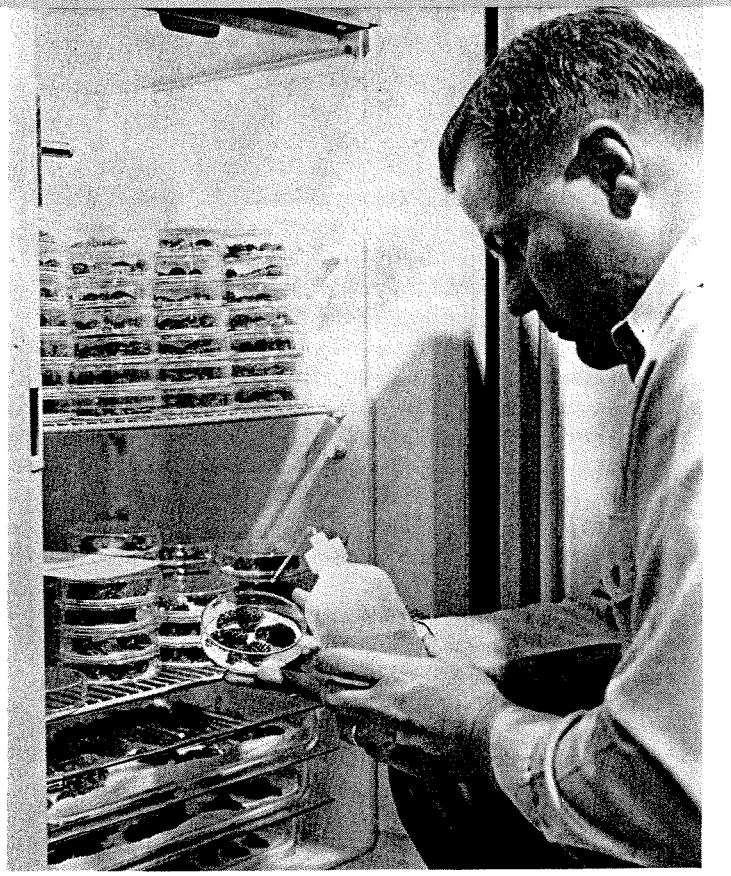
At first we reared these species in the forest to determine as accurately as possible their life histories and habits in a natural environment. To do this we caged infested material and observed the insects' development. General information about host relationships, and the influence of temperature, rainfall, and other environmental factors on the insects' development was obtained. Although such rearing is time-consuming, limited in scope and in information yield, it is nevertheless an essential step in research procedure.

When it became necessary to obtain more detailed and precise information about the various species under study, investigations on laboratory-rearing methods were begun. Preliminary study revealed that ***D. abietella*** presented fewer problems to overcome in rearing, and our primary effort was directed toward it. Uultimately a mass-rearing technique using a natural diet was developed. This is the first time that such a method has been designed for this species and, we believe, for the genus. Essentially it consists of mating male and female moths, isolating the females for egg deposition, providing treated, fresh, first-year cones for larvae, and finally collecting the moths of the new generation. Thus, hundreds of specimens of any desired stage of the insect can be produced within 30 days.

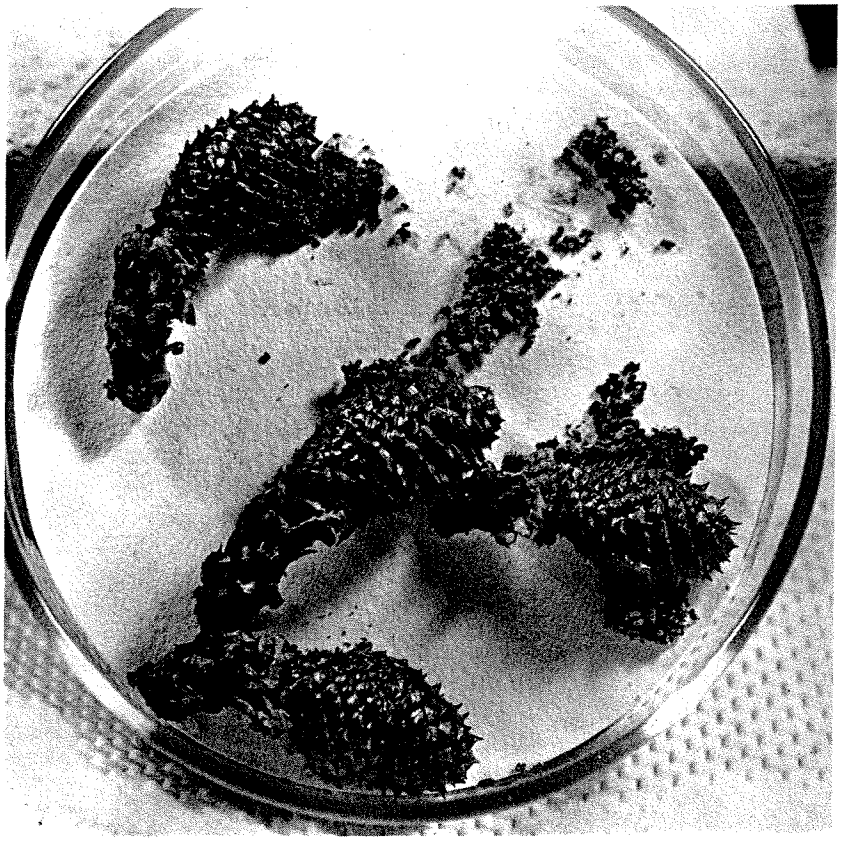
The outlined procedure may appear simple, but it represents the application of knowledge and experience in insect biology, trial and error effort, careful observation in the field, and experimentation in the laboratory. For example, food and moisture had to be provided to keep moths alive. Temperature, light, and moisture conditions suitable for egg laying were determined. Investigation was required to find a medium that moths would lay eggs on and from which eggs could be isolated. Conditions that prevented egg desiccation and encouraged hatching were determined and provided. Food that larvae would thrive on had to be discovered. Factors detrimental to larval survival, such as disease and desiccation, were determined and overcome. And to maintain healthy laboratory-reared populations, field-collected moths had to be introduced annually to reduce detrimental effects of inbreeding.



Rearing coneworms from caged host material.



Mass **rearing of Dioryctria abietella.** **Insects** *and* **food** *material are stored under controlled conditions.*



Rearing small groups of **Dioryctria abietella** *larvae. Cones* are waxed *to preserve moisture. Slits are cut in the cones to encourage* penetration *by young larvae.*

The technique has enabled entomologists to study intimately, under laboratory conditions, the insect's life stages, behavior, response to environment, relationship to associated insects and diseases, and other biological factors. For example, after finding that certain larval instars of coneworms migrate from cone to cone, we felt that control with insecticide sprays was possible. The technique enabled us to rear the hundreds of insect specimens required for screening numerous insecticide formulations. Determination of the life cycle in the laboratory, checked against field observation, revealed when and how many spray applications would be needed. Thus, an effective chemical control method was developed in a fraction of the time required in field study of the insects and empirical testing of insecticides.

Progress is now being made in formulating artificial and semi-artificial insect diets to provide suitable standard nutritive media. Such rearing media would greatly reduce the time and effort now required to collect, treat, and handle cones. ***D. abietella*** has been reared through one generation on an artificial medium consisting of corn products, vitamins, and preservatives.



Rearing Dioryctria abietella ***larvae on artificial media of corn products and vitamins. Note larvae burrowing into food (at arrow).***

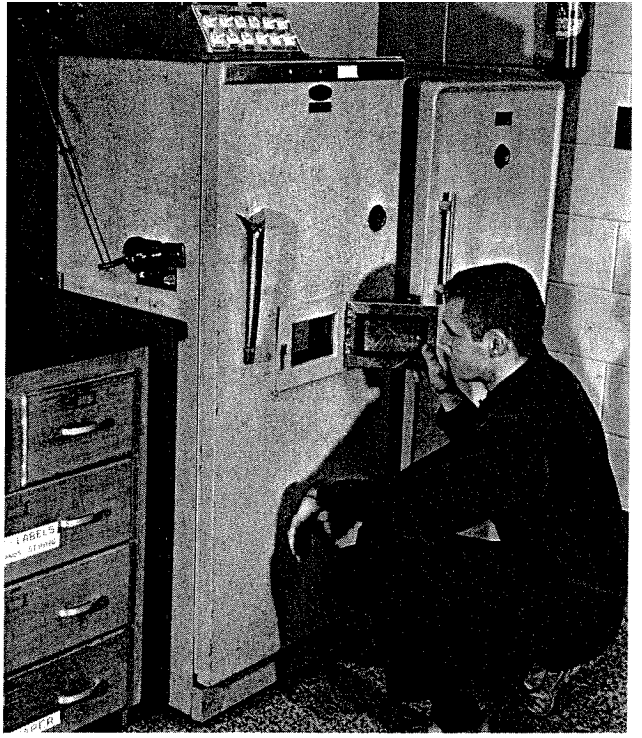
The mass-rearing method used so successfully with ***D. abietella*** is not effective for ***D. amatella.*** For one thing, we learned that this species was somewhat cannibalistic and thus mass rearing, as used with its related species, is precluded. Furthermore, this species is more exacting in its environmental requirements. Adults confined to breeding cages at room temperatures, humidities, and lighting produce few eggs. Studies being conducted within a cyclic environment chamber and other rearing equipment are producing strong evidence that photoperiod, temperature, humidity, and the nature of the egg-laying surface strongly influence mating and egg production of this insect. Reproduction of the average climatological environment for late February and early March has significantly increased egg production. The average number of eggs laid per female under these conditions, however, represents only 15 percent of the potential egg production as determined by dissection of developed eggs from mature female reproductive tracts.

To date only single specimens have been reared in the laboratory, but even this has enabled us to study certain biological factors in the life of the insect not previously subject to close observation. In mass-rearing studies we are giving special attention to changes in temperature, light, moisture, and air movement. When the factors limiting development of ***D. amatella*** are discovered and overcome, design of a mass-rearing technique will follow.

Bark Beetles

For nearly 50 years research on pine bark beetles, the primary killers of southern pine, has been severely restricted by lack of suitable rearing methods. This has been particularly true of the southern pine beetle, which virtually disappears during endemic periods. Even the Ips engraver beetles and the black turpentine beetle, which constantly maintain noticeable population levels, could not be produced in sufficient numbers for thorough study of their biology. Recognizing these deficiencies, entomologists of the Station decided on an all-out effort to overcome the problem, employing the best knowledge, experience, and facilities available at the new Forestry Sciences Laboratory at Durham, N. C.

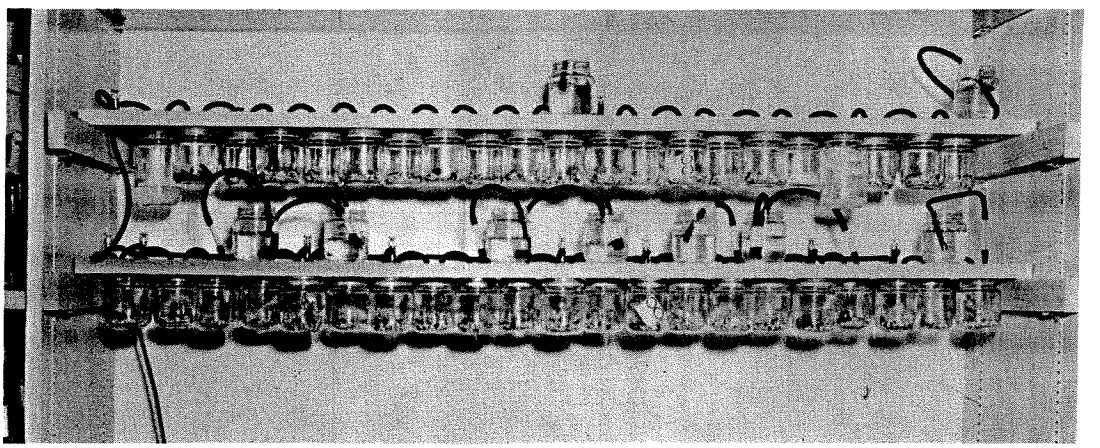
Their efforts have been rewarded. This year, for the first time, they designed successful methods to collect and produce unlimited numbers of the southern pine beetle. Methods for rearing Ips, which appears to have rearing' requirements similar to southern pine beetle, are



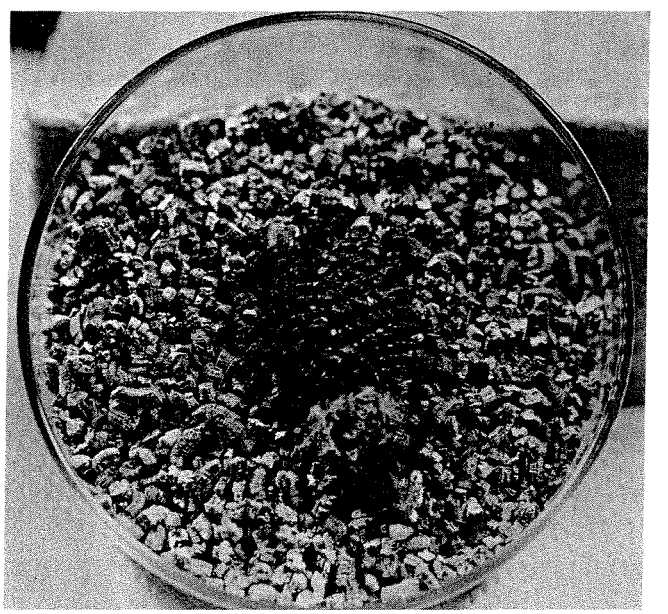
Entomologist observing the reaction **of cone** *moths to* **changing environmental conditions** *in a controlled cyclic environment cabinet.*

also well along. Thus, the complex questions entomologists have struggled with for years now have a reasonable chance of being answered: What triggers epidemic outbreaks of bark beetles:' What is the relationship of drought, of excessive rainfall, and other climatic factors to outbreaks? How important is the vigor of host trees or the forest to outbreaks? Intensive laboratory research into the biology of bark beetles will provide fundamental information essential for field study of these problems and will ultimately lead to efficient control of outbreaks.

Preliminary to the rearing of bark beetles was the need to devise efficient means of collecting field populations, particularly the southern pine beetle. In the past, various ways of collecting beetles from sections of infested trees were used, but the number recovered compared to the total infestation was low; of these, few were suitable for laboratory study because of severe, mutually inflicted injuries caused by unnatural environmental conditions. Our research has led to designs of collecting devices that enabled almost complete recovery of uninjured beetles.



Equipment used in studies to devise mass-rearing technique **for** Dioryctria amatella. A *continuous* **flow of** *warm air is passed through each jar containing* **larvae** *and food* **material.** *Humidity, temperature, light, and food are varied to* **find optimum** *condition for insect development.*



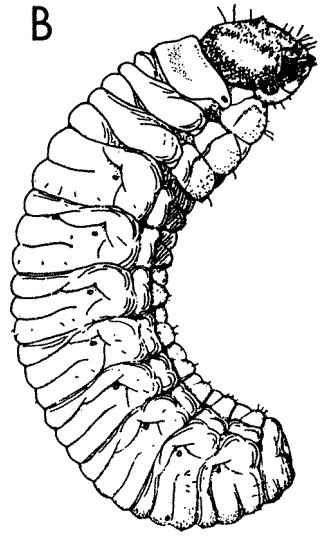
Rearing individual *larva* **of Dioryctria amatella** ***on waxed*** *conelet.* ***Note larval*** *frass* ***next to cone. Vermiculite particles maintain optimum humidity.***

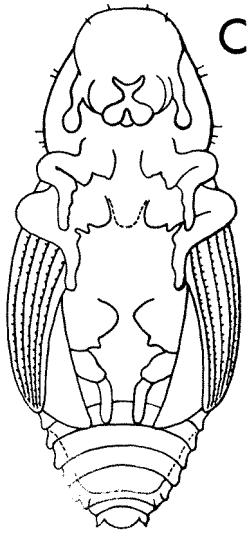


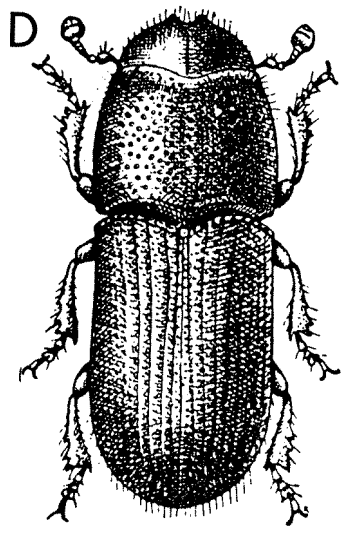
A kill or "hot spot" of pines infested by the southern pine beetle. Note that trees of all diameters have been killed.

Stages of the southern pine beetle: A, egg; B, larva; C, pupa; D, adult.









In the research on rearing, techniques were sought for rearing and study of single specimens and small numbers of individuals, and the production of large numbers of beetles.

The simplest technique for studying small numbers employed the use of heavy, clear plastic containers and fresh pine bolts. Bolts about 12 inches long and 4 inches in diameter were fitted snugly into the box and small numbers of beetles were released on the bolts. Study revealed that beetles would attack only in complete darkness; after attack, the container could be stored under normal room lighting. Desired moisture conditions were maintained by adjusting the box lid. Optimum insect development was obtained at a temperature of 80" F. during the day and 74" F. at night. Using this technique we were able to study the biology of both field-collected and known, laboratory-reared beetles. Gallery pattern, egg deposition and hatching, survival, influence of competition, and the effects of varying environmental conditions could be readily determined.

In another method, called the "sandwich technique," inner bark is held tightly between two plates of Lucite and insects are inserted. This technique proved extremely useful in studying the behavior of various stages of the insect, particularly the response to different moisture and temperature levels.

Two techniques that utilize fresh pine bolts are extremely effective in rearing small numbers of beetles for special biological research. In the study of single pairs of beetles, a female is confined in a gelatin capsule cemented over a 1/8-inch hole drilled into the bolt. After she has started a gallery, the male is introduced. The

bolt is then subjected to varying environmental conditions for investigation of the insect's fertility, genetics, and other biological phenomena. In the other method, pairs of beetles are confined in a paper-polyethylene chamber placed over the end of a bolt which has been notched at intervals at the edge of bark and wood. Under controlled conditions beetles will start galleries at the notches and continue normal life activity. The method provides a constant supply of all stages of the insect from groups of known parents for subsequent study.

A technique for rearing small numbers of beetles on artificial media is also being used and gradually improved. These media are composed of either ground inner bark or cellulose and other dietary constituents. In addition to southern pine beetles, Ips, flatheaded, and roundheaded beetles have been successfully reared; thus, the technique appears rather useful for detailed studies of several bark-feeding beetles.

The methods described are not completely new or original in concept, but their modification and successful adaptation to rearing the southern pine beetle mark significant progress in the study of this insect.

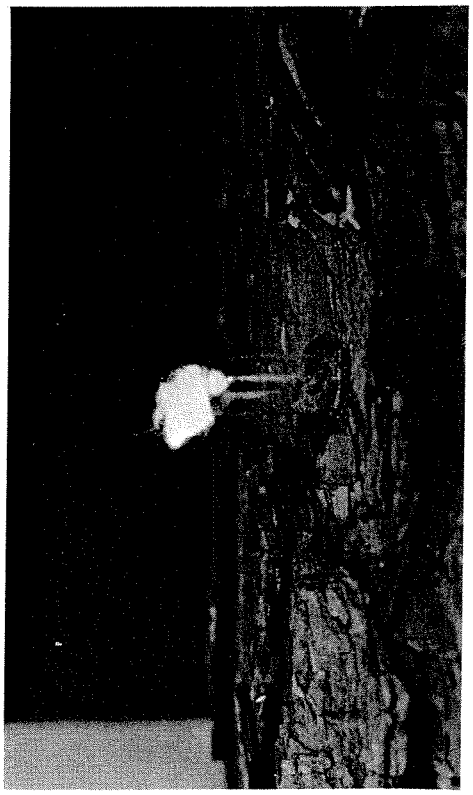
The most noteworthy accomplishment in bark beetle studies at the laboratory was the discovery of a method for mass rearing the southern pine beetle. Innumerable techniques studied by researchers in the past had failed. However, by introducing beetles to fresh bolts in a specially modified container where environmental conditions are simply controlled, we can now produce virtually unlimited quantities of beetles restricted only by equipment and space.

In designing the technique, detailed knowledge of the beetle's habits, behavior, and responses had to be employed. Beetles are introduced into the container that holds pine bolts 4 to 6 inches in diameter. (It was found that 30 to 40 beetles per square foot of bark area provided the best yield of progeny.) At this time all light is excluded from the container. Five days later a collecting jar is placed at the bottom of the can. By the end of 20 days the original beetles have completed mating and egg laying and have been collected in the jar for further study. New brood adults begin emerging in the jar in 30 days and continue for another 30. From the 5th to the 40th day dry air is passed through the container. A daytime temperature of 80° F. and a night temperature of 70" F. proved optimum for beetle activity. Under these conditions, and with the special design so that beetles emerge into the collecting jar, virtually complete recovery of new

Sandwich technique for rearing and observing behavior of bark beetles in various stages.



A gelatin capsule cemented to a pine bolt is useful in studying the biology of single pairs of bark beetles.



With this rather simple rearing technique, research scientists may readily obtain eggs and young larvae of bark beetles.



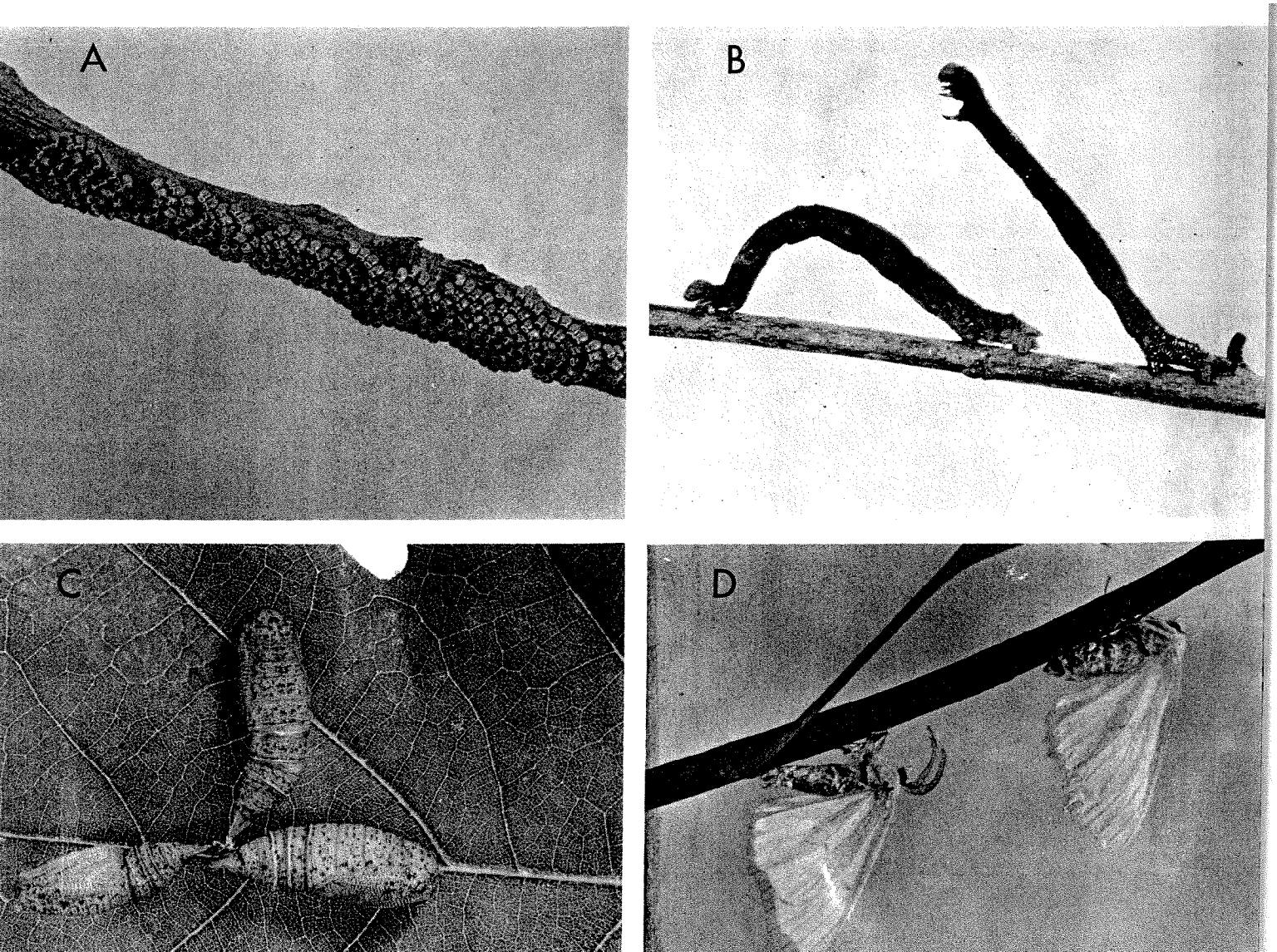
adults is possible. Total production of beetles is high; for every beetle introduced into a bolt 10 new brood adults emerge -a figure comparable to that in nature during epidemic peaks. A yield as high as 1 to 20 has been obtained.

The research possibilities opened up by these various discoveries are numerous and invaluable. Data are accumulating on such facets of the biology and physiology of the southern pine beetle as fecundity, tunnel length, emergence patterns, capability of the female for multiple attack, optimal attack density, optimal bark moisture, and a multitude of quantitative observations which are the by-products of rearing. The information obtained will be employed in studies now underway on the effects of temperature, nutritional requirements, and isolation of attractants — all utilizing and dependent upon the continuous rearing technique.

Elm Spanworm

The elm spanworm is an excellent example that illustrates the need for refined rearing methods. This insect, which has annually defoliated over a million acres of Appalachian hardwoods, has a 1-year life cycle. A few years ago, in response to the urgent need for a good control method, an attempt was made to screen low-toxicity insecticides and disease organisms for their effectiveness against the insect. Quantities of larvae would be needed for laboratory tests during winter and spring, yet efforts to force egg hatch were only slightly successful. Difficulties were encountered in feeding and maintaining larvae; few were reared, little was learned about them, and only inconclusive evaluation of test materials was obtained. Had it been possible to make careful study of the stages of the spanworm egg, larva, pupa, and adult and a

Stages** of **the elm spanworm: A, egg mass; B, Larvae; C, pupae; D, adult.





Stand *deterioration and overstory mortality following spanworm attack* **near** *Conasauga Lake* **on** *the* **Chattahoochee** *National Forest* **in** northern Georgia.

rearing method subsequently developed, the screening tests could have been successful.

In exploratory study to develop a rearing method, four techniques were tried during the past year at our Bent Creek, North Carolina, laboratory. One was successful. A newly hatched larva was carefully placed on a young, tender leaf partly immersed in a vial of water; a tight plastic seal at the top of the vial kept the larva from drowning and also conserved moisture. This setup was placed on a petri dish and covered with a glass lamp chimney. The top of the chimney was covered with muslin to cage the larva and protect it from air drafts which upset its normal behavior. Larvae were fed leaves of only one host — either northern red oak, white oak, or pignut hickory — to determine effects of food on survival, development, and other biological activity.

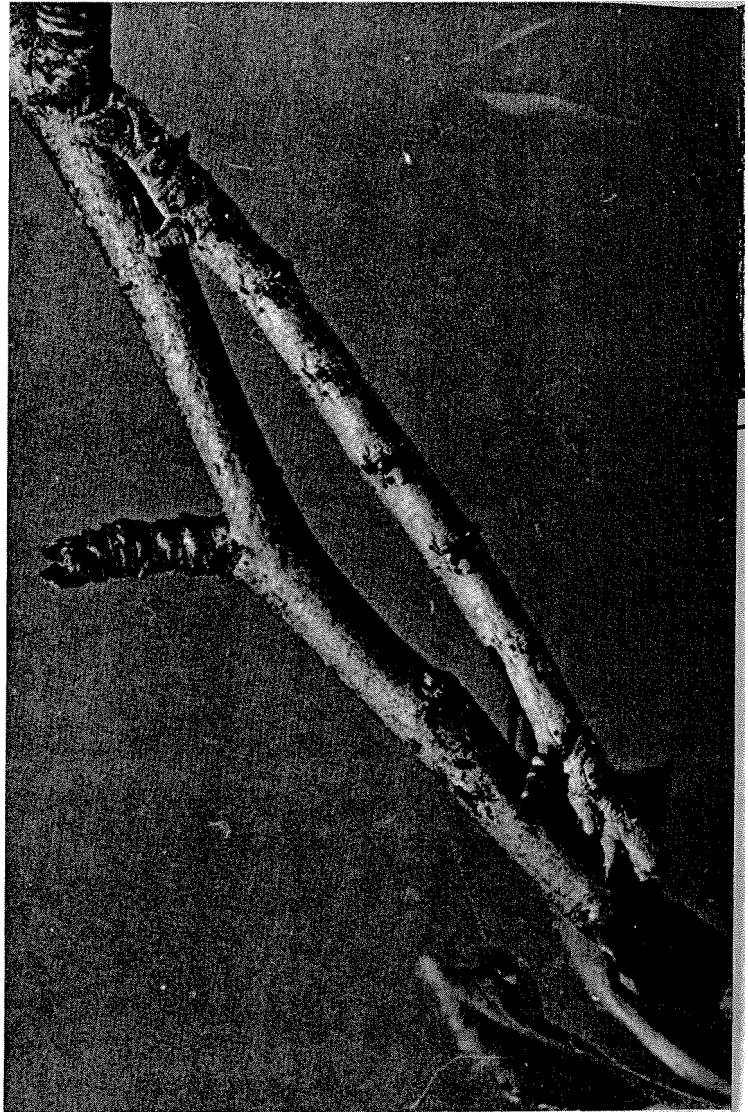
Records on each larva's daily excrement were kept so that we could measure food consumption, duration of each larval form (instar), head size of each instar (to ascertain the number of instars), and the length of the prepupal and pupal periods. The data obtained were prepared for analysis according to the host and sex of the mature moth to determine the influence of food and feeding habits on the ratio of adult males to females developed from the larvae. This information, aside from its theoretical value, could have practical value in predicting population trends, damage, and need and effectiveness of control measures.

The rearing of the spanworm from egg to adult was considered highly successful. While mating of adults in lamp chimneys was not as successful as desired, nevertheless enough eggs were produced to make us optimistic that the information gained thus far will ultimately lead to a mass-rearing technique.

During these studies, as in all rearing studies, many unexpected observations were made that have enhanced our understanding of the insect's biology and could contribute to its ultimate control. For example, it was noted that young larvae failed to feed and died when given white oak foliage. After considerable study it appeared that the heavy pubescence on the back of young leaves might be responsible; larvae seemed to find it difficult to move over the foliage. Later,



Battery of lamp chimney cages used to rear and study the elm spanworm.



An *individually reared, mature elm spanworm larva.*

examination of the gut revealed accumulations of pubescence. It was deduced that larval inability to reach actual chlorophyll tissue of the leaf caused malnutrition and starvation resulting in death. Tests confirmed our deductions. When pubescence was removed, the larvae behaved, fed, and developed normally. Practical use of this information might be made in considering control; whereas heavy egg deposits in a stand would normally call for control, such deposits in a predominantly white oak stand would preclude the need for control measures.

Another observation was of an unusual phenomenon: larvae reared singly were light in color, but those reared in groups were dark. This apparently constitutes protective coloration related to intensity of defoliation, a factor that might conceivably find immediate practical use. But more important, it is another discovery added to the total fund of information needed in developing sound control measures.

Conclusion

The recent progress made in our quest for greater knowledge about insect biology has been far beyond our expectations. Not only have we made significant steps in designing rearing methods, but in the process we have accumulated general and specific biological information in great quantity.

Thus, we are encouraged to envision, in the foreseeable future, profound changes in the prevention and control of forest insect outbreaks. We may prevent outbreaks of certain species by upsetting their biological functions, or by influencing their environment through silvicultural treatment, or by creating conditions favorable for disease and other natural enemies. We anticipate an ability to predict epidemics and when this cannot be done, to control them by biological means or chemical treatment.

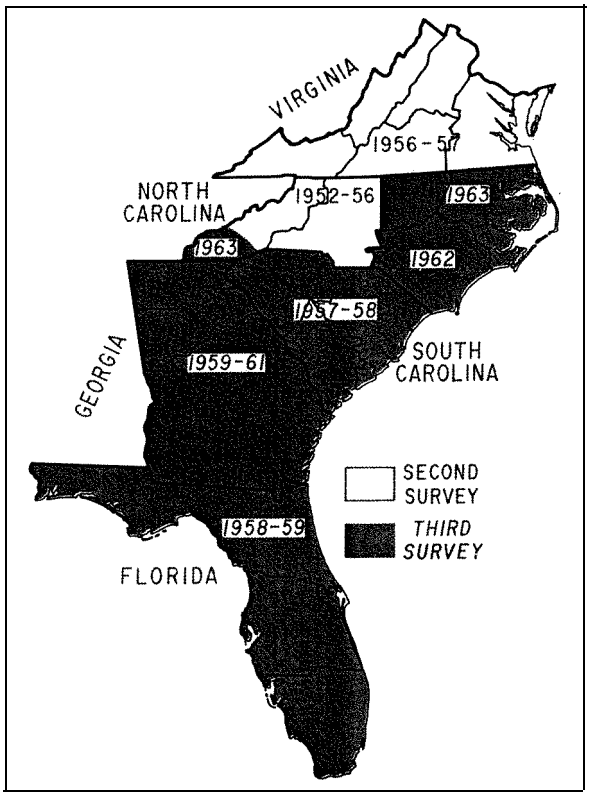


Forest Survey

Georgia Suwey Completed

Perhaps the most important finding covered in the final report of the third Georgia survey released in August 1963 is that, although the forestry picture is improved over former inventories, net growth is expected to remain well below potential unless forest management is intensified. Forest landowners are not taking advantage of the opportunities offered by their woodlands. Other important findings were that commercial forest land occupied slightly more than 68 percent of the total area of the state. Total timber volume is increasing but the upward trend in hardwood volume seems to be leveling off, while softwood volume increased at a faster rate between 19.53 and 1961 than for the earlier period 1936-1953.

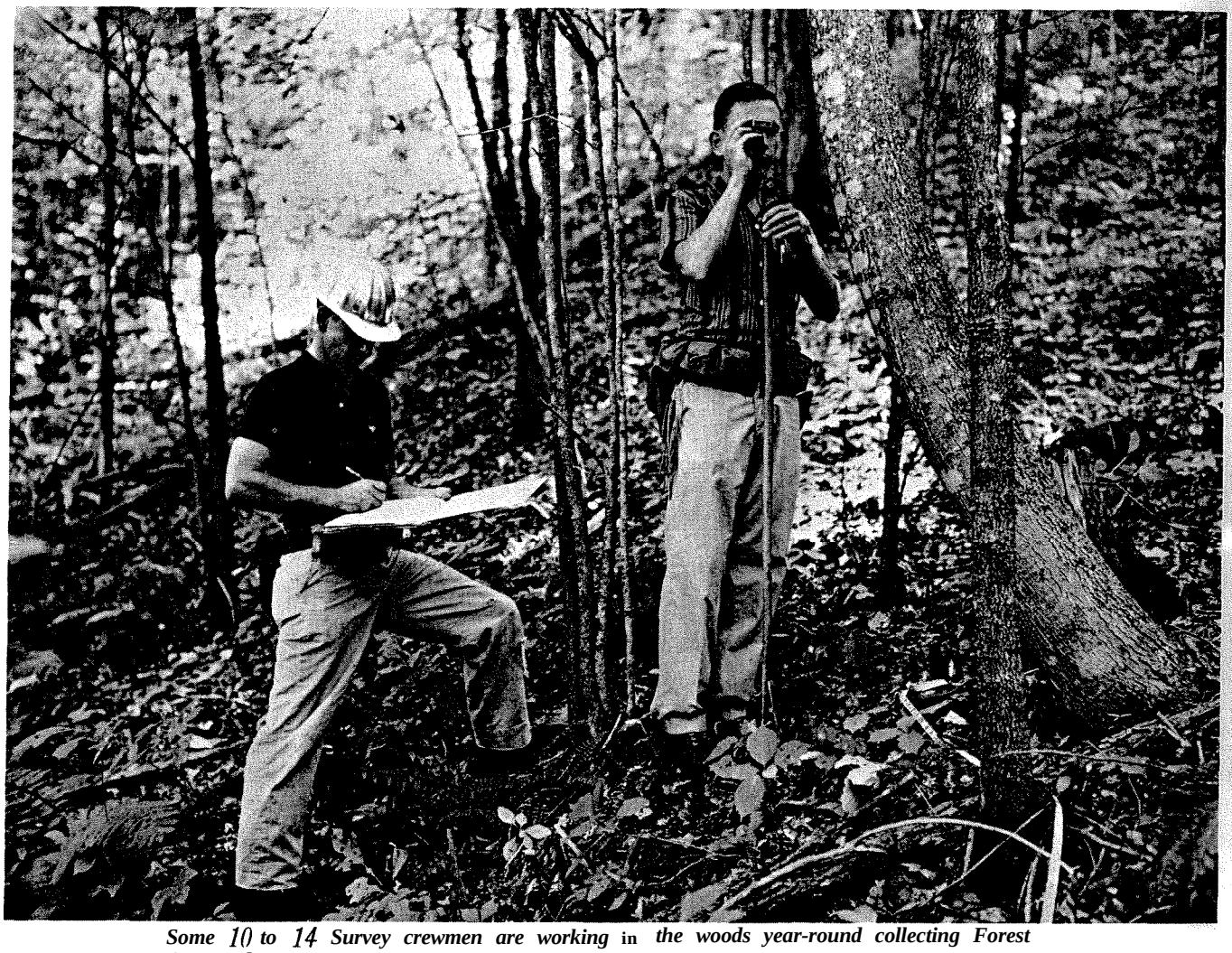
Meanwhile, the margin of softwood growth over cut is increasing. Indications are that this increase will level off. Softwood sawtimber growth, which failed to replace cut by a substantial margin in 1936, now exceeds the cut by 11 percent. Hardwood sawtimber growth, however, currently fails to replace cut. Georgia, a large and important timber-producing state, is highly favored in land and climate for rapid forest growth. It is indeed one of the great pine producing areas of the world. The report brings into sharp relief Georgia's unused growth potential capable of supporting increased forest industry, already the third most important industry in the state.



Three surveys completed in South Carolina, ***Florida, and Georgia,*** give a good ***base for long-term estimates and state planning. Third survey*** of ***North Carolina is well along, with Virginia to be next.***

North Carolina Survey Two-Thirds Complete

Field work on the third Forest Survey of North Carolina, also a large and heavily forested state, is now two-thirds completed and preliminary statistics for the two coastal plain units have been released. Special emphasis is being given the inventory on the Pisgah and Nantahala National Forests. The number of inventory plots in these areas was intensified to meet Forest Service timber management planning requirements. Results of this inventory will be used to prepare a new timber management plan for these areas, including a recalculation of the allowable cut, which is of great interest to timber buyers and wood-using industries.



Some 10 to 14 Survey crewmen are working in *the woods year-round collecting Forest Survey data.*

Gathering Information on Deer Range

In addition, on the Pisgah and Nantahala National Forests an inventory of deer browse production and utilization is being made, by agreement with the National Forests in North Carolina. Deer are among the most important animals hunted in the Southern Appalachians, and although many people think there are deer most everywhere in the forests, the fact is that deer are very unevenly distributed. White-tailed deer are highly localized, seldom in their lifetimes traveling more than a few miles from their birthplace. As a result, there are commonly too many deer for the feed in one place, with few or none to eat the abundant forage elsewhere. The new survey is showing not only where and how much deer food occurs, but where it is being heavily browsed (dense population) or scarcely eaten at all (light population or none). The forest manager must know these things, since the first rule in maintaining thrifty deer herds and good hunting is to keep the herd in balance with the forage supply. The survey is showing badly overbrowsed areas where the herd should be reduced — and other areas of abundant feed with little or no use where deer could be increased.

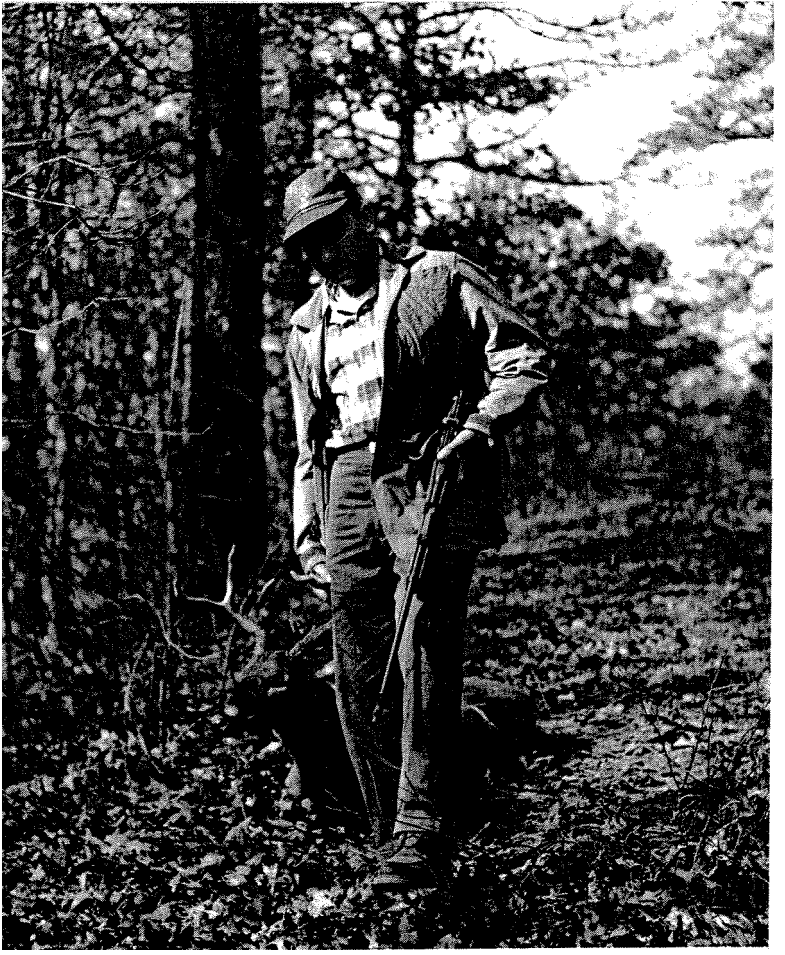


Collecting deer browse data on a permanent Forest Survey plot, Nantahala National Forest. Sprout ***stands such as this produce large amounts of good quality deer browse,*** but on ***this one there are no deer to eat it.***

The survey also provides information on quantity, quality, and distribution of deer browse in relation to forest types, ages, and stand conditions. Such knowledge in turn tells which cutting practices provide the best combination of deer food and tree reproduction. Specifically, we hope to learn where the most valuable deer food plants occur, and what conditions favor and spread them. All in all, the aim is to develop timber management practices that improve deer habitat on occupied range and to find which unoccupied areas are best suited for the establishment of new herds.

Standardized Field Procedures

During past years a number of different field procedures have been used by the various Forest Survey units throughout the United States. This has presented some problems to users of survey data when comparisons of resource statistics between regions were made or when coordination between the various agencies and industries doing field inventory work was attempted. To overcome the difficulty, a set of field procedures common to all eastern Forest Survey units was developed. Forest Survey at the Southeastern For-



Deer population in many parts of the Southern Appalachians could be increased without harm to timber reproduction.

est Experiment Station adopted these field procedures with the start of field work in the Piedmont and Mountain Units of North Carolina. The new standards will be made available to industrial foresters and others interested in inventory work and should assure uniformity of basic concepts and definitions in Forest Survey work as well as comparability of resource statistics between regions. Resource analysts have long expressed their need for such uniformity.

Southern Pulpwood Production Report

Continued cooperation with the Southern Forest Experiment Station and the Southern Pulpwood Conservation Association produced the eighteenth annual report of pulpwood production in the South. The 1962 output of 25.6 million cords set another all-time record. Georgia produced 5.2 million cords, to continue as southern leader for the fifteenth consecutive year. Alabama, with 3.4 million cords, ranked second. South Carolina, Florida, North Carolina, Mississippi, and Louisiana harvested more than 2 million cords each (table 1).

Table 1. --Pulpwood production in the South during 1962, and change since 1961

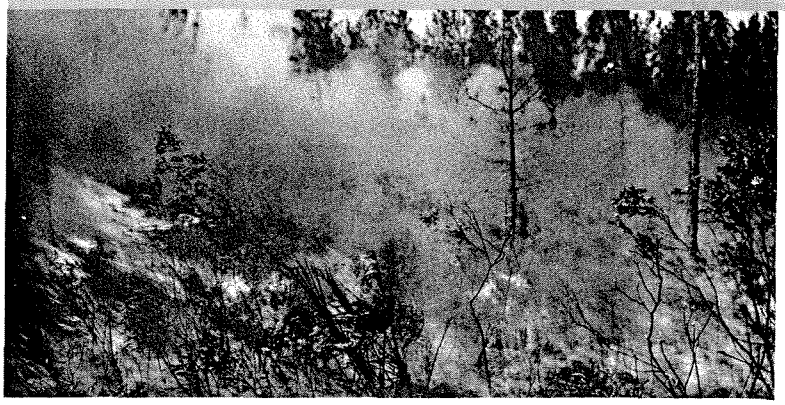
State	Round pulpwood and residues	Change
	Thousand cords	Percent
Alabama	3,448.2	+4
Arkansas	1,729.8	+5
Florida	2,464.5	+9
Georgia	5,217.0	+5
Louisiana	2.006.2	+9
Mississippi	2,100.0	i-9
North Carolina	2,323.9	+1
Oklahoma	59.3	i-47
South Carolina	2,481.5	+8
Tennessee	432.3	+3
Texas	1,429.6	-1
Virginia	1,894.0	+3
All states	25,586.3	+6

The 1962 pulpwood price survey revealed only slight changes from 1961. Average pine prices remained unchanged at $16.55, while hardwood prices averaged $13.40, ten cents a cord lower. The prices paid by point of delivery, including dealers' allowances, were as follows:

PINE (per cord):
- F.o.b. railroad car $16.25
- Trucked to yard $16.20
- Trucked to mill $17.35

HARDWOOD (per cord) :
- F.o.b. railroad car $12.90
- Trucked to yard $12.90
- Trucked to mill $13.85

CHIPS (per ton):
- Pine, f.o.b. point of origin . . . $ 6.55
- Hardwood, f.o.b point of origin . $ 5.10



Forest Fire

A BAD YEAR FOR FIRES, BUT RESEARCH HELPED HOLD DOWN DAMAGE

A dry period in early March following on the heels of a severe winter that killed much understory vegetation led to the buildup of extreme fire danger conditions in the Southeast. Our meteorologists, alert to this buildup, issued special regional weather advisories to the field daily and on request, in addition to the regular fire weather forecasts. Many of the research findings of the past few decades have been adopted by fire control organizations and have helped to prevent fires and to reduce the extensive damage that might occur during abnormal fire periods. Nevertheless, despite the combined efforts of all agencies concerned, the spring fire season of 1963 in the Southeast was disastrous and re-emphasizes the need for even more effective forest fire control measures than present suppression forces provide. In one day only, April 4, more than 12.5 fires burned a total of 185,000 acres in one southeastern state. There is urgent need for better information on how fuels and weather influence fire behavior during extremely dangerous periods, so that men and machines can be distributed and coordinated to the best advantage.

Fire Weather

Low relative humidities have been identified as important indicators of large fire occurrence. During the period 1950 through 19.59, slightly more than 75 percent of 200 fires — each burning more than 300 acres — occurred when relative humidity was 25 percent or less. This led to attempts to discover and describe weather patterns that cause low humidities. We found that one such pattern is a more or less stationary, high-pressure cell attended by strong clockwise winds, clear skies, and large-scale downward movement of dry air from aloft to the surface. This information plus the discovery of other significant patterns will increase a forecaster's effectiveness in predicting the approach of adverse fire weather.

Station personnel contributed substantially to the preparation of a Forest Service Handbook that describes the National Fire Danger Rating System. The mortarboard psychrometer developed at the Southern Forest Fire Laboratory and described in U. S. Forest Service Research Paper SE-S has been adopted by Regions 7 and 8 as a



Many of the 1963 wildfires ***left*** *devastation in their wake.*

means of estimating fine fuel moisture, one of the key elements in this new system. Under development for several years, this method of rating fire danger is scheduled to replace existing systems in most regions in 1964.

Hazard Reduction

Prescribed fires designed to cut down the amount of forest fuels definitely reduce the damage from wildfires. For example, from observations and measurements in the Georgia-Florida flatwoods, we have strong evidence that a carefully planned prescribed fire program can reduce the acreage loss from wildfire by 80 percent. Forest land managers and firefighting forces would have welcomed such a reduction in the spring of 1963.

Research continues on prescribed fire techniques. In both the rolling Piedmont country and the flatwoods, when we are burning experimental plots, strip head fires have been found effective and easily kept under control. Strip firing consists of burning successive strips, roughly 50 to 150 feet in depth depending upon fuels and weather, so that each following firefront stops when it reaches the immediately preceding burned-out strip.

The effectiveness of prescribed fire either for fuel reduction or for the removal of undesirable inferior species depends to a substantial degree on timing. In the especially stubborn palmetto-gallberry type in the coastal plain, we have reduced usual post-burn regrowth and sometimes killed the plants by following the initial burn with a strip head fire in the autumn and within 2 years. Also, in this same fuel type, a herbicide treatment of 2, 4, S-T in midsummer followed by a fall burn shows promise of effective control within a l-year span.

Chemical Fire Retardants

The use of chemical fire retardants most certainly helped to hold down the burn acreage and the damage caused by wildfires during the 1963 spring fire season. Delivered primarily from aerial tankers, both in initial attack and defensive action, chemicals provide an additional fire control tool that is widely appreciated. Developed for operational use by the Southern Fire Laboratory in 1959, ammonium phosphate solutions are being used nationwide by many fire control agencies.

Many technical problems still remain, however. Research efforts in 1963 were concentrated on refinements in the retardant formulation. Although 15 to 18 percent diammonium phosphate (DAP) solutions applied in sufficient quantity are adequate for retarding the spread of most forest fires in the Southeast, some fires require special treatment for best results. For example, when retardant attacks are made in coarse fuels or on crown fires where it is essential that much of the chemical mixture be retained on the aerial portions of the vegetation, thickened DAP solutions are more effective than unmodified solutions. Thickening agents improve the adhesive



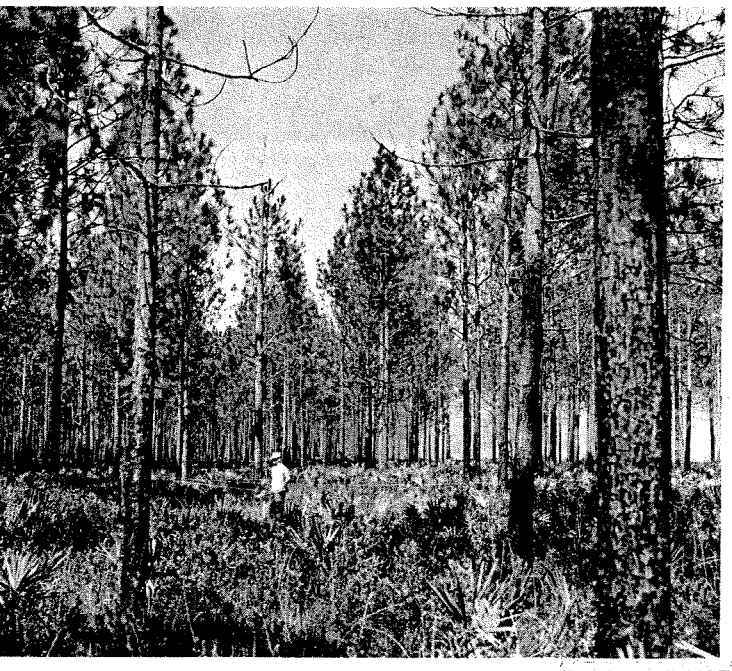
When fuels are allowed to build up in young pine stands, the chances of a killing wildfire are increased many times.

and retentive qualities of DAP solutions, thereby increasing the retardant action against fires. In addition, pigments or dyes in thickened solutions impart color to forest fuels, making application patterns more easily discernible from the air. In contrast, fires in organic soil areas such as those in eastern North Carolina require retardant penetration that is best accomplished by unthickened solutions or those treated with wetting agents.

Bentonitic and attapulgus clays are the least expensive DAP thickening agents evaluated to date. Concentrations of 2 percent produced mixtures thick enough to coat vegetative fuels adequately yet thin enough to allow necessary pumping. The cost was less than ¼ cent per gallon of solution. Jaguar 307, Keltex FF, Polysaccharide B-1459, and CMC 7HS are four industrial gums that successfully thickened DAP solutions at low concentrations, but comparable visicosities cost 3 cents or more per gallon. Hydroxyethyl cellulose and Gel-Guard were the most easily handled plain water thickeners tested, but they failed to increase the viscosities of salt solutions such as DAP.

DAP corrosion problems, although not entirely solved, are no longer considered serious. We know that aluminum and magnesium alloys are affected more than other metals tested. But we have learned that short storage periods and careful flushing of all metal parts following use keep corrosion at a negligible level. No all-purpose corrosion inhibitors have yet been developed. Fire retardant solutions prepared from ammoniated wet-process phosphoric acid show promise because of their relatively low corrosive action.

Liquid concentrates simplify mixing and loading operations. Cooperative trials with the Tennessee Valley Authority have shown that 11-37-O concentrates mix easily with water at a ratio of 1 to 5, yielding an 8-percent phosphate equivalent solution that is performing satisfactorily on wildfires.



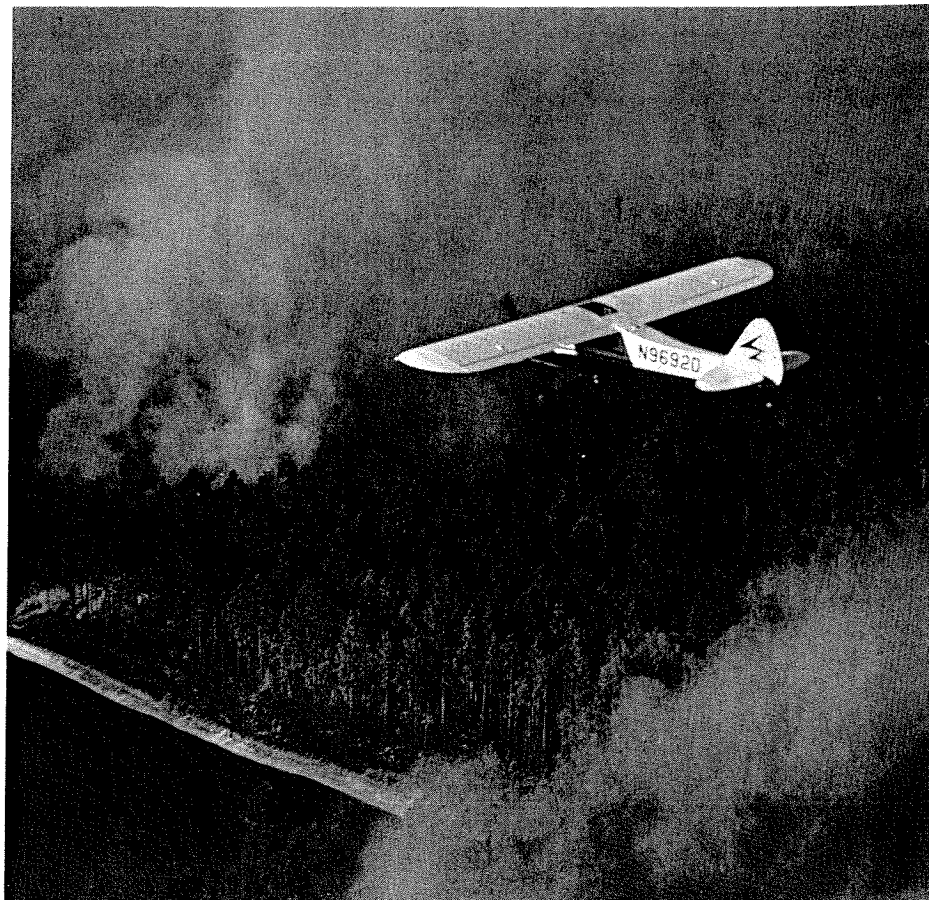
When used within a 2-year period following initial backfires, strip head fire prescriptions result in long-lasting fuel reductions.





Experimental aerial retardant drops in different timber types and conditions are providing some general guidelines for the flying tanker. In dense hardwood stands in full leaf, aerial retardant attacks of 600 gallons or less art: impractical except perhaps in rare crowning fires. When the trees are bare of leaves, tanker loads of 200 gallons or more produce 200-foot-long retardant lines capable of stopping most fires in hardwood litter. Two-hundred-gallon loads are also usually adequate in open areas or in poorly stocked stands of timber. Where fairly heavy pine canopies exist, drops of 400 gallons or more are required for effective action.

The aerial tanker and the chemical fire retardant **will continue** *to help reduce* ***wildfire losses.***



Estimates ***of flame*** *length made* **from** *the air,* **as** *well as observations of the shape and motion of the convection column, may be effective in gaging the retardant load required in* **an** *aerial attack.*



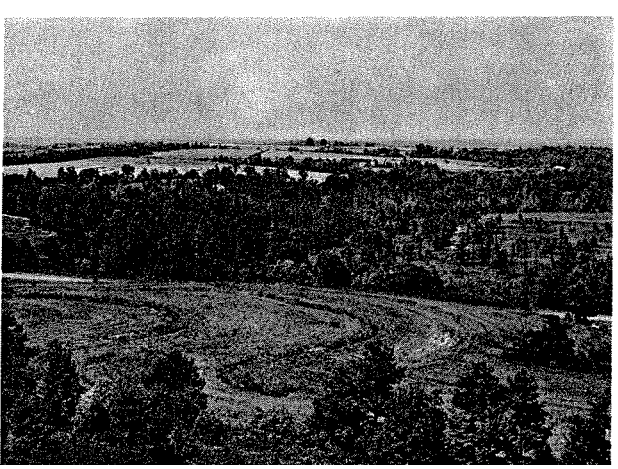
Timber Management

This year most of the Timber Management Research section is devoted to the often neglected Piedmont hardwoods. Also described are some of our tree improvement and naval stores findings. Those readers interested in other aspects will find over 50 annotated titles in the bibliography that are concerned with timber management research.

PIEDMONT HARD WOODS

During 1963 we were able to do two things that we had not been able to do before. One was to use fertilizer instead of repeated cultivation to get planted hardwoods to outgrow weeds. The other was to root and outplant yellow-poplar cuttings successfully. The importance of these findings can be emphasized by a brief review of our hardwood management program in the Piedmont.

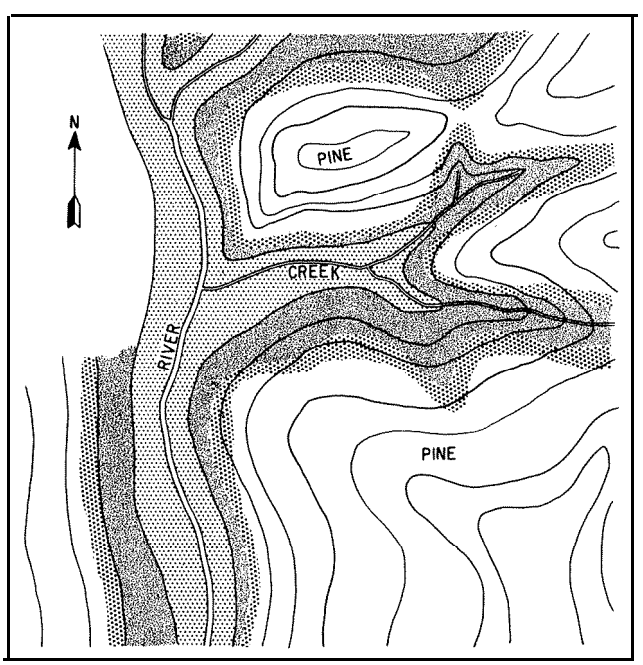
The Piedmont of the Southeast is gently rolling land; it has well-distributed rainfall and is well drained. Two hundred years ago it was described as being incredibly fertile. After two hundred years of misuse and erosion it is a problem area. Much of the land has been abandoned and has seeded in to pine or hardwoods. The old field pine on the upper slopes and ridges dominated the rapid transition from an agricultural to a forest economy. In an economy geared to pine, little attention was paid to the second growth hardwoods. The first step in our research program was to re-examine the land to decide where high quality hardwoods could be grown.



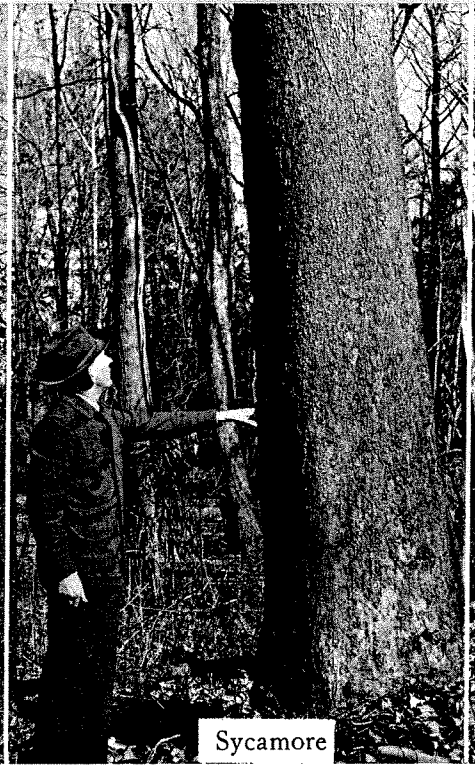
Species – Site Relationships

Topographic position is the most obvious thing that determines species-site relationships in the Piedmont. Some of the best hardwoods are found on the overflow bottomlands along the major rivers and streams. Just above the overflow bottoms are the terrace and lower slope sites. This is also good hardwood land, with a mixture of the bottomland and upland hardwood species.

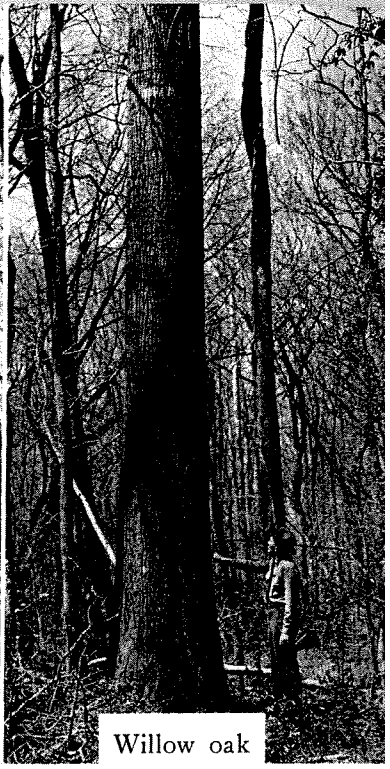
The extent of these sites is controlled by aspect as well as by position. The good sites go quite far up slope on north- and east-facing hillsides, but are quite narrow on the south and west. The middle slope land is a transition zone between the good hardwood sites and the dryer, often eroded pine land on the upper slopes and ridges. Hardwoods will grow on the pine sites, but the quality is poor and the growth rate slow. Pine or hardwood can be grown in the transition zone—management depends upon the condition of the existing stands and needs of the landowner.




Sweetgum


Sycamore

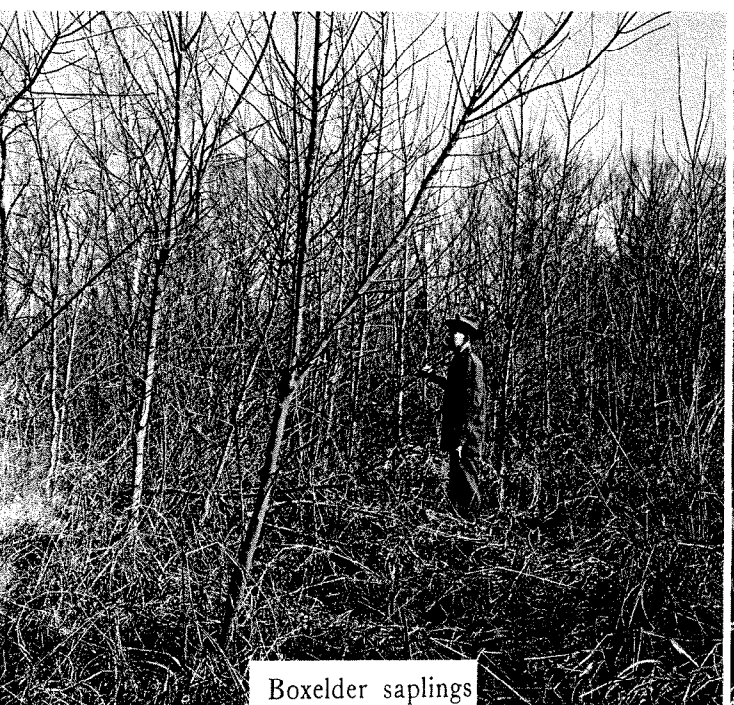

Cottonwood

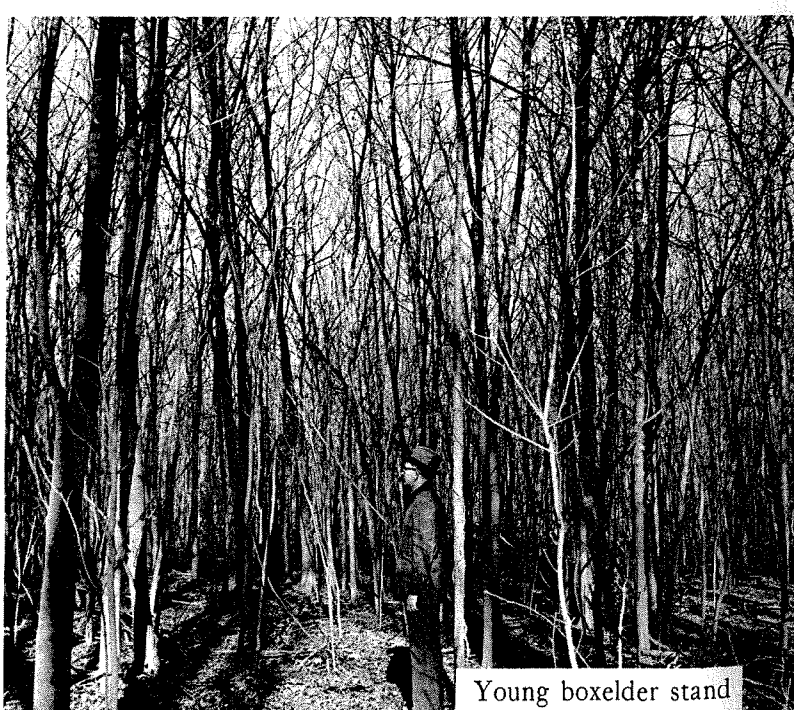

Willow oak

The Hardwood Potential

Despite past abuse of the timber, the hardwood sites are still potentially productive land. Specimen trees can be found that demonstrate both the productivity of the land and the genetic potential of the hardwood species. Sweetgum, sycamore, and cottonwood make rapid, high-quality growth on the bottomlands. Yellow-poplar and oak, in addition to the bottomland species, do well in the coves and on the lower slopes.

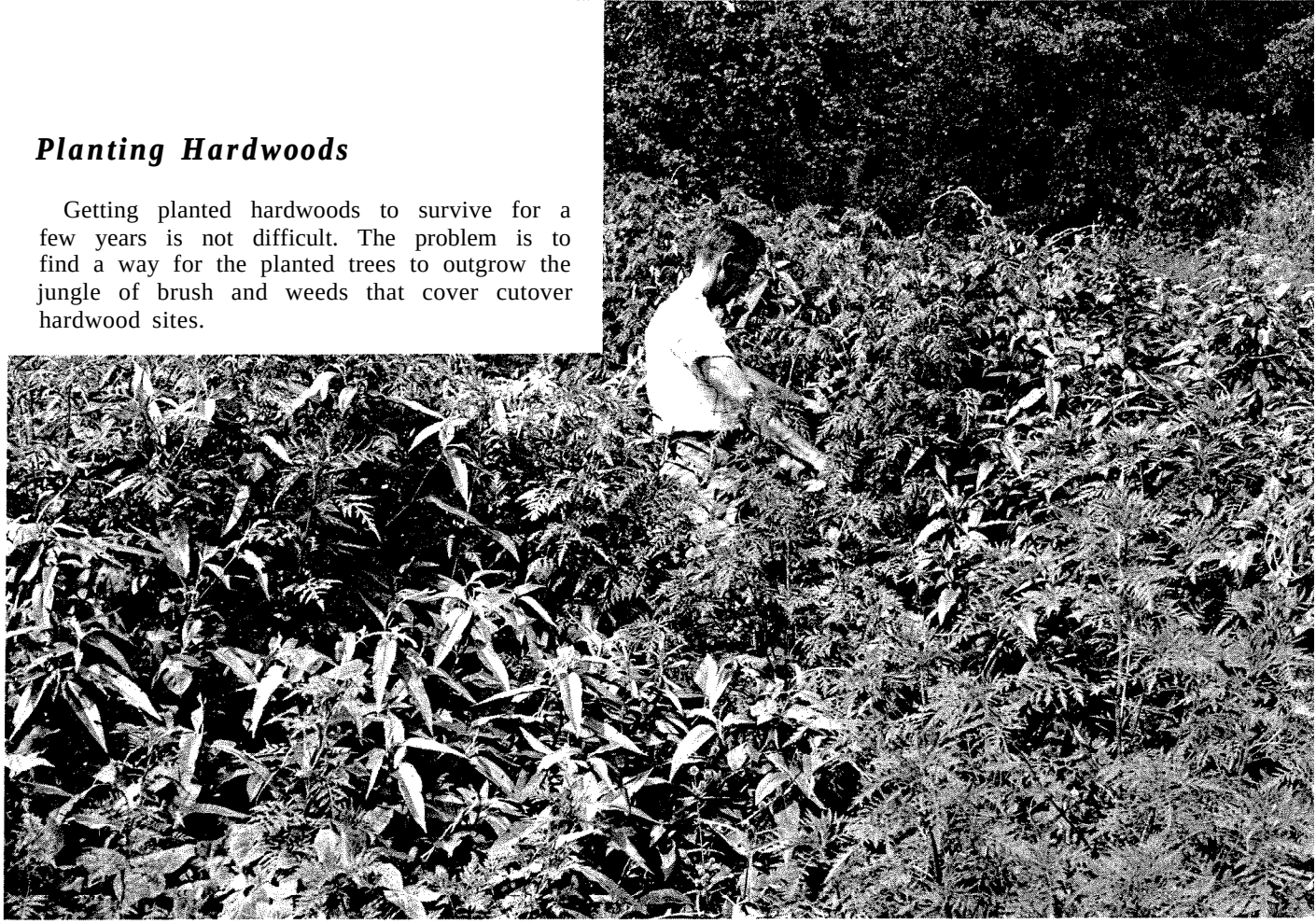
The present stands fall far short of the potential shown by the specimen trees. Most of the stands have been abused; the better seed trees cut, the cull trees left uncut, and inferior species allowed to reseed the area. Boxelder, one of the least promising species, seeds prolifically. The seed are high in viability and are spread by wind, water, and animals. Any time there is an opening, boxelder tends to take over the site, regenerating by the thousands. A few years later we have stands which are very thick, very low in value, and very difficult to get rid of. These stands are worthless and must be converted to better species. Now and then, we have a good seed source and a favorable seedbed, and can convert by cutting alone. Much of the time we must clear and plant.


Boxelder saplings


Young boxelder stand

Planting Hardwoods

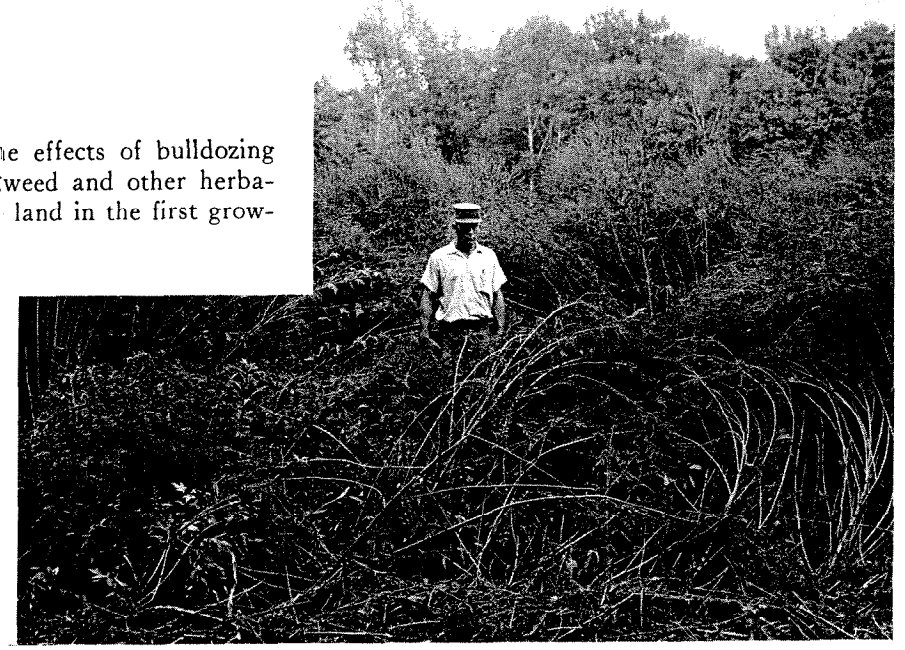
Getting planted hardwoods to survive for a few years is not difficult. The problem is to find a way for the planted trees to outgrow the jungle of brush and weeds that cover cutover hardwood sites.

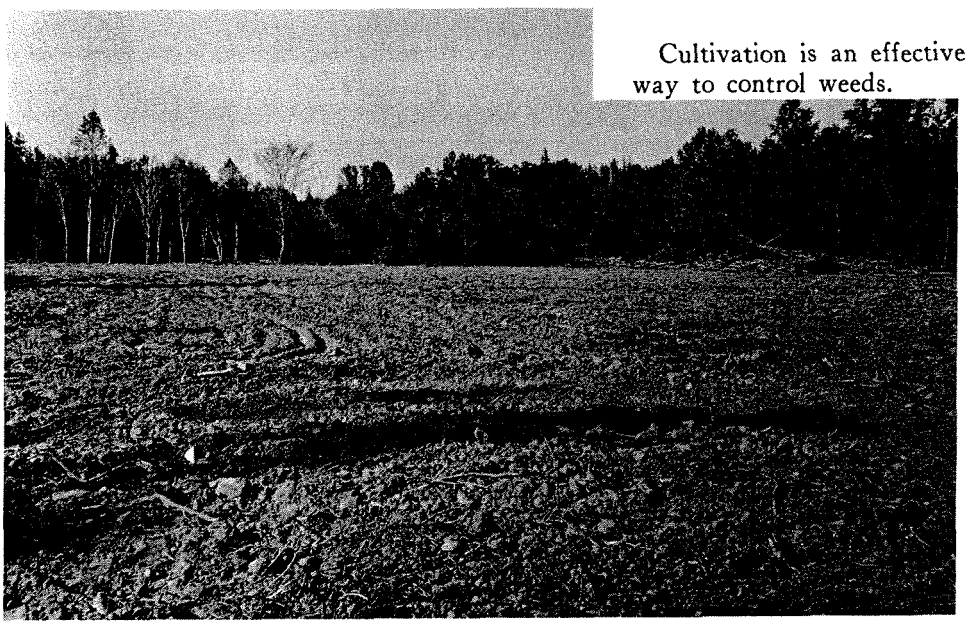


One approach is to clear the site completely by bulldozing to remove all competing vegetation.



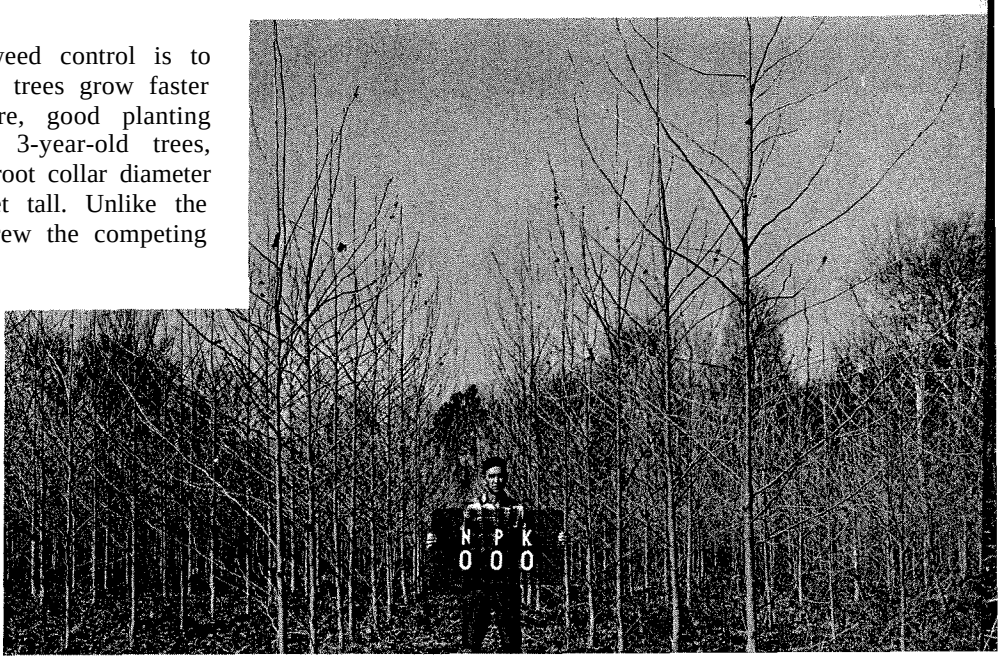
On bottomland sites the effects of bulldozing may be short-lived if ragweed and other herbaceous weeds take over the land in the first growing season.





Cultivation is an effective but quite expensive way to control weeds.

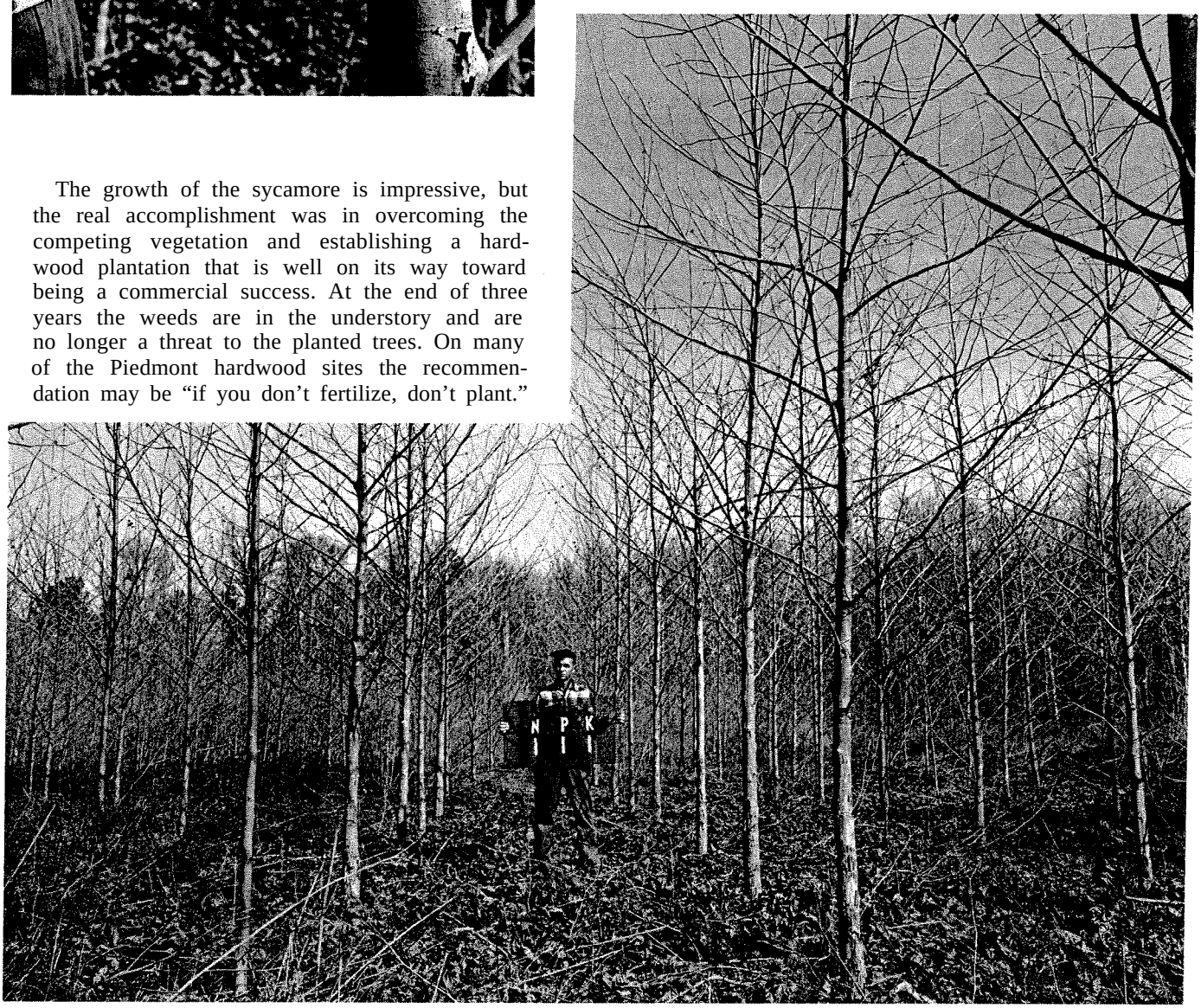
The logical alternative to weed control is to find ways to make the planted trees grow faster than the weeds. For sycamore, good planting stock is one answer. These 3-year-old trees, between 0.41 and 0.50 inch in root collar diameter when planted, are now 17 feet tall. Unlike the smaller stock, these trees outgrew the competing weeds.





Although the use of good planting stock helps, fertilization can provide further gains. This 3-year-old sycamore is 3.3 inches in diameter and 30 feet tall. It is the end result of good site preparation, good planting stock, and fertilization on a hardwood site.

The growth of the sycamore is impressive, but the real accomplishment was in overcoming the competing vegetation and establishing a hardwood plantation that is well on its way toward being a commercial success. At the end of three years the weeds are in the understory and are no longer a threat to the planted trees. On many of the Piedmont hardwood sites the recommendation may be "if you don't fertilize, don't plant."



Rooting Yellow-Poplar

Vegetative propagation-multiplying a selected tree through rooted cuttings-is one of the main tools in a tree improvement program. The ability to control genetic variability completely is also important in studying morphology, anatomy, tree nutrition, and species-site relationships. Cottonwood, sycamore, and willow are quite easy to root, but until recently we have had little success with yellow-poplar. The following note, reproduced from the June 1957 Journal of Forestry, presents the problem very well.

Wanted: A Method of Rooting Yellow-Poplar Cuttings

In extensive tests at Oxford, Mississippi, auxins conspicuously failed to induce rooting of cuttings of yellow-poplar (*Liriodendron tulipifera*).

The auxins were indolebutyric acid, indoleacetic acid, and naphthaleneacetic acid, all applied in a variety of concentrations and immersion periods.

The cuttings were taken from one hundred saplings on the Tallahatchie Experimental Forest. They were made from the tips of lateral branches in the middle and upper crown, and represented 1-, 2-, and 3-year-old wood. Cuttings were made at two dates during the dormant season and five times during the growing season. After treatment they were planted in a well-watered sand-soil mixture on greenhouse benches, and kept under observation for 90 days.

Of 1,650 cuttings, only one rooted, and it was an untreated check. With this solitary exception, no difference could be noted between cuttings that had been soaked in solutions of auxins and those that had not.

Though details of the tests have been published elsewhere[1], the results are summarized here in the hope of stimulating further research. A feasible method of rooting yellow-poplar cuttings would be of considerable practical value. Current nursery production of seedlings is inadequate, chiefly because the seed is low in viability and difficult and expensive to collect.

B. J. Huckenpahler
Southern Forest Experiment Station, Forest Service, U. S. Department of Agriculture

[1]Huckenpahler, B. J. Auxins fail to stimulate rooting of yellow-poplar cuttings. Bot. Gaz. 117:73-75. 1955.



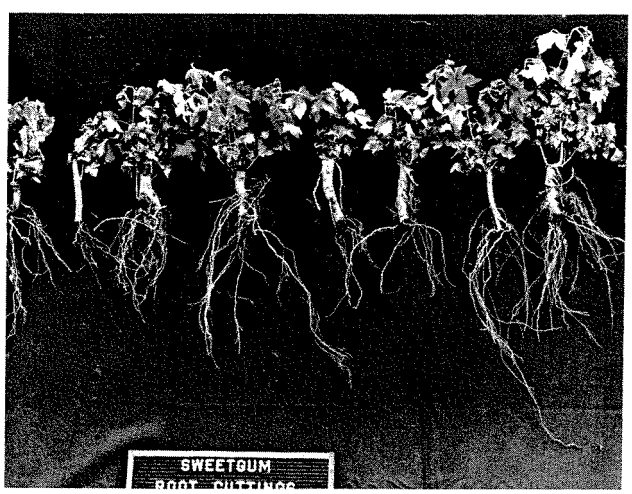
Our results were quite discouraging until we tried cuttings taken from yellow-poplar stump sprouts. Early in spring the stump sprouts were made into cuttings and placed in rooting beds under intermittent mist. In 3 to 4 weeks 80 to 100 percent of the cuttings developed roots.

The amazing thing about the sprout cuttings is their vigor. These cuttings grew 5 to 5½ feet in height in the first 2 months. The few conventional branch cuttings we were able to root were never vigorous. Most of the branch cuttings that do root die within the first year they are outplanted. In contrast, the sprout cuttings continued to grow rapidly after being outplanted.



This clonal orchard contains the first cuttings propagated by our new method. The trees will be allowed to grow until they are 1½ to 2 inches in diameter at the groundline. Then they will be cut and allowed to sprout. We hope to produce from 60 to 100 cuttings each growing season from each sprout. The only limit to production will be the amount of rooting-bed space available. Because of the vigorous growth of these sprout cuttings and the ease of propagation, sprout cuttings may replace the present method of nursery production of yellow-poplar seedlings.





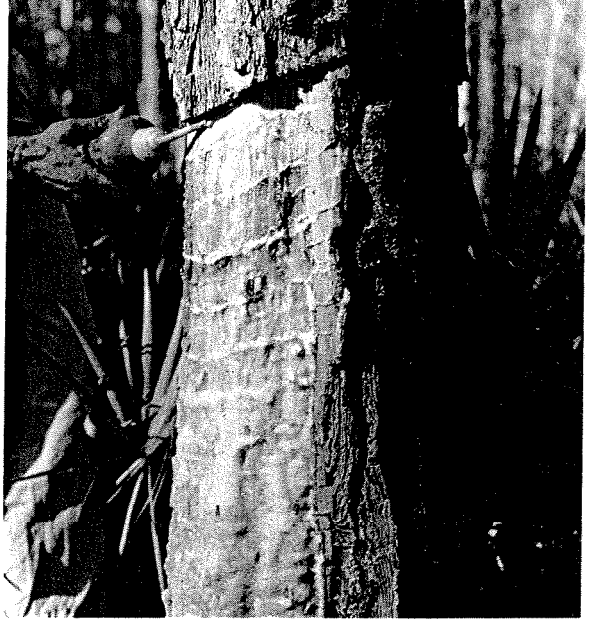
Propagating Sweetgum

The sprout cutting method that worked so well with yellow-poplar did not work with sweetgum. The few cuttings that rooted showed very little vigor. The solution here was to try a rather obvious lead — sweetgum reproduces naturally from root suckers. We found that we could take root cuttings and induce them to bud. We can't grow roots on the stems, but we can grow stems on the roots.

NAVAL STORES

The gum naval stores industry is one of our best customers — new techniques and practices developed by research are quickly put to use. The most striking example has been the use of aqueous solutions of sulfuric acid to prolong gum flow. For more than ten years this technique has reduced costs and increased yields for the industry. Now a new and promising variant may be to use sulfuric acid paste.







On this tree 60-percent acid paste penetrated 3 inches in a 2-week interval in mid-July. If penetration can be controlled, the main benefit may be a longer chipping interval rather than increased gum flow. With the standard aqueous solution, the third-week yield is very low. With paste, about 25 percent of the yield flowed during the last week of the triweekly trials.

To be effective, the composition of the paste must allow proper penetration of the acid into the inner bark. The paste must also be easy to apply and be able to weather periods of moderately severe conditions.

With this narrow-streak technique, developed for use with acid paste, it is unnecessary to remove the in-between bark. The bark on the face later presents a scrape formation problem, but the method may be useful in conjunction with disposable cup and gutter systems.

With paste, only 11 streaks per season were needed to produce the amount of gum yielded by 16 streaks treated with the standard water solution of sulfuric acid. This could mean a 15- to 20-percent reduction in production costs if the paste techniques become operationally feasible. The work is still too new for us to evaluate the effects of the techniques on the vigor and quality of worked timber. Sulfuric acid paste will not be recommended to the industry until we are certain that it is safe as well as effective.

Intensive Gum Extraction

Some producers and timber owners need a practical extraction method that will permit 4 years of work on a single tree yet result in a face height less than 54 inches from the ground. This can be done by using an intensive extraction method for 2 years on the front face and for 2 years on the back face.

The intensive extraction method used 16 biweekly streaks, each streak 1¼ inches in height and treated with 65-percent aqueous solution of sulfuric acid. As a check, the standard method used ¾-inch streaks, 16 per year, treated with SO-percent sulfuric acid. All 4 years of work for the standard method were confined to front faces.

Yields resulting from this Q-year study are shown in table 2.

The intensive front- and back-face work yielded 12 percent more gum in the slash pine plantation and 22 percent more gum in the longleaf stand than the standard method. Of equal importance, the 4 years of intensive work produced a maximum face height of only 40 inches in the slash area and 45 inches in the longleaf area. The standard method of working 4 years on one face produced total face height averaging 60 inches.

Mortality and incidence of insect attack were similar for all treatments.

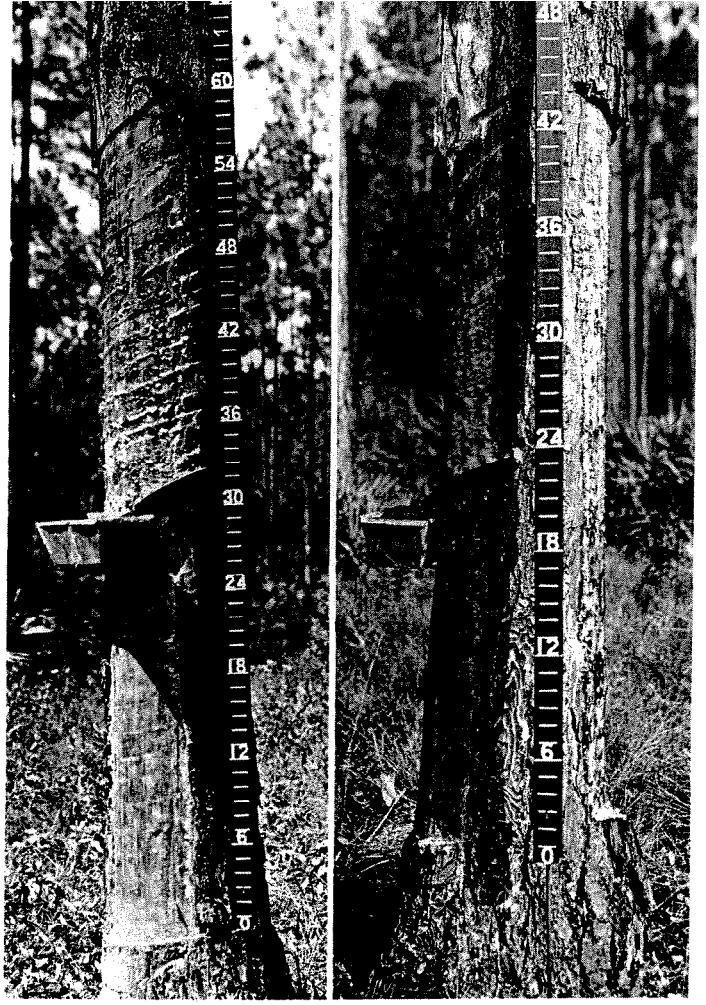


Table 2. --Comparison between standard and intensive methods (front and back face) for slash and longleaf pines

PLANTED SLASH PINE

Year of work	Yield per crop		Intensive standard yield
	Standard front face	Intensive front and back faces 1/	
	Barrels		Percent
First--1959	285	319	112
Second--1960	274	304	111
Third--1961	266	299	112
Fourth--1962	270	307	114
4 -year average	274	307	112
LONGLEAF PINE IN NATURAL STAND			
First	334	402	120
Second	327	385	118
Third	277	336	121
Fourth	254	333	131
4 -year average	298	364	122

1/ The first 2 years of work on the front face; the final 2 years on the back face.

Effect of 2, 4-D on Gum Yields From Slash Pine

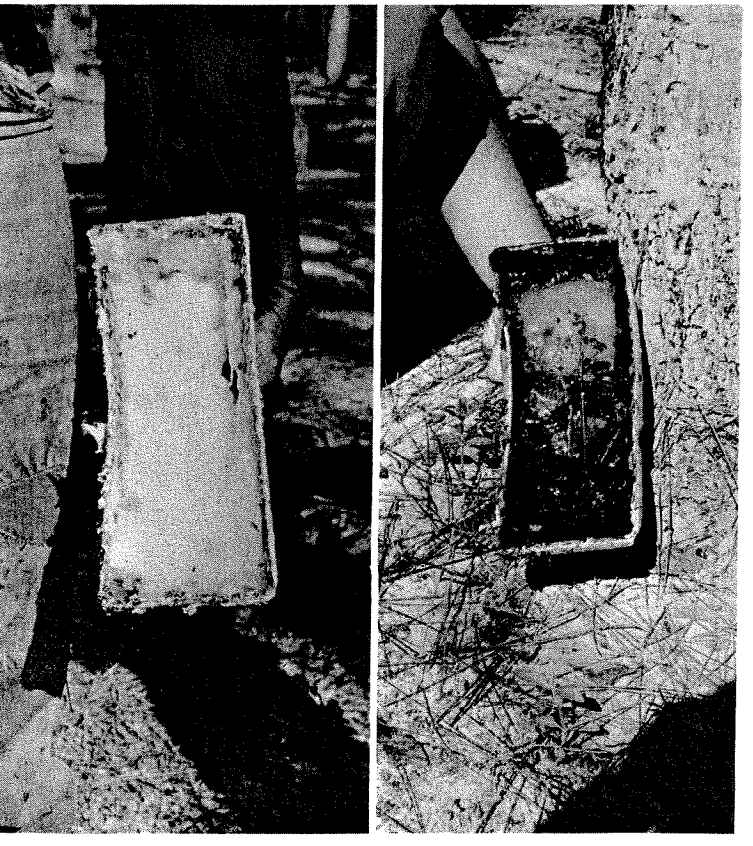
For the past 10 years we have been experimenting with 2, 4-D as a gum flow stimulant. It is noncorrosive and could be better than sulfuric acid. Closely controlled experiments proved that a 2-percent concentration of 2, 4-D in water produced gum flow in slash pine similar to that produced by sulfuric acid. All 2, 4-D treatments tested, however, killed longleaf pine; therefore, 2, 4-D can only be used on slash pine.

Commercial trials were begun in 1960 on two slash pine plantations near Vidalia and Sycamore, Georgia. The study trees averaged close to 10 inches d.b.h., with live crown ratios of 40 percent. A 2-percent concentration of 2, 4-D was tested against the standard extraction method — SO-percent sulfuric acid for a 4-year naval stores cycle (table 3).

After 3 years the 2, 4-D treatment is yielding as much gum as the sulfuric acid. Preliminary examination of the fourth-year yields show the same trend. By adding 2, 4-D to our gum extraction "bag of tricks" we can now produce a better grade of slash gum in the cups and gutters without the problem of acid corrosion.

Table 3. --Comparison of slash pine yields with 2,4-D and standard acid treatment

Test area and treatment	Yield per crop			3-year total yield	Total yield in percent of control
	First year	Second year	Third year		
	Barrels			Barrels	Percent
Sycamore					
2,4-D	243.8	307.5	267.7	819.0	103
Acid	240.4	287.3	267.4	795.1	
Vidalia					
2,4-D	208.9	291.9	256.8	757.6	103
Acid	220.3	275.4	243.2	738.9	



New cups were installed on all trees at the beginning of this study.

After 4 years of use, with 2, 4-D as the gum flow stimulant, the cup on the left is still free of rust and corrosion and the gum produced is free of iron contaminants. By contrast, after 4 years of sulfuric acid work the cup on the right is corroded and rusted, and the gum is dark and cloudy.

TREE IMPROVEMENT

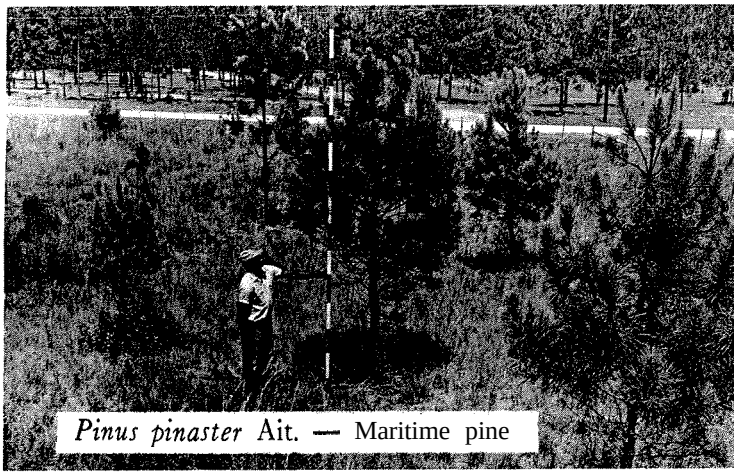
Being human, we tend to emphasize our most striking research results and give little space to the less dramatic but equally important negative results. Carried to extremes, this can leave many blind alleys open to other researchers.

The Olustee Arboretum

The poor performance of exotic pines in our arboretum at Olustee, Florida, has been a disappointing but worthwhile experience. Beginning in 1954, we have tested 67 species or varieties of pines and 7 interspecific hybrids, as well as 28 species of other genera. Only a few of these introduced species have remained alive and are considered active in the arboretum.

Past experiences, both at Olustee and in other parts of the South, indicate that the introduction of exotics in competition with the major southern pines is not likely to produce important results. None of the exotics thus far tested is faster growing or better formed than the southern pines. Most of them are at least as susceptible or more susceptible to insects and disease, and the question remains: Which characteristics of the exotics might be desirable when hybridized with one of the southern pines. On the basis of growth rate, it does not seem likely that an exotic species will be capable of out-producing our highest-gum-yielding species, or the high-gum-yielding strains being developed by intraspecific hybridization.

Although the chances of success are slight, we will continue to test exotic species because the possibility still exists that we may find one that will be worthwhile.



Pinus pinaster Ait. — Maritime pine

Maritime pine is native to the Mediterranean area, ranging from the Atlantic Coast of Portugal and France to Greece in the east, with scattered occurrence in Algeria and Morocco. In Spain, Portugal, and France it is intensively worked for the production of oleoresin. It has been ranked as second only to slash and longleaf pine in world naval stores production, accounting for 22.6 percent or the total output.

In the Olustee Arboretum, ***P. pinaster*** has been notable for its extreme susceptibility to brown spot needle blight. Observations indicate that this disease is probably the greatest enemy of the species. It appears that, given control of brown spot needle blight, maritime pine could survive and grow despite adverse soil conditions and tip moth attack.

Pinus massoniana Lamb. — Masson's pine



This little-known species is a small tree native to southeastern China. It bears a strong resemblance to Japanese red pine, and is worked for oleoresin in Indochina and probably in China. Point of origin was given as Purple Mountain, Nanking, China. Survival has been good, with 20 trees still living in April 1962. The outstanding characteristic of this species has been its precocious flowering; 3 seedlings produced male strobili in the seedbed, and 14 trees produced either male or female strobili the year after outplanting. Repeated damage by tip moth has resulted in poor form and much less height growth than might have developed.

Inbreeding in Slash Pine

The effect of inbreeding in forest tree species is more than an academic question. It is a very real problem to tree breeders concerned with the effects of inbreeding in relation to the number of clones in a clonal seed orchard. If the number of clones is kept small to intensify the transmission of desired traits, the danger of inbreeding is increased.

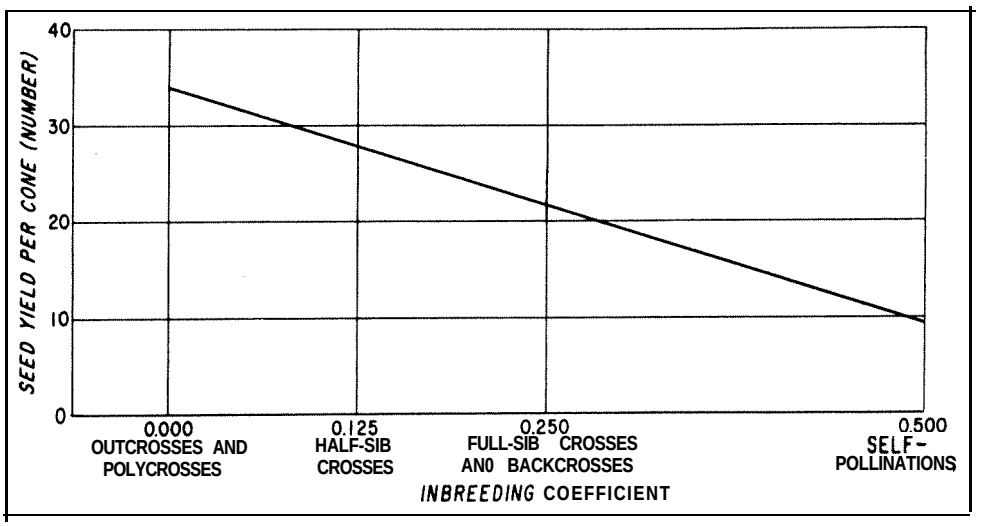
Now that our slash pine breeding project at Olustee, Florida, is 21 years old, we are able to do second-generation breeding. This second round of selection and breeding will further increase the genetic gains and also allow us to measure the effects of inbreeding on the third generation of slash pine.

The results of the first inbreeding studies are quite clear, although the terminology is a bit involved. As the degree of inbreeding increased we found a decrease in sound seed yields, percent and rate of germination, and first-year height growth. Cone yield, relative to the number of flowers pollinated, was not affected. The types of matings and the measures of inbreeding were:

Type of Mating	Correlation *between mates*	*Inbreeding coefficient*
Selfing	1	½
Backcrossing	½	¼
Full-sib crossing	½	¼
Half-sib crossing	¼	⅛
Outcrossing (including polycrossing)	0	0

These results have a direct and practical application to the tree breeding programs in the South. In seed orchards, where we are interested in producing large quantities of seed, the number of grafted trees of various clones will be high. Grafted trees of the same clone may self, but our studies show that they don't do this often; when they do, the seedlings are slow growing and can be culled in the nursery. In other breeding programs we may use inbreeding deliberately whenever there are beneficial rather than adverse effects or when the adverse effects are offset by the gains from intensifying other heritable traits.

These incestuous relationships can be translated into English. Selfing is obvious, backcrossing means that a second generation tree was crossed with one of its first generation parents. A full-sib crossing is a brother and sister affair, and a half-sib crossing is a bit better in that only half-brothers and half-sisters are involved. Outcrossing includes both the socially acceptable practice of mating with a single stranger and polycrossing, the interesting but often frowned upon practice of mating with a number of strangers. As the line chart shows, promiscuity has no apparent ill effects, but inbreeding does lower seed yield.





Range Management

WHAT HAVE WE LEARNED FROM THE CALOOSA ?

It takes real know-how these days to produce beef cattle, pine trees, and quail coveys on a spread of south Florida piney woods range; and this means researchers are going to have to work overtime to come up with many answers. Ways and means of keeping cattle from injuring young pines and of using fire safely in tree plantations pose some knotty problems, as do getting rid of saw-palmetto and upgrading forage and game foods, all under more intensive timber culture. But an overriding question and starting point is how many cattle will this land carry under a given system of management.

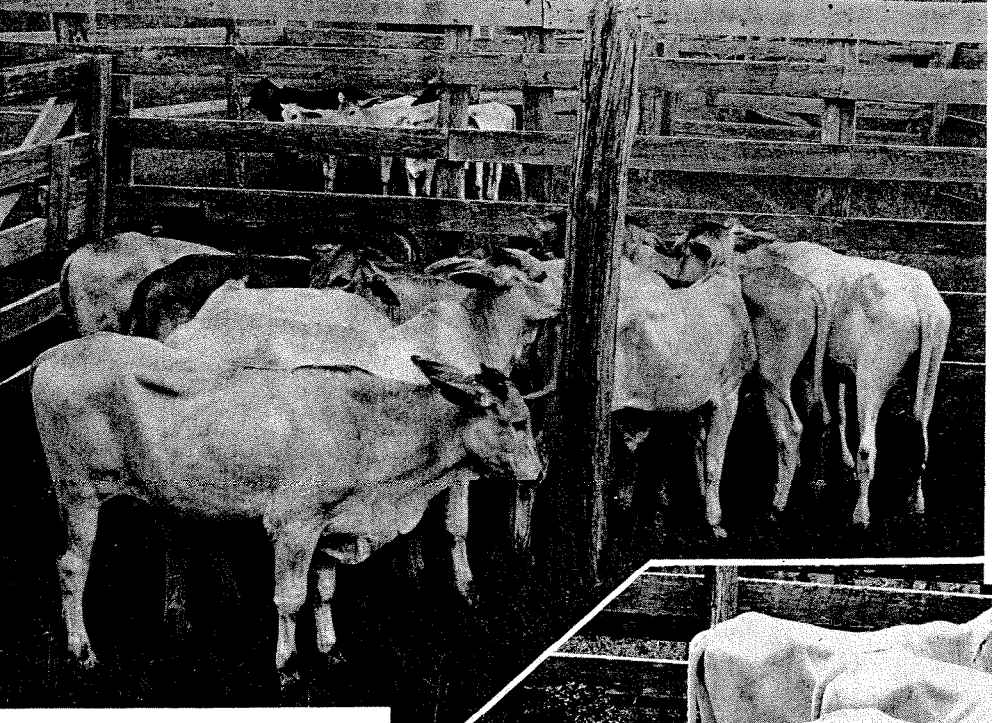
Cattle Stocking For Piney Woods Ranges

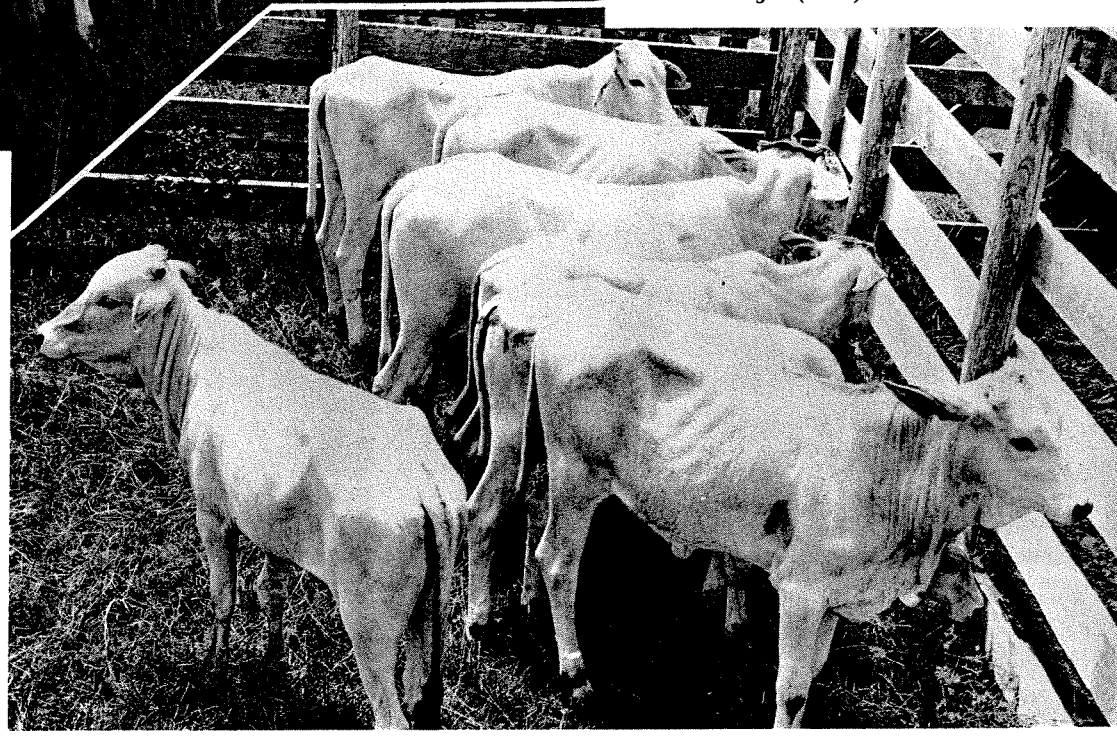
Any ground rules as to proper rate of stocking will, of course, change somewhat with shifts in cattle-timber management as well as with the forage responses of the range itself and knowledge of range requirements. In south Florida, the trend is toward production of better quality cattle; and clearly it will take better management — more careful range stocking and improved feed supplements — to produce the better quality animals. A 6-year study on the Caloosa Experimental Range in Charlotte County points this up and also demonstrates that under three levels of stocking with limited feed supplements, burned (but otherwise unimproved) native range did not supply the quality forage to enable cows to calve in consecutive years. On the other hand, other supporting studies afford good leads that there are effective ways to improve both production and quality of native forage, or in some situations to shift over to new, improved forage species.

The Caloosa study, a first phase of the south Florida work, was started in 1958, when cattle numbers were near an all-time high and proper stocking of ranges was the Number 1 problem in grazing cutover forest land. Twelve native range units of 90 acres each were stocked with cattle to allow 15, 22, or 35 acres per cow per year; and these allowances were adjusted periodically to achieve light, moderate, and heavy degrees of use of pineland three-awn, which is the dominant wiregrass.

A system of rotation grazing was followed, with one set of alternate ranges burned each fall. Six herds of native-brahman cattle were used and they were turned on recently burned ranges in early December. Since experience during a 2-year calibration period showed that protein supplement was needed to carry cows through the fall months, each cow was fed 67 pounds of cottonseed meal pellets containing 41 percent protein from September through November. Measurements and inventories included responses of cows, calves, and native range plants under the three rates of stocking.

During the 6-year study period, calves from ranges stocked at medium or low levels weaned 40 to 50 pounds heavier and usually rated one grade higher than those from units stocked heavily. Calving percentages, however, were quite low: whatever the stocking rate, all cows tended to calve in alternate years and only a few in units stocked at medium or low rates had calves in consecutive years. The calving percentages were 48, 52, and 55 percent for high, medium, and low stocking, respectively. This suggests, as in similar studies on piney woods experimental ranges (the Alapaha in Georgia and the Palustris in Louisiana), that the cows had too little quality feed, particularly during the nursing and breeding seasons. Thus, while 15 to 35 acres of south Florida native range will support a cow yearround, higher supplemental feed rations will have to be supplied to bring calf crops up to profitable levels.





Calves from units stocked at a medium rate ***(upper) weaned 50 pounds heavier than those from heavily stocked range (lower).***

Cattle stocking rate at these levels apparently had little effect on annual forage yield or on condition and trend of range species, although occasionally there was some evident impact of heavier use during unfavorable periods, especially droughts and cold spells. Wiregrass, which supplies 50 to 70 percent of total herbage weight, was little influenced by heavy grazing and indeed its crown coverage declined about 4 percent under light animal stocking. Other native grasses, some of higher year-round quality than pineland threeawn, increased slightly in abundance on the lightly stocked ranges, but not enough to improve calf crops significantly. Accompanying these changes in herbaceous vegetation was a gradual but definite increase in spread of saw-palmetto in all range units.

This study raises some important but hard-to-answer questions. One of these is how do we know when piney woods range is overused, or is in a good or declining condition? Since the dominant wiregrass seems to thrive under quite heavy animal use, we need some new criteria in trying to assess what we have learned in such studies; for obviously the heavy stocking rate will produce more beef and money return per acre than the light rate. Accordingly, judgment on whether the range resource has been impaired under these grazing intensities is likely to be a controlling consideration.

Another question this leads into is what kind of range forage are we trying to produce and maintain? Should management in south Florida continue to be geared to the requirements of wire-

grass range, i.e., frequent burning and heavy grazing. Or should we concentrate on modifying radically the native vegetation, using whatever management techniques there are for improving production of year-long quality forage. Among possible benefits, the latter course might afford practical alternatives to so much use of fire in maintaining nutrient quality of forage, thereby reducing some areas of conflict with tree plantation management.

Caloosa research has clearly documented some of these opportunities. For example, results from an early study, now being verified in a more comprehensive one, show that late winter and spring burns produce two to three times more herbage during the first two months after the fire than a fall burn. Effects of frequency of burning and length of grazing deferment afterward are under study in related investigations.

From other experiments we have learned that a ton of rock phosphate applied to either chopped or unchopped range more than doubles the production of forage and increases nutrient quality many fold. Moreover, this upswing in nutrients has been well sustained — into the fourth year. But perhaps the most dramatic change has been the decline in saw-palmetto as well as a take-over by goober grass and other better quality forage species, brought about by chopping treatment and induced heavy grazing of the fertilized range.

To supply sharper answers, the big Caloosa "rates" study has been revamped under a new phase using six new cattle herds. Beginning in the fall of 1963 the annual protein allowance will be increased from 67 pounds to 120 pounds per cow. Part of this will be fed during the fall, and part during the late winter or early spring just





Saw-palmetto *increased regardless* of *cattle* stocking: upper, 1956; lower, 1963.

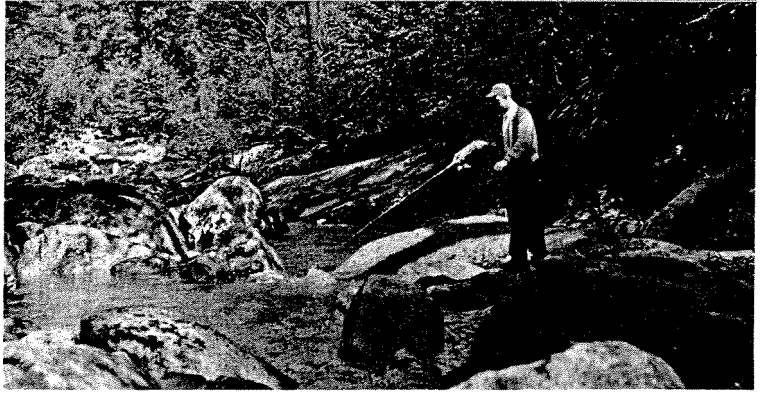
prior to or during the breeding season. In addition, half the grazing allotment will be burned in the fall and the other half in the spring.

Under this spring-fall system, cattle will be rotated to freshly burned ranges in both seasons. This should extend considerably the period when cattle will have access to more nutritious feed. Also, the new experiment will provide an evaluation of rate of stocking and season of burning; and, perhaps more importantly, the interacting effect of these two factors on beef production and native forage.

Other much-needed supporting, studies are planned or under way to provide new standards for appraising range conditions, to guide forage improvement efforts, and to harmonize multiple use production of timber, beef, and game on the same piece of real estate. In the meantime, a guiding figure of 15 to 25 acres per cow is a reasonable standard for stocking typical unimproved range, but the real decisions as to optimum carrying capacity remain about as wide-open as the considerable opportunities for modifying south Florida's forage resources.



Burning in May ***tripled forage production over that produced on fall-burned ranges.***



Forest Recreation

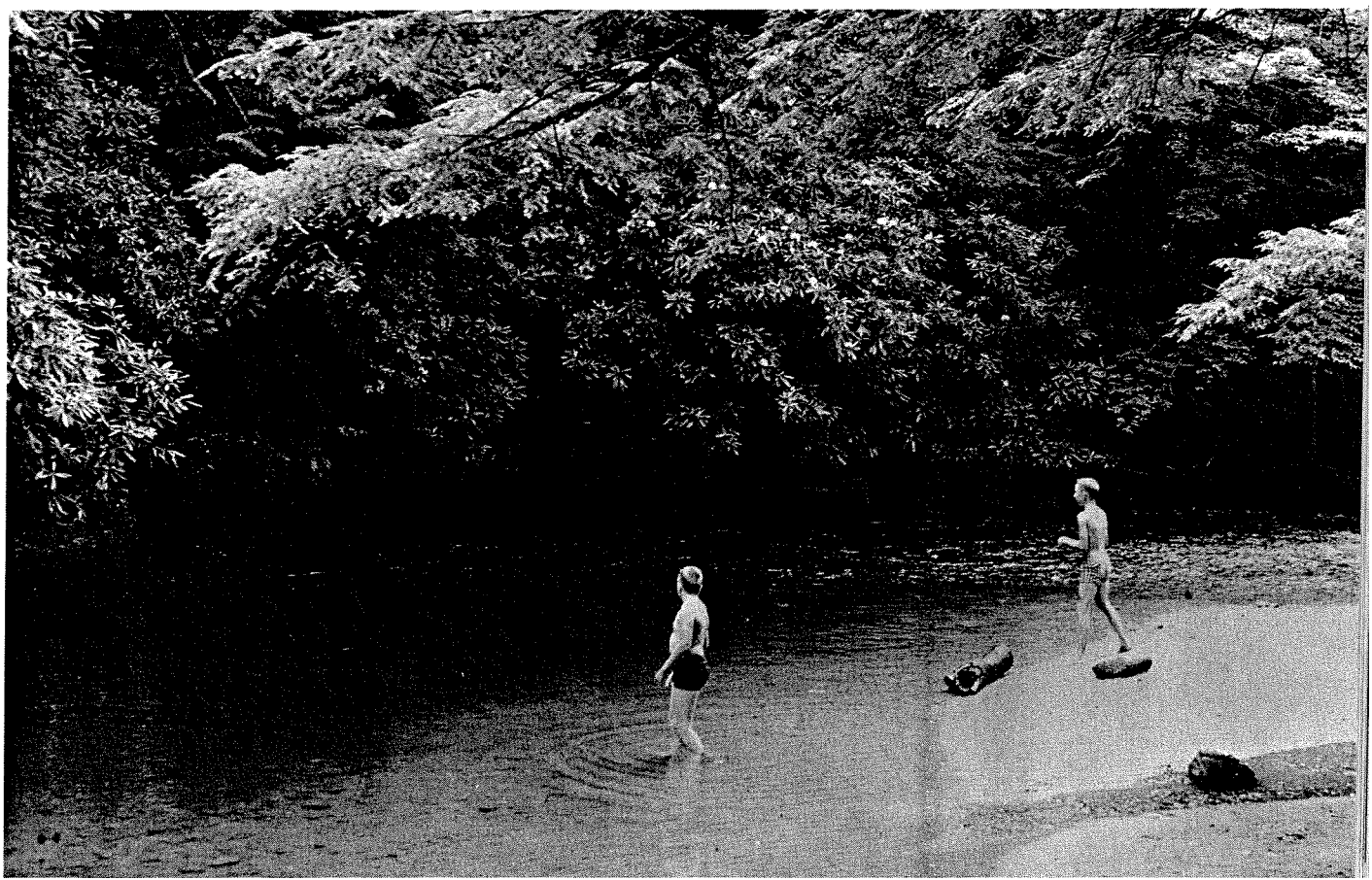
Recreational Use Keeps Increasing

Although forest recreation is a new field of research at the Station, considerable progress has been made during the past year. Important work dealing with problems in campground and picnic area management includes studies of native and planted vegetation, construction of facilities, and consideration of the needs and desires of camper and picnicker.

In 1962 we reported progress in the relatively unexplored field of recreation use measurement. This research has been expanded and we are now successfully pilot testing sampling procedures which will yield estimates of all kinds of recreation uses on the Ocala National Forest, in Florida, and on several campground and picnic areas throughout the Southeast. During approximately the first 120 days of sampling on the Ocala, from April 1 to July 27, 1963, over 11 million man-hours of recreation use were estimated.

Alternatives

The alternative opportunities for land or water use that confront the forest manager are of great concern. He needs a better scientific basis for decisions. To this end, research to determine the alternative recreation benefits from flowing streams vs. impoundments is being planned. The types of camping facilities best suited for remote areas, and what people think about these and other types of improvement are also important areas of study.





Big game bunters spent over 1 billion dollars in pursuit **of** *their sport* **in** *1960. Frequently their camps are quite elaborate.*

Hunting

Less spectacular but no less important is research aimed at providing expanded or improved opportunity for hunting and fishing — major types of forest recreation activity. In 1959-60, for example, 38 percent of the people in the United States fished and 17 percent hunted at least once, and participation in these activities was higher in the South than anywhere in the country. The picture is especially startling for big game, largely associated with forest areas. This type of hunting now provides recreation for over 6 million people in the United States each year. These hunters come from all walks of life, from big cities, from rural areas. In 1960 they spent approximately 1/3 billion dollars and almost 40 million days in pursuit of their sport. By the year 2000 probably twice as much time will be spent hunting big game.

Because the white-tail deer when left unchecked can cause extensive damage to browse plants and young trees, the study of ways and means of providing full utilization of surplus deer numbers has been given high priority in the Station's

recreation research effort. A little-understood but key element in this problem is the fact that a white-tail deer in its lifetime usually travels no more than 4 or 5 miles from its birthplace. Often an overpopulated herd starves in its valley though there is abundant feed beyond the ridge. This spotty, pocketed condition is a common problem on National Forests and private lands. With too many deer here and too few there, it is important that hunters thin out the overpopulated pockets.

Roads and Trails for Hunters

In order to reduce damage to valuable timber and range resources, hunting pressure must reach all of the herd to insure a good harvest throughout a range. Good access, including forest roads and trails, can result in uniform deer kill, and would probably reduce hazard to hunters by better distribution of pressure. The question facing the forest manager is how much, where, and what kinds of access should be provided.

In order to gather information on the use of roads and trails by successful deer hunters, we set up a cooperative study with the North Carolina Wildlife Resources Commission and the U. S. Fish and Wildlife Service. State Wildlife Commission personnel plotted deer-kill locations on the Uwharrie Game Management Area in the Piedmont and 13 western North Carolina Wildlife Management Areas in the mountains during four hunting seasons, 1959 to 1962. All successful hunters were assisted in plotting kill locations on small-scale compartment maps. The distance between some 4,100 deer-kill locations and the nearest road, trail, or trail-road combination was then measured and examined by U. S. Fish and Wildlife Service cooperators and Station personnel.

Access on these wildlife management areas generally seemed to provide an opportunity for reasonably uniform hunter distribution. Roads and trails were so located that a hunter could not travel very far cross-country without encountering some type of access. Largely because of good routes, most deer were harvested close to roads or trails. For example, approximately 40 percent of the Wildlife Management land area

A good network of well-spaced roads and trails is necessary to permit ready access into all areas by vehicle, and relatively easy penetration into remote sections by foot.



checked in both the Piedmont and mountains was within 300 feet of the nearest road or trail, and 63 percent was within 600 feet.

Important differences were found, however, between game management areas on the Piedmont and in the mountains. Despite the similarity in road and trail systems, hunters in the Piedmont apparently stayed closer to roads and trails than did mountain hunters. On the Uwharrie they killed approximately 81 percent of their deer within 600 feet of the nearest access route, a zone containing 64 percent of the land area. Hunting pressure diminished rapidly beyond 600 feet, with only 19 percent of kill scattered over the remaining 36 percent of the land area. No deer were killed beyond 1800 feet from road or trail.

In contrast, hunters in the mountain game management areas appeared to be more uniformly dispersed. Here they harvested 54 percent of their deer within 600 feet of the nearest access, a zone containing 62 percent of the total acreage. In addition, the zone from 601 to 1200 feet, which contained 22 percent of total area, yielded 30 percent of the kill; and the zone from 1201 to 2400 feet, containing 14 percent of the area, accounted for 14 percent. A few deer were killed more than 2400 feet from the nearest road or trail.

We believe that differences in hunting habits between urban and rural hunters account for the differences between Piedmont and mountain findings. According to local game managers, the Uwharrie is heavily used by hunters from nearby cities, whereas a large percentage of hunters in the mountain areas are rural residents who spend much of their lives out of doors.

The results indicate that the access system on the Uwharrie may not be adequate for the most effective kill distribution, and that additional roads, or especially trails, may be desirable there. On the other hand, in the mountain areas, with a much more uniform kill distribution, we suspect that present access is entirely adequate, and we may even have more roads and trails than we need. These findings point out that effecting uniform distribution of hunting effort may entail more than simply close placement of roads and trails. Plans for access development should be based on a study of visibility, terrain, and type of hunter.

Perhaps our most important finding was that roads and trails were apparently about equally important in obtaining uniform kill. Consequently, where increased access is obviously needed in other forest areas, the construction of additional trails rather than roads should be considered. Good trails, though certainly not inexpensive, are much less costly than roads to build and maintain, and frequently they are much more desirable aesthetically. Trails built into areas where greater deer harvest is desired should be well marked and should be located so as to utilize existing road networks.

Research to find ways of providing full recreational benefits from fish and game resources to meet the sharply increasing demand for outdoor recreation is being continued and expanded. The study reported here dealt with successful deer hunters only, but we are now developing plans to examine the hunting patterns of all deer hunters. Small game resources also provide an important source of forest recreation and we are directing effort to study the activities of squirrel and grouse hunters. Similar emphasis will be given to fisheries resources.



Wildlife

QUAIL — A VALUABLE PINEY WOODS RESOURCE

Demands for fish and game are mounting in the Southeast. Receipts from shooting rights alone more than cover tax costs in some areas; and many owners are creating public good will by allowing hunting and fishing on their lands. Accordingly, the Station's wildlife habitat research has focused on requirements for getting maximum wildlife production on commercial timberlands under intensive management.

Each major forest type has its own set of problems and opportunities, but few areas have a greater potential for game production than the piney woods of the coastal plain. Here the bobwhite quail is king. This principal game bird on vast acreages of valuable pine lands is often thought of as an inhabitant of farms and fields, but it has demonstrated its ability to thrive in the woods, and in woods under intensive pine management. Vigorous and repeated disturbance in the forest understory, including reduction of

Improved public relations is a major ***benefit derived from quail bunting on large*** commercial acreage.





Controlled burning in this area produced over 14 pounds of partridgepeas per acre — a favored quail food of the piney woods.

"rough" by fire has long been recognized as the key to quail management in the piney woods. Controlled burning in fully-stocked pine stands has repeatedly produced spectacular quail increases, largely because it increases seed production of the understory plants. Indeed, the quantity of sound, palatable seed available to quail over winter on any unit of range of appreciable size will control, to a large extent, the number of birds available for breeding purposes and for shooting. Native legumes, especially, respond to understory disturbance; and fire increases both number and vigor of these key food plants.

Important studies are under way cooperatively with the International Paper Company to provide better understanding of the environmental relations between site, tree overstory, stand management practices, and the occurrence of quail foods. A first need in this field was to identify easily-measured habitat characteristics and develop sampling procedures capable of detecting small but often critical changes induced by experimental treatment. Measuring ground supplies of seed offered a key.

The first study was installed on the International Paper Company's Southlands Experiment

Forest near Bainbridge, Georgia, during the late fall and early spring 19621963. Two areas believed to have extremes in seed production from low-growing legumes and grasses, especially partridgepea (*Cassia fasciculata*), were used to determine the feasibility of soil sampling as a means of measuring seasonal and area differences in seed supplies for quail. One l-acre test plot 1 by 10 chains in gross dimensions was located in the area appearing to be a heavy producer of quail foods; and a similar plot was established in an area producing little palatable seed. Sixty locations in each plot were sampled in November; and 20 locations in the heavy production area were used to estimate available seed in May. Eight soil samples 3 inches in diameter and 1 inch deep were taken at each location to provide 56.5 cubic inches of soil for seed extraction. Samples were screened and cleaned to remove all litter and soil. Two groups of seed were sorted, counted, and weighed: sound partridgepea, and all other.

This work showed that a composite sample of eight to ten 3-inch plots covering a total of 55 to 70 square inches probably constitutes an optimum size of unit sample. Although seed was locally highly variable, variation was rather consistent over the test acre, and a fully randomized location of plots probably was the most efficient way of estimating seed supplies. Based on variation in test plots, it was also determined that we could detect differences of 50 percent or more between similar test areas by the use of only 12 samples.

There were interesting differences in seed supplies. The fruitful area produced more than 18 pounds per acre, of which about 14 pounds was partridgepea. The poor area produced about 2 pounds, of which less than one was partridgepea seed. These differences were probably due to tree overwood density, with a much heavier production of seed in the well-stocked longleaf stands. Burning history also may have been important,

Samples from the upper inch of piney woods soils provide a good estimate of important ground supplies of seed.



although both areas had a similar fire history. These relationships are not simple, however, since grass competition or other associated factors may be involved.

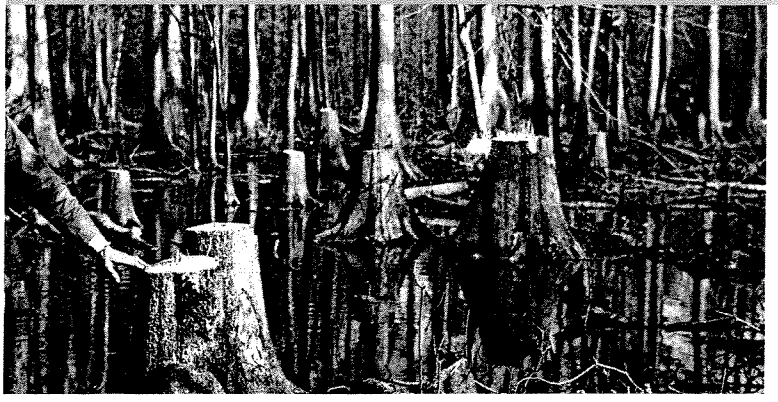
The decrease in seed supplies between November and May was also noteworthy, especially for partridgepea, which declined from about 14 to less than 6 pounds per acre — probably consumed by quail and other animals.

Supplementing these studies in measuring seed production, the cooperative work has been expanded to studies of environmental factors that affect seed production of important quail foods, centering on partridgepea. First attention has been given to the effects of shade as a single factor. Plastic shade cloth of several densities is being used in nursery plots containing planted partridgepea seedlings. The effects of grass competition, moisture, and other factors will also be examined in this complex.

Study of individual environmental factors should provide much better understanding of reasons why the plants respond as they do to various land treatments. Collectively, this work will afford practical guides for adjusting timber management programs to increase quail numbers in pine stands of the coastal plain. There is no question that quail will respond to disturbance, especially burning. We are now seeking ways to obtain a maximum quail response at least cost.



The effects of artificially prodwed shade on planted partridgepea plants are being studied in nursery sites.



Watershed Management

THE WETLANDS– WATERSHED MANAGEMENT3 NEW FRONTIER

Mention watershed research and it immediately suggests experiments on mountain catchments as featured at the Station's Coweeta Hydrologic Laboratory and reported for many years in our annual reports. Yet our new wetlands research at Charleston, South Carolina, is showing that opportunities and need for better soil and water management are just as great in the flat, waterlogged coastal plain forests as in well drained upland elsewhere in the Southeast. Indeed, water management of sorts is now a practical reality for large forest acreages in the low country, and the tempo of activities and interest in this work is increasing rapidly.

The wetland forests — about 20 million acres in all — stretch more than a thousand miles along the lower coastal plain from the James River in Virginia to southern Florida. The vegetation of these forests, the soils, the wildlife, and even their uses reflect the hydrology of this vast watery domain. The wetlands are the headwaters for countless streams and lakes, as well as the recharge areas for huge groundwater reserves which provide a fresh water buffer against intrusion of salt water into coastal plain water supplies. Moreover, they serve as water storage



At ***left of*** *ditch, controlled drainage in this large bay improved* ***forest productivity*** *and accessibility.*

sites for impoundments serving irrigation, fish and waterfowl management, hydropower production, and sundry other human activities.

Inherent wetness sets these areas apart from other forest lands and makes their management difficult. Some, though drowned much of the year, dry out surprisingly during certain seasons. Getting rid of the water is not necessarily a solution; for although some tree species respond to this change, others-both pines and hardwoods— produce top growth on some of the wettest situations. In any event, changing water relations through drainage, impoundment, or other means will surely modify the whole wetland environment; e.g., productivity of the soil for timber and other wood products; the groundwater levels including the timing and amount of streamflow and the hydrology of surrounding areas; and, the forest habitat potential for fish, waterfowl, and other wildlife.

More than a million acres of wetland forest has already been altered by drainage since 1950, and the end is nowhere in sight. Much of this work has been done by wood-using industries and government agencies; and most drainage features have been a byproduct of dredging operations to get spoil for building roads into wetland areas. Although the immediate aim is usually to facilitate logging and open up land for management, the opportunity to upgrade soil productivity is also a strong consideration.

A typical forest industry operation may involve construction of about 30 miles of main ditches and laterals on some 10,000 acres each year. Most of the ditches are dug along the lower, wettest areas to reduce construction costs, which depend upon the amount of clearing, size and spacing of ditches, and number of water control structures. Ditch design is usually based on farm drainage experience and hydrologic calculations which provide for comparatively slow rates of water removal because the trees can tolerate some flooding. However, where extra spoil for access roads is needed, the excavation often produces ditches much larger than they need be for water removal. Costs of the road-ditch systems may be as low as 6 or 7 dollars an acre, or they may run much higher, but they usually are well within the amounts owners estimate they can afford to spend on this type of improvement.

Accordingly, some forms of water management, however crude, are assured in wetland forests, if for no other reason than that ditching and road building open up boggy areas once accessible only by foot, boat, or swamp vehicle. Unfortunately, the pattern and effectiveness of drainage is geared to road access needs and rule-of-thumb procedures, with such critical questions remaining as: What are the peculiar water relations of wetland forests and how can they be modified? What unique properties and physical characteristics of wetland soils affect water movement and in turn are affected by it? What are the varying soil and water requirements of forest trees? And what are the management alternatives, particularly those which may improve wetland soils, yet conserve local and regional water supplies? Some answers to the first three questions must be obtained before much can be done about the fourth; hence they are priority phases for research attack in the Charleston, South Carolina, project.

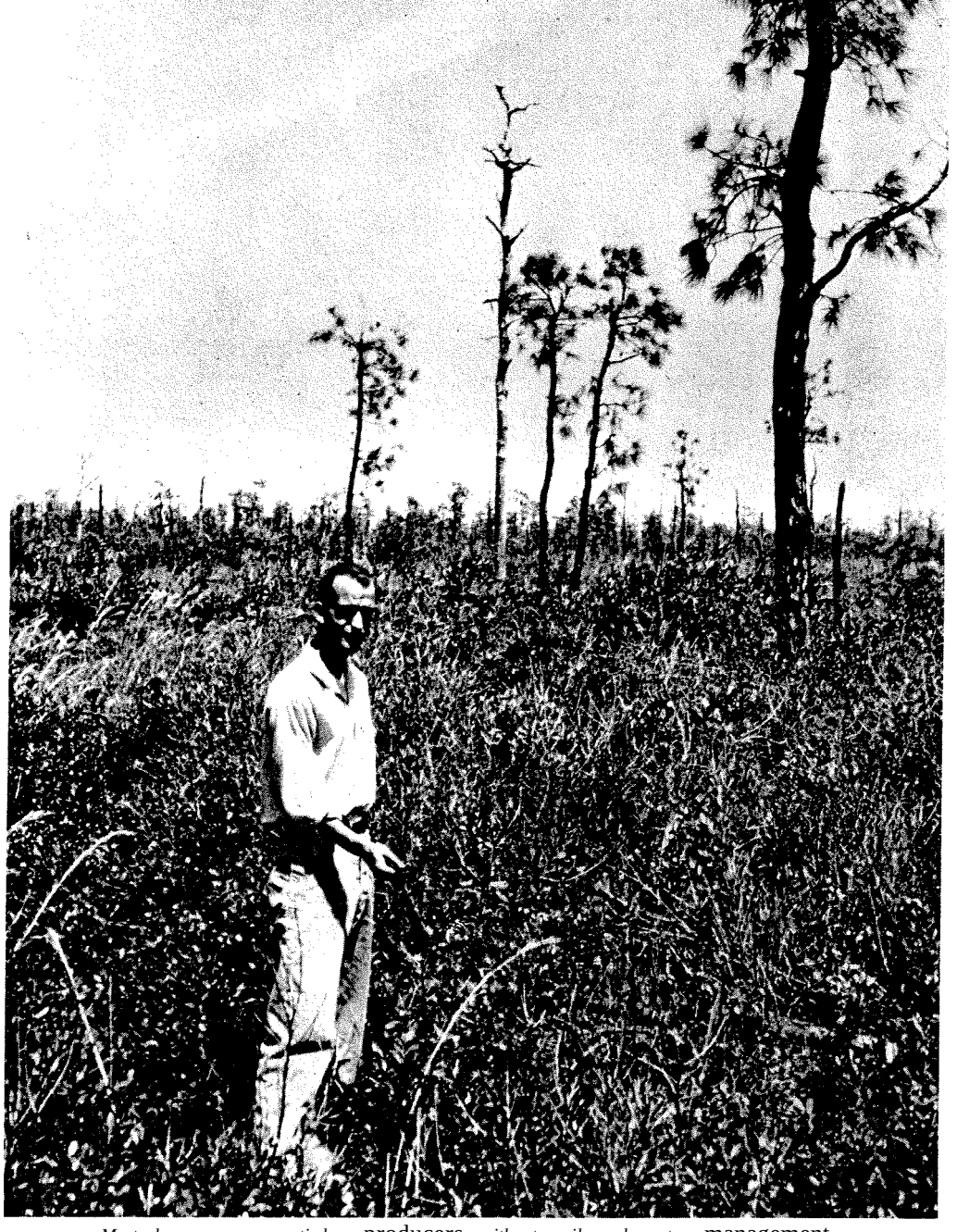
Bays, Pocosins, Swamps

As one might suspect, the wetlands are a vast complex of unlike wet situations. Some are highly productive timber sites; many support only low-growing heaths and degenerate forests. They include such oddities as well-elevated swamps having deep sandy soils which drain scarcely at all, and water-logged flatwoods where trees grow 120 feet tall in 50 years. Furthermore, the wetlands often are not separate types but are intermixed and merge gradually with the changes in soils, landform, and the level, constancy and source of water supply.

The best way to appreciate this diversity is to spend some time walking through wetlands. In a typical traverse, one might first find himself crossing a wet pine flat imbedded with small hardwood and cypress ponds, before entering a large water-filled depression — an upland bay or pocosin — that slowly drains along sinuous pathways into a bottomland creek swamp. Farther downstream, the creek swamps merge and may finally lose identity as a great river swamp near the Atlantic.

Along the coast, where the river empties into an estuary, one may again cross a series of bays— this time, of the coastal variety. Although the peaty soils and vegetation of coastal bays and upland bays are quite similar in many respects, they often differ considerably in water relations. Low gradient of drainage outlets and tidal effects usually limit the drainage of coastal bays much more than the upland ones, which normally are at elevations of 25 feet or more above sea level. The peaty areas, mostly in North Carolina and Virginia, and totaling about 3 million acres, are relatively unproductive and pose special problems.

The water cycle of swamp areas bordering the streams also varies greatly from one situation to the next. Creek swamps ordinarily lie along



Most bays are poor timber producers *without soil and water* management.

the "blackwater" rivers and streams that rise in bays and wet flats. Here the moisture cycle reflects the typical coastal plain summer-wet, winter-dry climate; and high water levels are maintained in the summer which favor surface accumulation of organic plant residues. In contrast, the large river swamps, most common along the lower reaches of "redwater" streams, flood deepest and longest in response to headwater Piedmont and mountain patterns of precipitation, i.e., dry summer and wet winter. However, the frequent summer thunderstorms and an occasional tropical blow on its northward trek sometimes supply enough additional moisture in summer months to maintain high water levels throughout the year.

Thus, needs and opportunities for water management in bays, swamps and other wetland types depend upon their peculiar hydrology. These processes and relationships must be studied and understood for a regional range of wetland situations before there can be any sound undergirding of programs and plans for drainage systems, impoundments, and other water control developments.



Pocosins with peaty soils cover vast expanses of the lower coastal plain.

Soil Is a Key Factor

Wetlands soils hold, transmit, and yield water, and after all are the basic element in forest productivity. Some of the soils are covered with water only during wet seasons, while others remain flooded all year, with all degrees between these extremes. The common denominator, however, is abundant water for prolonged periods, due to presence of an impermeable soil layer, flat topography, and a lack of stream dissection. High groundwater levels and frequent stream overflow are common. Beyond this, the wetland soils vary widely in their properties, reflecting the parent materials from which they have evolved.

Parent materials may be recent alluvial deposits or marine sediments laid down as beds of sand, silt and clay, as well as phosphatic and calcic materials and accumulated plant remains. Some of these materials have been layered but others have been mixed considerably, producing soils with a broad range of profile characteristics and physical properties. More than 80 soil series are recognized in wetland forests, and this list is sure to be extended when soil men get better acquainted with coastal plain bays and pocosins, where soils are now lumped into broad, ill-defined categories such as peats or swamp soils.

Within this broad complex, some of the soils seem highly productive for most forest species, while others are greatly limited in this respect. A farmer selects his best land for his most intensive cropping procedures--drainage, fertilization, or irrigation-because research has shown that on those soils he can expect highest returns. But for the forester trying to manage wetlands, selection is mostly a matter of guesswork, since he lacks knowledge of relationships, the factors affecting wetland productivity, and the probable responses to treatment.

For the time being, and strictly as an interim guide, we think priority research should center on about 6 million acres of the wetlands — 2,700,000 acres in pond pine bays and pocosins plus some 3 million of other wet pine lands. In part, this is to help narrow the field for research attack; but it also reflects the view that commercial pine types, to which most wetlands are being converted following drainage, are most likely to show favorable response from altered water regimes.

Trees Tell a Story

Undoubtedly, the best single index of how much wetlands are improved by water and soil management is the reaction of the tree itself. The dominant trees can tell us by changes in rates of growth whether altered water levels from controlled drainage of wet areas are such as to permit good root development; whether oxygen diffusion through the soil appears adequate; how closely we should space ditches to achieve various levels of site improvement; the optimum quantities of water that should be left in the soil seasonally for best timber growth; and many other important clues to better management.

Not all trees tell the same story, however. The combination which makes for a favorable site for one species may not be desirable for others. This has been demonstrated dramatically in our early studies, where first-year survival and growth of planted water tupelo was best under prolonged flooding, whereas loblolly pine on these same plots did best when water levels were at their lowest. Older, more mature trees show these same habitat preferences, which leads one to conclude that in speaking of wetland improvement much depends on which species and which site.

In most cases the commercially valuable pines are the preferred trees for the wetlands, and are planted on many drained areas. Hence, loblolly pine in the more northern sections and slash pine farther south will be used as plant gages or "phytometers" in evaluating degrees of site improvement. Large-scale planting of these pines introduces special soil-water problems, such as their varying tolerances to flooding, and their changing water use demands as a hydrologic factor of importance in drainage design and efficiency. These and related problems also are under study by Station teams of hydrologists and foresters.

Water As a Resource

Although wetland improvement is essentially a matter of water control, water conservation is just as much a central aim and need as disposing of the excess water. Future research doubtless will show that water tables must be maintained at adequate levels to get optimum timber growth and sustain wildlife habitat. But beyond this there are likely to be even more important regional water requirements.



Growth of slash *pine trees was speeded by controlled drainage.*

The lower coastal plain has enormous total groundwater supplies — a resource of incalculable value giving this territory a productive potential second to none. Water supplies for towns, farms, and industries more than satisfy present demand — but how about tomorrow and an expanding economy? Can we afford to lower water tables over vast areas of wetland forest without regard to the effects on water supplies of the territories adjacent? Can we be sure that the channels opened to the sea to carry away water during wet years and seasons will not carry salt water inland during dry ones to infiltrate aquifers now storing fresh, potable water supplies? Questions such as these and many others about the water relations of wetland forests are basic to wetland improvement; and they will take on added force as populations and water requirements pyramid in the years ahead. Indeed, some years hence the number one function of some wetland forests may be to provide sources of fresh water rather than grow pine trees and waterfowl.

Much Needs to Be Done

One of the biggest brakes slowing wetland improvement is lack of knowledge. There is plenty of operational experience and engineering know-how on designing ditch systems and draining wetlands, but virtually nothing on how this modifies soils and hydrology for timber production and other purposes. Systematic observations on cause-and-effect relationships are few and far between. The research job largely lies ahead.

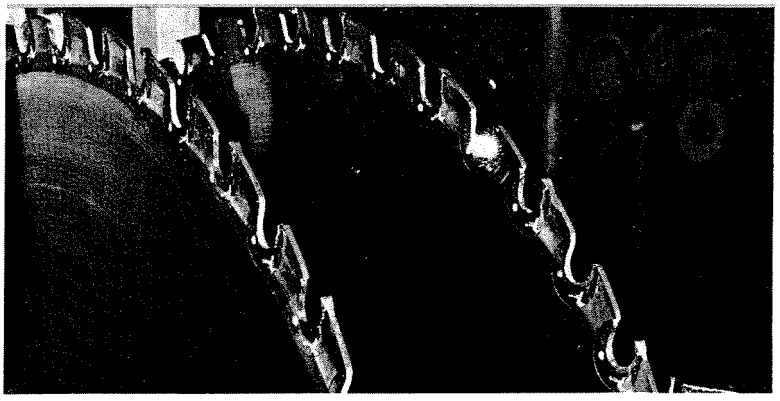
The new work at Charleston is proceeding under several subproject fields

relations, i.e., studies of hydrologic processes, the seasonal moisture regimes of wetlands, and soil property changes induced by water control measures; (2) Plant-water ***relations,*** i.e., studies of the responses of tree species to varying moisture regimes and at different stages of growth, and the adaptation of timber stands to environments created by drainage; and ***(3) Wetland management,*** involving the development and testing of techniques and study of the economics of controlled drainage and related practices.

Some of our current research at Charleston is exploratory in character, designed to help us in classifying wetland situations and in studying their little-understood hydrology. We recognize that interim guides to better management are needed, and that suitable techniques must be developed for estimating how much water is really surplus to the water economy of coastal plain drainages. Knowing this, it would be a relatively simple matter for engineers to design adequate drainage systems to remove the water. Approaches include study of the water balance of selected watershed units; and evaluations of drainage-soil-tree growth relations at selected index locations. These observations, combined with long-term weather records may give us important clues to the response of specific wetland sites. In any event, some early answers, however empirical, will be sought to guide new programs and help wetland managers avoid costly enterprises which could be highly damaging to the Southeast's water resources, timber sites, and game habitat.



Measurements of oxygen diffusion rates and tree growth indicate whether controlled drainage has reduced water levels enough for best loblolly pine diameter growth in wetland forest bay in the South Carolina coastal plain.



Forest Products

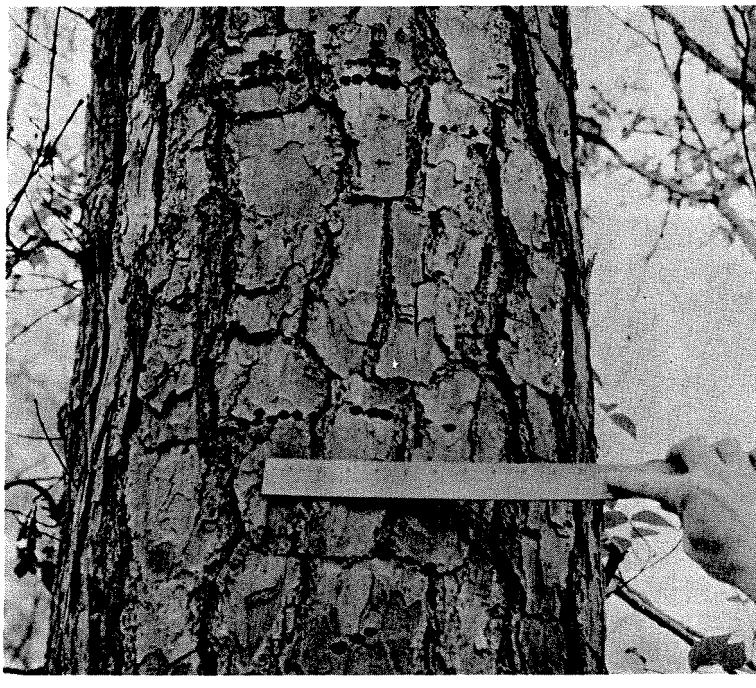
UTILIZATION

Grading Southern Pine Logs and Trees

The grade of lumber sawn from a log is known to be related to the occurrence of certain "blemishes" that appear on the log's surface. These blemishes take many forms: Limbs, knots, conks, and sweep, to name only a few. To apply log grades consistently and accurately, the grader must understand which of these blemishes cause actual degrade in lumber and how important they are.

Late in 1962 we completed a detailed study of sources of lumber degrade in the four major southern pine species — slash, loblolly, longleaf, and shortleaf. The results of this research are described and illustrated in Station Paper No. 1.56, published in March 1963.

The principal contribution of this study was the separation of surface blemishes into degrading and non-degrading. Knots, large holes, excess sweep, conks, and red heart are examples of surface blemishes that reflect degrade-causing conditions within the log. Certain other surface blemishes do not cause degrade but are economically important because they reduce usable volume. These include cankers, crook, fork, bird pecks, and insect and mechanical injuries. Still other features cause neither degrade nor reduction in usable volume, and can largely be ignored. These include compression wood, pitch soak and stain, adventitious limbs, ripples, and small holes.



These small bird pecks constitute a non-degrading blemish and are usually caused by birds looking for insects in the bark. Holes made by sapsuckers seldom penetrate the wood, and are usually found in horizontal bands or rows.





The conk on the left is the fruiting body of the fungus Fomes pini, which causes red heart (right), a scalable and degrading item. The fungus enters through exposed heartwood, usually in broken-off limbs or dead branches.

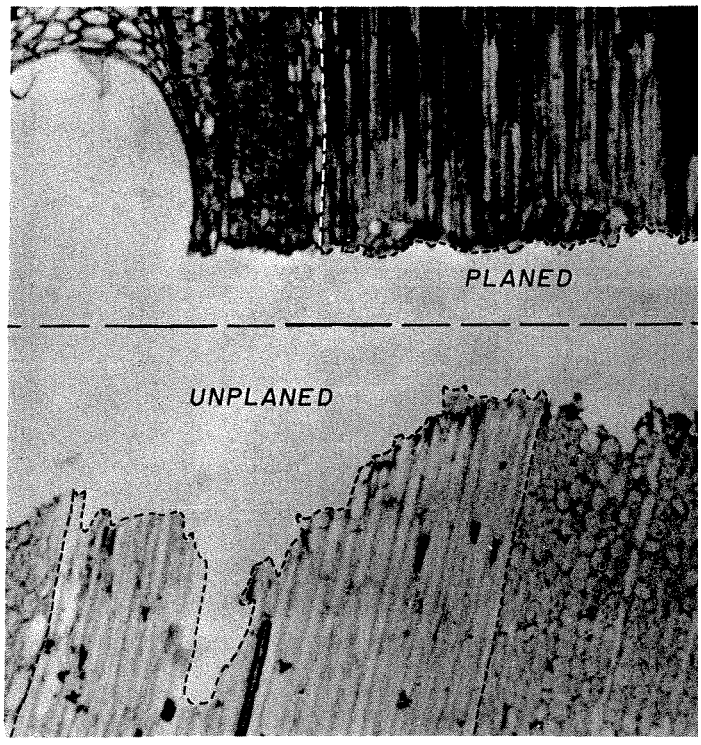
Green Surfacing Oak Lumber

Surface checks develop under too severe drying schedules, and if large enough and numerous enough will degrade lumber. Because of this, the use of faster drying techniques for certain hardwoods, such as the oaks, is restricted.

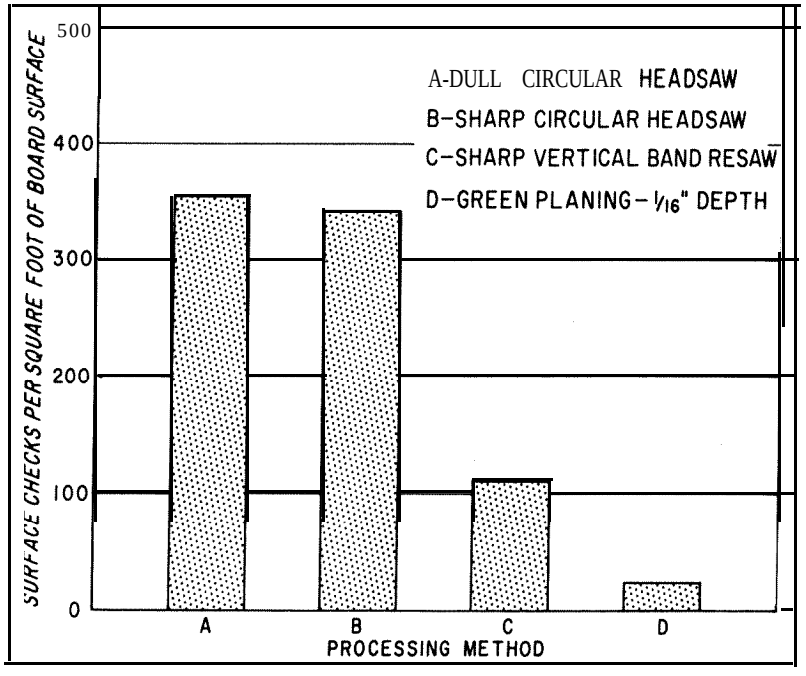
Preliminary studies indicated that surface checking of lumber is related to the sawing process, with circular-sawn boards checking more than band-sawn boards. However, it was believed that planing lumber in the green condition might minimize surface checking, regardless of how the boards were sawn.

To test our hypothesis, sample boards sawn by each process (circular and band headrigs) were dried. Some were planed before drying. A microscopic examination of the surface layers of the boards that were not planed showed that sawing caused many tears in the wood elements, with a high percentage of the subsequent checks occurring in the broad wood rays torn by headsawing. In the boards that were planed green, tears and subsequent checking were negligible. It was also found that planing as little as 1/32 inch in depth brought about a large reduction in surface checking.

Surfacing of green lumber has additional advantages because uniform board thickness increases kiln capacity, reduces warp, and produces a better quality product. The results of this study are expected to apply to other hardwood species in which broad rays occur.



A photomicrograph showing typical differences between planed and unplaned matched white oak boards.

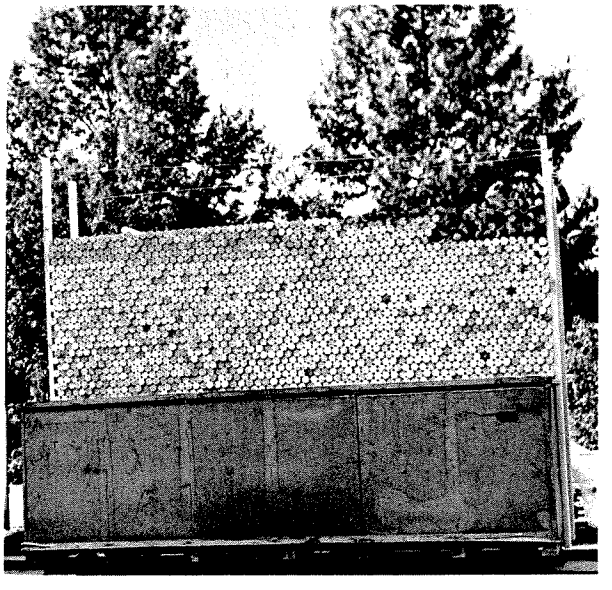


Effect of processing *method* on surface *check* count.

Drying Furniture Rounds by Solid Stacking in Portable Cradles

A relatively new solid wood product is the furniture "round," cut by tubular saws from short logs. These rounds have several advantages over conventional furniture squares. One important feature is a greater efficiency in the drying process; by means of solid stacking, more of the kiln capacity is utilized and kiln costs are reduced.

During the past year we sought, and found, the answer to one question about "rounds": Does solid stacking allow a reasonable drying rate without significant degrade? To find the answer we designed a study in which two test runs were made with a total of 3,000 sap gum rounds that were solid stacked in a portable cradle and dried at constant temperatures and equilibrium moisture content in an experimental dry kiln.



Rounds can be solid stacked for kiln drying and still have sufficient surface exposed to circulating air to dry satisfactorily.

Drying rates in both runs were satisfactory. "Rounds" in the first test (100" F. and 10 percent equilibrium moisture content) dried to 18 percent moisture content in 8.8 days from an initial moisture content of 83 percent. In the second run (120" F. and 8 percent equilibrium moisture content) the rounds dried to 18 percent moisture content in 7 days from an initial moisture content of 103 percent, and to a final 13 percent in 12 days. The distribution of moisture in the rounds in both tests was quite satisfactory.

The samples in both tests were practically free of seasoning degrade except for minor hair-like end checking. About 80 percent of the total number of checks were g-inch deep or less, and the remainder reached ½ inch and slightly deeper. None were severe enough to be called splits. All checks closed in the latter stages of drying. There appeared to be little, if any, surface checking. Only one sample billet from each test showed any warp, neither very serious.

Based on these tests, it is expected that drying time could be shortened without significant increase in seasoning degrade.

Protecting Kiln-Dried Lumber Stored in the Open

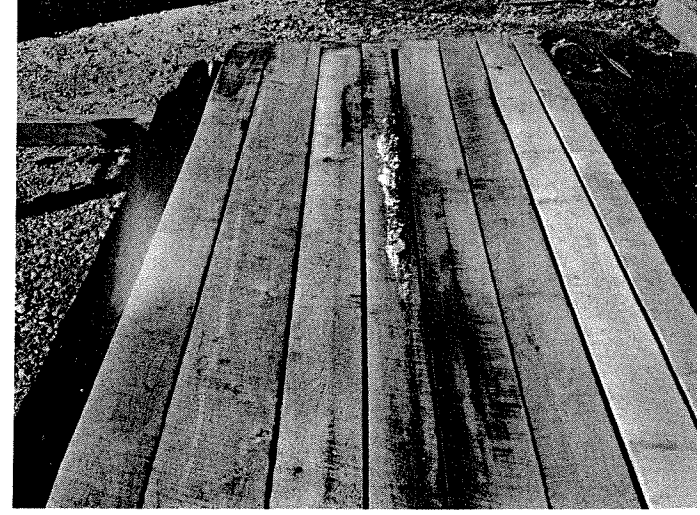
At some furniture plants where there is inadequate indoor storage for kiln-dried lumber, lumber is stored outdoors under various types of coverings to minimize moisture pickup. A study was made to evaluate the effectiveness of two materials and several methods of covering 4/4 inch, kiln-dried soft maple lumber in keeping the dry lumber dry.

Some small sample piles were either completely wrapped or shroud covered (4 sides and top) in 6-mil-thick, black polyethylene film; others in water repellent, fiber reinforced Kraft paper.

None of the coverings proved satisfactory; over a period of 6 months, the moisture content of all lumber piles increased as length of storage time increased, even though moisture pickup was somewhat retarded (table 4). In all experimental piles, the bottom courses contained the driest lumber and the top courses the wettest. This probably resulted from minute tears and holes which

developed from wind, weather, birds, animals, or other causes. Wet spots, stain, and even incipient decay occurred because these tears admitted free moisture and parts of the boards remained wet.

Small experimental piles shrouded with polythylene film were compared with large commercial lumber piles covered in the same manner and stored outdoors at the same plant. Although final moisture values were generally lower in the commercial piles, the tendency to pick up moisture was confirmed. Also, the difference in moisture content values among boards in the same pile was as great as that obtained in the experimental lumber piles.



Incipient decay and stain were found on lumber in some of the wrapped packages, but did not occur on lumber in the unprotected control pile.

Table 4. --Average moisture content of study lumber piles

Cover treatments	Days from initial moisture content readings					
	0	20	40	60	80	188
	Percent					
1. Solid piled lumber, polyethylene shroud on top, sides and ends	8.2	a.7	9.6	10.7	12.5	17.0
2. Stickered lumber, polyethylene shroud on top, sides and ends	8.8	a.4	9.0	9.7	11.2	14.8
3. Solid piled lumber, polyethylene wrapped entirely	8.5	9.1	10.3	11.5	12.9	19.2
4. Solid piled lumber, Kraft paper wrapped entirely	7.6	7.7	8.1	8.9	10.6	12.9
5. Stickered lumber, metal roofed only	7.9	10.6	11.4	12.0	13.8	14.5

Careers in Wood Science Discussed With Top-Ranking High School Students

The Forest Service, universities, and industries engaged in forest products research have been increasingly handicapped by a shortage of trained wood scientists. In an effort to reverse this trend, an Education Committee sponsored jointly by the Forest Products Research Society and the National Lumber Manufacturers Association was formed to acquaint high school students with career opportunities in the wood science fields. These embrace a wide array of disciplines, including wood technology, chemistry, physics, statistics, quality control, and other related subjects. The Station's Forest Products Research Division has been working closely with this Committee and reports some encouraging statistics from the past year's activities.

In 1963 our wood technologists talked to 966 students in 42 chemistry and physics classes at Richmond, Va. Of these 226, or 23 percent, requested additional information about curricula in wood science. Sessions were also held in 23 classes attended by over 500 students in Sumter and Sumter County, South Carolina. One hundred fifty-eight (32 percent) of these students asked for catalogs from colleges teaching wood technology. A final program was conducted in the Charlotte-Mecklenburg, North Carolina, school system where the Committee talked to 1,410 students in 57 classes, predominantly chemistry and physics. Additional information was requested by 300, or 21 percent, of these students.

From experience gained in this campaign a program has now been developed for the use of other groups who might wish to sponsor similar educational instruction.

ECONOMICS AND MARKETING

Management Opportunities in Virginia Farm Woodlands

Until recently, we had no answer for the farmer in the southern Virginia Piedmont who asked, "Which stands in my woodland would it pay me to spend time and money improving?" Nearly half the stands in farm woodlands in this area are less than well stocked with marketable or potentially marketable trees, and thus would be more productive if thinned, released or, in the case of some hardwoods, converted to pine. This situation is fairly typical of the Virginia-North Carolina Piedmont.

As one phase of a study to find the place of forestry on farms, we assembled and organized into cost-and-returns schedules the available cost, price, and growth response information for needed treatments. Separate schedules were prepared for average stands of each forest type, stand size, and level of stocking. Each one showed all expenses and incomes expected, and the difference between the totals, i.e., the net returns from treating the stand.

These schedules indicate that owners are not as a rule justified in treating pine stands. This does not mean pine markets are lacking or that pine does not grow well here. It is simply a question of how much a farmer can increase returns by treating pine. Many pine stands are so well stocked with desirable trees that they do not need treatment. And for stands that require thinning, releasing, or underplanting, increases in revenue will often be too small to cover treatment cost.

The hardwood picture is quite the other way. These stands, in general, are in such poor condition that if left alone they will earn the owners little or nothing. By treating them, however, owners could increase receipts substantially. In the better stocked sawtimber and poletimber stands, this can be done by thinning and release cutting. But poorly stocked hardwood stands of these sizes and all seedling and sapling stands offer so little potential for improvement, it is best to convert them to loblolly pine.

It should be emphasized that these results are for average stands growing on average sites, and thus contrary possibilities should not be ruled out. The fact remains that on typical Virginia Southern Piedmont farms untreated pine stands are producing at about their capacity; by contrast, the hardwoods will return little income to the owner unless he spends money or effort on needed forest improvement practices.

Integrated Marketing of Timber

In the *integrated* sale and utilization of standing timber each portion of a tree is utilized for its highest potential. For instance, the best trees might make poles or piling, good butt logs would go as veneer logs, and center portions if good enough would be saw logs, with tops producing pulpwood. When each tree or tree section is sold for its highest use, the buyer's prospective profits are increased and he is able to pay top prices for stumpage. The system has been widely discussed among foresters as a way of aiding timber buyers and sellers. Although examples of integrated logging can be found in the Southeast, it is still largely a theoretical concept.

The Station has undertaken a study to provide methods for determining the conditions under which integrated sales are possible and more profitable than one-product sales in the Southeast, and to provide guides for marking timber in integrated sales. These guides should include methods for deciding: (1) whether the size, volume, and timber stand structure will support the sale of more than one product, (2) what products can most profitably be combined, and (3) what trees or tree sections should be allocated to each product.

The first phase of this study is to develop mathematical equations for the prediction of operational costs of various timber products, taking into consideration stand conditions, topography, undergrowth type and density, and equipment combinations. Data for these equations are being obtained from time and cost studies of 20 operations for each product in Virginia, the Carolinas, Georgia, and Florida.

Wood-Use Trends in the Furniture Industry

As part of the current reappraisal of potential future demand for wood, the Station has made a study of wood-use trends nationwide in the furniture industry. This industry is particularly important in the Southeast, with North Carolina leading the U. S. in household furniture production. Furniture companies coast to coast annually consume about a third of all the hardwood lumber produced.

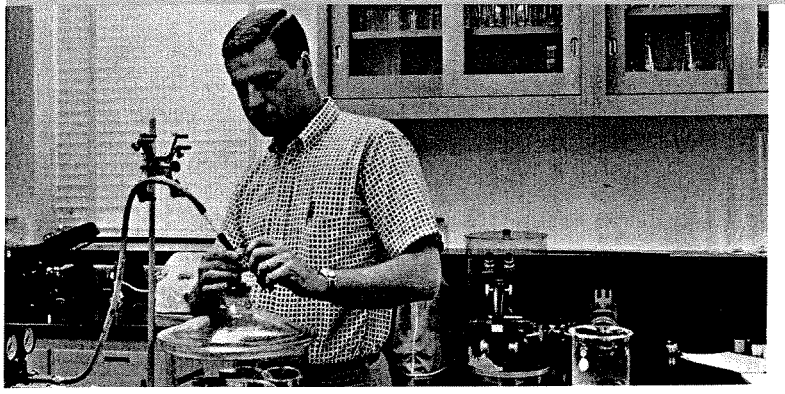
Wood use in the furniture industry was found to be related to trends in furniture output and styles. The bulky, high-gloss, amorphous furniture known in the trade as "Borax," which was prevalent in the prewar period, has given way to highly styled, thin-lined Modern as consumers' tastes have become more discriminating. Since furniture is becoming more and more an intensively styled fashion item which necessitates frequent design changes, long runs of any one pattern are becoming more difficult to obtain. The most prominent advantage wood appears to have over most competitive materials is thus the low tooling costs involved in making changes in the production process.





Style changes in present-day furniture require frequent design change. Retooling for ***wooden furniture is relatively inexpensive and gives this versatile material an advantage.***





Forest Diseases

Where Do We Stand on *Fomes annosus*?

The annosus root rot project, established in the fall of 1961, has grown to be the largest research effort on forest diseases at the Southeastern Station. This growth reflects an increasing awareness on the part of forest-land managers of the danger of heavy losses from annosus root rot, especially in thinned plantations.

The damage this disease can cause is emphasized by records from study plots established in 1959 (table 5). Annosus has continued to spread in 3 of 5 plots established in thinned slash pine plantations. The rate of spread in these plantations has been striking, and three of the plots are now nearing the SO-percent mortality level. One of the plots, with 1.5 by 15 spacing, has shown no increase in infection since it was established. A second widely spaced plot (8 by 15) showed no increase in infection during the past year, but total losses have been highest in this particular plot. It is possible, however, that spacing may have an effect on spread of the disease. This is one of a number of leads from these studies that will be followed up.

Our concentrated effort on annosus research has produced new information on the spread of *Fomes annosus* from cut stumps into roots, and on the competition of *F. annosus* with other organisms in stumps and roots; most significant of all, we have discovered a different avenue of infection through which the fungus invades a previously healthy stand.

How Fomes Begins

Before effective control measures could be developed, it was necessary to know how infections begin and how rapidly the fungus grows down through the stumps to the roots and thence to the roots of nearby trees. Answers to those questions were obtained from a study involving 2 years of painstaking and time-consuming observations, and now we are in a much better position to understand the pattern of infection. The study itself involved a series of inoculations of shortleaf pine stumps. Two types of annosus spores were used: basidiospores, produced on conks; and conidia, usually produced on the surface of decaying wood. Results show that colonization reached a peak 6 months after inoculation, but decreased rapidly after 9 months.

Table 5. --Increase in annosus root rot damage over a 4-year period

Plot location	Age of stand	Original spacing	Thinnings	Trees infected or dead		
				1959	1962	1963
	Years	Feet	Number	Percent		
South Carolina	24	5x8	2	12	27	31
South Carolina	26	6x6	1	5	35	46
South Carolina	24	6x6	2	24	41	46
Georgia	23	8x15	1	35	47	47
Georgia	28	15x15	1	13	13	13

The non-inoculated check stumps were also heavily infected by naturally occurring ***Fomes annosus***, but the fungus often colonized only a small portion of each stump. In these naturally infected stumps the fungus tended to grow downward in columns and did not spread laterally. Unless one of these columns of rot happened to be directly above the point of a root origin, it did not spread into the root system. This meant that in many naturally infected stumps there is an excellent possibility of the infection not reaching the lateral roots, which are the pathways of infection to adjacent trees. Therefore, the number of roots infected was related directly to the proportion of the stump cross-section actually colonized by ***F. annorur.***

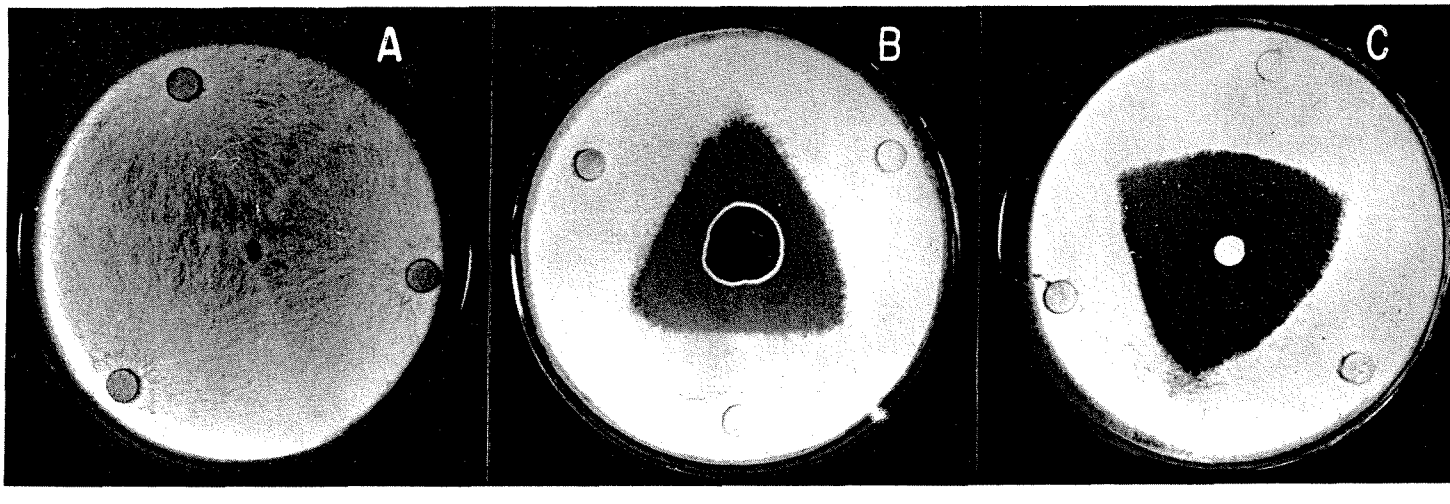
This study also gave our pathologists vital new information on the spore form of the fungus most important in starting infections, as well as an idea about the quantity of spores needed to colonize stumps effectively. Basidiospores were much more effective in colonizing stumps than conidiospores. In fact, a relatively low concentration of basidiospores colonized stumps more thoroughly than 600 times more conidiospores. In general, when the number of either type spore was increased tenfold, extent of colonization of the stump doubled. One unusual result, however, was that reducing the number of conidia in the inoculum to a very low level produced much less colonization and a slower rate of growth of *F. annosus* than in naturally non-inoculated stumps. Because the inoculated stumps were in the same area and were also exposed to the same natural spore shower, these results mean that inoculation with the low number of conidia either blocked infection by naturally occurring spores or prevented their development. These results also demonstrate that conidia are not as important a source of annosus infection as spores from conks. They all fit into the control picture because it may be possible to reduce the production of fungus conks by controlled burning to prevent the accumulation of litter which favors conk formation.

Important Competitors

The decrease in stump colonization by ***F.*** *annosus* 6 months after cutting was strongly correlated with the development of competitive fungi in these stumps. *Peniophora gigantea*, a common slash decomposer, was found to be the most important competitor of ***F.*** *annosus*. *Peniophora*, not present in the stumps 3 months after cutting, rapidly increased until it occupied 70 percent of the volume of the stumps. In addition to the competition from ***Peniophora,*** which infects the stump surface by air-borne spores, ***F.*** *annosus* must also compete with soil-borne fungi in the roots. Soil fungi sometimes invade dying root tissue and block the growth of *F.* ***annosus*** outward toward the root tip. Competitive fungi, therefore, play a very important role in the growth of *F. annosus* in stumps and roots, and may eventually be the decisive factors in the development of effective control measures.

Additional information on ***F.*** *annosus* has been provided from stump treatment experiments. These studies, established in newly thinned plantations during 1962, must be evaluated over a period of years, because the primary criterion is whether or not the treatments prevent spread of the disease into the residual stand. From careful

Normal ***growth*** of Fomes annosus ***in A has overgrown agar surface in petri plate. Antibiotics produced by a competitive*** *fungus* ***(B) and bacterium (C) have retarded the growth*** of F. annosus ***in these plates.***



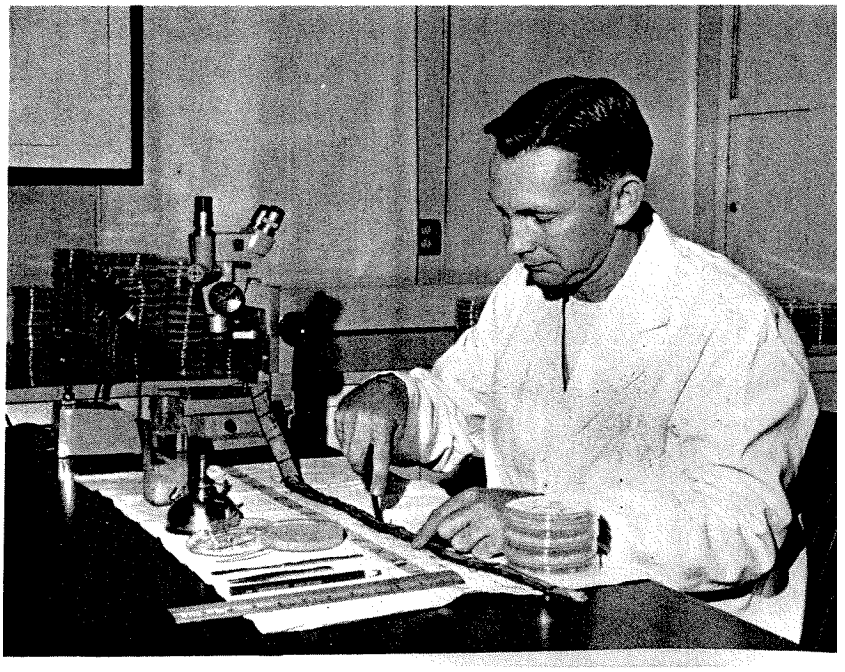
evaluation of observations made on the first series of stump samples, however, we have already added substantially to our knowledge of the biology and ecology of the fungus. Not only have we documented colonization trends and patterns by annosus and associated fungi, but we are much closer to an understanding of why and how season of thinning affects stand susceptibility to infection. We now believe that the critical factor is the period of time the stump and root tissues remain alive. ***F. annosus*** apparently is able to outgrow other fungi in the living tissue of freshly cut stumps and stump roots, but once the tissue begins to deteriorate, other fungi are able to outgrow it. Thus, when thinning was done in October, the majority of the roots remained alive through the winter and ***F.*** annosus was able to colonize most stumps free of competing organisms. In other experiments, when stands were thinned in the spring, we found that more than 50 percent of the stumps were dead after only 3 months, and 96 percent were dead after 7 months. ***F. annosus*** was isolated from less than 10 percent of these stumps.

Two key factors seem to be involved in the establishment of ***F. annosus*** in the residual stand following a thinning. First, does ***P. gigantea*** move rapidly enough down from the stump surface to replace ***F.*** annosus in the roots; and, secondly, do the roots die quickly enough so that soil-borne fungi invade and block the growth of ***F. annosus*** outward in the roots. If stump infection by ***F. annosus*** had to be considered solely, these two factors would probably restrict the spread of the fungus in the majority of cases. We now know, however, that infection of a substantial percentage of stump roots may originate some distance from the stump. In all probability, ***P.*** gigantea will not be able to replace ***F.*** annosus in these cases, nor will soil-borne invaders always move in rapidly enough to block the spread of annosus to adjacent healthy trees.

Fomes Invades Roots

Efforts to control annosus root rot have been based on the assumption that protection of the freshly cut stump surfaces would prevent infection of the stand by ***F. annosus.*** Earlier work, based on a large, 500-tree experiment, confirmed this assumption that the fungus could invade stump surfaces and grow out into the stump roots. Recent research has shown, however, that the fungus may cause infection in addition to that originating at the stump surface. By cutting roots of standing trees in an unthinned, healthy stand, our scientists have found that ***F. annosus*** can also infect dying roots ***without*** first going through stumps. The roots were cut as near as possible to the stem, with only enough soil removed to make the cut. After several months the excised roots were removed and examined for the presence of the fungus. ***F. annosus*** had infected through the cut surfaces, and also occasionally entered areas of the root far removed from the cut, where the soil was undisturbed. In summation, we have learned that it is unnecessary for ***F. annosus*** to become established first in the stump body, but that it can invade roots through wounds and even infect roots where the soil is undisturbed.

This new information is particularly significant because of the growth habit of southern pine roots. Much of the root system is in the humus and upper few inches of soil. A shallow root system is susceptible to injury by such things as insects and nematodes. These wounds are all



Cultural examination of pine roots to detect the presence **of** Fomes annosus.

potential entry points for *F. annosus*. In addition, thinning operations may wound roots of living trees and stumps. Direct invasion of stump roots by ***F. annosus,*** and subsequent infection of adjacent trees, would be much more rapid than if the fungus entered only through the stump surface and then had to grow down into the roots to spread to adjacent healthy trees. Root infection could explain the rapid development of the disease in some recently thinned plantations, as well as the occurrence of *F. annosus* root rot in unthinned stands where there are no stumps.

This information, gained during the past 2 years, makes it necessary to revise our concepts of what would constitute an effective control measure for annosus root rot. We now have a much clearer understanding of exactly what it is that a good stump treatment must accomplish. A chemical which causes rapid death of both stumps and roots would be ideal. In particular, the roots must be killed quickly because they are not only susceptible to direct invasion by *F. annosus*, but are also the pathways along which infection spreads to adjacent trees. If a chemical could also allow colonization by other fungi that compete with *F.* annosus, the treatment would be even more effective. Studies have already been installed to test a range of experimental herbicides, as well as other chemicals, such as ammonium fluoride, to determine whether any of these materials possess the required properties. Because we now know these requirements, final success in developing an effective stump treatment seems within reach.

Fusiform Rust

Breeding for resistance to fusiform rust is the objective of several major research programs in the South. This approach offers a possible means of field control for one of the most serious threats to slash and loblolly pines.

Our research on rust is designed to implement and support these breeding programs by supplying basic information on the virulence of the fusiform rust fungus. The objective is to detect, if possible, the existence of races or strains of the rust fungus, so that it will be possible to inoculate progeny from our breeding program with specific rust cultures of known virulence in order to get reproducible results. Initial studies have been directed at inoculation of oaks (alternate hosts of the rust), because the spore forms on the oaks are highly variable genetically.

An extensive program to develop clonal lines of a wide variety of oak species has been started, so that different rust cultures can be used to inoculate a series of genetically stable hosts. Over 10,800 shoot cuttings from 61 trees, representing 16 species of oaks, have been treated with various growth hormones and placed in propagation beds. After callus formation, the cuttings are removed from the beds and potted in sterile soil for root formation. Periodic checks have revealed that callused cuttings of water, laurel, scarlet, and southern red oak will produce roots in the sterile soil.

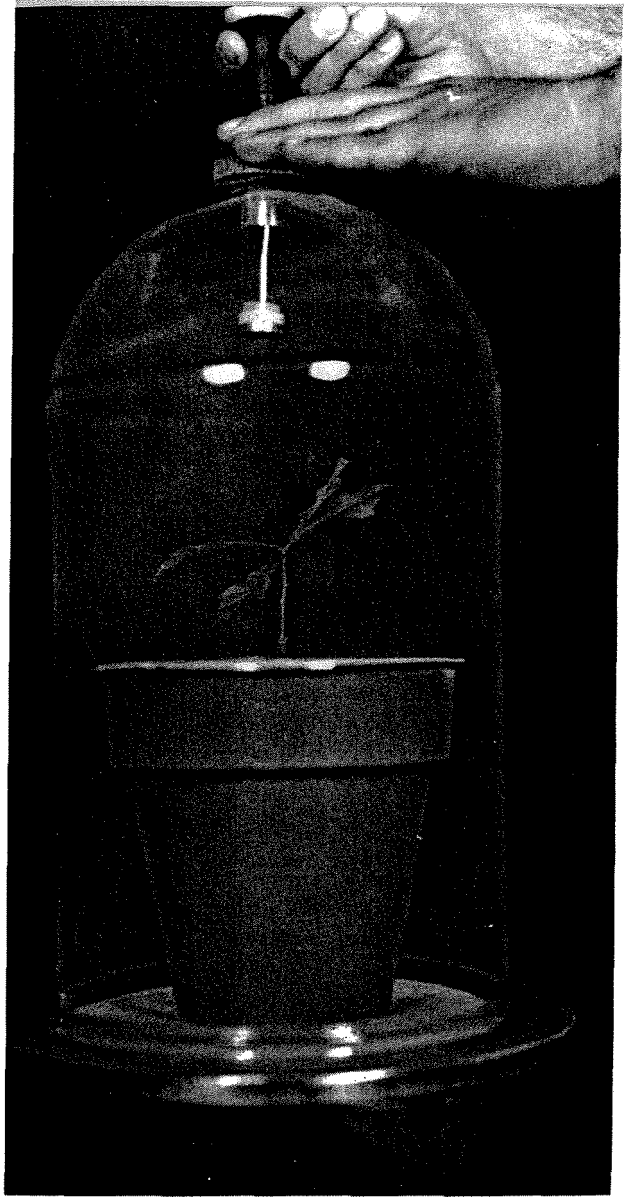
Root cuttings have also been utilized to develop clonal lines, but with limited success. Over 3,000 cuttings, representing 14 species, were hormone-treated and set in propagation beds. Rooting was successful in many cases, but often a shoot failed to develop. Clonal lines of only two species, myrtle oak and sand live oak, have been established by this method.

Because this research is just beginning, an important part of the program is our continuing effort to develop new techniques and to adapt old ones to new needs. Studies on storing rust spores have been undertaken to facilitate greenhouse inoculation tests on a year-round basis. We have found that dried spores stored under a vacuum and at a low temperature maintain high viability for as long as 6 months. Various techniques for inoculating oak leaves with aeciospores have been tested and evaluated. By using a vacuum chamber, we have inoculated oak seedlings with a known quantity of inoculum, and uniform infection patterns have been produced.

Nematology

Do nematodes damage planted pines! To find a partial answer to this question, our pathologists have designed fumigation studies to determine if plant-parasitic nematodes, which are microscopic soil organisms that feed on plant roots, affect the growth of slash pine seedlings in outplantings. These plots have now been observed over a S-year period. After the second growing season, height growth of the trees in plots treated with either methyl bromide (MB) or dichloropropane-dichloropropene (DD) was significantly greater than in unfumigated plots. Results from methyl bromide treatments were also definitely superior to DD when the two fumigants were compared.

After 5 years, methyl bromide fumigation of the field plots still gave the best growth. Fumigation with DD was not as good as methyl bromide but was still superior to no treatment.



Inoculating oak seedling with a cloud of fusiform rust spores in vacuum chamber.

Table 6. --Effect of soil fumigation in nursery and outplanting site on growth of slash pine after 5 years

Treatment 1/		Trees measured	Average height
Nursery	Outplanting site		
		Number	Centimeters
0	MB	50	254
MB	MB	40	237
MB	DD	42	159
0	DD	40	139
MB	0	32	125
0	0	19	94

1/ When used in treatments, MB was applied at the rate of 1 lb./100 sq. ft. and DD at the rate of 20 gal./acre.

Regardless of whether nursery stock was grown in fumigated or non-fumigated beds, fumigation of the outplanting site resulted in increased growth. A comparison of the mean heights (table 6) reveals that plant-parasitic nematodes native to the outplanting site were the primary cause of poor seedling growth. This is assumed because seedlings from untreated nursery beds grew equally well as those from treated beds, provided the outplanting site was fumigated. Therefore, the nematodes causing the damage were not transported from nurseries on planting stock. It is evident that protection from plant-parasitic nematodes immediately after outplanting is important. Pine seedlings protected from this damage should develop healthier root systems that would enable them to withstand adverse factors, such as low levels of moisture and fertility.

Air Pollution

During the past few years, the general public has become increasingly concerned about the problem of air pollution. Naturally, most of this concern is because the health of humans is involved. Recent experiments on air pollution damage to forest trees have shown that knowledge gained in these studies may provide useful techniques to aid in the study of the over-all air pollution problem which so vitally concerns all urban inhabitants. Air pollution damage to trees may provide the first evidence of a growing air pollution problem within a localized area. In addition, strains of pines are being selected which will not only detect air pollution but will respond to specific types of pollutants, thus giving a strong clue to the identity of the primary cause of pollution within a given area.

One study presently underway involves the measurement of the current level of air quality and white pine health surrounding a growing industrial area in order to follow future developments. Four methods are being used to collect data on this study: an aerial survey; color photographs; permanent study plots; and lead peroxide cylinders that determine current levels of sulfur dioxide.



Effect of soil fumigation on pine growth 5 years after treatment. A, fumigation killed nematodes and afforded protection to developing root systems during early growth. B, nonfumigated check plot.



The aerial survey covers about 1,200 square miles. Flights were made at an altitude of 500 feet on flight lines 1 mile apart. This survey will be compared with future surveys, to measure the pattern and rate of damage in the future. On the ground, color photographs are being taken of many stands throughout the study area. These same areas will be rephotographed later for comparison.

Nineteen permanent study plots, each containing 50 dominant or codominant trees, have been established, and data are being taken twice each year to follow any changes in the condition of the areas. Stations containing lead peroxide cylinders have been installed at 12 strategic points. The cylinders, replaced once a month throughout the year, are prepared and analyzed by the Department of Environmental Sciences and Engineering at the University of North Carolina.

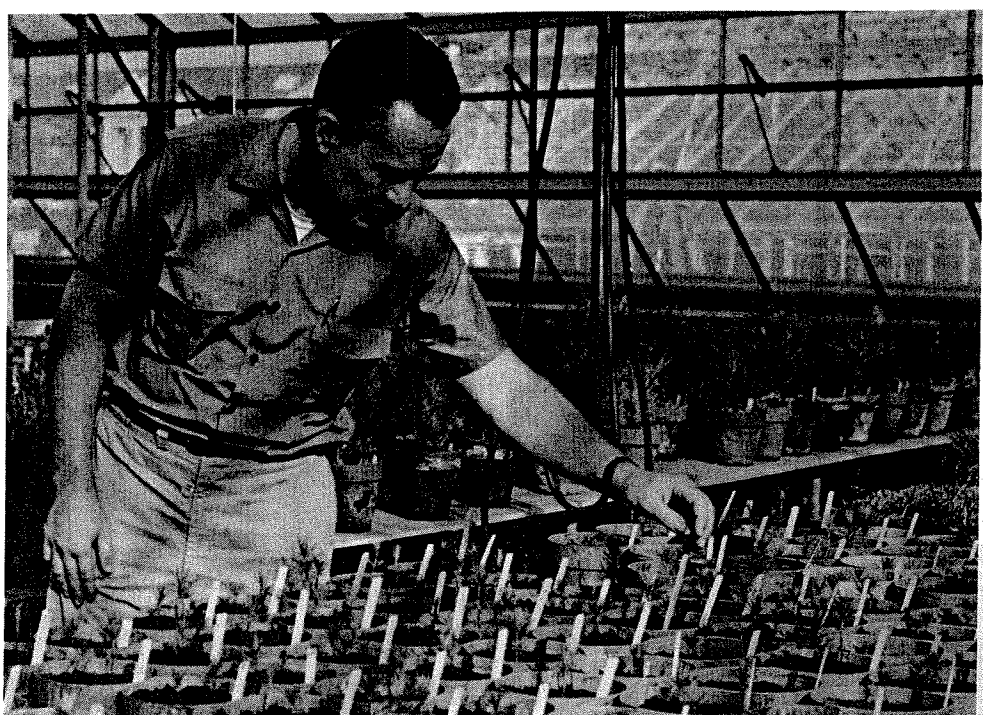
Another important long-term project started during the past year is an effort to select individual white pine seedlings that will be useful as biological indicators of air pollution. This study began after our pathologists noticed varying types of injury on individual white pines in the same area and exposed to the same pollutant. Now, several hundred seedlings are being exposed to air pollution in three areas. In each area there is a specific major pollutant: fluorine in one area, sulfur dioxide in the second, and ozone in the third. Eventually each seedling will be exposed in each area. We expect some seedlings to respond only to a single pollutant and be resistant to others. Seedlings susceptible to one pollutant but resistant to others will be invaluable as biological indicators of specific toxicants.

Antibiotic Research

Actidione, an antibiotic produced by the fungus *Streptomyces griseus,* reportedly controls blister rust on western white pine in the Pacific Northwest. The Southeastern Station has been experimenting with Acti-dione for 4 years to evaluate its effectiveness against blister rust on eastern white pine. These studies involve approximately 600 cankered trees ranging in size from It-foot seedlings to mature trees. Concentrations of 100, 150, 200, and 300 p.p.m. of the antibiotic were mixed in a fuel oil solvent and applied as basal sprays on diseased trees.

The primary criterion for judging the effectiveness of Acti-dione was whether or not treated trees were killed by blister rust. Additional study of living treated trees was necessary, however, to determine whether the disease had continued to develop and spread, or whether the infection had been arrested by Acti-dione treatment. Signs and symptoms of the disease, such as the presence of aecial blisters, pycnial scars, or typical orange-yellow coloration in the cankered areas were carefully examined. Comparisons were made between Acti-dione-treated trees, those treated with the fuel oil solvent alone, and untreated trees. Only trees with cankers girdling less than

Inoculation studies with nematodes. *For* ***the first time, numerous nematode species are being used to inoculate forest tree seedlings to determine if they cause damage.***



66 percent of their circumference were used in the final evaluation. Additionally, only cankers directly contacted by the basal spray were included in the study; early results gave no evidence that Acti-dione was translocated beyond the sprayed zone to eradicate cankers high up on the stem or on branches, as had been reported in the Northwest.

One quickly noticeable effect of spraying diseased trees with Acti-dione was a sharp reduction of canker fruiting 9 months after treatment. In comparison to 43 percent fruiting cankers in the untreated series, only 4 percent of the cankers treated with Acti-dione were fruiting. Treatment with fuel oil alone caused a reduction to 22 percent fruiting.

In spite of these encouraging results, we found that the lack of fruiting was not an indication of healing. Some cankers did not show any signs of fungus activity for 3 years after treatment with the antibiotic, only to begin fruiting the fourth year. This fruiting was proof that the blister rust fungus was still active.

After 4 years of observation and evaluation, we conclude that Acti-dione does not give effective control of blister rust on eastern white pine (table 7). To make our final analysis, the test trees were categorized as either (1) dead or with active infections which continued to enlarge, or (2) with cankers that had no signs of fungus activity. It is within this second group that any possible healing would be found, since trees in the first group were either dead or dying. As seen in the table, 87 percent of the trees treated with Acti-dione fell into this dead or dying group, and only 13 percent in the questionable group. This meant that at most only 13 percent of the trees benefited from the Acti-dione treatment. This is far too low a percentage for the Acti-dione treatment to be considered effective.

A statistical analysis of the data from the untreated check series, the fuel oil check series, and the Acti-dione series indicated highly significant differences among the three groups. A comparison between Acti-dione treated trees and those treated with fuel oil alone, however, showed no significant difference between these two groups. In effect, fuel oil alone was as beneficial as the Acti-dione treatment. Neither treatment, however, could be considered economically feasible.

Further evidence to support the ineffectiveness of the Acti-dione treatment was provided by microscopic examination of cankered tissue. Tissue from untreated cankers, cankers treated with fuel oil only, and Acti-dione-treated cankers was examined to determine if either treatment had produced any visible effects on the fungus. Fungus mycelium in all tissue examined was identical, regardless of treatment. There were no signs of any deleterious effects on the fungus in any of the material.

The results from these studies demonstrate that Acti-dione is not effective in treating blister rust on eastern white pines. Indications are that Acti-dione simply masks disease symptoms, as in the case of reduced canker fruiting, without having any healing effect on the cankers themselves. In addition, the analysis showed that fuel oil alone could produce an effect equal to that of the antibiotic, but obviously neither treatment could be considered practical because at least 87 percent of the treated trees were dead or dying.

Table 7. --Final results of treating white pine blister rust cankers with Acti-dione

Treatment	Total trees	Trees dead or with active infections		Trees with questionable cankers 1/	
		Number	Percent	Number	Percent
Untreated check	69	68	99	1	1
Fuel oil check	57	54	95	3	5
200 p.p.m. Acti-dione	97	84	87	13	13

1/ There were no indications of canker activity in this category.

PUBLICATIONS

by

MEMBERS OF THE STAFF
INCLUDING COOPERATORS

Calendar Year 1963

ADAMS, H. E., and SCHOCH, M. S.
1962 forest fires and fire danger in Connecticut, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia.
(Twelve separate reports containing tables and graphs analyzing forest fires and fire danger.)

ALTOBELLIS, A. T., and COOPER, R. W.
Moisture content of gallberry and palmetto during a dry period. Fire Control Notes 24: 10.
(Drought conditions during fall of 1961 did not significantly lower the moisture content of plants, as compared with 1959 and 1960, when normal rainfall occurred.)

AMMAN, G. D.
A new distribution record for the balsam twig aphid. Jour. Econ. Ent. 56: 113.
(*Mindarus abietinus* found on Fraser fir in North Carolina.)

AMMAN, G. D., and BERRY, C. R.
Insects not a cause of post-emergence chronic tipburn of white pine in eastern Tennessee. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Note SE-2, 3 pp.
(White pine trees kept free of insects were compared with check trees but revealed no difference in recovery from tipburn symptoms.)

ASHER, W. C.
Effects of 2-chloroethyltrimethylammonium chloride and 2,4-dichlorobenzyltributyl phosphonium chloride on growth and transpiration of slash pine. Nature 200: 912.
(Soil applications of CCC reduced both transpiration and growth of l-year-old slash pine.)

ASHER, W. C.
Squirrels prefer cones from fertilized trees. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Note SE-3, 1 p.
(Squirrels ate 11.7 percent of the cones on fertilized trees but only 1.3 percent of the cones on unfertilized slash pine.)

BARNES, R. L.
Nitrogen metabolism in relation to flowering in pine. (Abs.) Assoc. Southeast. Biol. Bui. 10(2): 23.
(Nitrogen composition, metabolism, and translocation in relation to flowering and fruiting in loblolly pine.)

BARNES, R. L.
Nitrogen transport in the xylem of trees. Jour. Forestry 61: 50-51.
(Nitrogen is transported from the roots to the tops of trees mainly as specific organic compounds in the xylem sap.)

BARNES, R. L.
Organic nitrogen compounds in tree xylem sap. Forest Sci. 9: 98-102.
(The free amino acids and ureides occurring in the xylem saps of 60 species of trees are listed and the implications of the study are discussed.)

BECK, D. E.
Cubic-foot volume tables for yellow-poplar in the southern Appalachians. Southeast. Forest Expt. Sta.. U. S. Fores; Serv. Res. Note SE-16, 4 pp.
(Total cubic-foot volume outside bark and cubic-foot volumes inside and outside bark to 4.0- and 8.0-inch top d.o.b. by diameter and total height.)

BEGA, R. V., CHILDS, T. W., ROTH, L. F., HODGES, C. S., Jr., and HEPTING, G. H.
Symposium on root diseases of forest trees. Phytopathology 53: 1120-1136.
(Review of four serious root diseases — *Fomes annosus* root rot, *Poria weirii* root rot, ***Phytophthora*** cinnamomi on Douglas-fir, and black root rot of pine.)

BENGTSON, G. W.
Slash pine selected from nurserybeds: 8-year performance record. Jour. Forestry 61: 422-425.
(After 8 years in the field under fairly typical "flatwoods" plantation conditions, outstanding slash pine seedlings selected from nurserybeds showed a mean height superiority of 23 percent over average stock.)

BENNETT, F. A.
Growth and yield of planted conifers in relation to initial spacing and stocking. Soc. Amer. Foresters Proc. 1962: 22-26.
(Yields from unthinned stands of slash pine, loblolly pine, longleaf pine, eastern white pine, and red pine show a similarity in relation to spacing.)

BENNETT, F. A.
Growth and yield of slash pine plantations. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Paper SE-l, 23 pp.
(Height and diameter growth patterns of field- and forest-planted slash pine are illustrated. Yields as correlated with age, site, and stand density from three formal analyses are tabulated and discussed.)

BERRY, C. R., and RIPPERTON, L. A.
Ozone, a possible cause of white pine emergence tipburn. Phytopathology 53: 552-557.
(Emergence tipburn was observed in the field following recorded ozone concentrations as high as 6.5 pphm. Similar symptoms were produced on greenhouse plants using artificially produced oxidant at the same levels.)

BETHUNE, J. E.
Introduction of loblolly pine south of its natural range in Florida. Jour. Forestry 61: 782, 784.
(After 6 years, survival and growth compare favorably with those of other planted and exotic pines.)

BETHUNE, J. E.
Pine tip moth damage to planted pines in south Florida. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Note SE-7, 4 pp.
(South Florida slash pine is less susceptible to pine tip moth than either typical slash pine or loblolly pine.)

BETHUNE, J. E.
Ridging — low-cost technique for increasing growth on wet flatwoods sites. Forest Farmer 23(2): 6-7, 18.
(After 3 years, South Florida slash pine planted on ridges were 63 percent taller than trees on unprepared sites. Ridging increases height growth of typical slash pine by 40 percent.)

BETHUNE, J. E., and HEPTING, G. H.
Pitch canker damage to South Florida slash pine. Jour. Forestry 61: 517-522.
(Observations of incidence, rate of spread, and effects on tree growth and mortality.)

CAMPBELL, W. A.
Clitocybe root rot. ***In*** Internationally dangerous forest tree diseases. U. S. Dept. Agr. Misc. Pub. 939, p. 9.
(Host, symptoms, effects, and range of Clitocybe root rot; also description of the fungus fruiting body.)

CAMPBELL, W. A.
Phytophthora spp. *In* Important forest diseases of mutual concern to member countries of the North American Forestry Commission. NAFC, FAO, pp. 55-57.
(Generalized discussion of three plant pathogenic species of covering hosts, life histories, damage, and control measures.)

CAMPBELL, W. A., GOODING, G. V., Jr., and HAASIS, F. A.
The occurrence of Phytophthora cinnamomi in Kentucky, North Carolina, Tennessee, and Virginia. Plant Dis. Rptr. 47: 924-926.
(***Phytophthora*** cinnamomi, the fungus causing littleleaf disease of shortleaf pine, was isolated from soils in littleleaf areas in Tennessee and Kentucky. The fungus is also widely distributed in both diseased and littleleaf-free areas in the coastal plain and Piedmont of Virginia and North Carolina.)

CAMPBELL, W. A., and VERRALL,, A. F.
Phytophthora cinnamomi associated with Lawson cypress mortality in Louisiana. Plant Dis. Rptr. 47: 808.
(An experimental planting of Lawson cypress was wiped out by ***Phytophthora cinnamomi*** root rot. This fungus is widely distributed in the South in coastal plain soils.)

CLEMENTS, R. W.
Four years of gum production on pole timber. South. Lumberman 207(2585): 131-133.
(Intensive chipping — 2 years on the front face and 2 years on the back face — is economically feasible and reduces face height on trees to be used for poles.)

CLUTTER, J. L.
Compatible growth and yield models for loblolly pine. Forest Sci. 9: 354-371.
(Equation developed can be used to predict total per-acre production for various rotation ages and thinning regimes.)

COOK, C. W., and LEWIS! C. E.
Competition between big sagebrush and seeded grasses on foothill ranges in Utah. Jour. Range Mangt. 16: 245-250.
(Control of sagebrush with 2,4-D results in improved soil moisture conditions and better grass growth.)

COTRUFO, COSIMO
Stimulation by citric acid on germination of eastern red cedar (*Juniperis virginiana* L.). Nature 199: 92-94.
(Pretreatment with citric acid increases both speed and total germination of eastern red cedar seed.)

CROSBY, J. S., JOHANSEN, R. W., and COOPER, R. W.
A new machine for forest fire control: the Model II Michigan Sand Caster. Cent. States Forest Expt. Sta., U. S. Forest Serv. Res. Paper CS-2, 30 pp.
(Operation and capabilities of the experimental model.)

CUSHWA, C. T.
Development of a method for measuring dispersed recreation use of forest land. Master of Science Thesis in Forestry and Wildlife, Va. Polytech. Inst.
(A l-year, case-history sampling study of recreation use on a 100-square-mile unit of the George Washington National Forest gave acceptable estimates of total and component recreation use. Methods can be adapted for use elsewhere.)

DAVIS, L. W., and COOPER. R. W.
How prescribed burning affects wildlife occurrence. Jour. Forestry 61: 915-917.
(Effect exerted by age-of-rough on forest fire occurrence and forest acreage burned in Florida and Georgia.)

DAY, M. W., and BENNETT, F. A.
Percent of height as a measure of density in slash pine plantations. Mich. State Univ. Agr. Expt. Sta. Quart. Bul. 45(2): 325-333.
(Although percent of height is a valid measure of density, it gives results that do not coincide with basal area or other measures of density.)

DIXON, J. C., and BENJAMIN, D. M.
Natural control factors associated with the jack-pine budworm, *Choristoneura pinus*. Jour. Econ. Ent. 56: 266-270.
(Forty-six parasites were recovered in Wisconsin during 1954-1957 from jack-pine budworm, 20 of which were new records. Contains an evaluation of parasitism on jack-pine budworm populations.)

DORMAN, K. W.
How scientists are attacking fusiform rust. Forest Farmer 22(11): 6-8, 16-18.
(Work of many different investigators on inheritance of resistance to fusiform rust in trees within species, in races, and in hybrids with slash and loblolly pine is summarized.)

DORMAN, K. W.
Planned parenthood for oine trees. Paper Mill News 66(39): 16, 21.
(A popularized account of the contributions of genetics studies to applied silviculture and applied tree breeding.)

DROOZ, A. T.
Aggregation affects color of elm spanworm larvae. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Note SE-13, 4 pp.
(Larvae reared singly were of light colors, whereas larvae reared in colonies were dark. This explains the occurrence of different-colored larvae in the field.)

DROOZ, A. T.
Elm spanworm head-capsule measurements. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Note SE-12, 1 p.
(Five distinct instars were found in a preliminary rearing. Additional work indicated that six instars may occur on certain hosts. This would present a problem in interpretation of the late instars.)

EBEL, B. H.
Insects affecting seed production of slash and longleaf pines — their identification and biological annotation. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Paper SE-6, 24 pp.
(Insects were collected and reared in northern Florida from 1956 to 1960. Paper contains habitat list of insects found in collected host material; annotated list of the insects in host material; key to common insect damage to flowers and cones of slash and longleaf pines.)

FEDDE, G. F.
Elm spanworm. U. S. Dept. Agr. Forest Pest Leaflet 81, 7 pp.
(Distribution, description of stages, life history and habits, hosts, damage, and control.)

FONS, W. L., CLEMENTS,, H. B., and GEORGE, P. M.
Scale effects on propagatron rates of laboratory crib fires. *In* Ninth Symposium (Internatl.) on Combustion, pp. 860-866. New York: Academic Press.
(Effect of the properties of fuel and fuel bed on the behavior of crib fires.)

GABY, L. I.
Surface checking of white oak as related to mechanical processing. Forest Prod. Jour. 13: 529-532.
(Green-surfaced white oak lumber surface checked less than either unsurfaced circular or band sawn lumber.)

GUILKEY, P. C., and NELSON, T. C.
Silvicultural factors affecting saw log quality of loblolly pine. Jour. Forestry 61: 190-192.
(The equation:
Log "K"-count/MBF = 3.313940
- .013522(Age) - .000185(Age X Site)
accounted for about 89 percent of the variation about the mean.)

HENDRIX, F. F., Jr., and KUHLMAN, E. G.
Effect of inoculum potential on colonization of Pinus echinata stumps by Fomes annosus. (Abs.) Phytopathology 53: 877.
(Compares colonization of *Pinus echinata* stumps by *Fomes* annosus where various numbers of conidia and basidiospores are used as inoculum.)

HEPTING, G. H.
Climate and forest diseases. Ann. Rev. Phytopath. *1: 31-50.*
(The relationship between climatic change and tree diseases.)

HEPTING, G. H.
Forest pathology. *In* A Special Field Institute in Forest Biology Proc. 1960. School Forestry, N. C. State Col., Raleigh, pp. 217-247.
(A comprehensive review of concepts, problems, and research-objectives in forest pathology.)

HEPTING, G. H.
Persimmon wilt. *In* Internationally dangerous forest tree diseases. U. S. Dept. Agr. Misc. Pub. 939, pp. 85-86.
(Symptoms, diagnostic features, and range of persimmon wilt.)

HEWLETT, J. D., and HIBBERT, A. R.
Moisture and energy conditions within a sloping soil mass during drainage. Jour. Geophys. Res. 68: 1081-1087.
(A model of a sloping soil profile is used to show that slow, unsaturated flow of soil moisture above the water table furnishes much of the sustained flow between storms in mountain land.)

HEWLETT, J. D., and KRAMER, P. J.
The measurement of water deficits in broadleaf plants. Protoplasma 57(1/4): 381-391.
(Reviews past work and the confusion of terminology in plant water deficits, and compares water deficits measured on leaf disks and whole leaves of many forest trees.)

HILMON, J. B., CLUTTER, J. L., and CABLE, D. R.
Layout of experimental units. *In* Range research methods. U. S. Dept. Agr. Misc. Pub. 940, pp. 124-131.
(Basic statistical requirements for proper layout are defined; biological and physical pitfalls are discussed through examples of grazing experiments from the south and central great plains.)

HILMON, J. B., LEWIS, C. E., and BETHUNE, J. E.
Highlights of recent results of range research in southern Florida. Soc. Amer. Foresters Proc. 1962: 73-76.
(Effects of cattle damage and fertilization on the integrated timber-livestock management of south Florida slash pine ranges.)

HODGES, C. S., and JORGENSEN, E.
Fomes annosus root rot. In Important forest diseases of mutual concern to member countries of the North American Forestry Commission. NAFC, FAO, pp. 36-37.
(Hosts, life history, range, and economic impact of annosus root rot, with discussion of control measures and research problems.)

HOEKSTRA, P. E., and HUTCHINSON, J. G.
First-year results indicate Virginia pine response to release. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Note SE-14, 2 pp.
(All crown classes of 10- to 30-year-old Virginia pine grew more rapidly in diameter during the first growing season after release.)

HUGHES, R. H., and SOUTHWELL, B. L.
Mineral consumption related to improved cattle management systems in Georgia. Jour. Range Mangt. 16: 109-112.
(Mineral consumption by several herds of cattle assigned various rations of native range, improved pasture, and protein supplements over a 6-year period.)

JAMES, G. A., and RIPLEY, T. H.
Instructions for using traffic counters to estimate recreation visits and use. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Paper SE-3, 12 pp.
(A simple, inexpensive, and reliable technique is described for obtaining estimates of recreation visits at unattended sites.)

JAMES, G. A., and RIPLEY, T. H.
Overuse — a threat to our developed recreation areas. Amer. Rec. Jour. 4(3) : 5-6.
(Sampling of developed camping and picnic sites in the southern Appalachians suggests guides for minimizing site deterioration.)

JOHANSEN, R. W.
Protecting the tractor-fireplow operator from radiant heat. Fire Control Notes 24: 73-7.5.
(Discusses use of screen wire for protection.)

JOHANSEN, R. W., and SHIMMEL, J. W.
Increasing the viscosity of water and chemical fire retardants with clays and gums. Ga. Forest Res. Paper 19, 7 pp.
(The effectiveness of two clays and five industrial gums in thickening water and diammonium phosphate solutions.)

JOHNSON, F. M., and DOWNING, R. L.
Preliminary investigations of deer census techniques applicable to' the Southeast. Soc. Amer. Foresters Proc. 1962: 162-165.
(Census results from pellet and track counts and day and night drives in a 746-acre enclosure in Georgia.)

JONES, E. P., Jr.
A test of direct seeding depths for slash and longleaf pine. Southeast. Forest Expt. Sta., U. S. Forest Serv. kes. Note SE-5, 2 pp.
(Slash and longleaf pine seed should have a soil covering of less than one-half inch for best germination.)

JONES, LeROY
Effect of various pre-germination treatments on germination of black cherry seed. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Note SE-8, 2 pp.
(A 48-hour soak in a 0.1 percent citric acid solution prior to stratification increased germination from 57 to 89 percent.)

JONES, LeROY
Germination of repellent-treated southern pine seed before and after storage. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Note SE-15, 4 pp.
(Aiasan-75 treated seed of the four major southern pines can be stored up to 60 days at 38° F. and up to 20 days at room temperature with little loss of viability.)

KETCHAM, D. E., and BETHUNE, J. E.
Fire resistance of South Florida slash pine. Jour. Forestry 61: 529-530.
(South Florida slash pine seedlings are more fire resistant than typical slash pine seedlings.)

KLAWITTER, R. A., STUBBS, JACK, and JOHNSON, F. M.
Tests of Arasan 75-Endrin SOW rodent repellent on Shumard and swamp chestnut oak acorns. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Note SE-4, 2 pp.
(Arasan 75-Endrin SOW will effectively repel rodents only when alternate food supplies are readily available.)

KNIPLING, E. B.
Investigation of the Schardakow Method for the measurement of diffusion pressure deficit. Master of Science Thesis in Botany, Duke Univ.
(Improvement of a simple method for measuring water potential in leaves. The relation between water potential and water deficit in dogwood and sourwood is shown.)

KORMANIK, P. P., and HOEKSTRA, P. E.
A comparison of loblolly, white, Virginia, and shortleaf pine in the Virginia Piedmont. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Note SE-11, 3 pp.
(Loblolly and white pine were taller than either Virginia or shortleaf pine after 16 growing seasons.)

KRAUS, J. F.
The Olustee Arboretum — performance of 67 species of forest trees. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Paper SE-4. 47 pp.
(The Olustee Arboretum was started in north Florida in 1954 as an introduction and breeding garden of exotic pines used by the naval stores industry. Survival and growth are described. Only a very few species grew well.)

KUHLMAN, E. G., and HENDRIX, F. F., Jr.
Phytophthora root rot of Fraser fir. Plant Dis. Rptr. 47: 552-553.
(Describes a new disease of Fraser fir in nurseries, with directions for preparing a selective medium for isolation of the fungus. Control measures are evaluated.)

LANGDON, 0. G.
Growth patterns of *Pinus elliottii* var. *densa*. Ecology ***44: 825-827.***
(Diameter growth occurs over a period of 10 months, peaking in both spring and fall at about the time of the vernal and autumnal equinoxes.)

LANGDON, 0. G.
Range of South Florida slash pine. Jour. Forestry 61: ***384-385.***
(Revision of a previously published range map shows that this species occurs inland in south-central Florida.)

LARSON, R. W., and SPADA, BENJAMIN
Georgia's timber. Southeast. Forest Expt. Sta., U. S. Forest Serv. Resource Bul. SE-I, 39 pp.
(Forest-land area increased 21 percent in the 25 years between the first and third surveys in Georgia. Since 1936, softwood growing stock increased 19 percent and still shows a rising trend, while hardwood growing stock increased 26 percent but shows some leveling off since 1953. Although the productivity of Georgia's forest land has improved in recent years, it is still far below its potential.)

LEWIS, C. E.
Early study results show application of rock phosphate boosts native forage. Fla. Cattleman and Livestock Jour. 27: 24.
(Herbage yield increased two and three times with treatments of 1 and 2 tons per acre of ground rock phosphate on both chopped and unchopped sites.)

LEWIS, C. E.
Rock phosphate proves aid to native range plants. Fla. Cattleman and Livestock Jour. 28: 34.
(Phosphorus, calcium, and protein levels increased in native range plants growing on plots treated with 1 ton per acre of rock phosphate.)

McALPINE, R. G.
A comparison of growth and survival between sycamore seedlings and cuttings. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Note SE-9, 1 p.
(Sycamore seedlings survive better, and when fertilized, outgrow cuttings.)

McALPINE, R. G.
Problems with cottonwood planted in the Georgia piedmont. Tree Planters' Notes 57: 5-7.
(Discusses animal, insect, disease, and forest damage to planted cottonwood.)

McGEE, C. E.
A nutritional study of slash pine seedlings grown in sand culture. Forest Sci. 9: 461469.
(Fresh weight, dry weight, and height growth appeared to maximize when the supply of N and K was greater than 125 ppm but less than 625 ppm.)

McGEE, C. E., and HATCHER, J. B.
Deep-planting small slash pine on old field sites in the Carolina Sandhills. Jour. Forestry 61: 382-383.
(Deep planting improved survival. The greatest benefits were with the smallest planting stock.)

McGINNES, B. S., and RIPLEY, T. H.
Evaluation of wildlife response to forest-wildlife management — a preliminary report. Soc. Amer. Foresters Proc. 1962: 167-171.
(Deer and turkey responses to forage clearings, waterholes, and improvement cuttings.)

McGREGOR, W. H. D., and KRAMER, P. J.
Seasonal trends in rates of photosynthesis and respiration of loblolly pine and white pine seedlings. Amer. Jour. Bot. 50: 760-765.
(Photosynthesis began in February; peaked in mid-July for white pine, and in mid-September for loblolly pine.)

McMINN, J. W.
Precommercial thinning of slash pine. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Note SE-6, 2 pp.
(Thinning did not appreciably increase total merchantable wood production for a 29-year rotation.)

McNASSER K. W.
Forest fire research. Fire Control Notes 24: 11-16.
(General discussion of work at the Southern Forest Fire Laboratory.)

MARTIN, R. E.
Thermal properties of bark. Forest Prod. Tour. 13: ***419-426.***
(Thermal conductivity, specific heat, and diffusivity were determined for 12 different pine and hardwood species.)

MATTHEWS, F. R.
Southern cone rust. *In* Important forest diseases of mutual concern to member countries of the North American Forestry Commission. NAFC, FAO, pp. 27-28.
(Hosts, range, and economic impact of southern cone rust plus review of control measures.)

MERKEL, E. P.
Distribution of the pine seedworm, *Laspeyresia anaranjada*, with notes on the occurrence of *Laspeyresia ingens*. Ann. Ent. Soc. Amer. 56: 667-669.
(Data on the geographic distribution of both seedworm species, collected from 35 well-distributed sampling points throughout the range of typical slash pine and its south Florida variety.)

MERKEL, E. P.
A new southern pine tip moth. Jour. Forestry 61: 226-227.
(A brief summary of known hosts and geographic distribution of ***Rhyacionia subtropica*** Miller, which was described as a new species in 1960.)

NELSON, T. C.
Basal area growth of natural loblolly pine stands. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Note SE-IO, 4 pp.
(Basal area growth is a function of stand density, density-age, and density-site interactions, and is described by a curvilinear form in relation to stand density and age.)

NELSON, T. C., and BENNETT,, F. A.
Growth and yield of slash pine plantations. Forest Farmer 23(2): 10-11, 17.
(Effects of age, site, and spacing on growth and yield of planted slash pine.)

NELSON, T. C., and BRENDER, E. V.
Comparison of stand density measures for loblolly pine cubic-foot growth predictions. Forest Sci. 9: 8-14.
(Stahelin's percent of full stocking, total basal area, Reineke's stand density index, and initial merchantable cubic-foot volume are essentially equally effective measures of stand density for growth predictions.)

NELSON, T. C., TROUSDELL, K. B., BRENDER, E. V., and LOTTI, THOMAS
Board-foot growth of loblolly pine as related to age, site, and stand densitv. Jour. Forestrv, 61: 120-123.
(Tables and equations are presented for the prediction of periodic annual board-foot growth in natural stands of loblolly pine.)

OSGOOD, E. A., Jr., and CLARK, E. W.
Methods of sexing and sex ratios of the southern pine beetle, *Dendroctonus frontalis* Zimm. Canad. Ent. 95: 1106-l 109.
(Of several sexual differences investigated, the combination of the prominence of the frontal tubercles and depth of the frontal groove in the male is the most useful criterion. The sex ratio is 1: 1.

PAGE, R. H.
Impact of naval stores on utilization of longleaf and slash pine timber. Forest Prod. Jour. 13: 361-364.
(Special emphasis on longleaf and slash pine for lumber, poles, and pulpwood.)

PAGE, R. H., and BOIS, P. J.
Selling by weight — some guidelines. Forest Farmer Manual 22 (7) : 24-26.
(Major factors affecting the buying and selling of saw logs and pulpwood by weight. Weight-volume tables for several species are presented.)

PATRIC, J. H.
Forest experiment demonstration area on trail. Appalachian Trailway News 24(2): 21.
(A demonstration of multiple use resource management in action along the Appalachian Trail.)

POWERS, H. R., Jr.
Disease and hardwood management. Forest Farmer 23(1): 15, 32-35.
(A review of forest management practices that reduce losses from several diseases of hardwoods.)

POWERS, H. R., Jr
Fusiform rust and annosus root rot — the South's most serious plantation diseases. Soc. Amer. Foresters Proc. 1962: 34-36
(Review of hosts, economic impacts, and control measures for rust and annosus root rot; also several research aspects on the biology of the fungi causing these diseases.)

POWERS, H. R., Jr., and BOYCE, J. S., Jr.
Annosus root rot in eastern pines. U. S. Dept. Agr. Forest Pest Leaflet 76, 7 pp.
(Current status of information on hosts, range, symptoms, means of spread, economic impact, and control of annosus root rot.)

REPPERT, J. N., HUGHES, R. H., and DUNCAN, D. A.
Herbage yield and its correlation with other plant measurements. *In* Range research methods. U. S. Dept. Agr. Misc. Pub. 940, pp. 15-21.
(The applications and shortcomings of direct measures, indirect estimates, and combination of these two basic methods are reviewed.)

RIPLEY, T. H.
The ups and downs of deer. Forest Farmer 22(6) : 6-7.
(Charts the changes in deer populations brought about by changes in land use and suggests future action.)

RIPLEY, T. H., JOHNSON, F. M., and MOORE, W. H.
A modification of the line intercept method for sampling understory vegetation. Jour. Range Mangt. 16: 9-11.
(A technique for measuring changes in browse composition and density in woody understory browse.)

RIPLEY, T. H., and MCLURE, J. P.
Deer browse resources of north Georgia. Southeast. Forest Expt. Sta., U. S. Forest Serv. Resource Bul. SE-2, 20 pp.
(Inventory of the quantity, quality, and use of woody deer browse in 3.2 million acres of commercial forest land in north Georgia.)

RODENBACH, R. C.
Millwrighting — key to more accurately sawn lumber. Furniture, Plywood and Veneer Council of the N. C. Forestry Assoc., Inc., Rpt. 11, 8 pp.
(Over 50 percent of the mtsmanufactured hardwood lumber produced by 10 small circular sawmills was due to minor mill misalignments and errors.)

ROTH, E. R., HELLER, R. C., and STEGALL, W. A.
Color photography for oak wilt detection. Jour. Forestry 61: 774, 776, 778.
(A study to determine whether oak wilt detection could be effectively and economically carried out by means of aerial color photography.)

SLUDER, E. R.
A white pine provenance study in the Southern Appalachians. Southeast. Forest Expt. Sta., U. S. Forest Serv. Res. Paper SE-2, 16 pp.
(White pine seedlings of southern origin were taller on the average than seedlings of northern origin after 3 years in plantations on 3 sites in the Southern Appalachians.)

SMITH, R. F.
Preferential attack by *Dendroctonus terebrans on Pinus elliottii.* Jour. Econ. Ent. 56: 817-819.
(Incidence was markedly greater on previously attacked than on unattacked trees.)

SMITH, W. R.
The hickory task force — promotional success. South. Lumberman 207(2585) : 101-102.
(Story of a group dedicated to the proper and full use of this species where appropriate.)

SOUTHEASTERN FOREST EXPERIMENT STATION
Annual report for 1962. 66 pp.
(Highlights of the Station's research results.)

SQUILLACE, A. E., and KRAUS, J. F.
The degree of natural selfing in slash pine as estimated from albino frequencies. Silvae Genetica 12(2) : 46-50.
(Natural selfing for 1 I trees varied from 0 to 27 percent, 9 of the trees showed 5 percent or less selfing, while 2 of them showed 23 to 27 percent, respectively.)

SQUILLACE, A. E., and KRAUS, J. F.
Effects of inbreeding on seed yield? germination, rate of germination, and seedling growth in slash pine. Forest Genetics Workshop Proc., South. Forest Tree Impr. Corn. Pub. 22, pp. 59-63.
(Sound seed yields, germination, rate of germination, and first-year total height decreased with increasing intensity of inbreeding.)

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